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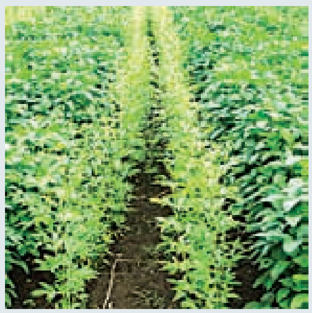

वार्षिक प्रतिवेदन
Annual Report 2017-18

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना
All India Coordinated Research Project for Dryland Agriculture
ICAR-Central Research Institute for Dryland Agriculture
Hyderabad, Telangana, India

The XVI Working Group Meeting of AICRPDA

AICRPDA Centre, Jagdalpur, IGKV, Chhattisgarh, 1-5 February 2018

Shri Kedar Kashyap ji, Hon'ble Education Minister, Govt. of Chhattisgarh, addressing the participants

Presentation of Best Dryland Farmer award to Smt. Sonadayi, Tahkapal village, Bastar District, Chhattisgarh

Inauguration of Exhibition by Shri Kedar Kashyap ji & Dr. S. Bhaskar, ADG (A,AF&CC)

Dr. S.K. Patil, Hon'ble Vice Chancellor, IGKV, addressing the participants

Release of publications

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ANNUAL REPORT

2017-18

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All India Coordinated Research Project for Dryland Agriculture

ICAR-Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad - 500 059, Telangana

2018

Citation: Annual Report 2017-18. All India Coordinated Research Project for Dryland Agriculture. ICAR - Central Research Institute for Dryland Agriculture, Indian Council of Agricultural Research, Hyderabad – 500 059, India. p.304

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Cover Photos

Front cover: Rainwater harvesting in farm pond, Phulbani, Odisha; Soybean + pigeonpea intercropping (4:2), Parbhani, Maharashtra; Tractor drawn compartment bund former, Vijayapura, Karnataka; Tamarind + fingermillet agri-horti system, Bengaluru, Karnataka. Back cover: Participants of the XVI Working Group Meeting of AICRPDA at AICRPDA centre, Jagdalpur

Printed at

Balaji Scan Pvt. Ltd.

11-2-1145, Beside Matas Temple, Nampally

Hyderabad-500 001, Tel: 23303424/25, 9848032644

www.balajiscan.com e-mail: bsplpress@gmail.com

Preface

Rainfed agriculture is practiced in about 73 Mha in India and contributes to about 40% of country's food basket. The climate change/variability, poor operational resource base, bridging yield gaps and soil health pose challenges in sustainability and environmental protection in rainfed agriculture. The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) since inception has the mandate to generate technologies to address agroecology specific problems in rained agriculture. The prioritized research is being undertaken at network Centres in the thematic areas of rainwater management, cropping systems, contingency crop planning, nutrient management, energy management including farm mechanization, identifying drought tolerant varieties, alternate land use and integrated farming systems. Self evaluation through Operational Research Project (ORP) centres and other outreach programmes of the project for technology assessment under real farm situations is unique to the project.

The research progress at the centres was thoroughly reviewed during the XXV Biennial Workshop (at Akola centre during 17-21 January, 2017) and Annual Review Workshop of AICRPDA-NICRA (National Innovations in Climate Resilient Agriculture) (at CRIDA during 26-27 May, 2017). As per the recommendations of these Workshops, the technical programme 2017-18 at the centres was finalized. During 2017-18, 197 on-station experiments and 104 on-farm trials were conducted in various thematic areas. In this Annual Report 2017-18 of AICRPDA, the salient findings of on-station experiments, on-farm participatory research, AICRPDA-NICRA programme, technologies upscaled and other activities are briefly presented. It is hoped that the information in this report is useful to the researchers, students, and other stakeholders engaged in rainfed agriculture research and development.

We are grateful to Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR), Dr. K. Alagusundaram, DDG (NRM) I/c & DDG (Agricultural Engg.) and Dr. S. Bhaskar, ADG (Agronomy, Agroforestry & Climate Change) for their kind support and constant guidance to the project. Thanks also due to scientists and officials from NRM Division, ICAR for their cooperation.

I appreciate the contribution and cooperation of the chief scientists and scientists from the 27 centers and 8 ORPs. I also acknowledge the cooperation of officials/scientists of SAUs/ICAR Institutes/ other AICRPs, KVKs, ATMA, state line departments, particularly the farmers from ORP and NICRA villages.

I wish to compliment Dr. K.A. Gopinath, Principal Scientist (Agronomy) and Dr. Boini Narsimlu, Senior Scientist (SWC Engg.) for their efforts in compilation and Dr. D. Anantha Rao for technical help in bringing out this report.

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

Contents

CONTENTS

कार्यकारी सारांश

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना (एक्रीपडा) देश के वर्षा आधारित उत्पादन प्रणालियों (चावल, मक्का, ज्वार, बाजरा, रागी, कपास, मूंगफली एवं सोयाबीन) के विभिन्न जैव-भोतिकी एवं सामाजिक आर्थिक व्यवस्था के शुष्क, अर्ध-शुष्क, उप-आर्द्र, आर्द्र एवं अति-आर्द्र जलवायु में स्थित 27 केंद्रों के नेटवर्क का प्रतिनिधित्व करता है। इस परियोजना का अधिदेश वर्षाजल प्रबंधन, सस्यसन प्रणाली, पोषकतत्व प्रबंधन, ऊर्जा प्रबंधन, उन्नत वर्षा आधारित फसलों का मूल्यांकन एवं वैकल्पिक भूमि उपयोग/समेकित कृषि प्रणाली के विषयों में फार्म पर अनुसंधान द्वारा स्थान विशेष की प्रौद्योगिकियों का निर्माण करना है। 8 चालू अनुसंधान परियोजनाओं द्वारा किसानों के खेतों पर प्रौद्योगिकियों का मूल्यांकन किया गया। वर्ष 2017-18 के दौरान, वर्षाजल प्रबंधन-40, सस्यसन प्रणाली-28, पोषकतत्व प्रबंधन-41, ऊर्जा प्रबंधन-15, उन्नत किस्मों के मूल्यांकन-20, वैकल्पिक भूमि उपयोग एवं समेकित कृषि प्रणाली-48 एवं संसाधन लक्षण-5 जैसे विषयों पर कुल 197 क्षेत्र स्थायी प्रदर्शनों का आयोजन किया गया। चालू अनुसंधान परियोजनाओं में वर्षाजल प्रबंधन-22, सस्यसन प्रणाली-23, पोषकतत्व प्रबंधन-15, ऊर्जा प्रबंधन-13, उन्नत किस्मों के मूल्यांकन-25, वैकल्पिक भूमि उपयोग एवं समेकित कृषि प्रणाली-6 जैसे विषयों पर 104 फार्म पर जांचों/प्रदर्शनों का आयोजन किया गया।

वर्ष 2017-18 के दौरान, राजकोट (18 दिनों की देरी), चियान्की (11 दिनों की देरी), फैज़ाबाद (11 दिनों की देरी) एवं विजयपुर (12 दिनों की देरी) को छोड़ एक्रीपडा के सभी केंद्रों में मानसून का आरंभ साधारण था। इसके अलावा, अकोला, अनंतपुरमु, बेंगलूरू, बिस्वनाथ चरिअलि, चियान्की, जगदलपुर, कोविलपट्टी, परभनी एवं फुलबानी में फसलों के विभिन्न स्तरों पर हर 10 दिनों से अधिक के 3-4 शुष्क दौर थे। जून 2017 के दौरान आगरा, अकलेरा, फैज़ाबाद, एवं वारणासी में वर्षा की कमी 40 प्रतिशत थी। जबकि हिसार, एसके नगर एवं अनंतपुरमु में वर्षा साधारण से 150 प्रतिशत अधिक थी। जुलाई में, आग्रा, अनंतपुरमु, बेंगलूरू, दरसी, कोविलपट्टी, परभनी, सोलापुर एवं वारणासी में वर्षा की कमी साधारण से 35 प्रतिशत अधिक थी। इसी प्रकार, अगस्त में, चियान्की, फुलबानी, रायचूर, राख धियंसर, रीवा, एसके नगर एवं वारणासी में वर्षा की कमी 35 प्रतिशत से अधिक दर्ज की गई। सितंबर में, आग्रा, अरजिया, चियान्की, हिसार, इंदौर, राजकोट, रीवा, राख धियंसर, एसके नगर, सोलापुर एवं वारणासी में 50-87 प्रतिशत कम वर्षा हुई। इसी प्रकार, अक्तूबर में, आग्रा, अकलेरा, अरजिया, बल्लोवाल सौंक्रि, फैज़ाबाद, हिसार, परभनी, राजकोट, राख धियंसर, रीवा, एसके नगर एवं वारणासी में वर्षा नहीं हुई। नवंबर में, हिसार को छोड सभी केंद्रों में वर्षा की कमी थी एवं आग्रा, अकलेरा, अकोला, अरजिया, बल्लोवाल सौंक्रि, फैज़ाबाद, इंदौर, जगदलपुर, परभनी, रायचूर, राजकोट, रीवा, एसके नगर, वारणासी एवं विजयपुर में वर्षा नहीं हुई।

विशेष उपलब्धियां नीचे दी गई है:

वर्षाजल प्रबंधन

स्व-स्थाने नमी संरक्षण

विभिन्न फसलों एवं फसल प्रणालियों में स्व-स्थाने नमी संरक्षण पर किए गए प्रयोगों में मेढ एवं कूंड प्रणाली, मेढ पर रोपण, संरक्षण कूंड, चौड़ी क्यारी कूंड प्रणाली, अवमृदा प्रयोग इत्यादि जैसे उपचारों को शामिल किया गया।

अनंतपुरमु के शुष्क एल्फीसोल मृदाओं में, अरहर, अरंड, ग्वार एवं बजरा में 2 मीटर की दूरी पर अवमृदा प्रयोग एवं बिना अवमृदा प्रयोग की तुलना में 1 मीटर पर अवमृदा प्रयोग से अधिक अरहर समतुल्य उत्पादन (669 किलोग्राम प्रति हेक्टेयर), कुल लाभ (11780/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.06) एवं वर्षाजल उपयोग क्षमता (1.24 किलोग्राम प्रति हेक्टेयर-मि.मी) दर्ज किया गया।

अर्ध-शुष्क वर्टीसोल : रायचूर में, चौड़ी क्यारी एवं कूंडों (1964 किलोग्राम प्रति हेक्टेयर) एवं सपाट क्यारी प्रणाली (1587 किलोग्राम प्रति हेक्टेयर) की तुलना में स्व-स्थाने वर्षाजल संरक्षण के लिए मेढों एवं कूंडों पर रोपण अपनाने से अधिक बीज कपास उत्पादन (2209 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। परभनी में, हर चार पंक्तियों के बाद कूंडों की खुदाई (1765 किलोग्राम प्रति हेक्टेयर) एवं 2.7 मिटर की दूरी पर संरक्षण कूंडों की खुदाई (1742 किलोग्राम प्रति हेक्टेयर) को छोड सभी अन्य उपचारों की तुलना में छोडी क्यारी एवं कूंड प्रणाली द्वारा स्व-स्थाने नमी संरक्षण से महत्वपूर्ण रूप से उन्नत सोयाबीन बीज उत्पादन (1936 किलोग्रामप्रति हेक्टेयर) एवं कुल लाभ (40488/- रुपए प्रति हेक्टेयर) दर्ज किया गया। इसके अलावा, सपाट क्यारी प्रणाली से 783 टन प्रति हेक्टेयर का अधिकतम मृदा हानि एवं चौड़ी क्यारी कूंड से 3.53 टन प्रति हेक्टेयर का न्यूनतम मृदा हानि दर्ज किया गया।

उप-आर्द्र इनसेप्टीसोल मृदा : मुंगेर में, उत्थित क्यारियों पर मक्का-रबी की बोवाई से महत्वपूर्ण रूप से उन्नत मक्का समतुल्य उत्पादन (9448 किलोग्राम प्रति हेक्टेयर), कुल लाभ (113378/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (12.88 किलोग्राम प्रतिहेक्टेयर-मि.मी.) दर्ज किया गया। इसके बाद मेढ एवं कूंड प्रणाली (क्रमशः 8914 किलोग्राम प्रति हेक्टेयर, 106965/- रुपए का कुल लाभ एवं 12.15 किलोग्राम प्रति हेक्टेयर-मि.मी. का वर्षाजल उपयोग क्षमता) का था। बल्लोवाल सौंक्रि में, सपाट क्यारी बोवाई (2918 किलोग्राम प्रति हेक्टेयर) की तुलना में मेढ़ पर रोपण, संरक्षण कूंड एवं क्यारी रोपण के परिणामस्वरूप मक्का के अनाज उत्पादन में क्रमशः 24, 21 एवं 15 प्रतिशत महत्वपूर्ण वृद्धि हुई; जगदलपुर में नियंत्रण (1723 किलोग्राम प्रति हेक्टेयर) की तुलना में शुष्क बिजाई के अंतर्गत बोवाई के 25 दिनों के बाद हर पांच पंक्तियों के बाद ढलान के विरूद्ध देसी हल चलाने से अधिकतम चावल का उत्पादन (3894 किलोग्राम प्रति हेक्टेयर), कुल लाभ (40065/-रुपए प्रति हेक्टेयर)एवं वर्षाजल उपयोग क्षमता(3.0 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया।

बहि-स्थाने वर्षजल प्रबंधन

कृषि तालाबों में वर्षाजल की सिंचाई, कृषि तालाबों से कम से कम वाष्पीकरण हानि एवं सूक्ष्म सिंचाई प्रणालियों से विशेषकर संरक्षण/अतिरिक्त सिंचाई के रूप में बेहतर उपयोग द्वारा मुख्य रूप से बहि-स्थाने वर्षाजल प्रबंधन किया जाता है।

अनंतपुरमु के शुष्क एल्फीसोल मृदाओं में, मृदा + सीमेंट (6:1) (1321 प्रति वर्ग मीटर प्रति दिन) एवं मृदा + सीमेंट (8:1) (1541 प्रति वर्ग मीटर प्रति दिन) के अस्तर की तुलना में कृषि तालाबों को रेत + सीमेंट (6:1) के अस्तर से जल के रिसाव से होने वाली हानि (72 लीटर प्रति वर्ग मीटर प्रति दिन) कम हुई।

अर्ध-शुष्क वर्टीसोल मृदा : परभनी में, अनुपचारित नियंत्रण की तुलना में हर 10 दिनों के बाद 30 मिलिग्राम प्रति वर्ग मीटर की दर से सिटेल अल्कोहल (cetyl alcohol) के प्रयोग से कृषि तालाबों से वाष्पीकरण हानि करीब 54.4 प्रतिशत कम हुई। सिटेल अल्कोहल (cetyl alcohol) का प्रयोग लागत 1/-रुपया प्रति वर्ग मीटर था। इसी प्रकार, विजयपुर में, अनुपचारित नियंत्रण (216.4 सेंटीमीटर) की तुलना में सिटेल अल्कोहल (cetyl alcohol) के प्रयोग से न्यूनतम वाष्पीकरण दर्ज किया गया। इसके बाद सिलिकन तेल (122.6 सेंटीमीटर) का स्थान था। इसके अलावा, विजयपुर में, बिना अतिरिक्त सिंचाई (क्रमशः 828 एवं 550 किलोग्राम प्रति हेक्टेयर) की तुलना में शुष्क दौर के दौरान ज्वार + चना (2:4) अंतर सस्यन एवं एकल चना में स्प्रिंकलरों द्वारा एक अतिरिक्त सिंचाई देने से क्रमशः 40 एवं 33 प्रतिशत अधिक उत्पादन हुआ। परभनी में, बिना संरक्षण सिंचाई की तुलना में सिंचित वर्षाजल से सोयाबीन को 50 मिलीमीटर का एक संरक्षण सिंचाई के प्रयोग से सोयाबीन के बीज उत्पादन में 61.5 प्रतिशत (1893 किलोग्राम प्रति हेक्टेयर) की वृद्धि हुई।

उप-आर्द्र इनसेप्टीसोल मृदा : बल्लोवाल सौंक्रि में, 3.43 हेक्टेयर के जल संग्रहण क्षेत्र के लिए जल सिंचाई प्रणाली का जलसंग्रहण-भंडारण, जलसंग्रहण-कमांड एवं भंडारण कमांड अनुपात क्रमशः 12.7, 6.86 एवं 0.54 था। जिसमें 0.5 हेक्टेयर क्षेत्र से 0.27 हेक्टेयर-मीटर जल संग्रहित किया गया। वाराणसी में, जल संतुलन घटकों ने सूचित किया कि वर्ष के दौरान सिंचित जल अपवाह 1257.9 घन मीटर, वाष्पीकरण हानि 386.59 घन मीटर एवं जल रिसाव हानि (मृदा मिश्रण योगदान) 321.53 घन मीटर प्रति सप्ताह था। सितंबर में जल रिसाव एवं वाष्पीकरण की हानियों के बाद कृषि तालाब में करीब 56.3 प्रतिशत सिंचित वर्षाजल उपलब्ध था।

सस्यन प्रणाली

अंतर सस्यन प्रणालियां

राख धियंसर के अर्ध-शुष्क इनसेप्टीसोल मृदाओं में, एकल मक्का (2887 किलोग्राम प्रतिहेक्टेयर) की तुलना में मक्का + लोबिया (1:1) अंतर सस्यन प्रणाली ने उन्न्त बीज कपास समतुल्य उत्पादन (3638 किलोग्राम प्रति हेक्टेयर), भूमि समतुल्य अनुपात (1.37), कुल लाभ

(41738/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (7.08 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया।

अर्ध-शुष्क वर्टिसोल मृदा : राजकोट में, एकल कपास (1998 किलोग्राम प्रति हेक्टेयर)की तुलना में कपास + तिल (1:1) के अंतर सस्यन प्रणाली ने उन्नत कपास बीज समतुल्य उत्पादन (2967 किलोग्राम प्रति हेक्टेयर), कुल लाभ (11531/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (4.19) दर्ज किया गया। परभनी में, एकल सोयाबीन (2080 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन + 3.6 मीटर का पट्टीदार अरहर (8 एवं 4 पंक्तियां प्रति पट्टी) (2838 किलोग्राम प्रति हेक्टेयर), 5.4 मीटर (12 एवं 9 पंक्तियां प्रति पट्टी) (2755 किलोग्राम प्रति हेक्टेयर) ने महत्वपूर्ण रूप से उन्नत सोयाबीन समतुल्य उत्पादन (2891 किलोग्राम प्रति हेक्टेयर) एवं समग्र प्रतिफल(88185/-रुपए प्रति हेक्टेयर) दिया जो सोयाबीन + अरहर (4:2) के समान था।

चियान्की के उप-आर्द्र इनसेप्टीसोल मृदाओं में, एकल अरहर (1442 किलोग्राम प्रति हेक्टेयर) की तुलना में अरहर + भिंडी अंतर सस्यन प्रणाली (1:1) ने महत्वपूर्ण रूप से अधिकतम अरहर समतुल्य उत्पादन (3238 किलोग्राम प्रति हेक्टेयर) सहित 2.93 का अधिकतम बी:सी अनुपात दिया।

पट्टीदार सस्यन प्रणाली

अरजिया के अर्ध-शुष्क वर्टीसोल मृदाओं में, एकल मक्का (6130 किलोग्राम प्रति हेक्टेयर) की तुलना में 2/3 क्षेत्र में मक्का का पट्टीदार सस्यन + 1/3 क्षेत्र में मक्का चारा ने अधिक कुल लाभ (77400/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (5.32) एवं वर्षाजल उपयोग क्षमता(4.14 किलाग्राम प्रति हेक्टेयर-मि.मी.) सहित 26 प्रतिशत उन्नत मक्का अनाज समतुल्य उत्पादन दिया।

बल्लोवाल सौंक्रि के उप-आर्द्र इनसेप्टीसोल मृदाओं में, एकल लोबिया एवं एकल मक्का की तुलना में, क्रमशः 4.8 मीटर : 1.2 मीटर (4.8:1.2) पट्टी की चौडाई से मक्का एवं लोबिया के पट्टीदार अंतर सस्यन प्रणाली ने 45.5 प्रतिशत एवं 11.3 प्रतिशत उत्पादन वृद्धि सहित महत्वपूर्ण रूप से उन्नत मक्का समतुल्य उत्पादन (3862 किलोग्राम प्रति हेक्टेयर), कुल लाभ (3862-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.97) एवं वर्षाजल उपयोग क्षमता (6.27 किलोग्राम प्रतिहेक्टेयर-मि.मी.) दिया। इसी प्रकार, बाकी सभी मक्का एवं लोबिया पट्टी की चौडाइयों (1.2:8; 4.8:1.2 एवं 6:0) की तुलना में 6 मीटर चौडी लोबिया की पट्टी से जल अपवाह (74 मि.मी.) एवं मृदा हानि (2.0 टन प्रति हेक्टेयर) काफी कम हो गया।

दोहरी सस्यन प्रणाली

दरसी के अर्ध-शुष्क वर्टीसोल मृदाओं में, एकल अरहर (490 किलोग्राम प्रति हेक्टेयर) की तुलना में बाजरा-लोबिया अनुक्रम ने अधिकतम प्रणाली उत्पादकता (1335 किलोग्राम प्रति हेक्टेयर), समग्र प्रतिफल (66772/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.39) दर्ज किया। इसके बाद कंगनी-मूंग अनुक्रम का स्थान था। जगदलपुर के उप-आर्द्र इनसेप्टीसोल मृदाओं में, पंक्ति बोवाई सहित पारंपरिक कर्षण के अंतर्गत चावल-चना से उन्नत चावल फसल समतुल्य उत्पादन (5569 किलोग्राम प्रति हेक्टेयर), कुल लाभ (68262/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.93) एवं वर्षाजल उपयोग क्षमता (4.14 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया। इमफॉल के अति-आर्द्र मृदाओं में, 150 प्रतिशत बीज दर सहित धान की कटाई के बाद छोटी मटर की बोवाई एवं धान के भूसे की पलवार ने उन्नत चावल समतुल्य उत्पादन (1395 किलोग्राम प्रति हेक्टेयर) दर्ज किया।

पोषक प्रबंधन

स्थायी उर्वरक जांच

बेंगलूरू के अर्ध-शुष्क मृदाओं में स्थायी उर्वरक जांच में, 40 वर्षों में रागी के एकल सस्यन के अंतर्गत, केवल सिफारिश किए गए नाइट्रोजन, फासफोरस एवं पोटाश (क्रमश:1032 एवं 1635 किलोग्राम प्रति हेक्टेयर) की तुलना में 10 टन प्रति हेक्टेयर की दर से गोबर का खाद + 100 प्रतिशत सिफारिश किए गए नाइट्रोजन, फासफोरस एवं पोटाश के प्रयोग से अधिक कुल लाभ (16481/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.65), वर्षाजल उपयोग क्षमता (2.46 किलोग्राम प्रतिहेक्टेयर-मि.मी.) सहित महत्वपूर्ण रूप से उन्न्त (क्रमश: 1860 एवं 3011 किलोग्राम प्रति हेक्टेयर) का अनाज एवं भूसा उत्पादन दिया। गोबर की खाद (10 टन प्रतिहेक्टेयर) + 100 प्रतिशत N, P_2O_5 एवं K_2O वाले खेतों में उन्नत जैविक कार्बन मात्रा (0.58 प्रतिशत), उपलब्ध नाइट्रोजन (245.1 किलोग्राम प्रति हेक्टेयर), फासफोरस (67.4 किलोग्राम प्रति हेक्टेयर) एवं पोटाश (90.4 किलोग्राम प्रति हेक्टेयर) भी दर्ज किया गया।

अनंतपुरमु के अर्ध-शुष्क एल्फीसोल्स मूंगफली में स्थायी उर्वरक जांचों के 33वें वर्ष में, नियंत्रण (2053 किलोग्राम प्रति हेक्टेयर) की तुलना मे 4 टन प्रति हेक्टेयर की दर से गोबर का खाद साथ ही 50 प्रतिशत सिफारिश किया गया उर्वरक (10:20:20 किलोग्राम N, P_2O_5 एवं K_2O प्रति हेक्टेयर) के प्रयोग से उन्नत फली उत्पादन (2202 किलोग्राम प्रति हेक्टेयर दर्ज किया गया। इसके बाद उर्वरकों की सिफारिश की गई

मात्रा (10 :20:20 किलोग्राम N, P_2O_5 एवं K_2O प्रति हेक्टेयर) (2053 किलोग्राम प्रति हेक्टेयर) का स्थान था। 4 टन प्रति हेक्टेयर की दर से गोबर का खाद साथ ही 50 प्रतिशत सिफारिश किया गया उर्वरक (10:20:20 किलोग्राम N, P_2O_5 एवं K_2O प्रति हेक्टेयर) की मात्रा के प्रयोग से उन्नत मृदा जैविक कार्बन दर्ज किया गया। 4 टन प्रति हेक्टेयर की दर से गोबर का खाद साथ ही 50 प्रतिशत सिफारिश किया गया उर्वरक प्रयोग किए गए खेतों में उन्नत मृदा उपलब्ध नाइट्रोजन (184 किलोग्राम प्रति हेक्टेयर) एवं उपलब्ध पोटाश (395 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया एवं 100 प्रतिशत सिफारिश किया गया + 50 किलोग्राम प्रति हेक्टेयर की दर से $ZnSO_4$ के प्रयोग से उन्नत फासफोरस (89 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। 100 प्रतिशत सिफारिश किया गया उर्वरक + 4 टन प्रति हेक्टेयर की दर से गोबर की खाद (13.42 मैगनीशियम प्रति हेक्टेयर) प्रयोग किए गए खेतों में उन्नत मृदा जैविक कार्बन दर्ज किया गया। इसके बाद 4 टन प्रति हेक्टेयर की दर से गोबर की खाद (12.66 मैगनीशियम प्रति हेक्टेयर) का स्थान था।

राख धियंसर में, मक्का आधारित सस्यन प्रणालियों के स्थायी उर्वरक जांचों के 23वें वर्ष में, 50 प्रतिशत सिफारिश किया गया उर्वरक नाइट्रोजन, फासफोरस, पोटाश + 50 प्रतिशत नाइट्रोजन फसल अवशेष (1717 किलोग्राम प्रति हेक्टेयर) एवं 100 प्रतिशत नाइट्रोजन, फासफोरस, पोटाश + 20 किलोग्राम प्रति हेक्टेयर की दर से $ZnSO_4$ को छोड़ अन्य उपचारों की तुलना में 50 प्रतिशत सिफारिश किया गया नाइट्रोजन,फासफोरस, पोटाश (30:20:10 किलोग्राम नाइट्रोजन, फासफोरस, पोटाश प्रति हेक्टेयर) + 50 प्रतिशत गोबर की खाद द्वारा प्राप्त नाइट्रोजन के प्रयोग से महत्वपूर्ण रूप से उन्नत मकका का अनाज उत्पादन (1823 किलोग्राम प्रति हेक्टेयर) हुआ। 10 टन प्रति हेक्टेयर की दर से गोबर की खाद के प्रयोग से अधिकतम जैविक कार्बन की मात्रा (0.57 प्रतिशत) दर्ज किया गया। इसके बाद 50 प्रतिशत सिफारिश किया गया नाइट्रोजन, फासफोरस, पोटाश + 50 प्रतिशत गोबर की खाद (0.54 प्रतिशत) द्वारा प्राप्त नाइट्रोजन के प्रयोग से एवं 50 प्रतिशत सिफारिश किया गया नाइट्रोजन, फासफोरस, पोटाश + 50 प्रतिशत नाइट्रोजन फसल अवशेष (0.49 प्रतिशत) के प्रयोग से दर्ज किया गया। 50 प्रतिशत सिफारिश किया गया नाइट्रोजन, फासफोरस, पोटाश + 50 प्रतिशत गोबर की खाद के एकीकरण से उन्नत उपलब्ध नाइट्रोजन (211.6 किलोग्राम प्रति हेक्टेयर), फासफोरस (17.1 किलोग्राम प्रति हेक्टेयर) एवं पोटाशियम (133.5 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

समेकित पोषक प्रबंधन

अर्ध-शुष्क वर्टीसोल मृदाएं : जगदलपुर में, कूंडों में 100 प्रतिशत साधारण रूप से सिफारिश की गई मात्रा + 3 क्विंटल प्रति हेक्टेयर की दर से चूना + 15 किलोग्राम प्रति हेक्टेयर की दर से $MgSO_4$ + 5 टन प्रति हेक्टेयर की दर से गोबर की खाद के प्रयोग से उन्नत मूंगफली का फली उत्पादन (2002 किलोग्राम प्रति हेक्टेयर), कुल लाभ (37654/- रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (2.38 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया। इसी प्रकार, कूंडों में 100 प्रतिशत साधारण रूप से सिफारिश की गई मात्रा + 3 क्विंटल प्रति हेक्टेयर की दर से चूना + 15 किलोग्राम प्रति हेक्टेयर की दर से $MgSO_4$ + 5 टन प्रति हेक्टेयर की दर से गोबर की खाद के प्रयोग के अंतर्गत नाइट्रोजन, फासफोरस, पोटाशियम (53.3, 26.6 एवं 53.3 किलोग्राम अनाज प्रति किलोग्राम उर्वरक पोषक प्रयोग) की सस्यी क्षमता दर्ज की गई। अरजिया के मक्का उड़द प्रणाली में, गोबर की खाद द्वारा 25 किलोग्राम नाइट्रोजन एवं रसायनिक उर्वरकों द्वारा 25 किलोग्राम नाइट्रोजन + **30** P_2O_5 के प्रयोग ने अधिक लाभ (45422/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.39) एवं वर्षाजल उपयोग क्षमता (5.54 किलोग्राम प्रति हेक्टेयर-मि.मी.) सहित का मक्का उन्नत अनाज उत्पादन (3107 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। विजयपुर में, 10 किलोग्राम लोहा एवं 10 किलोग्राम दस्ता + सिफारिश किया गया उर्वरक (10:25 किलोग्राम नाइट्रोजन, फासफोरस प्रति हेक्टेयर) के प्रयोग से महत्वपूर्ण रूप से उन्नत चना का उत्पादन (1782 किलोग्राम प्रति हेक्टेयर), कुल लाभ (45598/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.46) एवं वर्षाजल उपयोग क्षमता (86.5 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया। कोविलपट्टी में, कपास में स्व-स्थाने सनई से हरा खाद एवं 100 प्रतिशत सिफारिश किया गया उर्वरक (40:20:40 किलोग्राम नाइट्रोजन, फासफोरस, पोटाशियम प्रति हेक्टेयर) के प्रयोग से बिना हरा खाद (985 किलोग्राम प्रति हेक्टेयर) की तुलना महत्वपूर्ण रूप से उन्नत कपास बीज उत्पादन (1120 किलोग्राम प्रतिहेक्टेयर), कुल लाभ (24950/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.54) प्राप्त हुआ।

बल्लोवाल सौंक्रि के अर्ध-शुष्क इनसेप्टीसोल मृदाओं में, कपास में केवल सिफारिश किया गया नाइट्रोजन, फासफोरस के प्रयोग (2332 किलोग्राम प्रति हेक्टेयर) की तुलना में सिफारिश किया गया नाइट्रोजन, फासफोरस (80:40 किलोग्राम प्रतिहेक्टेयर) सहित 40 किलोग्राम K_2O प्रति हेक्टेयर एवं 30 किलोग्राम $MgSO_4$ प्रति हेक्टेयर के प्रयोग से महत्वपूर्ण रूप से उन्नत अनाज उत्पादन (3296 किलोग्राम प्रति

हेक्टेयर), कुल लाभ (31226/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.95) दर्ज किया गया।

पर्ण छिड़काव

अरजिया में, 1 प्रतिशत की दर से नाइट्रोजन, फासफोरस एवं पोटाश (18:18:18) के पर्ण छिड़काव की तुलना में शुष्क दौर के दौरान उड़द के पुष्पण एवं फली निर्माण स्तरों पर 2 प्रतिशत की दर से घुलनशील नाइट्रोजन, फासफोरस एवं पोटाश (18:18:18) के छिड़काव से अधिक कुल लाभ (38271/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.95) सहित महत्वपूर्ण रूप से उन्नत उड़द बीज उत्पादन (993 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

आग्रा में, सरसों में 100 प्रतिशत नाइट्रोजन, फासफोरस (60 एवं 40 किलोग्राम नाइट्रोजन, फासफोरस प्रति हेक्टेयर) + 50 किलोग्राम पोटाशियम का आधार + सिलिक्वा निर्माण अवस्था में 2 प्रतिशत की दर से जल में घुलनशील नाइट्रोजन, फासफोरस, पोटाशियम (19:19:19) के छिड़काव से सरसों का उन्नत बीज उत्पादन (1664 किलोग्राम प्रति हेक्टेयर), कुल लाभ (56321-रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.68) एवं वर्षाजल उपयोग क्षमता (11.85 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया। राख धियंसर में, 0.5 प्रतिशत पोटाशियम (KNO_3) + 0.5 प्रतिशत नाइट्रोजन (यूरिआ) के संयुक्त पर्णछिड़काव (2117 किलोग्राम प्रति हेक्टेयर) की तुलना में शुष्क दौरों के दौरान 0.5 प्रतिशत पोटाशियम (KCl) + 0.5 प्रतिशत नाइट्रोजन (यूरिआ) के पर्ण छिड़काव से 27875/-रुपए प्रति हेक्टेयर का कुल लाभ, 2.37 का बी:सी अनुपात एवं 22.0 किलोग्राम प्रति हेक्टेयर-मि.मी. का वर्षाजल उपयोग क्षमता सहित 2147 किलोग्राम प्रति हेक्टेयर महत्वपूर्ण रूप से उन्नत गेहूं का उत्पादन दर्ज किया गया।

कर्षण एवं पोषक प्रबंधन

अर्ध-शुष्क वर्टीसोल मृदा : विजयपुर में, अन्य कम कर्षण प्रक्रियाओं की तुलना में पारंपरिक कर्षण (1 बार हल चलाना + 2 हेरो चलाना + 2 बार गुड़ाई + 1 बार हांथ से निकौनी) से अधिक कुल लाभ (6315/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.44) एवं वर्षाजल उपयोग क्षमता (1.74 किलोग्राम प्रति हेक्टेयर-मि.मी) सहित उन्नत ज्वार अनाज उत्पादन (591 किलोग्राम प्रति हेक्टेयर) एवं कड़बी उत्पादन (739 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। पोषकतत्व प्रबंधन के अंतर्गत, अन्य उपचारों की तुलना में किसानों की प्रक्रिया + सनई के हरे खाद से महत्वपूर्ण रूप से उन्नत अनाज (685 किलोग्राम प्रति हेक्टेयर) एवं कड़बी का उत्पादन (806 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। परभनी में, अन्य कर्षण पद्धतियों की तुलना में सोयाबीन + अरहर प्रणाली में पारंपरिक कर्षण से उन्नत सोयाबीन बीज समतुल्य उत्पादन (3307 किलोग्राम प्रति हेक्टेयर), कुल लाभ (73287/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.66) एवं वर्षाजल उपयोग क्षमता (5.19 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया। पोषकतत्व के स्रोतों में, 50 प्रतिशत सिफारिश किया गया उर्वरक (50 प्रतिशत) + 2.5 टन प्रति हेक्टेयर की दर से गोबर का खाद सिफारिश किए गए उर्वरक के समान दर्ज किया गया एवं इससे महत्वपूर्ण रूप से उन्नत सोयाबीन बीज समतुल्य उत्पादन (3665 किलोग्राम प्रति हेक्टेयर), कुल लाभ (84206/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (4.05) एवं वर्षाजल उपयोग क्षमता (5.76 किलोग्राम प्रतिहेक्टेयर-मि.मी.) दर्ज किया गया।

उप-आर्द्र इनसेप्टीसोल मृदा : वाराणासी में, बिना मेढ़ निर्माण की तुलना में मेढ़ सहित धान की खेत से 15.5 प्रतिशत उन्नत अनाज उत्पादन (3150 किलोग्राम प्रति हेक्टेयर) हुआ। कम कर्षण उपचारों की तुलना में खरपतवार नियंत्रण एवं निराई-गुडाई सहित पारंपरिक कर्षण ने धान का अधिकतम बीज उत्पादन (3148 किलोग्राम प्रति हेक्टेयर) हुआ। पोषकतत्व प्रबंधन के अंतर्गत, जैविक स्रोतों द्वारा 100 प्रतिशत नाइट्रोजन की तुलना में अजैविक स्रोतों द्वारा 100 प्रतिशत सिफारिश किए गए उर्वरकों से महत्वपूर्ण रूप से उन्नत चावल का उत्पादन (3127 किलोग्राम प्रतिहेक्टेयर) दर्ज किया गया। राख धियंसर में, अन्य उपचारों की तुलना में 50 प्रतिशत पारंपरिक कर्षण + शाकनाशी + जैविक खाद द्वारा 50 प्रतिशत नाइट्रोजन (30 किलोग्राम प्रति हेक्टेयर) के प्रयोग सहित निराई-गुडाई + अजैविक उर्वरकों द्वारा 50 प्रतिशत नाइट्रोजन ने अधिक लाभ (25683/- रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.26) वर्षाजल उपयोग क्षमता (2.97 किलोग्राम प्रति हेक्टेयरमि.मी.) सहित अधिकतम मक्का का अनाज उत्पादन (2439 किलोग्राम प्रति हेक्टेयर) दर्ज किया।

कृषि यांत्रिकीकरण

अनंतपुरमु में, क्लस्टरबीन प्लांटर के विकास एवं मूल्यांकन पर किए अध्ययनों ने स्पष्ट किया कि क्लस्टरबीन प्लांटर से बोवाई करने से उन्नत बीज उत्पादन (368 किलोग्राम प्रति हेक्टेयर), कुल लाभ (2990/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.3), वर्षाजल उपयोग क्षमता (1.46 किलोग्राम प्रति हेक्टेयर-मि.मी.), क्षेत्र क्षमता (2.5 हेक्टेयर प्रति घंटा), उत्पादन ऊर्जा (11547.6 एमजे प्रति हेक्टेयर) एवं ऊर्जा उपयोग क्षमता (9.52) दर्ज किया गया। इसके अलावा, छोटे ट्रेक्टर से चलने वाले अनंता प्लांटर एवं किसान प्लांटर की अभिकल्पना एवं

विकास किया गया जिसमें मूंगफली की बोवाई के लिए उपयुक्त मीटरिंग उपकरण लगे हुए हैं।

अरजिया में, बैलों द्वारा चलने वाले उपकरण से मक्का की बोवाई + बैलों द्वारा चलने वाले कुलफा से निराई-गुड़ाई + हांथों से फसल कटाई और ट्रेक्टर से बोवाई + ट्रेक्टर से चलने वाले वीडर से निराई-गुड़ाई + ट्रेक्टर से चलने वाले रिप्पर से फसल कटाई समान हैं ,पर अन्य उपचारों की तुलना में इससे महत्वपूर्ण रूप से उन्नत अनाज उत्पादन 2748-2813 किलोग्राम प्रति हेक्टेयर दर्ज किया गया। जबकि, ट्रेक्टर से चलने वाले सीड ड्रिल से बोवाई + ट्रेक्टर से चलने वाले वीडर से निराई-गुड़ाई + ट्रेक्टर से चलने वाले रिप्पर से फसल कटाई से अधिकतम लाभ (39487/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.85) एवं अधिकतम समय बचत (82 प्रतिशत) दर्ज किया गया। विजयपुर में, किसानों की पद्धति (1052 किलोग्राम प्रति हेक्टेयर) की तुलना में अरहर के यांत्रिकी खेती से 22.0 का ऊर्जा उपयोग क्षमता सहित अधिक बीज उत्पादन (1130 किलोग्राम प्रति हेक्टेयर), कुल लाभ (55655/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (4.6), वर्षाजल उपयोग क्षमता (1.9 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया।

उन्नत किस्मों का मूल्यांकन

स्थानी जांचों/लोकप्रिय किस्मों की तुलना में उन्नत निष्पादन देने वाले किस्म/जननद्रव्य इस प्रकार हैं : बिस्वनाथ चरिअलि में धान का किस्म धेहंगी (1861 किलोग्राम प्रति हेक्टेयर); चियान्की में रागी किस्म बीएमएम-10 (3003 किलोग्राम प्रति हेक्टेयर), चना किस्म बीएयूजी-26 (1460 किलोग्राम प्रति हेक्टेयर); हिसार में एमएच-1315 (1242 किलोग्राम प्रति हेक्टेयर); इंदौर में अरहर किस्म सी-11 (2173 किलोग्राम प्रति हेक्टेयर), चना किस्म आईजी-593 (1300 किलोग्राम प्रति हेक्टेयर) ; विजयपुर में चना किस्म वीजीएच 44 (बीएल 44) (610 किलोग्राम प्रति हेक्टेयर), चना किस्म सी-1988 (1780 किलोग्राम प्रति हेक्टेयर); सोलापुर में चना किस्म एचजी 3 (793 किलोग्राम प्रति हेक्टेयर); अनंतपुरमु में मूंगफली किस्म एमएलटीजी (एसबी)-17-6 (1194 किलोग्राम प्रति हेक्टेयर), चना किस्म एचजी9 (1094 किलोग्राम प्रति हेक्टेयर) ।

वैकल्पिक भूमि उपयोग प्रणालियां

एसके नगर में, चौब आधारित कृषि-बागवानी प्रणाली में, अन्य प्रणालियों की तुलना में चौब + अरंड प्रणाली ने महत्वपूर्ण रूप से उन्नत चौब समतुल्य उत्पादन (1371 किलोग्रामप्रति हेक्टेयर), कुल लाभ (40873/- रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (0.66 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया। चियान्की में, आंवला आधारित कृषि-बागवानी प्रणाली में, एकल आंवला (8.43 टन प्रति हेक्टेयर) की तुलना में महत्वपूर्ण रूप से अधिकतम आंवला समतुल्य उत्पादन (14.44 टन प्रति हेक्टेयर) दर्ज किया गया। आंवला + उड़द प्रणाली में 3.77 का बी:सी अनुपात दर्ज किया गया, इसके बाद आंवला + तिल (12.30 टन प्रति हेक्टेयर) का स्थान था। रायचूर में, उथली काली मृदाओं में नीम आधारित कृषिवानिकी प्रणाली पर किए गए अध्ययन में, कंगनी एवं बाजरा की तुलना में अंतर फसल के रूप में अरहर ने बेहतर निष्पादन दिया एवं 5 मीटर x 3 मीटर, 5 मीटर x 4 मीटर एवं 5 मीटर x 5 मीटर के नीम पौधे के अंतराल में क्रमश: 933, 1039 एवं 1223 किलोग्राम प्रति हेक्टेयर का उन्नत उत्पादन दर्ज किया गया।

वर्षा आधारित समेकित कृषि प्रणालियां

वर्ष 2017-18 दौरान, एक्रीपडा में आरआईएफएस फार्म पर अनुसंधान को फ्लैगशिप कार्यक्रम के रूप में बदल दिया गया। हर एक्रीपडा केंद्रों के कृषि-पारिस्थितिकी में पारंपरिक वर्षा आधारित कृषि प्रणालियों की सूची एवं लक्षणो के लिए मानक कार्यप्रणाली का विकास किया गया। विश्लेषणों के आधार पर, प्रमुख वर्षा आधारित कृषि प्रणालियों को परिस्थिति के आधार पर (आंशिक रूप से सिंचित एवं पूर्णरूप से सिंचित) एवं किसानों के वर्गीकरण के आधार पर (छोटे, सीमांत, मध्यम एवं बडे) पहचाना गया।

चालू अनुसंधान परियोजना (ओआरपी)

भागीदारी प्रौद्योगिकी विकास

कर्नूल जिला, आंध्र प्रदेश (अनंतपुरमु केंद्र) के येर्रगुंट्लपल्ली गांव में, किसानों की प्रक्रिया से 9177/- रुपए प्रति हेक्टेयर का औसत अतिरिक्त लाभ एवं 2.37 किलोग्राम प्रति हेक्टेयर-मि.मी. की तुलना में चिसिल हल द्वारा गहरी जुताई से 12.5 प्रतिशत अधिक अरहर बीज का उत्पादन हुआ।

चित्तौगढ़ जिला, राजस्थान (अरजिया केंद्र) के नेवारिया गांव में, किसानों की प्रक्रिया (1880 किलोग्राम प्रति हेक्टेयर) की तुलना में मक्का (पीईएचएम-2) में उन्नत नमी संरक्षण प्रक्रियाओं (परिधीय मेढ़, गहरी जुताई, ढलान के विरूद्ध कर्षण एवं बोवाई, मृदा पलवार, बोवाई के 30 दिनों के बाद मेढ़ बांधना) को अपनाने से उन्नत अनाज उत्पादन (2407 किलोग्राम प्रति हेक्टेयर), कुल लाभ (23552/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.56) दर्ज किया गया।

होशियारपुर जिला, पंजाब (बल्लोवाल सौंक्रि केंद्र) के बेहदरया-कोठी गांव में, एकल गेहूं की फसल की तुलना में, गेहूं - राया अंतर सस्यन में, गेहूं के खेतों मेढ़ों पर राया फसल की बोवाई से 3368 किलोग्राम प्रति हेक्टेयर का अधिकतम औसत गेहूं समतुल्य उत्पादन दर्ज किया गया, इसके बाद गेहूं + राया का अंतर सस्यन (12:1) जो 17.0 एवं 9.0 प्रतिशत अधिक था।

तुमकूर जिला, कर्नाटक (बेंगलूरू केंद्र) के बैचनहल्ली एवं इरकसंद्रा गांवों में, एकल अरहर (705 किलोग्राम प्रति हेक्टेयर एवं 1.20 बी:सी अनुपात) एवं ग्वार (216 किलोग्राम प्रति हेक्टेयर एवं 0.34 बी:सी अनुपात) की तुलना में अरहर + ग्वार (1:1) अंतर सस्यन ने उन्नत अरहर समतुल्य उत्पादन (882 किलोग्राम प्रति हेक्टेयर) एवं बी:सी अनुपात (1.24) दिया। एकल मक्का (क्रमश: -8306/-रुपए प्रतिहेक्टेयर एवं 0.71) की तुलना में अरहर + मक्का प्रणाली (1:1) से अधिकतम लाभ (1330/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.04) दर्ज किया गया।

भिवानी जिला, हरियाणा (हिसार केंद्र) छप्पर जोगियन गांव में, किसानों की प्रक्रिया (1580 एवं 3620 किलोग्राम प्रति हेक्टेयर) की तुलना, बाजरा (उन्नत एचएचबी 67) में उन्नत प्रक्रियाओं के मूल्यांकन में, उन्नत संकर + सिफारिश किए गए उर्वरक (40:20 किलोग्राम नाइट्रोजन, फासफोरस प्रतिहेक्टेयर) + व्हील हैंड हो से निराई-गुड़ाई से उन्नत अनाज एवं खडबी उत्पादन (क्रमश: 2010 एवं 4430 किलोग्राम प्रति हेक्टेयर), कुल लाभ (16130/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (1.82) एवं वर्षाजल उपयोग क्षमता (14.10 किलोग्राम प्रति हेक्टेयर-मि.मी.) दर्ज किया गया।

उजैन जिला, मध्य प्रदेश (इंदौर केंद्र) के पिप्लोडा द्वारकाधीश गांव में, बिना अतिरिक्त सिंचाई के किसानों की प्रक्रिया की तुलना में कृषि तालाबों में संचित वर्षाजल से अतिरिक्त सिंचाई देने से चना की किस्म जाकी 9218 (1920 किलोग्राम प्रति हेक्टेयर) में 21.7 प्रतिशत एवं विशाल तथा डालर (1800 किलोग्राम प्रति हेक्टेयर) में 16.4 प्रतिशत उत्पादन में वृद्धि हुई।

सतारा जिला, महाराष्ट्र (सोलापुर केंद्र) के हिंगनी गांव में, अधिक लाभ (18470/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.34) एवं वर्षाजल उपयोग क्षमता (6.15 किलोग्राम प्रति हेक्टेयर-मि.मी.) सहित किसानों की प्रक्रिया की तुलना में, खरीफ मौसम के दौरान खंड मेढ़ सहित रबी ज्वार के स्व-स्थाने नमी संरक्षण के मूल्यांकन में 1150 किलोग्राम प्रति हेक्टेयर का उन्नत औसत अनाज उत्पादन एवं 2895 किलोग्राम प्रति हेक्टेयर का कडबी उत्पादन दर्ज किया गया।

प्रौद्योगिकी का उन्नयन

उन्नयन की गई उन्नत प्रौद्योगिकियां इस प्रकार हैं : कर्नूल जिला, आंध्रप्रदेश (अनुतपूरमु केंद्र) के येर्रगुंट्लापल्ली गांव में उन्नत मूंगफली किस्म (धरणी) एवं मृदा जांच आधारित उर्वरक का प्रयोग; चित्तौगढ़ जिला, राजस्थान (अरजिया केंद्र) के नेवारिया गांव में मक्का, तिल, ज्वार, उड़द एवं मूंग के अनुकूल प्रौद्योगिकियों सहित उन्नत किस्म; होशियारपुर जिला, पंजाब (बल्लोवाल सौंक्रि केंद्र) के बेहदरया-कोठी गांव में मक्का, उड़द एवं तिल के उन्नत उत्पादन प्रौद्योगिकियां; तुमकूर जिला, कर्नाटक (बेंगलूरू केंद्र) के बैचलहल्ली एवं इरकसंद्रा गांवों में स्व-स्थाने नमी संरक्षण एवं अंतर सस्यन प्रणालियां; भिवानी जिला, हरियाणा (हिसार केंद्र) छप्पर जोगियन गांव में बाजरा, मूंग एवं सरसों की उन्नत किस्में; सतारा जिला, महाराष्ट्र (सोलापुर केंद्र) के हिंगनी गांव में बाजरा, ज्वार एवं चना की उन्नत किस्में तथा बाजरा में पोषक प्रबंधन।

रार्ष्टीय जलवायु समुत्थान कृषि नवप्रवर्तन (निक्रा)

वर्ष के दौरान, 15 राज्यों में फैले 24 जिलों के वर्तमान 32 गांवों (कुल 54 गांव) के आस-पास के 22 और गांवों में चालू कृषि कार्यक्रम को विस्तृत किया गया। इस अवधि के दौरान, सही समय पर आकस्मिक फसल योजनाओं का कार्यान्वयन एवं मौसम प्रतिकूलताओं से जूझने की तैयारी पर जोर देना जारी था एवं इसे 1000 से अधिक किसानों के खेतों पर कार्यान्वित किया गया। वर्ष 2017-18 के दौरान, जामनगर (गुजरात), गढ़वा (झारखंड) एवं बंसकांता (गुजरात) में स्थित निक्रा के गांवों में मानसून का आरंभ में क्रमश: 25, 13 एवं 11 दिनों की देरी हुई। इसके अलावा, अकोला, अनंतपुरमु, बेंगलूरू, जगदलपुर, लखिमपुर, गढ़वा, कंधमल, परभनी एवं कोविलपट्टी जिलों के निक्रा के गांवों में फसल के विभिन्न स्तरों पर 3-4 शुष्क दौर आए। साधारणतया, चिकामानाहल्ली (बेंगलूरू), कवलगी (विजयपुर), चमुआ (लखिमपुर), बलावास (भिवानी), तहकपाल (बस्तर), कडेसारा कलन (ललितपुर), मुत्तुकृष्णापुरम (टूटक्कोड़ी), बबुलगांव (परभनी), पेटामेघापुर (जामनगर) एवं कालिमती (बनसतंता) को छोड़ निक्रा के सभी गांवों में खरीफ मौसम (जून-सितंबर), 2017 के दौरान कुल वर्षा साधारण से कम थी। मानसून देर से आरंभ होने की स्थित से जूझने के लिए विभिन्न फसलों के लघु अवधि के किस्मों को प्रस्तुत किया गया, जिससे उत्पादन में 35 प्रतिशत तक की वृद्धि हुई। सभी वर्षा आधारित उत्पादन प्रणालियों में आरंभिक/मध्य मौसम/अंतिम सूखा से जूझने के लिए सही समय की आकस्मिक योजनाओं के परिणामस्वरूप उत्पादन में 25-30 प्रतिशत की वृद्धि हुई। गांव जलवायु जोखिम प्रबंधन समितियां एवं किराए केंद्रों

इत्यादि गांव स्तरीय संस्थाओं ने आकस्मिक उपायों को वास्तविक समय पर कार्यान्वित करने में बड़ी भूमिका निभाई है।

मॉनिटरी एवं मूल्यांकन

इस अवधि के दौरान एक्रीपडा के सभी नेटवर्क केंद्रों में तकनीकी, भौतिकी एवं आर्थिक लक्ष्यों की मॉनीटरी एवं मूल्यांकन किया गया। एक्रीपडा के परियोजना समन्वयक एवं इस यूनिट के वैज्ञानिकों ने अरजिया, बेंगलूरू, इंदौर, जगदलपुर, राख धियंसर, परभनी एवं राजकोट केंद्रों का दौरा किया। संबंधित अधिकारियों द्वारा फसलों को सुधारने/आवश्यक कार्रवाई के लिए दौरे के दौरान ही कार्यवाहियां तैयार किया गया।

दिनांक 01-05 फरवरी, 2018 के दौरान आईजीकेवी, छत्तीगढ़ के जगदलपुर केंद्र में आयोजित एक्रीपडा के चौदहवीं कार्यदल बैठक के दौरान तकनीकी, भौतिक एवं आर्थिक लक्ष्यों पर भी समीक्षा की गई। दिनांक 22-27 मई, 2017 को भाकृअनुप-केंद्रीय बारानी कृषि अनुसंधान संस्थान में एक्रीपडा-निक्रा के दो दिवसीय कार्यशाला के दौरान निक्रा के अंतर्गत संपूर्ण प्रगति की समीक्षा की गई एवं निक्रा (2017-20) के अगले चरण के लिए तकनीकी कार्यक्रम का विकास किया गया।

संपर्क एवं सहयोग

आंध्र प्रदेश, कर्नाटक, राजस्थान, महाराष्ट्र एवं तमिलनाडु में विभिन्न राज्य स्तरीय इंटरफेस बैठकों में केंद्रों ने भाग लिया एवं राज्य से संबंधित विभागों से संपर्क कर जिला स्तरीय कृषि आकस्मिक योजनाओं के संचालन में योगदान दिया। प्रधान मंत्री कृषि सिंचाई योजना, कृषि भाग्य (कर्नाटक), पंट संजीवनी (आंध्र प्रदेश) जैसे विभिन्न केंद्र एवं राज्य स्तरीय कार्यक्रमों से प्रौद्योगिकीय उन्नयनों को जोडा गया एवं राज्य स्तरीय विभागों, आत्मा, कृषि विज्ञान केंद्र इत्यादि के संपर्क में विभिन्न पणधारियों का क्षमता निर्माण का कार्य जारी है। पहचान किए गए समान केंद्रों पर एक्रिप-आईएफएस एवं एक्रिप-कृषिवानिकी से अनुसंधान सहयोग को मजबूती प्रदान किया गया।

प्रकाशन

वर्ष के दौरान एक्रीपडा दल द्वारा 76 अनुसंधान लेख, 29 पुस्तक/पुस्तक के अध्याय/ मैनुअल/बुलेटिन; सेमिनारों/संगोष्ठियों/ सम्मेलनों में शामिल किए गए 59 लेख इत्यादि एवं 21 लोकप्रिय लेख कुल 185 प्रकाशनों का योगदान दिया गया।

पुरस्कार/मान्यताएं

एक्रीपडा केंद्र, विजयपुर को बारानी कृषि प्रणालियों में उत्कृष्ट अनुसंधान प्रयोग के लिए भाकृअनुप-वसंतराव नायक पुरस्कार-2017 प्राप्त हुआ।

मानव संसाधन विकास, वर्षा आधारित प्रौद्योगिकियों का प्रभाव एवं उन्नयन

इस अवधि के दौरान 3000 से अधिक किसानों/पणधारियों के लाभ के लिए 50 प्रशिक्षण एवं प्रौद्योगिकी प्रदर्शन/प्रसार गतिविधियां आयोजित की गई।

बजट

वर्ष 2017-18 की अवधि के लिए एक्रीपडा के 22 नेटवर्क केंद्रों एवं 5 स्वैच्छिक केंद्रों के कुल बजट 2176.64 लाख रुपए आबंटित किया गया एवं 8 चालू अनुसंधान परियोजनाओं केंद्रो के लिए 447.87 लाख रुपए आबंटित किया गया।

EXECUTIVE SUMMARY

Executive Summary

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) with network of 27 centers located in arid, semi-arid, sub-humid, humid and per-humid climates represent diverse bio-physical and socio-economic settings of the rainfed production systems (rice, maize, sorghum, pearlmillet, fingermillet, cotton, groundnut and soybean) of the country. The project has the mandate to generate location specific technologies through on-station research in thematic areas of rainwater management (RWM), cropping systems (CS), nutrient management (NM), energy management (EM), evaluation of improved varieties (EIV) of rainfed crops, and alternate land use(ALU)/integrated farming systems (IFS). The technologies are assessed on farmers' fields through 8 Operational Research Projects (ORPs). During 2017-18, a total of 197 on-station experiments were conducted *viz.* RWM-40; CS-28; NM-41; EM-15; EIV-20; ALU & IFS-48; and resource characterization-5. In ORPs, 104 on-farm trials/demonstrations were conducted viz. RWM-22; CS-23; NM-15; EM-13; EIV-25; ALU/IFS-6.

During 2017-18, the onset of monsoon was normal across all AICRPDA centres except Rajkot (delay by 18 days), Chianki (11 days), Faizabad (11 days) and Vijayapura (12 days). Further, there were 3-4 dry spells of more than 10 days each at different stages of crops at Akola, Ananthapuramu, Bengaluru, Biswanath Chariali, Chianki, Jagdalpur, Kovilpatti, Parbhani and Phulbani. The rainfall was deficit by more than 40% during June 2017 at Agra, Aklera, Faizabad and Varanasi whereas the rainfall exceeded the normal by more than 150% at Hisar, SK Nagar and Ananthapuramu. In July, the deficit in rainfall was more than 35% at Agra, Anantapuramu, Bengaluru, Darsi, Kovilpatti, Parbhani, Phulbani, Solapur and Varanasi. Similarly, in August, Chianki, Phulbani, Raichur, Rakh Dhiansar, Rewa, SK Nagar and Varanasi recorded more than 35% deficit rainfall. In September, Agra, Arjia, Chianki, Hisar, Indore, Rajkot, Rewa, Rakh Dhiansar, SK Nagar, Solapur and Varanasi received 50-87% deficit rainfall. Similarly, in October, Agra, Aklera, Arjia, Ballowal Saunkhri, Faizabad, Hisar, Parbhani, Rajkot, Rakh Dhiansar, Rewa, SK Nagar and Varanasi did not receive any rainfall. In November, the rainfall was deficit across all centres except Hisar and no rainfall was received at Agra, Aklera, Akola, Arjia, Ballowal Saunkhri, Faizabad, Indore, Jagdalpur, Parbhani, Raichur, Rajkot, Rewa, SK Nagar, Varanasi and Vijayapura.

The salient achievements are given below.

Rainwater management

In-situ moisture conservation

The experiments on *in-situ* moisture conservation included treatments such as ridge and furrow system, ridge planting, conservation furrow, broad bed furrow system, subsoiling etc. in different crops and cropping systems.

In arid Alfisols at Ananthapuramu, subsoiling at 1 m distance recorded higher pigeonpea equivalent yield (PEY) (669 kg/ha), net returns (Rs.11780/ha), B:C ratio (1.06) and RWUE (1.24 kg/ha-mm) compared to subsoiling at 2 m distance and no subsoiling in pigeonpea, castor, clusterbean and pearlmillet.

Semiarid Vertisils: At Raichur, adoption of ridges and furrow system of planting for *in-situ* rainwater conservation recorded significantly higher seed cotton yield (2209 kg/ha) as compared to broad bed and furrows (1964 kg/ha) and flat bed system (1587 kg/ha); at Parbhani, *in-situ* moisture conservation through broad bed and furrow system (BBF) recorded significantly higher soybean seed yield (1936 kg/ha) and net returns (Rs.40488/ha) as compared to all other treatments except opening of furrow after every 4 rows (1765 kg/ha) and conservation furrow at 2.7 m distance (1742 kg/ha). Further, the highest soil loss of 7.83 t/ha was recorded in flat bed system and minimum soil loss of 3.53 t/ha was in BBF.

Subhumid Inceptisols: At Munger, maize-*rabi* crops sown on raised beds recorded significantly higher maize equivalent yield (9448 kg/ha), net returns (Rs.113378/ha) and RWUE (12.88 kg/ha-mm) followed by ridge and furrow system (8914 kg/ha, Rs.106965/ha and 12.15 kg/ha-mm, respectively); at Ballowal Saunkhri, *in-situ* moisture conservation due to ridge planting, conservation furrows and bed planting resulted in significant increase in the grain yield of maize by 24, 21 and 15%, respectively over flat bed sowing (2918 kg/ha); at Jagdalpur, highest rice grain yield (3894 kg/ha), net returns (Rs.40065/ha) and RWUE (3.0 kg/ha-mm) was recorded with furrow opening after every 5th row across slope with country plough at 25 DAS under dry seeding compared to control (1723 kg/ha).

Ex-situ rainwater management

The *ex-situ* rainwater management was mainly through harvesting of rainwater in farm ponds, minimization of evaporation losses from farm ponds and efficient utilization as protective/supplemental irrigation preferably with micro-irrigation systems.

In arid Alfisols at Ananthapuramu, the seepage loss was less (72 l/m^2/day) with sand + cement lining (6:1) of farm pond as compared to soil + cement (6:1) (132 l/m^2/day) and soil + cement (8:1) lining (154 l/m^2/day).

Semiarid Vertisols: At Parbhani, application of cetyl alcohol @ 30 mg/m^2 after every 10 days reduced evaporation losses from farm pond by 54.4% compared to untreated control. The cost of application of cetyl alcohol was Rs. 1/m^2. Similarly, at Vijayapura, least evaporation (120.9 cm) was recorded with application of cetyl alcohol followed by silicon oil (122.6 cm) compared to untreated control (216.4 cm). Further, at Vijayapura, one supplemental irrigation (5 cm) with sprinklers during dry spell in sorghum + chickpea (2:4) intercropping and sole chickpea gave 40 and 33% higher yield, respectively compared to without supplemental irrigation (828 and 550 kg/ha, respectively); at Parbhani, application of one protective irrigation of 50 mm to soybean from harvested rainwater increased the soybean seed yield by 61.5% (1893 kg/ha) compared to no protective irrigation.

Subhumid Inceptisols: At Ballowal Saunkhri, the catchment-storage, catchment-command and storage command ratio of the water harvesting system were 12.7, 6.86 and 0.54, respectively for a catchment area of 3.43 ha which stored 0.27 ha-m water with command area of 0.5 ha; at Varanasi, the water balance components indicated that total runoff harvested was 1257.9 m^3, evaporation losses were 386.59 m^3 and seepage loss (soil moisture contribution) was 321.53 m^3/week during the year. About 56.3% of harvested rainwater was available in farm pond after seepage and evaporation losses in September.

Cropping systems

Intercropping systems

In semiarid Inceptisols at Rakh Dhiansar, maize + cowpea (1:1) intercropping system recorded the highest maize equivalent yield (MEY) (3638 kg/ha), land equivalent ratio (1.37), net returns (Rs.41738/ha) and RWUE of 7.08 (kg/ha-mm) compared to sole maize (2887 kg/ha).

Semiarid Vertisols: At Rajkot, cotton + sesame (1:1) intercropping system recorded higher seed cotton equivalent yield (2967 kg/ha), net returns (Rs.115317/ha) and B:C ratio (4.19) compared to sole cotton (1998 kg/ha); at Parbhani, intercropping system of soybean + pigeonpea (4:2) being at par with soybean + pigeonpea strip of 3.6 m (8 & 4 rows/strip) (2838 kg/ha), 5.4 m (12 & 9 rows/strip) (2755 kg/ha) produced significantly higher soybean equivalent yield (2891 kg/ha) and gross returns (Rs.88185/ha) over sole soybean (2080 kg/ha).

In subhumid Inceptisols at Chianki, significantly highest pigeonpea equivalent yield (3238 kg/ha) was recorded with pigeonpea + okra intercropping system (1:1) with highest B:C ratio of 2.9 compared to sole pigeonpea (1442 kg/ha).

Strip cropping systems

In semiarid Vertisols at Arjia, strip cropping of maize (grain) with 2/3 area + maize (fodder) with 1/3 area gave 26% higher maize grain equivalent yield compared to sole maize (6130 kg/ha) with higher net returns (Rs.77400/ha), B:C ratio (5.32) and RWUE (4.14 kg/ha-mm).

In subhumid Inceptisols at Ballowal Saunkhri, strip intercropping of maize and cowpea with strip width of 4.8

m: 1.2 m (4.8:1.2) gave significantly higher MEY (3862 kg/ha), net returns (Rs.3862/ha), B:C ratio (1.97) and RWUE (6.27 kg/ha-mm) with yield increase of 45.5 and 11.3% over sole cowpea and sole maize. Similarly, cowpea strip of 6 m width drastically reduced the runoff (74 mm) and soil loss (2.0 t/ha) compared to rest of the maize and cowpea strip widths (1.2:4.8; 3:3, 4.8:1.2 and 6:0)

Double cropping systems

In semiarid Alfisols at Darsi, pearlmillet-cowpea sequence recorded the highest system productivity (1335 kg/ha), gross returns (Rs.66772/ha) and B;C ratio (2.39) followed by foxtail millet –greengram sequence (1255 kg/ha) compared to sole pigeonpea (490 kg/ha). In subhumid Inceptisols at Jagdalpur, higher rice crop equivalent yield (5569 kg/ha), net returns (Rs.68262/ha), B:C ratio (3.93) and RWUE (4.14 kg/ha-mm) was recorded with rice-chickpea under conventional tillage with line sowing. In perhumid Inceptisols at Imphal, sowing of field pea at rice harvest with 150% seed rate and mulching with paddy straw recorded significantly higher rice equivalent yield (1395 kg/ha).

Nutrient management

Permanent manurial trials (PMTs)

In PMT in semiarid alfisols at Bengaluru, in the 40th year under mono-cropping of fingermillet, the grain and straw yield was significantly higher (1860 and 3011 kg/ha, respectively) with higher net returns (Rs. 16481/ha), B:C ratio (1.65), RWUE (2.46 kg/ha-mm) and SYI (0.70) with application of FYM @ 10 t/ha+ 100 % Rec. NPK (50:40:25 kg/ha) compared to application of Rec. NPK alone (1032 and 1635 kg/ha, respectively). Higher organic carbon content (0.58%), available N (245.1 kg/ha), P (67.4 kg/ha) and K (90.4 kg/ha) was also recorded in plots under FYM (10 t/ha) + 100% N, P_2O_5 and K_2O.

In PMT in semiarid alfisols in groundnut at Ananthapuramu, in the 33rd year, application of 50% RDF (10:20:20 kg N, P_2O_5, K_2O/ha) along with FYM @ 4 t/ha recorded higher pod yield (2202 kg/ha), followed by recommended dose of fertilizers (20:40:40 N, P_2O_5, K_2O kg/ha) (2053 kg/ha) compared to control (2053 kg/ha). Application of 50% recommended dose of fertilizer (10:20:20 kg NP_2O_5, K_2O/ha) along with FYM @ 4 t/ha recorded higher soil organic carbon (0.6%). Higher soil available N (184 kg/ha) and K (395 kg/ha) in plots under 50% RDF along with FYM @ 4 t/ha and higher P (89 kg/ha) was recorded with 100% RDF + $ZnSO_4$ @ 50 kg/ha. The soil organic carbon stocks were higher in the plots under 50% RDF + FYM @ 4 t/ha (13.42 Mg/ha) followed by FYM@ 4 t/ha (12.66 Mg/ha).

At Rakh Dhiansar, in a permanent manurial trial in maize based cropping system, in the 23rd year, significantly higher grain yield of maize (1823 kg/ha) was obtained with application of 50% recommended NPK (30:20:10 kg NPK/ha) + 50% N through FYM compared to other treatments except 50% recommended NPK + 50% N crop residue (1717 kg/ha) and 100% NPK + 20 kg $ZnSO_4$/ha. The highest organic carbon content (0.57%) was recorded with application of FYM @ 10 t/ha followed by 50% recommended NPK + 50% N through FYM (0.54%), and 50% recommended NPK + 50% N through crop residue (0.49%). Integration of 50% recommended NPK + 50% N through FYM recorded higher available N (211.6 kg/ha), P (17.1 kg/ha) and K (133.5 kg/ha).

Integrated nutrient management

Semiarid Vertisols: At Jagdalpur, application of 100% general recommended dose (GRD) + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM @ 5 t/ha in furrow recorded higher groundnut pod yield (2002 kg/ha), net returns (Rs.37654/ha) and RWUE (2.38 kg/ha-mm). Similarly, agronomic efficiency of NPK (53.3, 26.6 and 53.3 kg grain/kg fertilizer nutrient applied) was also found higher under 100% GRD + lime @ 3 q/ha + $MgSO_4$ @15 kg/ha + FYM 5 t/ha in furrows; at Arjia, in maize-blackgram cropping system, application of 25 kg N through FYM and 25 kg N through chemical fertilizer + 30 kg P_2O_5 gave higher grain yield of maize (3107 kg/ha) with higher net returns (Rs.45422/ha), B:C ratio (3.39) and RWUE (5.54 kg/ha-mm); at Vijayapura, application of 10 kg/ha each of Fe and Zna + RDF (10:25 kg NP/ha) recorded significantly higher seed yield of chickpea (1782 kg/ha), net returns (Rs.45598/ha), B:C ratio (3.46) and RWUE (86.5 kg/ha-mm); at Kovilpatti, *in-situ* green manuring with sunhemp and application of 100% RDF (40:20:40 kg NPK/ha) in cotton gave significantly higher seed cotton yield (1120 kg/ha), net returns (Rs. 24950/ha) and B:C ratio (2.54) compared to RDF without green manuring (985 kg/ha).

In semiarid Inceptisols at Ballowal Saunkhri, application of 40 kg K_2O/ha and 30 kg $MgSO_4$/ha along with recommended NP (80:40 kg/ha) in maize recorded significantly higher grain yield (3296 kg/ha), net returns (Rs. 31226/ha) and B:C ratio (1.95) compared to application of recommended NP alone (2332 kg/ha).

Foliar sprays

At Arjia, foliar spray of soluble NPK (18:18:18 NPK) @ 2% at flower initiation and pod filling stages of blackgram during dry spell produced significantly higher blackgram seed yield (993 kg/ha) with higher net returns (Rs.38271/ha), B:C ratio (2.08) and RWUE (1.67 kg/ha-mm) except foliar spray of NPK (18:18:18) @ 1% (973 kg/ha).

At Agra, application of 100% NP (60 & 40 kg NP/ha) + 50 kg K as basal + foliar spray of 2.0% water soluble NPK (19:19:19) at siliqua formation recorded higher seed yield of mustard (1664 kg/ha), net returns (Rs.56321/ha), B:C ratio (3.68) and RWUE (11.85 kg/ha-mm). At Rakh Dhiansar, significantly higher wheat grain yield of 2147 kg/ha with net returns of Rs.27875/ha, B:C ratio of 2.37 and RWUE of 22.0 kg/ha-mm was recorded with foliar spray of 0.5% K (KCl) + 0.5% N (urea) during dry spells except combined foliar spray of 0.5% K (KNO_3) + 0.5% N (urea) (2117 kg/ha).

Tillage and nutrient management

Semiarid Vertisols: At Vijayapura, higher sorghum grain (591 kg/ha) and stover yields (739 kg/ha) were recorded with conventional tillage (1 ploughing + 2 harrowings + 2 hoeings + 1 hand weeding), with higher net returns (Rs.6315/ha), B:C ratio (1.44) and RWUE (1.74 kg/ha-mm) as compared to other low tillage practices. Under nutrient management, farmer's practice + sunhemp green manuring recorded significantly higher grain (685 kg/ha) and stover yield (806 kg/ha) compared to other treatments; at Parbhani, conventional tillage in soybean + pigeonpea (4:2) system recorded significantly higher soybean seed equivalent yield (3307 kg/ha), net returns (Rs. 73287/ha), B:C ratio (3.66) and RWUE (5.19 kg/ha-mm) compared to other tillage methods. Among nutrient sources, application of 50% RDF (50%) + FYM @ 2.5 t/ha being at par with RDF recorded significantly higher soybean seed equivalent yield (3665 kg/ha), net returns (Rs.84206/ha), B:C ratio (4.05) and RWUE (5.76 kg/ha-mm).

Subhumid Inceptisols: At Varanasi, rice with field bunding produced 15.5% higher grain yield (3150 kg/ha) compared to without field bunds. Conventional tillage (CT) along with weed control and interculture produced maximum seed yield of rice (3148 kg/ha) over low tillage treatments. Under nutrient management, significantly higher grain yield of rice (3127 kg/ha) was recorded with 100% recommended dose of fertilizer through inorganic source compared to 100% N through organic sources. At Rakh Dhiansar, 50% CT + herbicide + interculture with application of 50% N (30 kg/ha) through organic manure + 50% N through inorganic fertilizer recorded the highest grain yield of maize (2439 kg/ha) with higher net returns (Rs 25683/ha), B:C ratio (2.26) and RWUE (2.97 kg/ha-mm) compared to other treatments.

Farm mechanization

At Ananthapuramu, in a study on development and evaluation of clusterbean planter, higher seed yield (368 kg/ha), net returns (Rs.2990/ha), B:C ratio (1.3), RWUE (1.46 kg/ha-mm), field efficiency (2.5 hr/ha), output energy (11547.6 MJ/ha) and energy use efficiency (9.52) was recorded due to sowing with clusterbean planter. Further, mini tractor drawn Ananta planter and Kisan planters were designed and developed with suitable seed metering devices for sowing of groundnut.

At Arjia, maize sowing with bullock drawn implement + interculture with bullock drawn *kulpha* + manual harvesting, and sowing with tractor + interculture with tractor drawn weeder + harvesting by tractor drawn ripper being at par recorded significantly higher grain yield (2748-2813 kg/ha) than other treatments. However, sowing with tractor drawn seed drill + interculture with tractor drawn weeder + harvesting with ripper recorded highest net returns (Rs.39487/ha), B:C ratio (2.85) and maximum saving in time (82%). At Vijayapura, mechanized cultivation of pigeonpea recorded higher seed yield (1130 kg/ha), net returns (Rs.55655/ha), B:C ratio (4.6), RWUE (1.9 kg/ha-mm) with energy use efficiency of 22.0 compared to farmers' method (1052 kg/ha).

Evaluation of improved varieties

The varieties/germplasm that performed better compared to local checks/popular varieties were: rice cv. Dehangi (1861 kg/ha) at Biswanath Chariali; fingermillet cv. BMM-10 (3003 kg/ha), chickpea cv. BAUG-26 (1460 kg/ha) at Chianki; greengram cv. MH-1315 (1242 kg/ha) at Hisar; pigeonpea cv. C-11 (2173 kg/ha), chickpea cv. IG-593 (1300 kg/ha) at Indore; horsegram cv. VGH44 (BL 44) (610 kg/ha), chickpea cv. C-1988 (1780 kg/ha) at Vijayapura; horsegram cv.HG 3 (793 kg/ha) at Solapur; groundnut cv. MLTG (SB)-17-6 (1194 kg/ha), horsegram cv. HG-9 (1094 kg/ha) at Ananthapuramu.

Alternate land use systems

At SK Nagar, among drumstick based agri-horti systems, drumstick + castor system recorded significantly higher drumstick equivalent yield (1371 kg/ha), net returns (Rs.40873/ha) and RWUE (0.66 kg/ha-mm) compared to other systems. At Chianki, in aonla based agri-horti system, significantly highest aonla equivalent yield (14.44 t/ha) with B:C ratio of 3.77 was recorded in aonla + blackgram system followed by aonla + sesame (12.30 t/ha) compared to sole aonla (8.43 t/ha). At Raichur, in a study on neem (*Melia dubia* L.) based agroforestry system in shallow black soils, pigeonpea performed better as intercrop and recorded higher seed yield of 933, 1039 and 1223 kg/ha in neem plant spacing of 5 m x 3 m, 5 m x 4 m and 5 m x 5 m, respectively compared to foxtail millet and pearlmillet.

Rainfed integrated farming systems

During 2017-18, RIFS on-farm research was redesigned as flagship programme in AICRPDA. A standard methodology was developed for inventory and characterization of traditional rainfed farming systems (TRIFS) in each AICRPDA centre's agroecology. Based on the analysis, predominant traditional rained farming systems were identified situation-wise (partially irrigated and core rainfed) and farmers' category-wise (small, marginal, medium and large).

Operational Research Project (ORP)

Participatory technology development

In Yerraguntlapalli village, Kurnool district, Andhra Pradesh (Ananthapuramu centre), the seed yield of pigeonpea was 12.5% more with deep ploughing by chisel plough over farmers' practice with average additional net returns of Rs.9177/ha and RWUE of 2.37 kg/ha-mm.

In Newariya village, Chittorgarh district, Rajasthan (Arjia centre), improved moisture conservation practices (peripheral bunding, deep ploughing, tillage and sowing across the slope, soil mulching, ridging at 30DAS) in maize (PEHM-2) gave higher grain yield (2407 kg/ha), net returns (Rs. 23552/ha) and B:C ratio (2.56) compared to farmer's practice (1880 kg/ha).

In Behdarya-Kothi village, Hoshiarpur district, Punjab (Ballowal Saunkhri centre), in wheat-raya intercropping, the maximum mean wheat equivalent yield (WEY) of 3368 kg/ha was recorded with sowing of raya crop on the boundary of wheat field followed by wheat + raya intercropping (12:1) which was 17.0 and 9.0% higher as compared to sole wheat crop.

In Baichenahalli and Iraksandra villages, Tumkur district, Karnataka (Bengaluru centre), pigeonpea + field bean intercropping system (1:1) gave higher pigeonpea equivalent yield (882 kg/ha) and B:C (1.24) compared to sole pigeonpea (705 kg/ha and 1.20, respectively) and field bean (216 kg/ha and 0.34, respectively) and pigeonpea + maize (1:1) system recorded higher net returns (Rs. 1330/ha) and B:C ratio (1.04) as compared to sole maize (Rs. -8306/ha and 0.71, respectively).

In Chappar Jogiyan village, Bhiwani district, Haryana (Hisar centre), in an assessment of improved practices in pearlmillet (HHB 67 improved), adoption of package of practices such as improved hybrid + RDF (40:20 kg NP/ha) + interculture with wheel hand hoe recorded higher grain and stover yield (2010 and 4430 kg/ha), net returns (Rs.16130/ha), B:C ratio (1.82) and RWUE (14.10 kg/ha-mm) compared to farmers' practice (1580 and 3620 kg/ha).

In Piploda Dwarakdheesh village, Ujjain district, Madhya Pradesh (Indore centre), supplemental irrigation from harvested rainwater in farm pond enhanced the yields of chickpea varieties by 21.7% in JAKI 9218 (1920 kg/ha) and 16.4% each in Vishal and Dollar (1800 kg/ha) compared to farmers' practice of no supplemental irrigation.

In Hingani village, Satara district, Maharashtra (Solapur centre), in an assessment of *in-situ* moisture conservation in *rabi* sorghum, higher mean grain yield of 1150 kg/ha and stover yield 2895 kg/ha was recorded with compartmental bunding during *kharif* season compared to farmers' practice (582 kg/ha), with higher net returns (Rs.18470/ha), B:C ratio (2.34) and RWUE (6.15 kg/ha-mm).

Technology upscaling

The improved technologies upscaled were: improved groundnut variety (Dharani) and soil test based fertilizer application in groundnut in Yerraguntlapalli village, Kurnool district, Andhra Pradesh (Ananthapuramu centre); improved varieties with matching production technologies of maize, sesame, sorghum, blackgram and greengram in Newariya village, Chittorgarh district, Rajasthan (Arjia centre); improved production technologies of maize, blackgram and sesame in Behdarya-Kothi village, Hoshiarpur district, Punjab (Ballowal Saunkhri centre);

in-situ moisture conservation and intercropping systems in Baichenahalli and Iraksandra villages, Tumkur district, Karnataka (Bengaluru centre); improved varieties of pearlmillet, greengram and mustard in Chappar Jogiyan village, Bhiwani district, Haryana (Hisar centre); and improved varieties of pearlmillet, sorghum and horsegram, and nutrient management in pearlmillet in Hingani village, Satara district, Maharashtra (Solapur centre).

National Innovations in Climate Resilient Agriculture (NICRA)

During the year, the on-farm programme was extended to 22 more adjoining villages to the existing 32 villages (total 54 villages) in 24 districts across 15 states. During the period, the emphasis continued on real time contingency crop plan implementation and preparedness to cope with weather aberrations and implemented in more than 1000 farmers' fields. During 2017-18, the onset of monsoon was delayed by 25, 13 and 11 days respectively in NICRA villages located in Jamnagar (Gujarat), Garhwa (Jharkhand) and Banaskantha (Gujarat) districts. Further, there were 3-4 dry spells at different stages of crops in NICRA villages in Akola, Ananthapuramu, Bengaluru, Jagdalpur, Lakhimpur, Garhwa, Kandhamal, Parbhani and Kovilpatti districts. In general, the total rainfall during *kharif* season (June-September), 2017 was below normal in all NICRA villages except in Chikamanahalli (Bengaluru), Kavalagi (Vijayapura), Chamuha (Lakhimpur), Balawas (Bhiwani), Tahakapal (Bastar), Kadesara Kalan (Lalithpur), Muttukrishnapuram (Toothukkudi), Babhulgaon (Parbhani), Petameghapar (Jamnagar) and Kalimati (Banastantha). Introduction of short duration varieties of various crops to cope with delayed onset of monsoon resulted in yield increase up to 35%. Real-time contingency measures to cope with early/midseason/terminal drought impacted yield enhancement by 25-30% across different rainfed production systems. The village institutions such as Village Climate Risk Management Committees, custom hiring centres etc. played greater role in near-real time implementation of contingency measures.

Monitoring and Evaluation

During the period the technical, physical and financial targets were monitored and evaluated across AICRPDA network centers. Project Coordinator (AICRPDA) and scientists from PC Unit, AICRPDA visited Arjia,Bengaluru, Indore, Jagdalpur, Rakh Dhiansar, Parbhani and Rajkot centers. The proceedings were brought out during the visits itself for improving /any necessary action by the concerned oficials.

The technical, physical and financial targets were also reviewed during XVI Working Group Meeting of AICRPDA held at Jagdalpur centre, IGKV, Chhattisgarh during 01-05 February, 2018. The overall progress under NICRA was reviwed and technical programme for next phase of NICRA (2017-20) was developed during the Two-day Technical Workshop of AICRPDA-NICRA held at ICAR-CRIDA during 22-27 May 2017.

Linkages and Collaboration

The centres were involved in various state level interface meetings in Andhra Pradesh, Karnataka, Rajasthan, Maharashtra, and Tamil Nadu and contributed for operationalization of district level agricultural contingency plans in linkage with state line departments. The technology upscaling linked with various centres and state level programs such as PMKSY, *Krishi bhagya* (Karnataka), *Panta Sanjeevani* (Andhra Pradesh) and capacity buillding of various stakeholders continued in linkage with SLDs, ATMA, KVKs etc. The research collaboration was strengthened with AICRP-IFS and AICRP-Agroforestry at identified common centres.

Publications

Overall, 185 publications were contributed by AICRPDA team comprising of 76 research papers, 29 books/book chapters/manuals/bulletins, 59 papers in seminars/ symposia/conferences etc and 21 popular articles during the year.

Awards/Recognitions

AICRPDA centre, Vijayapura received ICAR-Vasantarao Naik Award-2017 for Outstanding Research Applications in Dryland Farming systems.

HRD, impacts and upscaling of rainfed technologies

During the period 50 trainings and technology demonstration/disseminaton activities were conducted to benefit more than 3000 farmers/stakeholders.

Budget

The total budget allocated for 22 network centers and 5 voluntary centres of AICRPDA for the period 2017-18 was Rs.2176.64 lakhs and Rs. 447.87 lakhs was allocated for 8 Operational Research Project centers.

1. Introduction

INTRODUCTION

Rainfed agriculture, which is practiced in about 73 Mha (52% of the net cultivated area) in India contributes to about 40% of national food basket and supports more than 60% livestock population, thus plays a crucial role in the country's economy. The key factors impacting sustainability and environmental protection in rainfed production systems are climate change/variability, poor operational resource base, bridging yield gaps, enhancing water productivity and maintaining soil health. The efforts are being made in All India Coordinated Research Project for Dryland Agriculture (AICRPDA) to generate agroecology specific rainfed technologies at network centers spread across diverse rainfed agro-ecologies in 17 states. During 2017-18, AICRPDA network has 19 main centers, 3 subcentres, 8 Operational Research Project (ORP) centres and 5 voluntary centres located in 24 SAUs, one each under CAU, Imphal; RBS College, Agra and BHU, Varanasi (Fig.1.1; Table 1.1). The Organogram of AICRPDA Network is given in Fig. 1.2.

Mandate

Main/Sub/Voluntary-centres

- To optimize the use of natural resources in rainfed regions and to develop and promote technologies that lead towards minimizing soil and water loss and degradation of environment
- To evolve simple technologies to substantially increase crop productivity and viability
- To increase stability of crop production over years by providing crop management systems and alternate crop production technologies matching weather aberrations
- To evaluate the traditional farming systems and study transfer ability of improved dryland technology to farmers' fields

ORP centres

- To understand the strength and weakness in the traditional system of dryland agriculture
- To evaluate the performance of each component of dryland technology under farmers management conditions
- To provide feedback to research stations for refinement of non-adopted recommendations

Fig.1.1: Location map of AICRPDA Network Centres

Table 1.1: 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
Agra (SC)	RBSC, Agra	South–western semiarid zone in Uttar Pradesh (4.1)	Semiarid (Hot dry)	665	Inceptisols	Pearlmillet
Akola (MC)	PDKV, Akola	Western Vidarbha Zone in Maharashtra (6.3)	Semiarid (Hot moist)	824	Vertisols	Cotton
Anantapuramu (MC & ORP)	ANGRAU, Guntur	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	544	Alfisols	Groundnut
Arjia (MC & ORP)	MPUAT, Udaipur	Southern zone in Rajasthan (4.2)	Semiarid (Hot dry)	656	Vertisols	Maize
Ballowal Saunkhri (MC & ORP)	PAU, Ludhiana	Kandi region in Punjab (9.1)	Subhumid (Hot dry)	1011	Inceptisols	Maize
Bengaluru (MC & ORP)	UAS, Bengaluru	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermillet
Biswanath Chariali (MC)	AAU, Jorhat	North Bank plain zone in Assam(15.2)	Humid (Hot)	1990	Alfisols	Rice
Chianki (MC & ORP)	BAU, Ranchi	Western plateau zone of Jharkhand (11.0)	Subhumid (Hot moist)	1179	Inceptisols	Rice
Faizabad (SC)	NDUAT, Faizabad	Eastern plain zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	1051	Inceptisols	Rice
Hisar (MC & ORP)	CCSHAU, Hisar	South-western dry zone in Haryana (2.3)	Arid (Hyper)	412	Inceptisols	Pearlmillet
Indore (MC & ORP)	RVSKVV, Gwalior	Malwa plateau in Madhya Pradesh (5.2)	Semiarid (Hot moist)	958	Vertisols	Soybean
Jagadalpur (MC)	IGAU, Raipur	Basthar Plateau zone in Chattisgarh (12.1)	Subhumid (Hot moist)	1297	Inceptisols	Rice
Kovilpatti (MC)	TNAU, Coimbatore	Southern zone of Tamil Nadu (8.1)	Semiarid (Hot dry)	723	Vertisols	Cotton
Parbhani (MC)	VNMKV, Parbhani	Central Maharastra Plateau Zone in Maharashtra (6.2)	Semiarid (Hot moist)	901	Vertisols	Cotton
Phulbani (MC)	OUAT, Bhubaneswar	Eastern Ghat Zone in Odisha (12.1)	Subhumid Hot moist)	1580	Oxisols	Rice
Rajkot (MC)	JAU, Junagarh	North Saurashtra zones in Gujarat (5.1)	Semiarid (Hot dry)	590	Vertisols	Groundnut
Rakh Dhiansar (SC)	SKUAS_T, Jammu	Low altitude subtropical zone in Jammu and Kashmir (14.2)	Semiarid (Moist dry)	860	Inceptisols	Maize
Rewa (MC)	JNKVV, Jabalpur	Keymore plateau and Satpura Hill zone in Madhya Pradesh (10.3)	Subhumid (Hot dry)	1088	Vertisols	Soybean
S.K. Nagar (MC)	SDAU, Dantewada	Northern Gujarat in Gujarat (2.3)	Semiarid/Arid (Hot dry)	670	Entisols	Pearlmillet
Solapur (MC & ORP)	MPKV, Rahuri	Scarcity zone in Maharashtra (6.1)	Semiarid (Hot dry)	732	Vertisols	*Rabi* sorghum
Varanasi (MC)	BHU, Varanasi	Eastern Plain and Vindhyan Zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	1049	Inceptisols	Rice
Vijayapura (Bijapur) (MC)	UAS, Dharwad	Northern dry zone in Karnataka (6.1)	Semiarid (Hot dry)	595	Vertisols	Rabi sorghum
Akhlera (VC)	AU, Kota	South eastern plain zone of Rajasthan (5.2)	Semiarid	844	Vertic Inceptisols	Soybean
Ballari (VC)	CSWCRTI, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	502	Vertisols	*Rabi* sorghum
Darsi (VC)	ANGRAU, Guntur	Krishna-Godavari zone of Andhra Pradesh (7.3)	Semiarid	871	Alfisols/ Vertisols	Pigeonpea
Imphal (VC)	CAU, Imphal	Sub-tropical zone of Manipur (17.2)	Perhumid	1372	Inceptisols	Rice
Jhansi (VC)	IGFRI, Jhansi	Bundhelkhand zone in Uttar Pradesh (4.4)	Semiarid (Hot moist)	870	Inceptisols	*Kharif* sorghum
Jodhpur (VC)	CAZRI, Jodhpur	Arid Western zone of Rajasthan (2.1)	Arid (Hyper)	331	Aridisols	Pearlmillet
Munger (VC)	BAU, Sabour	South Bihar Alluvial plain zone of Bihar (13.1)	Subhumid	1143	Inceptisols	Maize
Raichur (VC)	UAS, Raichur	North-eastern dry zone of Karnataka (6.2)	Semiarid	621	Vertisols/ Alfisols	*Rabi* sorghum

MC- Main Centre; SC- Sub Centre; VC: Voluntary Centre; ORP: Operational Research Project **Climate details as per AESR details given by NBSSLUP (ICAR); MARF- Mean Annual Rainfall; MRPS- Major Rained Production System

The research in diverse climates and soil types is being undertaken in 8 rainfed crop based production systems, viz., rainfed rice (6 centers), sorghum (2 centers), pearlmillet (3 centers), fingermillet (1 center), maize (3 centers), cotton (3 centers), groundnut (2 centers) and soybean (2 centers) and 5 voluntary centres in thematic areas of rainwater management, cropping systems, nutrient management, alternate land use and integrated farming systems, energy management and evaluation of improved varieties. The technology assessment and refinement of the research findings is carried out as on-farm participatory research through 8 Operational Research Project centres at Anantapuramu, Arjia, Ballowal Saunkhri, Bengaluru, Chainki, Hisar, Indore and Solapur.

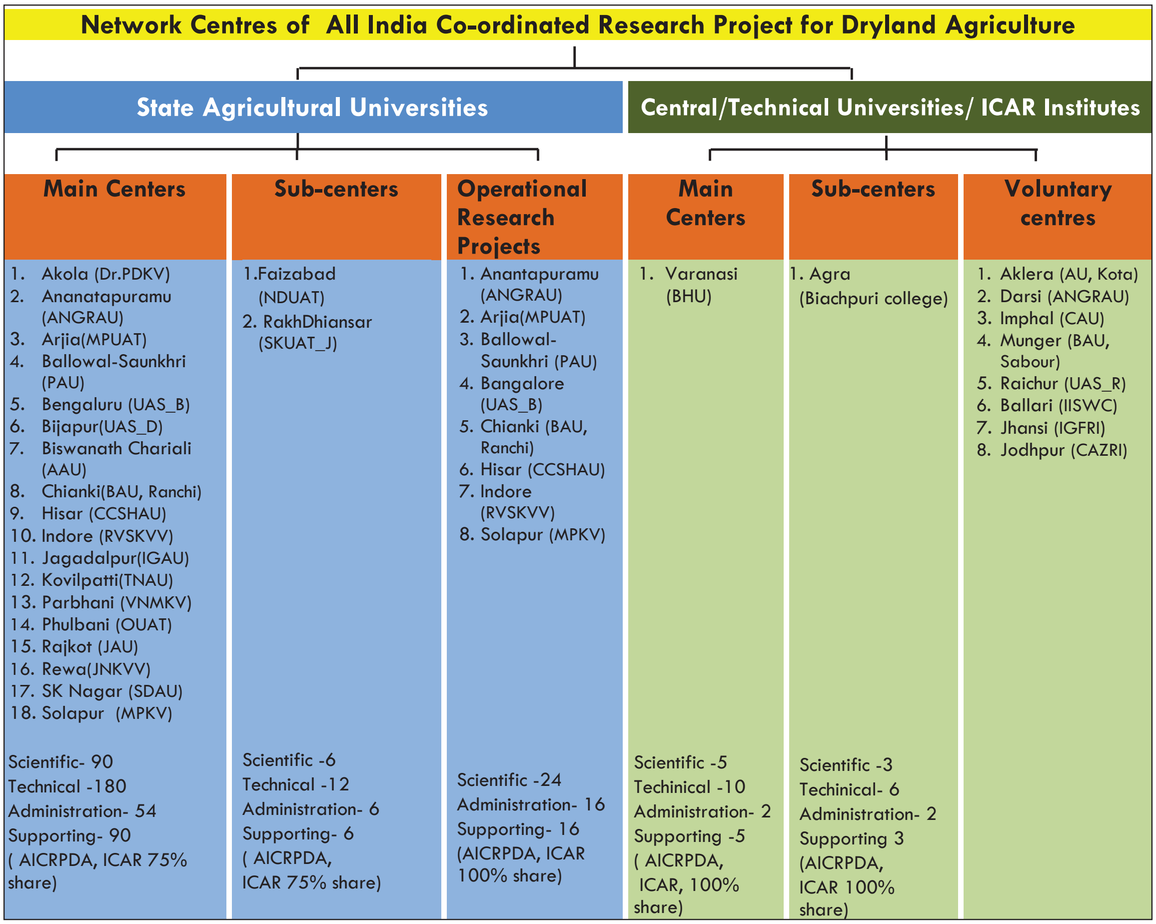


Fig. 1.2: Organogram of AICRPDA Network

Research Focus - 2017-18

The research prioritization at the centres in the key thematic areas are to address the rainfed agriculture problems in a centre's agroclimatic zone domain in particular and broadly in tune with ICAR/national priorities in rainfed agriculture. During 2010 to 2017, the research had been prioritized (Fig 1.3) based on the recommendations/ outcome of Research Advisory Committees (RACs) of CRIDA, Quinquennial Review Teams (QRTs) of CRIDA-AICRPDA-AICRPAM , Biennial Workshops/Working

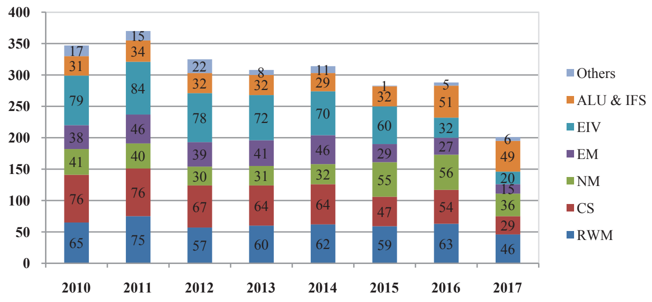


Fig 1.3: Theme-wise number of experiments during different years

Group Meetings of AICRPDA, Stakeholder Consultation Workshops held at the centres for research prioritization and technologies upscaling, Technical Workshops and Zonal Research Extension Advisory Committee (ZREAC) Meetings in SAUs and scientists-farmers interaction meetings.

During 2017-18, the technical programme was critically during Two day Technical Workshop of AICRPDA-NICRA (at ICAR-CRIDA, 26-27 May, 2017) and the XVI Working Group Meeting (at AICRPDA Centre, Jagdalpur, IGKV, Chhattisgarh,1-5 February, 2018) (The Proceedings are given in Annexure I).

Dr. S. Bhaskar, ADG (A, AF & CC) addressing the participants of Two-day Technical Workshop of AICRPDA-NICRA

Dr. J.C. Katyal, VII QRT Chairman, CRIDA-AICPRDA-AICRPAM (left) and Dr. S.K. Patil, Vice Chancellor, IGKV (right) addressing the participants of XVI Working Group Meeting of AICRPDA

The major recommendations for on-station research were:

- To develop Intensity-Frequency-Duration (IFD) relationship in runoff and to develop seepage equations for unlined farm ponds
- To conduct experiments at selected Centres on minimization of evaporation losses from farm ponds and to explore various methods and to conduct experiments on minimizing seepage losses from farm ponds. Water budgeting at village level may also be worked out by the centres.
- On-farm participatory Rainfed Integrated Farming System (RIFS) research to be strengthened at all centres
- Studies on suitable perennials including specified with low gestation period, low volume and high income species and annual component species at all centres
- Best performing treatments from Permanent Manorial Trials (PMTs) at 15 centres to be evaluated in large plots as satellite experiments with 2/3 best treatments in support of PMTs
- Evaluation of farm implements/machinery for various agricultural operations
- Evaluation of elite germplasm/ suitable varieties of predominant rainfed crops to cope with delayed onset of monsoon by 2/4/6/8 weeks

Collaborative research

In addition to the approved technical programme of AICRPDA, centres are also involved in the collaborative research with focused experiments as given below.

AICRPDA-CRIDA: i) Development of microbial consortia for drought tolerance in rainfed crops will be conducted at Ballowal Saunkhri, Ananthapuramu, Vijayapura and Parbhani; ii) ICAR-CRP-Conservation Agriculture project at Akola and Bengaluru

AICRPDA-ICAR-CICR/AICRP on Cotton: Evaluation of high density planting system (HDPS) of cotton in diverse rainfed agro-ecologies at Kovilpatti, Parbhani, Akola and Rajkot centres.

AICRPDA-AICRPAM: A common experiment on Real time monitoring and management of agricultural drought in major rainfed crops at 7 common centres viz. Ananthapuramu, Bengaluru, Akola, Parbhani, Solapur, Kovilpatti and Vijayapura.

Further, collaborative research/programme is also initiated with CRIDA, AICRPAM, and identified/common centres of AICRPDA and other AICRPs as given below.

Collaboration with	Collaboration for	AICRPDA centres involved
CRIDA	Common experiments and ICAR-CRP-Conservation Agriculture	Ballowal Saunkhri, Ananthapuramu, Vijayapura and Parbhani, Akola and Bengaluru
AICRP on Agrometeorolgy	Agro-Advisory Services AICRPDA centres would give technical support for validation of RTCPs in NICRA villages	Common centres of AICRPDA and AICRPAM
AICRP on Agroforestry	Observations and technical guidance	Hisar, SK Nagar, Rakh Dhiansar, Ballowal Saunkhri, Indore, Bengaluru, Biswanath Chairiali, Phulbani, Arjia, Akola, Vijayapura, Solapur
AICRP on Integrated Farming Systems	Observations and technical guidance	Biswanath Chariali, Jagdalpur, Varanasi, SK Nagar, Indore, Parbhani
AICRP on Forage Crops , IGFRI, Jhansi	Observations and technical guidance	Chianki , Phulbani, Imphal, Biswanath Chariali, Hisar, Jagdalpur
AICRP on Fruits, IIHR, Bengaluru	Observations and technical guidance	Akola, Phulbani, Biswanath Chariali, Chianki, Imphal
Crop AICRPs		
AICRP on Pigeonpea	Suitable germplasm/cultivars	Arjia, Indore
AICRP on Chickpea	Suitable germplasm/cultivars	Hisar, Vijayapura, Varanasi
AICRP on MULLaRP	Suitable germplasm/cultivars	Arjia, Anantapuramu, Vijayapura, Solapur
AICRP on Arid Legumes	Suitable germplasm/cultivars	Arjia, Anantapuramu, Vijayapura, Solapur
AICRP on Sesame & Niger	Suitable germplasm/cultivars	Arjia

During 2017-18, in total, 197 on-station experiments were conducted across the centres (Fig 1.4; Table 1.2). Among these, 20.3% experiments were on rainwater management, 14.2% on cropping systems, 20.8% on nutrient management, 7.6% on energy management, 10.2% on evaluation of improved varieties, 13.2% on alternate land use, 11.2% on integrated farming systems and 2.5% on resource characterization. Further, 58 experiments were concluded during 2016-17 (Fig 1.5). The abstract of number of technologies for participatory technology development and upscaling centre-wise and theme-wise is given in Table 1.3.

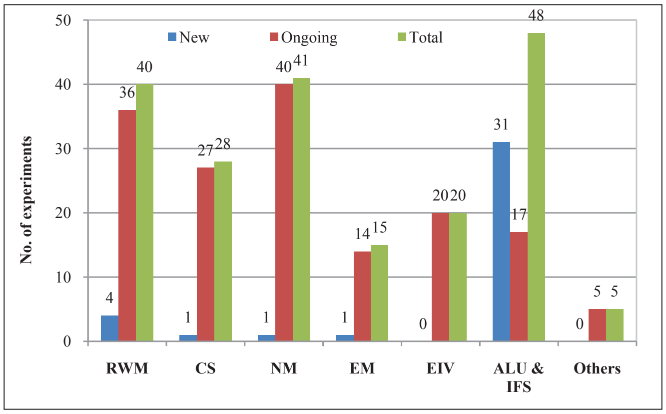


Fig 1.4: Theme-wise new and on-going experiments during 2017-18

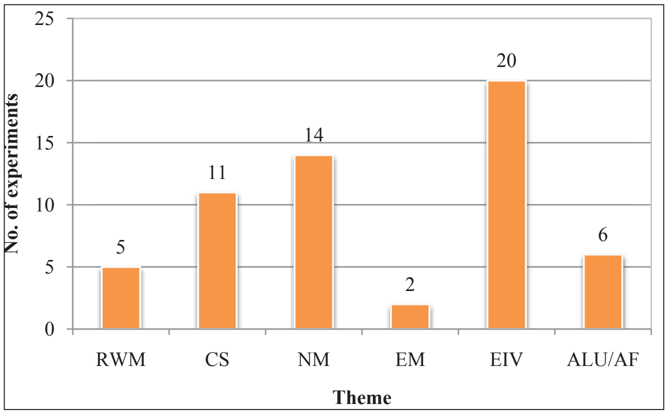


Fig 1.5: Theme-wise concluded experiments during 2016-17

Table 1.2: Number of experiments conducted by AICRPDA centers (on-station) during 2017-18

Production System/Center	RWM	CS	NM	EM	EIV	ALU/AF	IFS	RC	Total
Rice based production system									
Biswanath Chariali	2	2	2	-	1	1	1	-	9
Chianki	1	1	-	-	2	2	1	-	7
Faizabad	2	1	1	-	-	1	1	-	6
Jagadalpur	2	1	3	1	-	1	1	-	9
Phulbani	2	1	2	-	-	1	1	-	7
Varanasi	2	-	2	1	1	1	1	-	8
Total	**11**	**6**	**10**	**2**	**4**	**7**	**6**	**-**	**46**
Maize based production system									
Arjia	2	1	3	1	4	1	1	-	13
Ballowal Saunkhri	1	1	2	-	-	1	1	-	6
RakhDhiansar	1	1	2	1	-	1	1	-	7
Total	**4**	**3**	**7**	**2**	**4**	**3**	**3**	**-**	**26**
Fingermillet based production system									
Bengaluru	2	1	2	-	-	2	1	-	8
Total	**2**	**1**	**2**	**-**	**-**	**2**	**1**	**-**	**8**
Pearlmillet based production system									
Agra	1	2	2	-	-	1	1	-	7
Hisar	2	1	2	1	1	-	1	-	8
SK Nagar	1	-	2	-	-	1	1	-	5
Total	**4**	**3**	**6**	**1**	**1**	**2**	**3**	-	**20**
Sorghum based production system									
Vijayapura	3	3	3	2	4	1	1	-	17
Solapur	1	2	1	1	2	-	1	-	8
Total	**4**	**5**	**4**	**3**	**6**	**1**	**2**	**-**	**25**
Soybean based production system									
Indore	1	-	2	1	1	1	1	-	7
Rewa	1	1	1	-	-	-	1	-	4
Total	**2**	**1**	**3**	**1**	**1**	**1**	**2**	**-**	**11**
Groundnut based production system									
Anantapuramu	3	1	1	3	4	1	1	-	14
Rajkot	1	1	1	-	-	1	1	-	5
Total	**4**	**2**	**2**	**3**	**4**	**2**	**2**	**-**	**19**
Cotton based production system									
Akola	2	2	3	-	-	2	1	-	10
Kovilpatti	2	2	1	-	-	2	1	-	8
Pharbani	1	-	1	2	-	1	1	-	6
Total	**5**	**4**	**5**	**2**	**-**	**5**	**3**	**-**	**24**
New voluntary centers									
Aklera	-	-	1	1	-	-	-	1	3
Darsi	1	1	-	-	-	1	-	1	4
Imphal	-	1	-	-	-	1	-	1	3
Raichur	2	1	-	-	-	1	-	1	5
Munger	1	-	1	-	-	-	-	1	3
Total	**4**	**3**	**2**	**1**	**-**	**3**	**-**	**5**	**18**
Grand Total	**40**	**28**	**41**	**15**	**20**	**26**	**22**	**5**	**197**
% Experiments	**20.3**	**14.2**	**20.8**	**7.6**	**10.2**	**13.2**	**11.2**	**2.5**	**100**

Table 1.3: On-farm trials/demonstrations in ORP villages during 2017-18

ORP village/ORP centre	Technologies for participatory research development/refinement (PTD)						Technologies for upscaling						Total
	RWM	CS	NM	EM	EIV	IFS/ ALU	RWM	CS	NM	EM	EIV	IFS/ ALU	
Yerraguntlapalli (Ananthapuramu)	3	1	1	1	-	1	-	-	1	2	1	-	11
Nevariya (Arjia)	2	2	2	1	4	1	1	-	-	-	1	-	14
Behdarya-Kothi (Ballowal-Saunkhri)	2	2	2	1	-	1	1	1	-	-	1	-	11
Baichenahalli (Bengaluru)	1	-	-	-	4	-	1	5	-	4	-	1	16
Gonda (Chianki)	2	1	-	1	8	-	-	3	1	-	-	-	16
Chhaparjogiyan (Hiasr)	1	2	2	-	2	1	1	-	-	1	1	-	11
Piplodadwarkadeesh (Indore)	2	1	-	1	1	1	1	-	1	-	-	-	8
Hingani (Solapur)	3	3	2	1	2	-	1	3	1	1	-	-	17
Grand Total	**16**	**12**	**9**	**6**	**21**	**5**	**6**	**12**	**4**	**8**	**4**	**1**	**104**
% of Total	**15.4**	**11.5**	**8.7**	**5.8**	**20.2**	**4.8**	**5.8**	**11.5**	**3.8**	**7.7**	**3.8**	**1.0**	**100**

RWM: Rainwater Management; CS: Cropping Systems; NM: Nutrient Management; EM: Energy Management; EIV: Evaluation of Improved Varieties; IFS/ALU: Integrated Farming System/Alternate Land Use System RC: Resource Characterization

2. Resource Characterization

2.1 Climate and soils

The AICRPDA network centres are located in diverse rainfed agro-ecological settings i.e., arid, semiarid (dry and moist), subhumid (dry and moist) and humid climates and soil types viz. Entisols, Inceptisols, Vertisols, Alfisols, Aridisols and Oxisols. The mean annual rainfall across network centres ranges from 412 mm to 1990 mm; while PET from 455 mm to 1681 mm, water surplus from 0 mm to 609 mm, water deficit from 0 mm to 655 mm, mean annual maximum temperature from 27.8^{o}C to 42.4^{o}C and mean annual minimum temperature from 26.7^{o}C to 16.4^{o}C.

Across the network centres, the length of growing period (LGP) i.e. moisture availability period varies from 60 days to 270 days. Over years, due to continuous monocropping of predominant rainfed crops/cropping systems, the locations are identified with multiple nutrient stresses (Table 2.1).

Table 2.1: Soil types, LGP & limiting nutrients across AICRPDA network centres

AICRPDA Centre	Soil characteristics		
	Dominant soil type	LGP (days)	Limiting nutrients
Agra	Inceptisols	90-120	N, K, Mg, Zn, B
Akola	Vertisols	120-150	N, P, S, ZN, B
Anantapur	Alfisols	60-90	N, K, Mg, Zn, B
Arjia	Vertisols	90-120	N, Mg, Zn, B
Ballowal Saunkhri	Inceptisols	120-150	N, K, S, Mg, Zn
Bangalore	Alfisols	120-150	N, K, Ca, Mg, Zn, B
Vijayapura	Vertisols	90-120	N, Zn, Fe
Biswanath Chariali	Inceptisols	240-270	K, Zn, B
Chianki	Inceptisols	150-180	N, Zn, B
Faizabad	Inceptisols	150-180	N, Zn, B
Hisar	Inceptisols/Aridisols	60-90	N, Mg, B
Indore	Vertisols	120-150	N, Zn, S
Jagdalpur	Inceptisols	180-210	N, P
Kovilpatti	Vertisols	90-120	N, P
Parbhani	Vertisols	120-150	N, Zn, Fe
Phulbani	Alfisols / Oxisols	180-210	N, Ca, Mg, Zn, B
Rajkot	Vertisols	90-120	N, P, S, Zn, Fe, B
Rakh Dhiansar	Inceptisols	150-210	N, K, Ca, Mg, Zn, B
Rewa	Vertisols	150-180	N, Zn
Sardar Krishi Nagar	Aridisols / Entisols	60-90	N, K, S, Ca, Mg, Zn, B
Solapur	Vertisols	90-120	N, P, Zn
Varanasi	Inceptisols	120-150/ 150-180	N, Zn, B

The details of onset of monsoon, annual rainfall and seasonal rainfall, both actual and annual received at different AICRPDA centres during 2016 is briefly presented below (Table 2.2).

Rice based production system

At Biswanath Chariali during 2017, the onset of monsoon was normal (1st June). A rainfall of 2217.5 mm was received which was excess by 352.7.0 mm compared to normal (1864.8 mm). During south-west monsoon (*kharif*), a rainfall of 1413.8 mm was received against a normal rainfall of 1182.2 mm. The rainfall during *rabi* was excess by 33.8 mm compared to normal rainfall of 120 mm and in summer, rainfall was 575.0 mm which was excess by 71.3 mm as against normal of 503.7 mm (Fig 2.1).

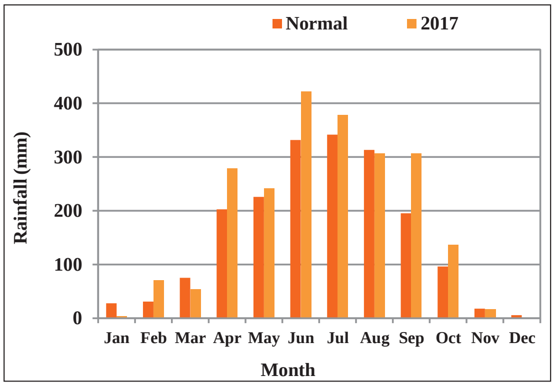


Fig.2.1: Normal and actual (2017) monthly rainfall at Biswanath Chariali

At Chianki, the onset of monsoon was delayed by 11 days (21st June). A rainfall of 1007.8 mm was received which was dificit by 172.5 mm compared to normal (1180.3 mm). During *kharif* (June–September), 941.4 mm of rainfall was received which was excess by 186.6 mm compared to normal of 1038 mm. During *rabi* season, it was 27.8 mm which was dificit by 38.1 mm compared to normal of 65.9 mm and in summer, rainfall was 6.2 mm which was dificit by 36.5 mm as against normal of 42.7 mm (Fig 2.2).

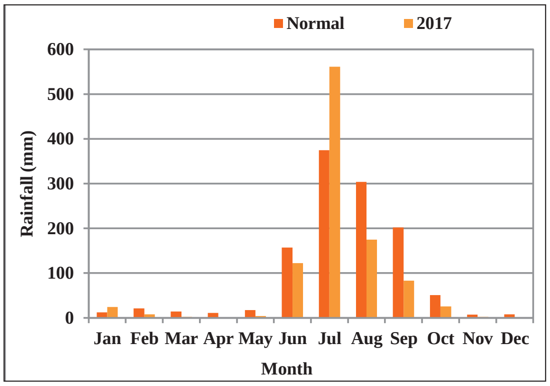


Fig.2.2: Normal and actual (2017) monthly rainfall at Chianki

At Faizabad, the onset of monsoon was delayed by 11 days (2 July). A rainfall of 882.5 mm was received which was deficit by 157.6 mm (15.2%) compared to normal rainfall (1040.1 mm). During south-west monsoon (*kharif*), 855.1 mm rainfall was received which was deficit by 59.8 mm (6.54%) compared to normal of 914.9 mm. During *rabi*, no rainfall was received against the normal rainfall of 65.6 mm. During summer, 10.6 mm of rainfall was received which was deficit by 22.6 mm compared to normal rainfall (33.2 mm) (Fig.2.3).

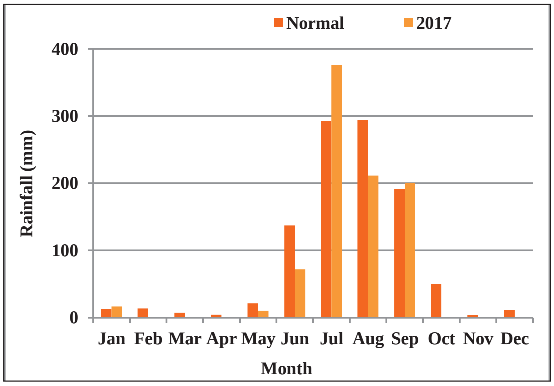


Fig.2.3: Normal and actual (2017) monthly rainfall at Faizabad

At Jagdalpur, the onset of monsoon was normal (8th June). A total rainfall of 1740.8 mm was received which was excess by 336.4 mm compared to normal of 1404.4 mm. During south-west monsoon (*kharif*), there was 1421.9 mm rainfall which was excess of 300.4 mm (26.8%) as against normal rainfall of 1122 mm. During North-east monsoon (October - December), 182.6 mm of rainfall was received

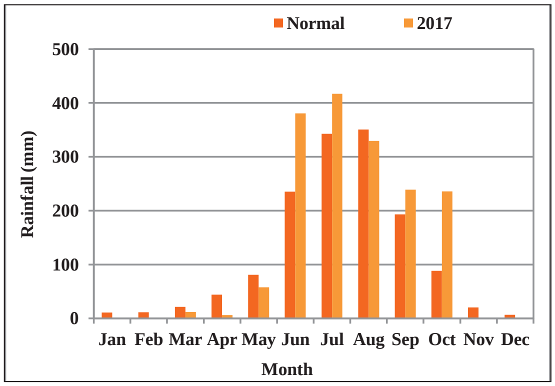


Fig.2.4: Normal and actual (2017) monthly rainfall at Jagdalpur

which was excess 67.6 mm as that of normal (115 mm). During summer, 125.7 mm of rainfall was received which was deficit by 13.9% (-20.4 mm) compared to normal rainfall of 146.1 mm (Fig 2.4).

At Phulbani, the onset of monsoon was normal (10th June). A rainfall of 1265.9 mm was received during the year which was deficit by 141.4 mm than normal (1407.3 mm). Out of total rainfall, 894.6 mm was received during *kharif* (June- September) and was dificit by 255.9 mm (22.24%) than normal (1150.5 mm). In *rabi*, there was 128.9% excess rainfall (160.8 mm) than normal (124.7 mm) and in summer, it was deficit by 81.0 mm (20.9%) than normal of 108.4 mm (Fig.2.5).

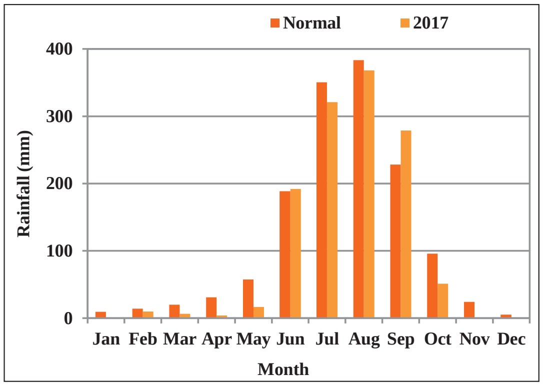


Fig.2.5: Normal and actual (2017) monthly rainfall at Phulbani

At Varanasi, the onset of monsoon was timely (20 June). A rainfall of 635.2 mm was received which was deficit by 446.5 mm (41.3%) compared to normal (1081.7 mm). During south-west monsoon (*kharif*), 629.6 mm of rainfall was received which was deficit by 312.5 mm compared to normal (944.5 mm), During rabi, no rainfall was received against the normal rainfall of 60.9 mm (Fig. 2.6). During summer (March- May), 2.2 mm of rainfall was received which was deficit by 30.1 mm compared to normal (32.3 mm)

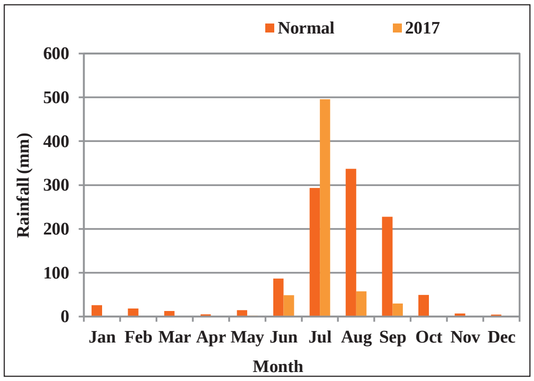


Fig.2.6: Normal and actual (2017) monthly rainfall at Varanasi

Maize based production system

At Arjia, the onset of monsoon was early by 3 days (29th June). A rainfall of 984.8 mm was received which was excess by 327.1 mm compared to normal rainfall of 657.7 mm. During South-West monsoon (June to September), 964.1 mm rainfall was received which was excess by 349.6 mm (56.9%). During October-December, no rainfall was received against normal of 20.2 mm. During summer (March- May), 19.0 mm of rainfall was received which was excess by 3.9 mm compared to normal (15.1 mm) (Fig.2.7).

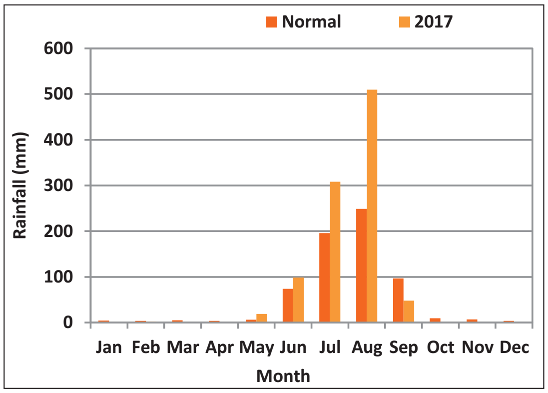


Fig.2.7: Normal and actual (2017) monthly rainfall at Arjia

At Ballowal Saunkhri, the onset of monsoon was early by 5 days (1st July). A rainfall of 1046.6 mm was received, which was deficit by 47.7 mm than the normal annual rainfall of 1094.3 mm. Out of the total rainfall, 887.0 mm was

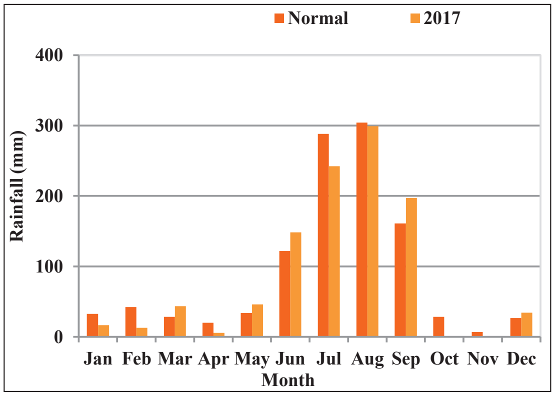


Fig.2.8: Normal and actual (2017) monthly rainfall at Ballowal Saunkhri

received during the *kharif* season (June to September) as against normal of 875.6 mm. In *rabi*, 34.4 mm rainfall was received which was 27.5 mm deficit than normal of 61.9 mm. In summer season, 95.6 mm rainfall was received which was excess by 13.5 mm as against normal of 82.1 mm (Fig.2.8).

At Rakh Dhiansar, the onset of monsoon was early (21st June). A rainfall of 890.5 mm was received with was deficit by 257.5 mm (22.4%) compared to normal (1148.0). During *Kharif* 664.6 mm was received which was deficit by 221.2 mm compared to normal (885.8 mm). During *rabi* (October - December), 44.8 mm of rainfall was received against the normal (47.6 mm). During summer (March -May), 51.9 mm of rainfall was received which was deficit by 62.2 mm compared to normal 114.1 mm (Fig.2.9).

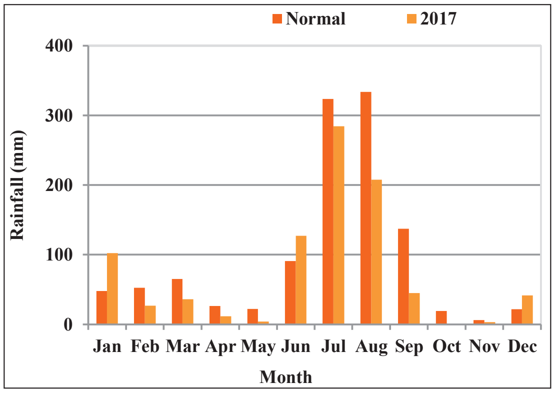


Fig.2.9: Normal and actual (2017) monthly rainfall at Rakh Dhiansar

Fingermillet based production system

At Bengaluru, the onset of monsoon was delayed by 4 days (6th June). A rainfall of 694.9 mm was received which was deficit by 228.1 mm (24.7%) compared to normal (923.1 mm). During *kharif* season (June–September), 480.9 mm rainfall was recorded which was deficit by 36.0 mm (6.9%) against normal of 516.9 mm. In *rabi* season, it was 93.7 mm which was deficit by 147.4 mm (61.1%) than the normal of 241.1 mm and in summer 118.0 mm rain fall was recorded and was deficit by 37.8 mm (24.3%) than normal of 155.8 mm (Fig.2.10).

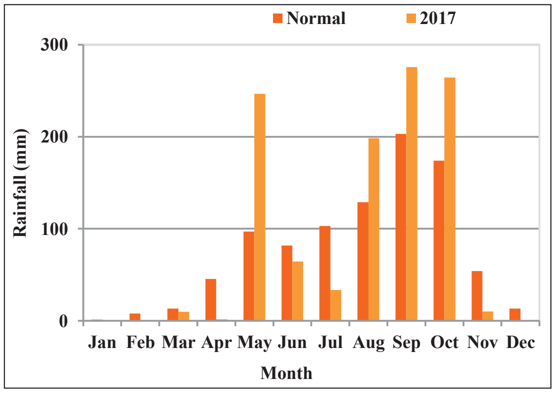


Fig.2.10: Normal and actual (2017) monthly rainfall at Bangalore

Pearlmillet based production system

At Agra, the onset of monsoon was normal (2nd July). A rainfall of 346.2 mm was received which was deficit by 316.3 mm compared to normal (662.5 mm). During south-west monsoon (*kharif*), 246.3 mm rainfall was received which was deficit by 340.8 mm (58.04%) as against normal of 587.1 mm. During north-east monsoon (October-December), 1.2 mm rainfall was received which was deficit by 27.3 mm compared to normal (28.5 mm). During summer (March-May), 71.7 mm of rainfall was received which was excess by 48.3 mm compared to normal (23.4 mm) (Fig. 2.11).

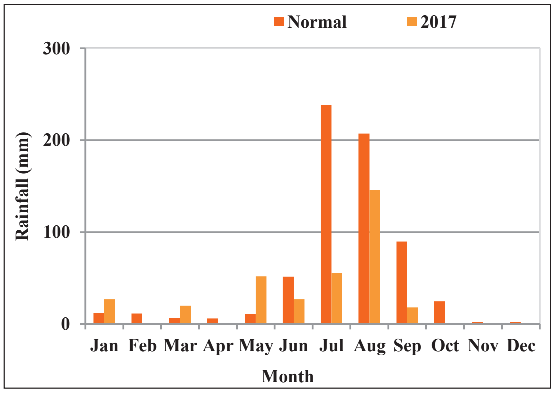


Fig.2.11: Normal and actual (2017) monthly rainfall at Agra

At Hisar, the onset of monsoon was early (29th June) and a rainfall of 506.3 mm was received which was excess by 94.3 mm (22.8%) compared to normal (412.0 mm). During *kharif* season, 461.0 mm rainfall was received which was excess by 125.2 mm (37.3 %) than normal of 335.8 mm. In *rabi*, 2.0 mm rainfall was received which was 7.2 mm deficit than normal of 9.2 mm and in summer, rainfall was deficit by 25.2 mm than normal of 38.0 mm (Fig.2.12).

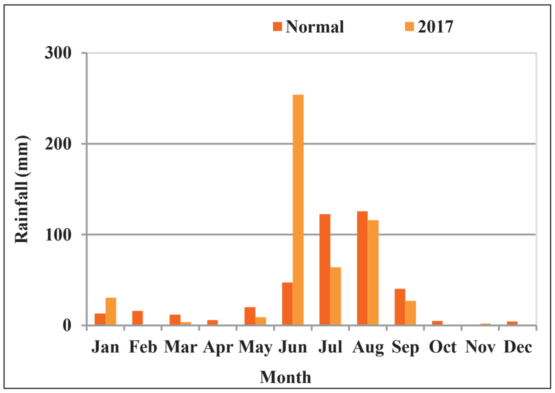


Fig.2.12: Normal and actual (2017) monthly rainfall at Hisar

At SK Nagar, the onset of monsoon was delayed by 2 days (27th June 12th July). A rainfall of 1392 mm was received which was excess by 754.8 mm compared to normal (638 mm) (Fig.2.13). During south-west monsoon (kharif), 1383.3 mm rainfall was received which was excess by 785.2 mm than normal rainfall of 598.1 mm; during October- December no rainfall was received against the normal rainfall of 27.1 and in summer (March-May), 9.5 mm rainfall was received.

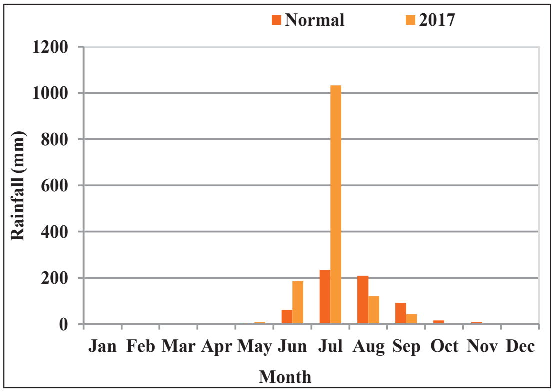


Fig.2.13: Normal and actual (2017) monthly rainfall at SK Nagar

Sorghum based production system

At Vijayapura, the onset of monsoon was delayed by 11 days (16th June). A rainfall of 765.0 mm was received which was excess by 170.7 mm (28.7%) compared to normal (594.4 mm). During *kharif* (June- September) 555.5 mm rainfall was recorded which was excess by 168.0 mm (43.4%) than seasonal normal of 387.5 mm. During *rabi*, it was 167.0 mm which was excess by 33.0 mm (24.6%) than normal of 134.0 mm and in summer 42.6 mm rainfall was recorded against 66.1 mm (Fig.2.14).

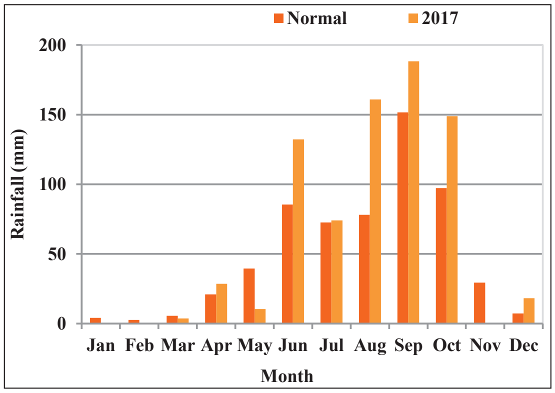


Fig.2.14: Normal and actual (2017) monthly rainfall at Vijayapura

At Solapur, the onset of monsoon was early by 3 days (4th June). A rainfall of 589.6 mm was received which was deficit by 131.8 mm compared to normal of 721.4 mm. During *kharif,* 454.0 mm rainfall was recorded, which was deficit by 81.2 mm than normal of 535.2 mm; *rabi* recorded 118.1 mm which was deficit by 7.4 mm than normal rainfall (125.5 mm) and in summer, 17.5 mm rainfall was received against normal (52.6 mm) (Fig.2.15).

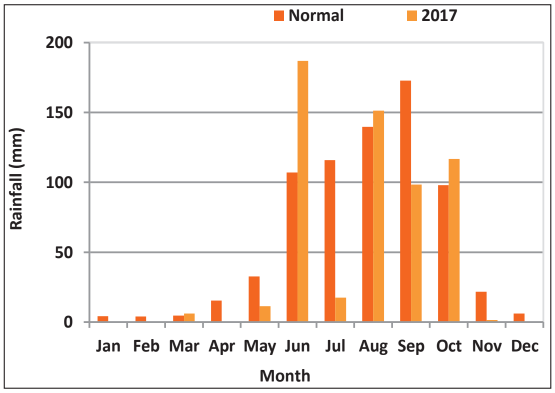


Fig.2.15: Normal and actual (2017) monthly rainfall at Solapur

Soybean based production system

At Indore, the onset of monsoon was normal (15 June), and an annual rainfall of 880.4 mm was received which was deficit by 77.6 mm compared to normal (958 mm). During south-west monsoon (*kharif),* the rainfall received was 871.9 mm against the normal (854.5 mm) which was excess by 17.4 mm. During *rabi* October-December, 1.4 mm rainfall was received which was deficit by 63.1 mm (97.8%) compared to normal (64.5 mm). During summer, 7.1 mm rainfall was received against normal of 30.6 mm (Fig.2.16).

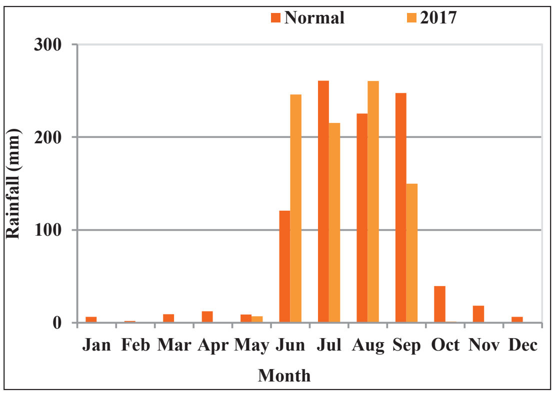


Fig.2.16: Normal and actual (2017) monthly rainfall at Indore

At Rewa, the onset of monsoon was normal (22nd June). A rainfall of 869.8 mm was received which was deficit by 20.2% compared to normal rainfall of 1090.2 mm. The rainfall during *kharif* season was 849.8 mm as against normal rainfall of 965.1 mm. During *rabi* season, no rainfall received against normal rainfall of 50.1 mm (Fig.2.17).

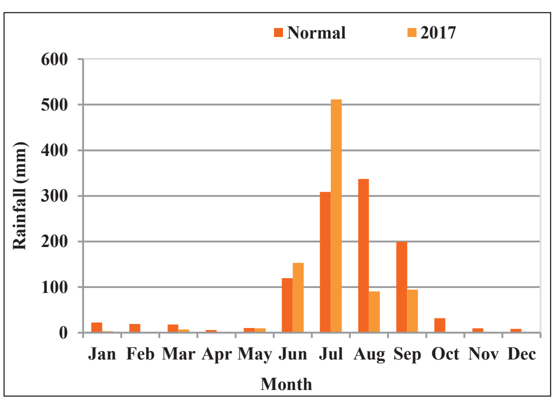


Fig.2.17: Normal and actual (2017) monthly rainfall at Rewa

Groundnut based production system

At Anantapuramu, the onset of monsoon was delayed by 6 days (11th June). A total rainfall of 663.2 mm was received which was excess by 93.4 mm (16.4%) compared to normal (570 mm). Out of total rainfall 441.2 mm was received in *kharif* season which was 89.1 mm excess (25.3%) than normal of 352 mm. In *rabi*, it was 213.0 mm and was excess by 69.0 mm (47.9%) than normal of 144 mm and in summer season, 8.4 mm rainfall was received which was deficit by 63.1 mm (63.1%) than normal of 71.5 mm (Fig.2.18).

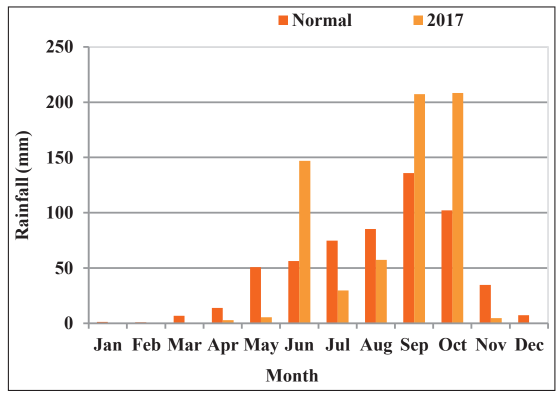


Fig.2.18: Normal and actual (2017) monthly rainfall at Anantapuramu

At Rajkot, the onset of monsoon was early by 12 days (2nd June). A rainfall of 1365.7 mm was received which was excess by 775.3 mm compared to normal of 590.4 mm (Fig.). During south-west monsoon (*kharif*), 1238.5 mm rainfall was received which was excess by 770.6 mm (138.1%) than normal of 557.9 mm. During *rabi,* it was 37.2 mm and was excess by 12.7 mm compared to normal 24.5 mm and during summer there was no rainfall compared to normal of 6.0 mm (Fig.2.19).

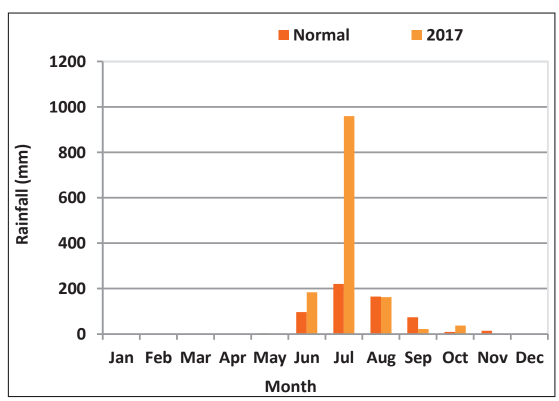


Fig.2.19: Normal and actual (2017) monthly rainfall at Rajkot

Cotton based production system

At Akola, the onset of monsoon was delayed by 6 days (16th June) and a rainfall of 518.1 mm was received which was deficit by 256.7 mm (33.1%) compared to normal (774.8 mm). Out of total rainfall received, 455.3 mm was received during *kharif* season which was deficit by 211.0 mm compared to normal of 666.3 mm. During *rabi* (October-December), 62.0 mm of rainfall was received compared to normal of 66.8 mm. During summer (March-May), 0.3 mm of rainfall was received which was deficit by 23.0 mm compared to normal (23.3 mm) (Fig 2.20).

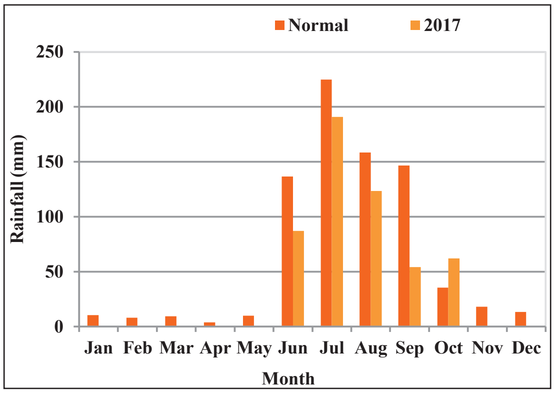


Fig.2.20: Normal and actual (2017) monthly rainfall at Akola

At Kovilpatti, the onset of monsoon was delayed by 5 days (6th June) and a rainfall of 801.7 mm was received which excess by 79.1 mm (10.94%) was compared to normal 722.6 mm. During *kharif* (June to September), 321.4 mm rainfall was received which was excess by 171.2 mm than normal of 150.2 mm; in *rabi* season (October – December), 421.4 mm rainfall was received which was deficit by 30.5 mm than normal of 390.9 mm and during summer (March to May), 39.1 mm rainfall was received which was also deficit by 101.8 mm than normal of 140.9 mm (Fig. 2.21).

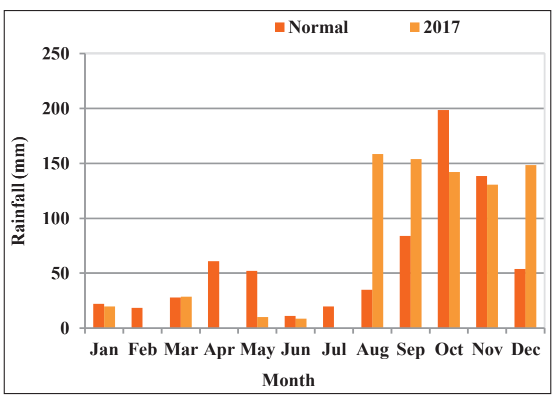


Fig.2.21: Normal and actual (2017) monthly rainfall at Kovilpatti

At Parbhani, the onset of monsoon was early by 3 days (7th June). A rainfall of 987.2 mm was received which was excess by 24.2 mm compared to normal (963 mm). During *kharif* season, 825.5 mm rainfall was recorded which was excess by 25.0 mm than normal rainfall of 800.5 mm; *rabi* season received 161.7 mm rainfall and was excess by 51.2 mm (46.3%) than normal of 110.5 mm and summer season received no rainfall against normal of 36.5 mm (Fig. 2.22).

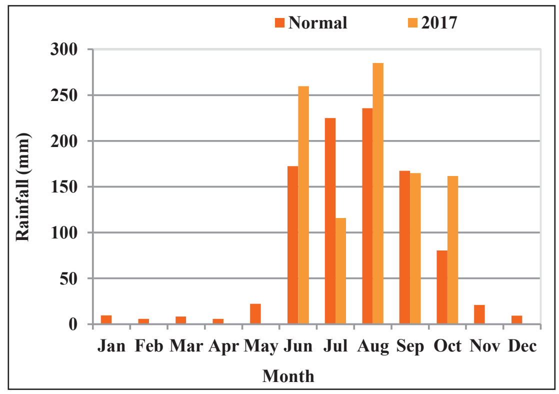


Fig.2.22: Normal and actual (2017) monthly rainfall at Parbhani

Voluntary centres

At Aklera, the onset of monsoon was delayed by 10 days (10th July) and a rainfall of 1106 mm was received which was deficit by 53.8 mm (4.6%) compared to normal (1159.8 mm). Out of total rainfall received, 1076.0 mm was received during *kharif* season which was deficit by 11.5 mm compared to normal of 1087.5 mm. During *rabi* (October-December), 30.0 mm of rainfall was received compared to normal of 47.0 During summer (March-May), no rainfall was received against the normal (9.8 mm) (Fig 2.23).

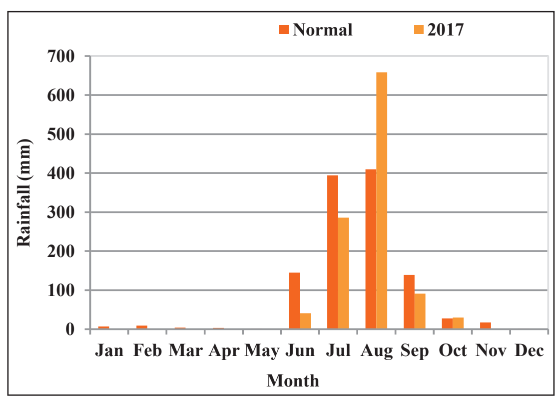


Fig.2.23: Normal and actual (2017) monthly rainfall at Aklera

At Darsi, the onset of monsoon was early by 6 days (8th June). A rainfall of 578.2 mm was received which was deficit by 147.8 mm compared to normal (726.0 mm). During *kharif* season, 414.5 mm rainfall was recorded which was excess by 2.5 mm than normal rainfall of 412.0 mm; *rabi* season received 107.4 mm rainfall and was deficit by 84.2 mm (43.9%) than normal of 191.6 mm and summer season received 54.9 mm rainfall against normal of 113.0 mm (Fig 2.24).

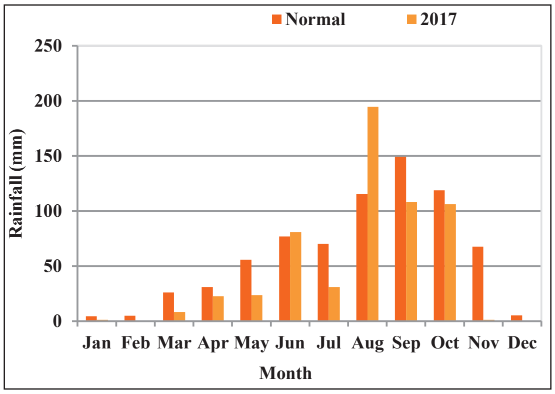


Fig.2.24: Normal and actual (2017) monthly rainfall at Darsi

At Imphal, the onset of monsoon was early by 7 days (28th May) and a rainfall of 3404.2 mm was received which was excess by 1371.0 mm (67.4%) was compared to normal 2033.3 mm. During *kharif* (June to September), 1974.1 mm rainfall was received which was excess by 545.7 mm than normal of 1428.4 mm; in *rabi* season (October – December), 373.9 mm rainfall was received which was excess by 168.8 mm than normal of 205.1 mm and during summer (March to May), 1029.4 mm rainfall was received which was also excess by 643.4 mm than normal of 385.9 mm (Fig. 2.25).

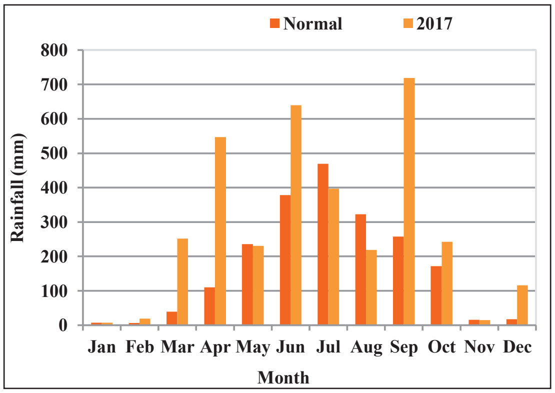


Fig.2.25: Normal and actual (2017) monthly rainfall at Imphal

At Munger, the onset of monsoon was early by 2 days (20th June) and a rainfall of 778.9 mm was received which was deficit by 367.5 mm (32.1%) was compared to normal 1146.8 mm. During *kharif* (June to September), 648.5 mm rainfall was received which was deficit by 337.8 mm than normal of 986.3 mm; in *rabi* season (October – December), 42.5 mm rainfall was received which was deficit by 47.1 mm than normal of 89.6 mm and during summer (March to May), 78.9 mm rainfall was received which was excess by 19.7 mm than normal of 59.2 mm (Fig. 2.26).

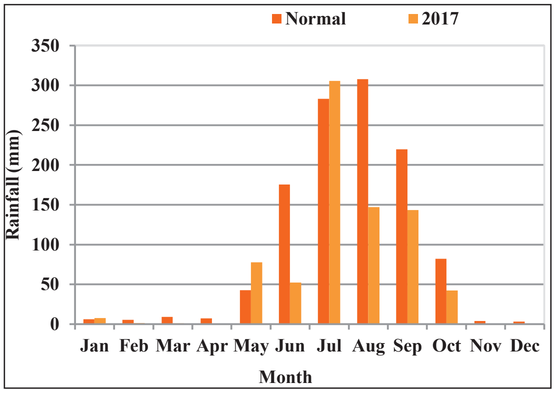


Fig.2.26: Normal and actual (2017) monthly rainfall at Munger

At Raichur, the onset of monsoon was early by 13 days (7th June) and a rainfall of 838.5 mm was received which was access by 167.1 mm (24.9%) compared to normal (671.4 mm). Out of total rainfall received, 707.0 mm was received during *kharif* season which was excess by 221.0 mm compared to normal of 485.2 mm. During *rabi* (October-December), 47.4 mm of rainfall was received compared to normal of 124.4 mm. During summer (March-May), 82.7 mm of rainfall was received which was excess by 26.9 mm compared to normal (55.8 mm) (Fig 2.27).

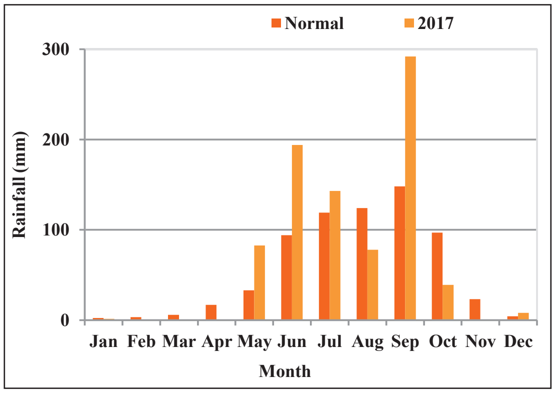


Fig.2.27: Normal and actual (2017) monthly rainfall at Raichur

Table 2.2: Month-wise, actual and normal rainfall (mm) received at AICRPDA centres during 2017

Centre	June			July			August			September			October			November			December		
	N	A	D (%)	N	A	D (%)	N	A	D (%)	N	A	D (%)	N	A	D (%)	N	A	D (%)	N	A	D (%)
Rice based production system																					
Biswanath Chariali	331.6	421.8	27.2	341.9	378.3	10.6	313.4	307.1	-2.0	195.3	306.6	57.0	96.3	137.0	42.3	17.8	16.8	-5.6	5.9	0.0	-100.0
Chianki	157.3	122.4	-22.2	374.6	561.2	49.8	303.8	174.6	-42.5	202.3	83.2	-58.9	50.8	25.6	-49.6	7.2	2.2	-69.4	7.9	0.0	-100.0
Faizabad	137.4	71.9	-47.7	292.5	376.4	28.7	294.1	211.4	-28.1	191.1	200.4	4.9	50.5	0.0	-100.0	4.0	0.0	-100.0	11.1	0.0	-100.0
Jagdalpur	235.5	380.6	61.6	342.6	416.8	21.7	350.5	329.4	-6.0	192.9	239.0	23.9	88.2	235.9	167.5	20.2	0.0	-100.0	6.4	0.0	-100.0
Phulbani	188.7	245.8	30.3	350.4	218.0	-37.8	383.2	176.2	-54.0	228.2	254.6	11.6	95.7	262.5	174.3	24.0	23.0	-4.2	5.0	0.0	-100.0
Varanasi	86.8	48.9	-43.7	293.3	495.5	68.9	336.9	57.8	-82.8	227.5	29.8	-86.9	49.1	0.0	-100.0	7.2	0.0	-100.0	4.6	0.0	-100.0
Maize based production system																					
Arjia	73.5	98.3	33.7	195.6	308.1	57.5	248.8	509.9	104.9	96.6	47.8	-50.5	9.6	0.0	-100.0	6.8	0.0	-100.0	3.8	0.0	-100.0
Ballowal Saunkhri	122.0	148.3	21.6	288.1	242.3	-15.9	304.3	299.0	-1.7	161.2	197.4	22.5	28.2	0.0	-100.0	6.9	0.0	-100.0	26.8	34.4	28.4
Rakh Dhiansar	90.8	127.3	40.2	323.8	284.4	-12.2	333.9	207.8	-37.8	137.3	45.1	-67.2	19.3	0.0	-100.0	6.4	3.3	-48.4	21.9	41.5	89.5
Fingermillet based production system																					
Bangalore	81.7	64.4	-21.2	103.0	33.4	-67.6	129.0	198.5	53.9	203.2	275.6	35.6	173.9	264.4	52.0	53.9	10.0	-81.4	13.3	0.0	-100.0
Pearlmillet based production system																					
Agra	51.5	27.0	-47.6	238.6	55.3	-76.8	207.2	146.0	-29.5	89.8	18.0	-80.0	24.6	0.0	-100.0	2.0	0.0	-100.0	1.9	1.2	-36.8
Hisar	47.4	254.0	435.9	122.4	64.0	-47.7	125.6	116.0	-7.6	40.4	27.0	-33.2	4.9	0.0	-100.0	0.1	2.0	1900.0	4.2	0.0	-100.0
SK Nagar	61.2	186.0	203.9	234.6	1032.6	340.2	209.8	122.0	-41.8	92.5	42.7	-53.8	16.6	0.0	-100.0	9.4	0.0	-100.0	1.1	0.0	-100.0
Sorghum based production system																					
Vijayapura	85.4	132.2	54.8	72.5	74.0	2.1	78.0	161.0	106.4	151.6	188.3	24.2	97.3	148.8	52.9	29.5	0.0	-100.0	7.2	18.2	152.8
Solapur	107.1	186.9	74.5	115.8	17.4	-85.0	139.6	151.3	8.4	172.7	98.4	-43.0	97.9	116.7	19.2	21.6	1.4	-93.5	6.0	0.0	-100.0
Soybean based production system																					
Indore	120.8	245.9	103.6	260.8	215.4	-17.4	225.4	260.6	15.6	247.5	150.0	-39.4	39.7	1.4	-96.5	18.3	0.0	-100.0	6.5	0.0	-100.0
Rewa	119.8	153.4	28.0	308.8	511.6	65.7	337.4	90.4	-73.2	199.1	94.4	-52.6	31.9	0.0	-100.0	9.7	0.0	-100.0	8.5	0.0	-100.0
Groundnut based production system																					
Anantapur	56.3	147.0	161.1	74.7	29.6	-60.4	85.2	57.4	-32.6	135.9	207.2	52.5	102.1	208.4	104.1	34.6	4.6	-86.7	7.3	0.0	-100.0
Rajkot	97.2	183.6	89.0	221.2	959.8	333.8	165.6	162.8	-1.7	73.9	22.3	-69.8	9.3	37.2	300.0	14.6	0.0	-100.0	0.5	0.0	-100.0
Cotton based production system																					
Akola	136.5	87.0	-36.3	224.8	190.8	-15.1	158.5	123.3	-22.2	146.5	54.2	-63.0	35.4	62.0	75.1	18.0	0.0	-100.0	13.4	0.0	-100.0
Kovilpatti	11.1	8.8	-20.7	19.8	0.0	-100	35.1	158.6	351.9	84.2	154.0	82.9	198.6	142.3	-28.3	138.5	130.7	-5.6	53.8	148.4	175.8
Pharbani	172.4	259.8	50.7	225.0	115.9	-48.5	235.8	285.1	20.9	167.3	164.7	-1.6	80.4	161.7	101.1	20.9	0.0	-100.0	9.2	0.0	-100.0
Voluntary centres																					
Aklera	145.0	41	-71.7	394.1	286	-27.4	409.6	658	60.7	138.8	91	-34.4	27.9	30	7.6	17.3	0	-100.0	1.8	0	-100.0
Darsi	76.8	80.7	5.1	70.3	31.1	-55.8	115.5	194.6	68.5	149.4	108.1	-27.6	118.7	106.0	-10.7	67.7	1.4	-97.9	5.2	0.0	-100.0
Imphal	378.4	639.6	69.0	469.6	396.8	-15.5	322.7	219.3	-32.1	257.7	718.4	178.8	172.1	242.6	41.0	16.0	15	-6.3	17.0	116.3	583.2
Munger	175.5	52.4	-70.1	283.3	305.6	7.9	307.7	147	-52.2	219.8	143.5	-34.7	82.2	42.5	-48.3	4.0	0	-100.0	3.4	0	-100.0
Raichur	94.2	194.0	105.9	119.0	143.0	20.2	124.0	78.0	-37.1	148.0	292.0	97.3	96.9	39.2	-59.5	23.3	0.0	-100.0	4.2	8.2	95.2

3. Salient Achievements

3.1 Rice Based Production System

3.1.1 Rainwater management

At Chianki, in an experiment on effect of tillage and mulching on productivity of maize under upland situation, raised bed sowing with polythene mulching (25 micron) gave significantly higher gain yield (4525 kg/ha) and RWUE (4.74 kg/ha-mm) whereas net returns (Rs.34623/ha) and B:C ratio (1.38) was higher with raised bed sowing + farm waste mulch. Further, polythene mulch gave 90-95% weed control equal to one complete weeding as in conventional tillage without mulch (Table 3.1).

Table 3.1 : Yield and economics of maize (Rasi-4212 Hyb) as affected by tillage and mulching – Chianki

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ ha-mm)
T_1M_1: Conventional tillage + without mulch	3014	7475	21500	21419	1.00	3.16
T_1M_2: Conventional tillage + farm waste mulch	3489	8653	23500	26183	1.11	3.65
T_1M_3: Conventional tillage + polythene mulch	4115	10205	28500	30098	1.06	4.31
T_1M_4: Conventional tillage + soil mulch	3187	7904	21500	23883	1.11	3.34
T_2M_1: Minimum tillage + without mulch	2825	7006	22225	18003	0.81	2.96
T_2M_2: Minimum tillage + farm waste mulch	3419	8479	24225	24462	1.01	3.58
T_2M_3: Minimum tillage + polythene mulch	4089	10141	29225	29002	0.99	4.28
T_2M_4: Minimum tillage + soil mulch	3087	7656	22225	21734	0.98	3.23
T_3M_1-Raised bed sowing + without mulch	3154	7822	23000	21913	0.95	3.30
T_3M_2: Raised bed sowing + farm waste mulch	4187	10384	25000	34623	1.38	4.38
T_3M_3: Raised bed sowing + polythene mulch	4525	11222	30000	34436	1.15	4.74
T_3M_4: Raised bed sowing + soil mulch	3287	8152	23000	23807	1.04	3.44
CD at 5%	157	-	-	-	-	-

Polythene mulch

Soil mulch

No mulch

Performance of maize under difference treatments

At Faizabad, in an experiment on *in-situ* moisture conservation in maize, significantly higher grain yield of 2706 kg/ha with net returns of Rs. 23508/ha was recorded with ridge-furrow planting followed by broad bed (90 cm) furrow planting (2449 kg/ha). Similarly, maximum RWUE (3.07 kg/ha-mm) and B:C ratio (1.78) was recorded with ridge-furrow planting compared to other treatments (Table 3.2).

Table 3.2 : Yield and economics of maize as affected by *in-situ* moisture conservation - Faizabad

Treatment	Grain yield (kg/ha)		Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (3 years)					
T_1: Flat bed	1862	1922	2788	12600	12780	1.01	2.13
T_2: Ridge-furrow	2706	3158	4074	13200	23508	1.78	3.07
T_3: Broad bed furrow (90 cm)	2449	2804	3693	13500	19854	1.47	2.79
T_4: Broad bed furrow (150 cm)	2253	2315	3364	13100	17136	1.31	2.53
T_5: Broad bed furrow (210 cm)	2016	2058	2984	12835	14222	1.11	2.27
CD at 5%	91	182	301	-	-	--	--

At Jagdalpur, in an experiment on *in-situ* moisture conservation in *mal* or *marhan* conditions, highest rice grain yield (3894 kg/ha) was recorded with furrow opening across slope by country plough after every *5*th row at 25 DAS under dry seeding, followed by seeding dhaincha with rice in same row by seed drill and spraying of 2,4-D at 25 DAS (3823 kg/ha). Similarly, net returns (Rs.40065/ha) and RWUE (3.00 kg/ha-mm) were higher in T_2 but B:C ratio was higher in T_4 (seeding dhaincha with rice in same row by seed drill and spraying of 2,4-D at 25 DAS) (Table 3.3).

Table 3.3 : Effect of *in-situ* moisture conservation on rice (MTU1001) yield and economics - Jagdalpur

Treatment	Grain yield(kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1	2989	15132	29696	1.96	2.30
T_2	3894	18347	40065	2.18	3.00
T_3	3558	18245	35120	1.92	2.74
T_4	3823	16184	41163	2.54	2.95
T_5	1723	12790	13048	1.02	1.33

T_1: Summer ploughing after 1st shower of rainfall under dry seeding; T_2: Furrow opening across slope by country plough after every 5th row at 25 DAS under dry seeding; T_3: *Biasi* (beushening) by country plough at 25 DAS under dry seeding; T_4: Seeding dhaincha with rice in same row by seed drill & spraying of 2, 4-D at 25 DAS; T_5: Control



Seeding rice + dhaincha (2:1) in prepared field for brown manuring

At Phulbani, in an experiment on effect of *in-situ* soil moisture conservation on performance of vegetable-vegetable sequence, ridge and furrow system with crop residue mulching in tomato-radish sequence resulted in highest tomato equivalent yield (TEY) (16700 kg/ha) followed by ridge and furrow method (16170 kg/ha) in the same cropping sequence. Similarly, net returns (Rs.218000/ha), B:C ratio (2.88) and RWUE (17.88 kg/ha-mm) were also higher in ridge and furrow system with mulching in tomato- radish sequence (Table 3.4 & 3.5).

Table 3.4 : Yield and economics of tomato – radish system under different treatments – Phulbani

Treatment	Yield (kg/ha)		TEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Tomato	Radish					
Life saving irrigation from pond water							
T_1: BBF	11000	10850	15340	115000	191800	2.67	16.42
T_2: BBF + M	11400	11250	15900	116000	202000	2.74	17.02
T_3: RF	11750	11050	16170	115000	208400	2.81	17.31
T_4: RF + M	12050	11650	16700	116000	218000	2.88	17.88
No life saving irrigation							
T_1: BBF	10250	8800	13770	113000	162400	2.44	14.74
T_2: BBF + M	10400	9050	14020	114000	166400	2.46	15.01
T_3: RF	10650	9150	14310	113000	173200	2.53	15.32
T_4: RF + M	10850	9450	14630	114000	178600	2.57	15.66

BBF - Broad bed furrow system; RF – Ridge furrow system; M: Mulching with crop residues; TEY – Tomato equivalent yield

Table 3.5 : Tomato equivalent yield (q/ha) of tomato-radish sequence under different moisture conservation practices - Phulbani

Moisture conservation practice	Protective irrigation (PI)		
	With PI	Without PI	Mean
Broad bed furrow	15340	13770	14560
Broad bed furrow + mulching	15900	14020	14960
Ridge furrow	16170	14310	15240
Ridge furrow + mulching	16700	14630	15670
Mean	16030	14180	
		SEm±	**CD at 5%**
Protective irrigation (P)		320	1180
Moisture conservation practice (M)		250	810
P X M		650	1820

Farm pond

Broad bed furrow in tomato

Mulching in tomato

Mulching in radish

At Varanasi, in an experiment on catchment-storage-command relationship for enhancing water productivity, farm pond was filled in July month due to continuous rainfall of 518.5 mm. About 5.5 ha area can be irrigated with one protective irrigation when farm pond filled to its full capacity of 2806 m^3 (Table 3.6). The water balance components indicated that total runoff harvested was 1257.9 m^3, evaporation losses were 386.59 m^3 and seepage loss (soil moisture contribution) was 321.53 m^3/week during the year. About 56.3% of harvested rainwater was available in farm pond after seepage and evaporation losses at the end of September for further use.

Table 3.6 : Availability of harvested rainwater in farm pond - Varanasi

SMW	Depth (m)	Water loss (m^3)	Evaporation rate (mm/day)	Evaporation loss (m^3/week)	Seepage loss (m^3/week)	Seepage rate (mm/day)	Water availability in farm pond (m^3)	Area that can be irrigated from stored water (ha)
28	1.95	-	2.4	14.32	-577.31	-62.04	2103.60	4.21
29	2.4	-562.99	3.7	23.29	-586.28	-58.81	2666.59	5.33
30	2.45	-64.43	2.7	17.09	-81.52	-8.12	2731.02	5.46
31	2.3	192.16	2.8	17.42	174.74	17.79	2538.86	5.08
32	2.2	126.23	2.9	17.83	108.39	11.21	2412.63	4.83
33	2.0	247.97	2.9	17.40	230.56	24.58	2164.66	4.33
34	1.95	61.07	3.7	22.05	38.99	4.19	2103.60	4.21
35	1.85	121.02	3.4	20.04	100.98	11.02	1982.57	3.97
36	1.80	59.96	4.1	24.02	35.94	3.95	1922.62	3.85
37	1.78	23.88	4.1	23.96	-0.07	-.01	1898.73	3.80
38	1.75	35.71	3.3	19.21	16.50	1.83	1863.02	3.73

SMW	Depth (m)	Water loss (m^3)	Evaporation rate (mm/day)	Evaporation loss (m^3/week)	Seepage loss (m^3/week)	Seepage rate (mm/day)	Water availability in farm pond (m^3)	Area that can be irrigated from stored water (ha)
39	1.6	176.59	3.3	18.86	157.74	17.92	1686.42	3.37
40	1.55	58.14	3.3	18.74	39.40	4.51	1628.28	3.26
41	1.54	11.58	3.0	17.02	-5.43	-0.62	1616.69	3.23
42	1.50	46.19	2.3	12.98	33.21	3.84	1570.5	3.14
43	1.2	339.16	2.8	15.21	323.93	39.34	1231.34	2.46
44	1.15	55.28	2.3	12.42	42.86	5.25	1176.06	2.35
45	1.12	32.99	2.0	10.75	22.24	2.74	1143.06	2.29
46	1.1	21.93	2.0	10.73	11.19	1.38	1121.13	2.24
47	1.08	21.87	3.0	16.06	5.81	0.72	1099.26	2.20
48	1.04	43.58	1.7	9.05	34.53	4.31	1055.69	2.11
49	1.	43.35	1.8	9.53	33.81	4.25	1012.33	2.02
50	0.9	107.40	1.8	9.41	97.99	12.53	904.93	1.81
51	0.95	58.55	1.4	9.20	63.33	10.56	850.65	1.70
Total	-	**1257.9**	-	**386.59**	**321.53**	-	-	-

3.1.2 Cropping systems

At Chianki, in a study on pigeonpea based intercropping systems during *kharif* 2016 and 2017, significantly highest pigeonpea equivalent yield (3817 and 3238 kg/ha) was recorded with pigeonpea + okra intercropping system (1:1) with highest B:C ratio of 3.63 and 2.93, respectively compared to all other intercropping systems (Table 3.7).

Table 3.7 : Performance of pigeonpea based intercropping systems - Chianki

Treatment	Pigeonpea yield (kg/ha)			Intercrop yield (kg/ha)			Pigeonpea equivalent yield (kg/ha)			B:C ratio		
	2016	2017	Mean (2yrs)	2016	2017	Mean (2yrs)	2016	2017	Mean (2yrs)	2016	2017	Mean (2yrs)
T_1: Pigeonpea + okra (1:1)	1150	831	991	6168	5564	5866	3817	3238	3528	3.63	2.93	3.28
T_2: Pigeonpea + cowpea (1:1)	923	1687	1305	4985	2416	3701	3079	2732	2906	3.13	2.66	2.90
T_3: Pigeonpea + black gram (1:1)	1242	1057	1150	940	918	929	2182	1454	1818	2.24	1.16	1.70
T_4: Pigeonpea + maize (1:1)	1247	889	1068	1385	1800	1593	1643	1668	1656	1.61	1.64	1.63
T_5: Pigeonpea + upland rice (1:1)	1033	1680	1357	1085	411	748	1406	1858	1632	1.35	2.08	1.72
T_6: Pigeonpea + sorghum (1:1)	1248	997	1123	1357	1078	1218	1662	1463	1563	1.76	1.44	1.60
T_7: Pigeonpea (sole)	1425	1442	1434	0.00	0.00	0.00	1425	1442	1434	1.87	1.90	1.89
CD at 5%	204	299	-	-	-	-	238	365	-			

Varieties: Pigeonpea (Birsa Arhar-1); Okra (US 7902); Black gram (Birsa Urd-1); Maize (BirsaVikas Makka-2); Upland rice (BVD-109); Sorghum (CSV-20)

Pigeonpea + okra (1:1)

Pigeonpea + cowpea (1:1)

Pigeonpea + blackgram (1:1)

Pigeonpea + maize (1:1)

At Jagdalpur, in an experiment on rice based double cropping system under *gabhar* situation conventional tillage (2 pass of country plough and sowing of seed) for field pea recorded higher seed yield (1823 kg/ha), net returns (Rs. 63812/ha), B:C ratio (3.48) and RWUE (3.41) followed by relay cropping of field pea (*Utera*) (1234 kg/ha) compared to other treatments (Table 3.8).

Table 3.8 : Effect of relay cropping on yield and economics – Jagdalpur

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Relay cropping of field pea (*Utera*)	1234	12358	43204	3.50	2.31
T_2: Relay cropping of chickpea (*Utera*)	692	12558	24203	1.93	1.29
T_3: Conventional tillage (2 pass of country plough and sowing of seed) for field pea	1823	18350	63812	3.48	3.41
T_4: Conventional tillage (2 pass of country plough and sowing of seed) for chickpea	1113	18850	38966	2.07	2.08
T_5: Zero till sowing of field pea	873	8448	30555	3.62	1.63
T_6: Zero till sowing of chickpea	576	8648	20171	2.33	1.08

Rice - field pea relay cropping

Chickpea under conventional tillage

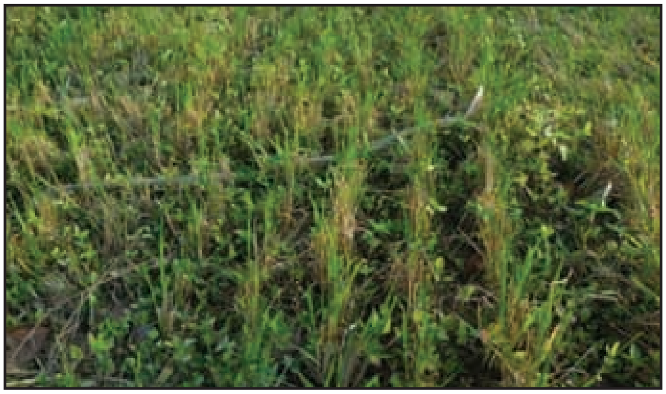
At Jagdalpur, in the relay cropping of rice (MTU 1001)-chickpea (JG-11) under lowland farming situation, higher rice crop equivalent yield (5569 kg/ha), net returns (Rs.68262/ha), B:C ratio (3.93) and RWUE (4.14 kg/ha-mm) was recorded with rice-chickpea under conventional tillage with line sowing compared to other treatments. Rice-chickpea under conventional tillage with broadcasting was the next best treatment (4708 kg/ha) (Table 3.9).

Table 3.9 : Performance of rice (MTU 1001) – chickpea (JG-11) (relay crop) under lowland farming situation – Jagdalpur

Treatment	Yield (kg/ha)		RCEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Rice	Chickpea					
T_1: Rice-fallow	2651	-	2651	10874	28884	2.34	1.97
T_2: Rice-relay crop of chickpea	2583	1664	4247	11747	51958	3.89	3.16
T_3: Rice-chickpea under conventional tillage with line sowing	2557	3012	5569	15267	68262	3.93	4.14
T_4: Rice-chickpea under conventional tillage with broadcasting	2747	1961	4708	13067	57552	3.87	3.50

RCEY: Rice crop equivalent yield

Line sown chickpea after rice



Rice-chickpea relay cropping

At Phulbani, in an experiment on performance of upland rice + fodder cropping system as affected by nutrient management, sole crop of rice gave higher rice equivalent yield (REY) (2970 kg/ha) other than treatments. Among rice + fodder cropping systems, intercropping of rice + cowpea gave marginally higher rice equivalent yield

(2870 kg/ha), net returns (Rs.14485/ha) and B:C ratio (1.48) compared to rice + ricebean system. Among nutrient management, application of FYM @ 5 t/ha + 50% RDF being at par with 100% RDF through fertilizers recorded significantly highest rice equivalent yield (3040 kg/ha) and RWUE (3.68 kg/ha-mm). Whereas, 100% RDF through fertilizers recorded higher net returns (Rs.16950/ha) and B:C ratio (1.61) (Table 3.10).

Table 3.10 : Yield and economics of crops as affected by intercropping and nutrient management – Phulbani

Treatment	REY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Cropping system				
C_1: Rice	2970	16035	1.53	3.60
C_2: Rice + cowpea (F) (5:2)	2870	14485	1.48	3.47
C_3: Rice + ricebean (F) (5:2)	2810	13555	1.45	3.40
CD at 5%	NS			
Nutrient management				
N_1: FYM 5 t/ha	2710	11005	1.36	3.28
N_2: 100% RDF (60:30:30 kg NPK/ha)	2900	16950	1.61	3.51
N_3: FYM 5 t/ha + 50% RDF (inorganic)	3040	15120	1.47	3.68
CD at 5%	275			

REY: Rice equivalent yield

Application of FYM @ 5 t/ha + 50% inorganic fertilizer as basal resulted in higher available N in rice + cowpea intercropping system (326 kg/ha). However, available P & K was higher with application of FYM @ 5 t/ha alone under rice + cowpea system (123 & 179 kg/ha, respectively) while available K was higher with 100% RDF (60:30:30 kg NPK/ha) as basal application under same intercropping system (Table 3.11).

Table 3.11 : Effect of rice + fodder cropping system and nutrient management on soil properties - Phulbani

Treatment	pH	EC (dS/m)	Organic C (g/kg)	Available nutrients (kg/ha)			
				N	P	K	S
Initial	4.56	0.010	3.20	358.0	14.7	331.0	-
C_1N_1	5.37	0.003	4.45	264.0	90.0	81.0	4.3
C_1N_2	5.37	0.006	4.80	233.0	118.0	93.0	4.7
C_1N_3	5.49	0.003	4.99	233.0	103.0	118.0	4.0
C_2N_1	5.14	0.005	3.74	279.0	123.0	179.0	3.6
C_2N_2	5.77	0.003	4.63	286.0	94.0	178.0	6.8
C_2N_3	5.38	0.003	4.99	326.0	83.0	109.0	5.6
C_3N_1	5.17	0.004	4.10	264.0	106.0	86.0	1.1
C_3N_2	5.46	0.003	4.45	271.0	108.0	70.0	4.4
C_3N_3	5.84	0.003	4.50	248.0	97.0	115.0	2.2

C_1: Sole rice; C_2: Rice + Cow pea F (5:2); C_3: Rice + rice bean F (5:2); N_1: FYM 5 t/ha; N_2: Inorganic fertilizer (Dosage for rice- 60:30:30 kg N-P_2O_5-K_2O); N_3: 5 t/ha FYM + 50% inorganic fertilizer

Rice + rice bean (5:2)

Rice + cowpea (5:2)

3.1.3 Nutrient management

At Biswanath Chariali, in a network project on evaluation of Nanoclay Polymer Composite (NCPC) on resource use efficiency and crop productivity, application of 15 kg NCPC + 100% RDF (40:20:20 kg NPK/ha) recorded significantly higher grain yield (1245 kg/ha) and straw yield (2647 kg/ha) of upland rice compared to other treatments. Application of 15 kg NCPC + 75% RDF (30:15:15 kg NPK/ha) was the nest best treatment (1097 kg/ha) (Table 3.12).

At Chianki, in an integrated nutrient management (INM) trial on cereal -legume rotation, application of 50% NPK (inorganic) + 50% N through FYM recorded the highest pigeonpea equivalent (PEY) yield (2426 kg/ha), net returns (Rs. 68040/ha), B:C ratio (2.35) and RWUE of 2.54 kg/ha-mm. Further, the higher grain yield of sorghum (2014 kg/ha) was recorded with application of 50% NPK (inorganic) + 50% N through FYM and pigeonpea seed yield (1825 kg/ha) was higher with application of 50% N through *Mahua* cake + 50% NPK (inorganic) during *kharif,* 2017. However, the mean of 7 years also showed that application of 50% NPK (inorganic) + 50% N through FYM recorded the highest sorghum grain (1688 kg/ha) as well as pigeonpea seed yield (1477 kg/ha) with highest mean PEY of 1830 kg/ha closely followed by application of 50% N through *Mahua* cake + 50% NPK (inorganic) (Table 3.13).

Table 3.12 : Effect of treatments on rice yield– Biswanath Chariali

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)
T_1: Recommended dose of fertilizer (RDF)	878	1577
T_2: 5 kg/ha NCPC	721	1523
T_3: 10 kg/ha NCPC	745	1641
T_4: 15 kg/ha NCPC	768	1705
T_5: 5 kg/ha NCPC + 100% RDF	853	1816
T_6: 5 kg/ha NCPC + 75% RDF	847	1775
T_7: 5 kg/ha NCPC + 25% RDF	838	1715
T_8: 10 kg/ha NCPC + 100% RDF	1067	2231
T_9: 10 kg/ha NCPC + 75% RDF	977	2015
T_{10}: 10 kg/ha NCPC + 25% RDF	912	1996
T_{11}: 15 kg/ha NCPC + 100% RDF	1245	2647
T_{12}: 15 kg/ha NCPC + 75% RDF	1097	2455
T_{13}: 15 kg/ha NCPC + 25% RDF	987	2130
CD at 5%	145	298

Table 3.13 : Effect of INM on sorghum and pigeonpea yield and economics under cereal -legume rotation - Chianki

Treatment	Sorghum grain yield (kg/ha)		Pigeonpea seed yield (kg/ha)		PEY (kg/ha) 2017	Mean PEY (kg/ha) (7 yrs)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (7 yrs)	2017	Mean (7 yrs)						
T_1: Control	1232	1192	987	1066	1423	1260	29000	27920	0.96	1.49
T_2: 100% NPK (inorganic)	1735	1641	1525	1399	2014	1690	29000	51560	1.78	2.11
T_3: 50% NPK (inorganic) + 50% FYM	2014	1688	1784	1477	2426	1830	29000	68040	2.35	2.54

Treatment	Sorghum grain yield (kg/ha)		Pigeonpea seed yield (kg/ha)		PEY (kg/ha) 2017	Mean PEY (kg/ha) (7 yrs)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (7 yrs)	2017	Mean (7 yrs)						
T_4: 100% *Karanj* cake	1752	1543	1532	1400	1933	1585	29000	48320	1.67	2.02
T_5: 50% *Karanj* cake + 50% NPK (inorganic)	1698	1594	1632	1437	1874	1727	29000	45960	1.58	1.96
T_6: 100% *Mahua* cake	1724	1487	1521	1336	1754	1582	29000	41160	1.42	1.84
T_7: 50% *Mahua* cake+ 50% NPK (inorganic)	1725	1595	1825	1452	2217	1750	29000	59680	2.06	2.32
T_8: 25 % NPK + 25% FYM + 25% *Karanj* cake + 25% *Mahua* cake	1748	1572	1432	1365	2023	1691	29000	51920	1.79	2.12
CD at 5%	596		979	-	744		-			

100% NPK: 20:40: kg/ha for pigeonpea: 60:30:30 kg/ha for sorghum

At Faizabad, in an experiment on integrated nutrient management in pigeonpea based intercropping systems under rainfed condition, maximum pigeonpea equivalent yield (2063 kg/ha) and RWUE (2.39 kg/ha-mm) was recorded with pigeonpea + sorghum (1:1) followed by pigeonpea + sesame (1:1) (1952 kg/ha) intercropping systems. Pigeonpea + sorghum intercropping system (1:1) gave higher net returns (Rs.84176/ha) compared to other treatments. Similarly, significantly higher PEY (2079 kg/ha), net returns (Rs.84583/ha), B:C ratio (2.84) and higher RWUE (2.41 kg/ha-mm) was recorded with application of 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha + Zinc sulphate @ 25 kg/ha + 1.5 kg boron/ha, compared to other treatments (Table 3.14)

Table 3.14 : Effect of INM on yield and economics of pigeonpea based intercropping systems - Faizabad

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop		PEY				
		Sesame	Sorghum					
Intercropping system								
C_1: Pigeonpea sole	1660	-	-	1660	25378	65867	2.59	1.88
C_2: Pigeonpea + sesame (1:1)	1458	429		1952	29068	78314	2.69	2.26
C_3: Pigeonpea + sorghum (1:1)	1482	-	1278	2061	29278	84176	2.87	2.39
CD at 5%	98	-	-	109	-	-	-	-
Nutrient management								
N_1: RDF (20:40 kg NP/ha for pigeonpea and 60:30:30 kg NPK/ha for sorghum)	1266	315	1100	1588	24740	62618	2.52	1.84
N_2: 75% RDF + FYM @ 5 t/ha	1490	400	1242	1823	27620	72645	2.63	2.12
N_3: 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha	1571	455	1300	1934	28170	78218	2.77	2.24
N_4: 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha + $ZnSO_4$ @ 25 kg/ha	1648	480	1362	2032	29230	82530	2.82	2.36
N_5: 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha + $ZnSO_4$ @ 25 kg/ha + boron @1.5 kg/ha	1691	495	1385	2079	29780	84583	2.84	2.41
CD at 5%	127	-	-	141	-	-	-	-

PEY: Pigeonpea equivalent yield

The organic carbon content was significantly higher (0.33%) under pigeonpea sole system compared to other cropping systems, with higher available N (163.8 kg/ha), available P (17.6 kg/ha) and available K (268.3 kg/ha) and was on par with pigeonpea + sesame intercropping system (1:1). Among nutrient management treatments, organic carbon content was marginally higher (0.33%) under 75% RDF + FYM 5 t/ha + sulphur @ 40 kg/ha and 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha + $ZnSO_4$ @25 kg/ha + boron @ 1.5 kg/ha compared to other treatments. The available N (167.1 kg/ha) was highest in the plots under 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha + $ZnSO_4$ @ 25 kg/ha. However, the available P (18.5 kg/ha) and available K (271.5 kg/ha) was highest in the plots under 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha + $ZnSO_4$ @ 25 kg/ha compared to other treatments (Table 3.15).

Table 3.15 : Effect of INM on soil chemical properties in pigeonpea based intercropping systems - Faizabad

Treatment	**Organic C (%)**	**Available nutrients (kg/ha)**		
		N	**P**	**K**
Intercropping system				
C_1: Pigeonpea sole	0.33	163.8	17.6	268.3
C_2: Pigeonpea + sesame (1:1)	0.32	163.7	17.1	269.6
C_3: Pigeonpea + sorghum (1:1)	0.31	163.4	17.7	267.5
CD at 5%	0.01	NS	1.3	5.3
Nutrient management				
N_1: RDF (20:40 kg NP/ha for pigeonpea and 60:30:30 kg NPK/ha for sorghum)	0.30	160.0	15.1	258.9
N_2: 75% RDF + FYM @ 5 t/ha	0.32	167.1	18.2	272.1
N_3: 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha	0.33	163.4	17.8	269.7
N_4: 75% RDF + FYM @ 5 t/ha + sulphur @ 40 kg/ha + $ZnSO_4$ @ 25 kg/ha	0.32	164.6	18.5	271.5
N_5: 75% RDF + FYM @ 5 t/ha +Sulphur @ 40 kg/ha + $ZnSO_4$ @ 25 kg/ha + Boron @1.5 kg/ha	0.33	163.0	17.7	270.1
N_1: RDF (20:40 kg NP/ha for pigeonpea and 60:30:30 kg NPK/ha for sorghum)	0.02	4.4	1.7	6.9

At Jagdalpur, in an INM trial on groundnut, application of 100% general recommended dose (GRD) + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow (T_{10}) recorded higher groundnut pod yield (2002 kg/ha), net returns (Rs.37654/ha) and RWUE (2.38 kg/ha-mm) as compared to other nutrient management practices (Table). Similarly, agronomic efficiency of NPK (36, 18 and 36 kg grain/kg fertilizer nutrient applied) was also higher under T_{10}-100% RDF + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha applied in furrows. However, higher B:C ratio (0.93) was recorded with RDF (30:60:30) + $ZnSO_4$ @ 25 kg/ha) compared to other treatments. While, higher nutrient use efficiencies of primary nutrients were recorded with 100% RDF + $MgSO_4$ @ 15 kg/ha + FYM @ 5 t/ha in furrows compared to other treatments (Table 3.16).

Table 3.16 : Effect of INM on groundnut (K-6) productivity, economics and nutrient use efficiency - Jagdalpur

Treatment	**Pod yield (kg/ha)**	**RWUE (kg/ha-mm)**	**NMR (Rs/ha)**	**B:C ratio**	**AE (kg grain/kg fertilizer nutrient applied)**			**Nutrient use efficiency (kg grain/ kg nutrient absorbed)**		
					N	**P**	**K**	**N**	**P**	**K**
T_1: Control	923	1.10	5608	0.18	-	-	-	-	-	-
T_2: RDF (30:60:30 kg NPK/ha)	1601	1.91	28808	0.82	22.6	11.3	22.6	16.4	137.0	72.1
T_3: RDF + $ZnSO_4$ @ 25 kg/ha	1756	2.09	33893	0.93	27.8	13.9	27.8	16.0	135.6	69.7
T_4: RDF + FYM @ 5 t/ha in furrows	1693	2.02	28040	0.71	25.7	12.8	25.7	16.1	136.8	70.0
T_5: RDF + FYM @ 5 t/ha in furrows + $ZnSO_4$ @ 25 kg/ha	1800	2.14	31284	0.77	29.2	14.6	29.2	15.8	136.5	70.9
T_6: 50% RDF + FYM @ 5t/ha in furrows	1704	2.03	30514	0.81	26.0	13.0	26.0	15.2	130.1	66.1

Treatment	Pod yield (kg/ha)	RWUE (kg/ha-mm)	NMR (Rs/ha)	B:C ratio	AE (kg grain/kg fertilizer nutrient applied)			Nutrient use efficiency (kg grain/ kg nutrient absorbed)		
					N	P	K	N	P	K
T_7: 50% RDF + $ZnSO_4$ @ 25 kg/ha + FYM @ 5 t/ha in furrows	1717	2.04	29821	0.77	26.5	13.2	26.5	15.6	132.5	68.0
T_8: 100% RDF + lime @ 3q/ha + FYM 5 t/ha in furrows	1926	2.29	35309	0.85	33.4	16.7	33.4	16.2	138.9	70.1
T_9: 100% RDF + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrows	1832	2.18	32845	0.81	30.3	15.1	30.3	16.6	141.5	72.7
T_{10}: 100% RDF + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrows	2002	2.38	37654	0.89	36.0	18.0	36.0	16.0	134.5	68.7
CD at 5%	42.06	-	-	-	-	-	-	-	-	-

At Jagdalpur, in a long term study on effect of inorganic fertilizers and organic manures on soil fertility and productivity of direct seeded rice-field pea system, application of full dose of NPK (60:40:30 kg NPK/ha) + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha (T_8) resulted in higher rice grain yield (3768 kg/ha) and RWUE (2.88 kg/ha-mm); While, higher net returns (Rs.32266/ha) and B:C ratio (1.59) was recorded with application of 100% NPK (T_2) compared to other treatments. Application of 50% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha (T_{12}) resulted in higher agronomic efficiency of primary nutrients as compared to other treatments (Table 3.17).

Table 3.17 : Effect of nutrients management on productivity and economics of direct seeded rice (MTU-1010) - Jagdalpur

Treatment	Grain yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha–mm)	AE (kg grain/kg fertilizer nutrient applied)			Production efficiency (kg grain/kg nutrient absorbed)		
					N	P	K	N	P	K
T_1: Control	2033	15633	1.04	1.55	-	-	-	-	-	-
T_2: 100% NPK	3426	32266	1.59	2.62	13.9	23.2	34.8	66.0	280.8	59.3
T_3: 100% PK	2246	15773	0.88	1.72	-	3.6	5.3	-	154.9	104.9
T_4: 100% NK	2752	23855	1.31	2.10	7.2	-	18.0	72.3	-	63.8
$T_{5:}$ 100% NP	2844	24769	1.33	2.17	8.1	13.5	-	58.7	291.3	-
T_6: 100% NPK + 5 t FYM/ha	3681	32298	1.35	2.81	16.5	27.5	41.2	61.0	248.0	60.0
T_7: 100% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha	3724	31772	1.27	2.85	16.9	28.2	42.3	60.4	267.1	65.3
T_8: 100% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha	3768	30433	1.13	2.88	17.4	28.9	43.4	58.7	284.6	63.4
T_9: 50% NPK	2804	25100	1.44	2.30	19.4	32.4	48.6	63.0	243.0	64.2
T_{10}: 50% NPK + 5 t FYM/ha	3233	27695	1.28	2.47	24.0	40.0	60.0	62.6	208.1	71.3
T_{11}: 50% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha	3358	28398	1.25	2.57	26.5	44.2	66.3	60.3	280.4	69.6
T_{12}: 50% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha	3426	27528	1.12	2.62	27.9	46.4	69.7	64.9	261.6	66.3
CD at 5%	242									

100% NPK: 60:40:30 kg/ha

Application of 100% NPK + 5 t FYM + $ZnSO_4$ @ 25 kg/ha recorded higher soil organic C (0.72%) and available N (258 kg/ha). However, higher available P (32 kg/ha) was recorded with application of 100% NP and higher available K (182 kg/ha) with 100% NPK + 5 t FYM/ha compared to other treatments. However, micronutrients Zn, Cu and Mn (1.16, 1.7 and 42.0 ppm, respectively) were higher with application of 50% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha compared to other treatments (Table 3.18).

Table 3.18 : Effect of nutrient management in direct seeded rice on soil fertility - Jagdalpur

Treatment	pH	OC (%)	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)	Avail. Zn (ppm)	Avail. Cu (ppm)	Avail. Mn (ppm)	Avail. Fe (ppm)
Initial	6.34	0.67	225	23	154	1.05	1.68	30.4	32.6
T_1: Control	6.28	0.65	212	23	148	1.03	1.60	38.4	41.2
T_2: 100% NPK	6.11	0.68	237	27	167	1.02	1.45	31.2	38.4
T_3: 100% PK	6.13	0.64	206	26	178	1.02	1.50	29.4	43.2
T_4: 100% NK	6.29	0.62	235	22	173	1.03	1.45	36.4	40.5
$T_{5:}$ 100% NP	6.41	0.66	222	32	143	1.02	1.48	30.9	42.6
T_6: 100% NPK + 5 t FYM/ha	6.37	0.71	258	26	182	1.07	1.70	34.6	37.8
T_7: 100% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha	6.45	0.72	258	26	177	1.14	1.65	28.4	33.2
T_8: 100% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha	6.53	0.70	245	30	173	1.11	1.65	28.4	38.2
T_9: 50% NPK	6.12	0.69	232	27	161	1.02	1.60	34.6	40.2
T_{10}: 50% NPK + 5 t FYM/ha	6.15	0.70	253	29	182	1.10	1.60	38.4	37.4
T_{11}: 50% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha	6.24	0.72	247	31	175	1.16	1.70	34.9	39.6
T_{12}: 50% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha	6.32	0.71	243	30	179	1.16	1.70	42.0	33.4
CD at 5%	0.2	0.04	14	3	10	0.02	0.30	3.42	3.26

At Jagdalpur, during *rabi,* in an experiment on residual effect of long term effect of nutrient management on soil fertility and productivity of field pea, higher seed and stalk yield (628 and 1017 kg/ha) and net returns (Rs.10974/ha) were recorded with RDF as compared to control. However, B:C ratio was higher under control (0.76) as compared to RDF. Higher seed yield, net returns and agronomic efficiency of N, P & K was recorded under *kharif treatment* T_8 (100% NPK + 5 t FYM/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha) compared to other treatments (Table 3.19).

Table 3.19 : Residual effect of nutrient management in direct seeded rice on productivity, economics and agronomic efficiency of field pea - Jagdalpur

Treatment	Seed yield (kg/ha)		Stalk yield (kg/ha)		NMR (Rs/ha)		B:C ratio		Agronomic efficiency		
	Control	RDF	Control	RDF	Control	RDF	Control	RDF	N	P	K
T_1	256	416	702	942	269	2469	0.17	-0.22	1.49	0.74	1.24
T_2	342	460	785	835	3723	4278	0.51	-0.09	1.10	0.55	0.91
T_3	310	515	750	955	2436	6429	0.38	0.05	1.91	0.95	1.59
T_4	294	435	683	854	1799	3244	0.32	-0.16	1.31	0.66	1.09
T_5	280	416	653	895	1244	2498	0.27	-0.21	1.27	0.63	1.05
T_6	366	525	844	1017	4671	6814	0.6	0.08	1.48	0.74	1.23
T_7	410	508	888	964	6429	6198	0.76	0.04	0.91	0.46	0.76
T_8	364	628	798	884	4600	10974	0.59	0.37	2.46	1.23	2.05
T_9	326	476	718	886	3053	4883	0.44	-0.05	1.40	0.70	1.16
T_{10}	390	514	802	990	5642	6373	0.69	0.05	1.15	0.58	0.96
T_{11}	372	523	788	942	4901	6807	0.62	0.08	1.40	0.70	1.17
T_{12}	380	510	856	923	5245	6275	0.65	0.05	1.21	0.60	1.01

At Phulbani, in an experiment on effect of nutrient management on productivity and economics of maize + vegetable intercropping system, intercropping of maize + cowpea (2:2) gave higher maize equivalent yield (5590 kg/ha), net returns (Rs.57120/ha) and B:C ratio (2.31) followed by maize + runner bean (2:2) intercropping system. In case of nutrient management, application of FYM @ 10 t/ha + vermicompost @ 2 t/ha as basal + pot manure spray 4 times at 15 days interval recorded higher maize equivalent yield (5300 kg/ha), net returns (Rs.52400/ha), B:C ratio (2.22) and RWUE (5.82 kg/ha-mm) compared to other treatments (Table 3.20).

Table 3.20 : Yield and economics of crops as affected by cropping system and organic nutrient management – Phulbani

Treatment	MEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Cropping system				
C_1: Sole maize	2950	18100	1.52	3.24
C_2: Maize + runner bean (2:2)	5130	50340	2.20	5.63
C_3: Maize + cowpea (2:2)	5590	57120	2.31	6.14
C_4: Maize + bitter gourd (2:1)	4910	44380	2.0	5.39
CD at 5%	640			
Nutrient management				
N_1: FYM @ 10 t/ha	3660	25880	1.65	4.0
N_2: FYM @ 10 t/ha + VC @ 2 t/ha as basal	4990	47320	2.11	5.47
N_3: FYM + VC @ 2 t/ha as basal + pot manure spray	5300	52400	2.22	5.82
CD at 5%	670			

MEY: Maize equivalent yield

At Phulbani, application of FYM @ 10 t/ha and FYM @ 10 t/ha + vermicompost @ 2 t/ha as basal resulted in improvement in soil pH from 5.13 (initial) to 5.18-5.52 and OC from 2.83 g/kg (initial) to 4.10-5.81 g/kg in all the treatments. Application of FYM @ 10 t/ha + VC @ 2 t/ha at basal resulted in higher available N under maize + runner bean and maize + cowpea systems (286 & 286 kg/ha) and application of FYM 10 t/ha + vermicompost 2 t/ha + pot manure spray in maize + bitter gourd cropping system. However, available P & K was higher with application of FYM 10 t/ha + vermicompost 2 t/ha + pot manure spray under maize + bitter guard system (120 & 197 kg/ha). However, available S was higher with FYM @ 10 t/ha at basal application under maize + bitter guard intercropping system compared to other treatments (Table 3.21).

Table 3.21 : Effect of maize + vegetable intercropping systems and organic nutrient management on soil properties - Phulbani

Treatment	pH	EC (dS/m)	OC (g/kg)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)	Av. S (kg/ha)
Initial	5.13	0.004	2.83	389.0	15.4	285.0	-
C_1N_1	5.21	0.003	4.14	248.0	41.0	103.0	1.0
C_1N_2	5.29	0.003	4.46	247.0	62.0	100.0	7.3
C_1N_3	5.18	0.002	4.56	233.0	43.0	99.0	2.2
C_2N_1	5.52	0.003	5.52	279.0	95.0	103.0	7.8
C_2N_2	5.27	0.003	5.69	286.0	55.0	86.0	4.0
C_2N_3	4.95	0.005	5.81	248.0	36.0	102.0	5.7
C_3N_1	5.37	0.003	4.10	264.0	47.0	134.0	7.4
C_3N_2	5.45	0.004	5.40	286.0	60.0	165.0	4.2
C_3N_3	5.40	0.004	5.14	217.0	101.0	113.0	3.2
C_4N_1	5.12	0.004	4.05	217.0	77.0	121.0	8.3
C_4N_2	5.29	0.002	5.21	272.0	73.3	114.0	5.8
C_4N_3	5.19	0.004	5.60	286.0	120.0	197.0	2.2

C_1: Sole maize; C_2: Maize + runner bean (2:2); C_3: Maize + cowpea (2:2); C_4: Maize + bitter gourd (2:2); N_1: FYM 10 t/ha; N_2: FYM 10 t/ha + vermicompost 2 t/ha; N_3: FYM 10 t/ha + vermicompost 2 t/ha + pot manure spray 4 times at 15 days interval from sowing

Maize + cowpea intercropping system (2:2)

Maize + bittergourd intercropping system (2:2)

At Phulbani, in an organic nutrient management experiment on turmeric, FYM application @ 5 t/ha + Sal leaf mulching @ 6 t/ha produced higher yield (10250 kg/ha) of organic turmeric which was at par with that of application of FYM @ 5 t/ha + Sal leaf mulching @ 4 t/ha (9980 kg/ha) and 10 t FYM/ha (10150 kg/ha). Similarly, FYM @ 5 t/ha and Sal leaf mulching @ 6 t/ha gave higher net returns (Rs.111250/ha), B:C ratio (1.77) and RWUE (10.96 kg/ha-mm) compared to other treatments (Table 3.22). Application of FYM as basal resulted in improvement in organic C content in all the treatments and higher OC content (5.10 g/kg) was recorded with FYM @ 5 t/ha + rice straw mulching @ 6 t/ha. Application of FYM @ 5 t/ha + rice straw mulching @ 4 t/ha at basal resulted in higher available N (388 kg/ha). However, available P & K was higher with application of FYM @ 5 t/ha + sal leaf mulching @ 6 t/ha (51and 217 kg/ha). However, available S was higher (12.8 kg/ha) with sal leaf mulching @ 6 t/ha compared to other treatments.

Turmeric with mulching

Table 3.22 : Yield and economics of turmeric under different treatments - Phulbani

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Sal leaf mulching @ 4 t/ha	9100	140000	87500	1.63	9.73
T_2: Sal leaf mulching @ 6 t/ha	9250	140000	91250	1.65	9.89
T_3: Rice straw mulching @ 4 t/ha	8850	140000	81250	1.58	9.47
T_4: Rice straw mulching @ 6 t/ha	9180	140000	89500	1.64	9.82
T_5: FYM @ 5 t/ha + sal leaf mulching @ 4 t/ha	9980	145000	104500	1.72	10.67
T_6: FYM @ 5 t/ha + sal leaf mulching @ 6 t/ha	10250	145000	111250	1.77	10.96
T_7: FYM @ 5 t/ha + rice straw mulching @ 4 t/ha	9560	145000	94000	1.65	10.22
T_8: FYM @ 5 t/ha + rice straw mulching @ 6 t/ha	9850	145000	101250	1.70	10.53
T_9: FYM @ 10 t/ha	10150	150000	103750	1.69	10.86
CD at 5%	330				

At Varanasi, in an evaluation of nanoclay polymer composite (NCPC) on resource use efficiency and productivity, yield of rice was significantly affected under the influence of NCPC together with application of inorganic nutrient treatments. Application of recommended dose of inorganic fertilizer (80:40:40 kg NPK/ha) in conjunction with NCPC as source of different nutrient elements resulted in comparable yield response and proved significantly superior to application of recommended dose of fertilizer alone. A significant yield improvement was recorded in rice (2486 kg/ha) and lentil (1104 kg/ha) respectively in the treatment T_9- 100% RDF + NCPC- superabsorbent @ 25 kg/ha loaded with Sulphur @ 10 kg/ha + Zinc @ 10 kg/ha + Molybdenum @ 10 kg/ha compared to other treatments.

Similarly, higher net returns (Rs.61407/ha) and B:C ratio (0.49) was recorded with 100% RDF + NCPC-superabsorbent @ 25 kg/ha loaded with sulphur @ 10 kg/ha + zinc @ 10 kg/ha + molybdenum @ 10 kg/ha compared to other treatments (Table 3.23).

Table 3.23 : Yield and economics of rice as influenced by NCPC and inorganic source of nutrients - Varanasi

Treatment	Yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Rice	Lentil				
T_1: 100% RDF (80:40:40 kg NPK/ha)	1677	566	1081	23680.	17745	0.75
T_2: 100% RDF+ NCPC- superabsorbent @ 10 kg/ha	1836	687	3162	26040	19318	0.74
T_3: 100% RDF+ NCPC- superabsorbent@ 10 kg/ha loaded with sulphur @ 5 kg/ha	1896	780	1874	29245	17597	0.60
T_4: 100% RDF +NCPC- superabsorbent @ 10 kg/ha loaded with sulphur @ 5 kg/ha + Zinc @ 5 kg/ha	2137	808	1468	33071	19705	0.60
T_5: 100% RDF +NCPC- superabsorbent @ 10 kg/ha loaded with sulphur @ 5 kg/ha + Zinc @ 5 kg/ha + molybdenum @ 5 kg/ha	2195	834	2718	33975	20239	0.60
T_6: 100% RDF + NCPC- superabsorbent @ 25 kg/ha	2321	1019	2076	35120	22197	0.63
T_7: 100% RDF + NCPC- superabsorbent @ 25 kg/ha loaded with sulphur @ 10 kg/ha	2341	1055	2632	36471	21339	0.59
T_8: 100% RDF + NCPC- superabsorbent @ 25 kg/ha loaded with sulphur @ 10 kg/ha + zinc @ 10 kg/ha	2385	1073	2409	38782	20130	0.52
T_9: 100% RDF + NCPC- superabsorbent @ 25 kg/ha loaded with sulphur @ 10 kg/ha + zinc @ 10 kg/ha + molybdenum @ 10 kg/ha	2486	1104	3143	41300	20107	0.49
CD at 5%	220	78	215	-	-	-

Rice with 100% RDF

Rice with 100% RDF + NCPC- superabsorbent @ 25 kg/ha loaded with sulphur @ 10 kg/ha + zinc @ 10 kg/ha + molybdenum @ 10 kg/ha

At Varanasi, in a permanent manurial trial (PMT) on conjunctive use of organic and inorganic sources of nutrients in rice-lentil system, significantly higher grain yield of rice (1040 kg/ha) was recorded with application of 100% through N (FYM) followed by 50% RDF + 50% N (FYM) (981 kg/ha) which was at par with 100% RDF and 50% RDF (soil) + 50% N (foliar) (997 and 923 kg/ha). However, net returns and B:C ratio were negative due to very low yields owing to prolonged dry spells. The mean data of 31 years also indicated that 50% RDF + 50% N (FYM) being on par with 100% N (FYM) and 100% RDF recorded significantly higher grain yield of rice (2038 kg/ha) compared to other treatments (Table 3.24).

Table 3.24 : PMT: Effect on yield and economics of rice - Varanasi

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	NMR (Rs/ha)	B:C ratio	Mean yield (kg/ha) (n=31)	Sustainable yield index (n=31)
T_1 – Control	416	914.1	39865	13286	-26579	-0.67	1211	0.39
T_2 – 100% N (FYM)	1040	2288.9	44588	22339	-22249	-0.50	1925	0.57
T_3 – 100% RDF	997	2193.4	43172	15024	-28148	-0.65	1888	0.60
T_4 – 50% RDF (soil) + 50 % N (foliar)	923	2030.6	42254	18802	-23452	-0.56	1633	0.52
T_5 – 50% RDF	685	1507.0	42522	18737	-23785	-0.56	1521	0.44
T_6 – 50% RDF + 50% N (FYM)	981	2157.1	43850	17449	-26402	-0.60	2038	0.66
T_7 – 50% N (FYM)	810	1782.9	42462	18018	-24444	-0.58	1644	0.53
T_8 – Farmers' practice (20 kg N/ha)	568	1249.2	41327	12262	-29065	-0.70	1493	0.45
CD at 5 %	123	215	-	-	-	-	-	-

100% RDF: 80:40:40 kg NPK/ha

At Varanasi, in a permanent manurial trial initiated in 1985, on conjunctive use of organic and inorganic sources of nutrients in rice-lentil system, significantly higher seed yield of lentil (311 kg/ha) was recorded with application of 50% RDF + 50% N (FYM) compared to other treatments except 100% RDF (310 kg/ha) and 50% RDF (soil) + 50% N (foliar) and 100% N (FYM) (295). Similarly, higher net returns (Rs.12729/ha and B:C ratio (4.1) were recorded with 50% RDF + 50% N (FYM) compared to other treatments. The mean data of 31 years also revealed similar results (Table 3.25).

Table 3.25 : PMT: Effect of on yield and economics of lentil - Varanasi

Treatment	Seed yield (kg/ha)	NMR (Rs/ha)	Mean yield (n=31)	Mean (n=31) NMR (Rs/ha)	B:C ratio (n=31)	Sustainability yield index (n=31)
T_1: Control	117	-128	585	15856	1 :2.1	0.32
T_2: 100% N (FYM)	290	11303	787	23835	1 :3.1	0.53
T_3: 100% RDF	309	12577	692	20037	1 :2.7	0.56
T_4: 50% RDF (soil) + 50% N (foliar)	294	11587	597	16239	1 :2.2	0.45
T_5: 50% RDF	260	9343	671	19277	1 :2.6	0.42
T_6: 50% RDF + 50% N (FYM)	312	12729	965	30676	1 :4.1	0.65
T_7: 50% N (FYM)	200	5357	711	20794	1 :2.8	0.50
T_8: Farmers' practice (20 kg N/ha)	135	1086	323	5596	1 :0.8	0.45
CD at 5%	20	-	-	-	-	-

100 % RDF: 20:40:20 kg NPK/ha

Lentil (HUL-57) with no fertilizer application

Lentil (HUL-57) with 50% RDF + 50 % N (FYM)

3.1.4 Energy management

In an experiment on tillage and nutrient management in maize at Chianki, significantly higher grain yield of maize (4150 kg/ha) was recorded with offseason tillage + ½ convencional tillage + weedicide + 1 hand weeding + 50% nutrient through organic source + 50% NPK (M_3S_2) compared to other treatments except offseason tillage + ½ conventional tillage + weedicide + 1 hand weeding + 100% NPK (M_3S_3) (3904 kg/ha). However, the maximum mean grain yield (1981 kg/ha) over 7 years (2011-2017) was obtained with offseason tillage + conventional tillage + 2 hand weedings + 100% NPK (M_2S_1) followed by offseason tillage + ½ conventional tillage + weedicide + 1 hand weeding + 100% NPK (M_3S_3) (1859 kg/ha) and off seasonal tillage + ½ conventional tillage + weedicide + 1 hand weeding + 50% NPK + 50% NPK (M_3S_2) (1815 kg/ha). The B:C ratio (2.31) was found maximum in off seasonal tillage + ½ conventional tillage + 2 hand weedings + 100% NPK (M_2S_1) (Table 3.26).

Table 3.26 : Effect of tillage and nutrient management on yield and economics of maize - Chianki

Treatment	Grain yield (kg/ha)		B:C ratio	Plant height (cm)	Cob length (cm)	Cob girth (cm)	100 Seed weight (g)	RWUE (kg/ha-mm)
	2017	Mean (2011-17)						
M_2S_2	2805	1673	1.95	196.1	17.13	19.06	23.55	2.94
M_1S_3	3629	1815	2.11	187.4	16.14	17.85	22.19	3.80
M_1S_2	3608	1859	2.16	164.8	14.65	16.47	21.18	3.78
M_3S_3	3904	1689	1.97	197.9	21.36	17.85	22.53	4.09
M_2S_3	3712	1754	2.04	182.5	19.47	17.6	21.82	3.89
M_2S_1	3242	1981	2.31	187.2	19.47	8.04	20.42	3.40
M_3S_2	4150	1623	1.69	219.1	24.23	19.25	21.54	4.35
M_1S_1	3662	1556	1.81	190.8	16.86	13.8	19.08	3.83
M_3S_1	3551	1779	2.07	213.5	15.23	15.24	21.09	3.72
CD at 5%	240	-	-	-	-	-	-	-

M_1: Off seasonal tillage + conventional tillage + 2 Hand weeding; M_2: Off season tillage + ½ conventional tillage + 2 hand weeding; M_3: Off season tillage + ½ conventional tillage + weedicide + 1 hand weeding; S_1: 100% nutrient through organic source; S_2: 50% nutrient through organic source + 50% NPK; S_3: 100% NPK (100:60:40 kg NPK/ha)

At Jagdalpur, in an evaluation of bullock drawn implements for interculture in rainfed rice under midland situation, higher grain yield (5391 kg/ha), net returns (Rs.48407/ha), B:C ratio (2.09) and RWUE (4.66 kg/ha-mm) was recorded with manual removal of weeds at 25 DAS when compared to other methods of interculture and control (Table 3.27).

Table 3.27 : Effect of different interculture methods on yield and economics of rice - Jagdalpur

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Use of country plough in between rows of rice at 25 DAS	4038	22045	38532	2.12	3.49
T_2: Use of Ambika paddy weeder in between rows of rice at 25 DAS	3154	24150	23159	2.05	2.73
T_3: Manual removal of weeds at 25 DAS	5391	32451	48407	2.09	4.66
T_4: Biasi (*Beushening*) at 25 DAS	2793	16812	25078	1.57	2.42
T_5: Control	1524	9175	13686	1.34	-

Bueshening in rice field

At Varanasi, in a study on tillage and nutrient management, during *kharif* 2017, crop experienced terminal drought, and two supplemental irrigations of 5 cm each were applied from harvested rainwater in farm pond. Rice with field bunding produced significantly higher grain yield (3150 kg/ha) as compared to rice sown without bunds. Conventional tillage along with weed control and interculture (T_1) produced maximum grain yield of rice (3148 kg/ha) and was significantly superior over low tillage treatments. Under nutrient management, maximum grain yield (3127 kg/ha) was recorded with 100% recommended dose of fertilizer through inorganic source (F_1) which was statistically at par with 50% N through inorganic + 50% N through organic sources (F_2) and significantly superior to 100% N through organic sources (F_3) (Table 3.28).

Table 3.28 : Effect of treatments on yield and economics of rice - Varanasi

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (13 years)					
Bunding							
B_1: Compartmental bunding	3150	2420	5868	17600	37998	3.2	5.17
B_2: Without bunding	2728	2082	4275	15600	30792	2.97	4.34
CD at 5 %	380		813				
Tillage							
T_1: Conventional tillage + weed control + interculture	3148	2389	5888	17000	23219	2.37:1	5.29
T_2: Minimum tillage + weed control + interculture	2808	2255	4923	16200	34605	3.14:1	4.75
T_3: Low tillage+ weed control + interculture	2760	2109	4404	15800	29583	2.87:1	4.24
CD at 5%	248		940				
Nutrient management							
F_1:100% N through inorganic	3127	2290	5414	15088	39430	3.61:1	5.11
F_2: 50% N through inorganic + 50% N through organic	3038	2327	5074	15788	36194	3.29:1	4.85
F_3: 100% N through organic	2752	2144	4726	16300	29984	2.84:1	4.31
CD at 5 %	203	-	844	-	-	-	-

100 % RDF: 80:40:40 kg NPK/ha

Rice field without bunding

Rice field with bunding

3.1.5 Evaluation of improved varieties

At Biswanath Chariali, in a study on **c**ollection and evaluation of *Ahu* rice germplasm, Dehangi genotype gave significantly higher grain yield (1861 kg/ha) and B:C ratio (2.18) compared to other genotypes. Genotype Safalu was the next best genetype with grain yield of 1683 kg/ha (Table 3.29).

Performance of rice cv. Dehangi

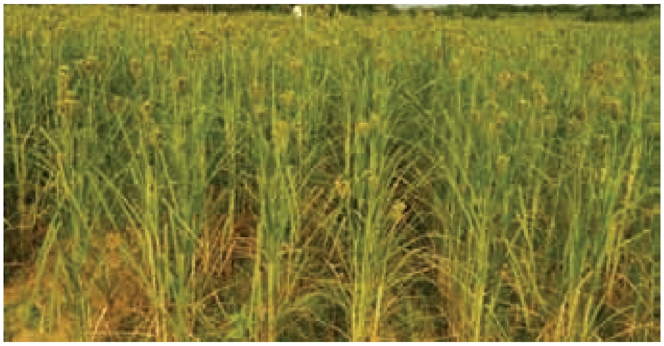
Table 3.29 : Performance of Ahu rice genotypes under upland rainfed condition - Biswanath Chariali

Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	Grain yield (kg/ha)	B:C ratio	RWUE (kg/ha-mm)
Dehangi	60	101	110	1861	2.18	1.28
Inglongkiri	60	100	120	1596	1.82	1.07
Haccha	60	100	105	1548	1.97	1.16
Ranghang	60	100	110	1381	1.44	0.85
Kola ahu	65	105	135	1019	1.2	0.71
Rongadoria	70	110	140	1157	1.54	0.91
Safalu	70	110	140	1683	2.1	1.24
Jara ahu	70	110	138	979	1.14	0.67
Banglami	70	110	130	1543	1.79	1.06
Bihari ahu	70	110	155	1377	1.71	1.01
Dimrou	60	100	105	1130	1.48	0.87
Dabra bao	70	110	160	1137	1.32	0.78
CD at 5%	-	-	-	83.6	-	-

At Chianki, in an evaluation of drought tolerant lines of fingermillet, the genotype BMM-10 recorded significantly highest grain yield (3003 kg/ha) compared to other genotypes except GPU-67 (2855 kg/ha), BBM-11 (2674 kg/ha) and the best check A-404 (2659 kg/ha). The higher yield in BMM-10 may be due to higher no of tillers/plant, no of fingers/tiller, length of finger and 1000 seed weight (Table 3.30).

Table 3.30 : Yield and ancillary characters of drought tolerant lines of fingermillet - Chianki

Genotype	Grain yield (kg/ha)	Days to 50% flowering	Days to maturity	Plant height (cm)	No of tillers/ plant	No of fingers/ tiller	Finger length (cm)	1000-seed weight (g)
BBM-10	3003	78	120	88.0	5.7	10.2	9.4	3.7
GPU-67	2855	80	118	67.0	5.2	8.2	8.4	2.8
BBM-11	2674	79	120	83.9	4.4	7.6	6.8	2.9
A-404©	2659	79	121	87.7	4.3	7.6	6.6	3.1
BM-2	2559	77	115	68.3	5.2	8.0	6.1	2.9
GPU-28	2478	78	117	85.5	4.5	9.4	8.7	3.0
BBM-13	2329	83	124	89.2	4.3	8.8	8.7	3.5
HR-374	2296	67	109	85.3	5.2	7.8	6.3	2.9
GPU-48	2085	73	113	80.6	4.0	7.2	6.5	2.8
VL-149	2078	70	110	90.3	4.5	9.8	9.8	3.0
RAU-08	1922	75	117	85.6	4.2	7.6	8.2	2.8
VR-708	1918	66	105	81.8	5.5	7.6	8.1	3.0
JWM-1	1792	67	107	85.8	4.5	8.0	8.1	3.0
BM-1	1626	72	111	86.8	5.1	8.0	8.2	2.7
Local	1485	65	105	81.32	4.1	6.6	7.4	2.1
CD at 5%	390	-	-	-	-	-	-	-



Varietal trial in fingermillet

At chianki, in an evaluation of drought tolerant lines of 15 entries of chickpea, entry BAUG-26 recorded significantly higher seed yield (1460 kg/ha) compared to other genotypes except that BAUG-28 (1401 kg/ha), BAUG-46 (1400 kg/ha), JG-14 (1390 kg/ha) and Annegri (1330 kg/ha). Similarly, higher RWUE (45.6 kg/ha-mm) was recorded with BAUG-26 followed by BAUG-28 (44.1 kg/ha-mm) and BAUG-46 (43.8 kg/ha-mm), respectively (Table 3.31).

Table 3.31 : Yield and ancillary characters of drought tolerant genotypes of chickpea - Chianki

Entry	Seed yield (kg/ha)	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of pods/ plant	No. of seeds/ pod	100 seed weight (g)	RWUE (kg/ha-mm)
BAUG-8	1300	73	124	53.4	51.1	2.1	24.7	40.6
BAUG-11	1260	74	124	61.9	56.7	1.6	24.2	40.6
BAUG-15	1110	74	124	45.2	53.9	1.8	26.7	34.7
BAUG-16	1160	66	117	43.1	57.4	1.8	27.7	36.3
BAUG-1034	1050	68	119	47.5	42.6	1.6	25.9	32.8

Entry	Seed yield (kg/ha)	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of pods/ plant	No. of seeds/ pod	100 seed weight (g)	RWUE (kg/ha-mm)
BG-3	1050	65	120	44.4	30.9	1.6	27.7	32.8
KAK-2	990	66	121	46.5	78.3	2.2	27.5	30.9
KPG-59	1170	60	115	41.4	59.6	1.6	23.7	36.6
Annegri	1330	67	123	41.3	44.3	2.0	24.7	41.6
JG-14	1390	66	122	43.3	69.0	1.8	27.2	43.4
BAUG-26	1460	69	119	42.7	44.2	2.0	28.2	45.6
BAUG-28	1410	70	121	46.6	42.2	1.8	25.1	44.1
BAUG-46	1400	63	118	47.5	52.1	1.5	22.7	43.8
BAUG-10-3	1300	65	120	51.6	50.3	1.8	23.7	40.6
Local	1120	70	122	51.3	53.2	1.8	18.8	35.0
CD at 5%	130	-	-	-	-	-	-	-

3.1.6 Alternate land use system

At Chianki, in aonla based agri-horti system, significantly highest aonla yield (12.09 t/ha) was recorded in aonla + blackgram system followed by aonla + sesame system (10.98 t/ha) whereas, sole crop of aonla yielded was 8.43 t/ha. Similarly, significantly highest aonla equivalent yield (14.44 t/ha) with highest benefit-cost ratio of 3.77 was recorded in aonla + blackgram system followed by aonla + sesame (12.30 t/ha) (Table 3.32).

Table 3.32 : Performance of aonla based agri-horti systems - Chianki

Treatment	Aonla yield (t/ha)		Intercrop yield (t/ha)		Aonla equivalent yield (t/ha)		B:C ratio	
	2017-18	Mean (2 yrs)	2017-18	Mean (2 yrs)	2017-18	Mean (2 yrs)	2017-18	Mean (2 yrs)
T_1: Aonla + blackgram	12.09	12.44	0.76	0.81	14.44	14.96	3.77	3.95
T_2: Aonla + sesame	10.98	11.20	0.42	0.41	12.30	12.49	3.55	3.62
T_3: Aonla + fingermillet	9.17	9.61	1.08	1.11	10.36	10.84	2.88	3.07
T_4: Aonla + maize	9.39	9.87	1.33	1.48	10.56	11.18	2.30	2.49
T_5: Aonla + sorghum	9.44	9.30	0.94	1.02	10.44	10.39	2.84	2.82
T_6: Aonla + pigeonpea	10.50	10.68	1.02	1.12	13.64	14.15	3.26	3.42
T_7: Aonla (sole)	8.43	8.96	-	-	8.43	8.96	2.30	2.51
CD at 5%	1.60	-	-	-	1.69	-	-	-

Aonla + fingermillet system

Aonla + maize system

At Faizabad, in an evaluation of ber, anola, guava and kajurina based agri-horti-silvi system, maximum pigeonpea equivalent yield (1968 kg/ha) was recorded in T_{10}- Pigeonpea sole. Similarly maximum net return (Rs.98522/ha), B:C (5.02) and RWUE (2.22 kg/ha-mm) was also recorded with sole pigeonpea compared to other treatments (Table 3.33).

Table 3.33 : Evaluation of most remunerative land use system for rainfed areas - Faizabad

Treatment	Intercrop yield (kg/ha)			PEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Maize	Pigeonpea	Mustard					
Agri-horti system								
T_1: Bel + (maize – mustard)	1972	-	625	910	33878	20702	0.61	1.02
T_2: Bel + pigeonpea	-	1794	-	1784	19578	88088	4.50	2.02
T_3: Aonla + (maize – mustard)	1845	-	584	851	33878	17157	0.51	0.96
T_4: Aonla + pigeonpea	-	1858	-	1858	19578	91922	4.70	2.09
Agri-silvi system								
T_5: Kajurina + (maize – mustard)	1923	-	637	905	33878	20447	0.60	1.02
T_6: Kajurina + pigeonpea	-	1841	-	1841	19578	90902	4.65	2.08
Agri- horti- silvi system								
T_7: Guava- kajurina + (maize – mustard)	1944	-	601	887	33878	19322	0.57	1.00
T_8: Guava-kajurina + pigeonpea	-	1863	-	1863	19578	92222	4.71	2.10
Control								
T_9: Maize - mustard	1930	-	648	915	33878	20992	0.62	1.03
T_{10}: Pigeonpea sole	-	1968	-	1968	19578	98522	5.02	2.22

PEY: Pigeonpea equivalent yield; No main crop (fruit) yield was recorded during the year

At Jagdalpur, under evaluation of alternate land use systems (horti-agri system), among different crops evaluated in fruit plantation (mango), ragi (fingermillet) gave higher grain yield (2912 kg/ha) and RWUE (2.59 kg/ha-mm) compared to other crops. Whereas, multi-cut sorghum gave higher net returns (Rs.19348/ha) and little millet gave higher B:C ratio (2.32) compared to other crops (Table 3.34).

Table 3.34 : Effect of intercropping on yield and economics - Jagdalpur

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Ragi in between fruit plantation	2912	5016	8089	1.62	2.59
T_2: Little millet in between fruit plantation	562	7026	5340	2.32	1.73
T_3: Multi-cut sorghum in between fruit plantation	1526	12560	17960	1.70	1.65
T_4: Horsegram in between fruit plantation	945	9058	14571	1.62	1.80
T_5: Control	245	9059	-5382	-0.68	0.47

In a study on intensification of land use in mango orchard at Phulbani, fodder cowpea gave higher yield (21250 kg/ha) and RWUE (36.89 kg/ha-mm). Whereas, radish gave higher net returns (Rs.58900/ha) and B:C ratio (3.0) compared to other treatments (Table 3.35).

Table 3.35 : Performamce of different crops in mango orchand - Phulbani

Treat-ment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Fodder cowpea	21250	16000	5250	1.34	36.89
Radish	11050	29500	58900	3.0	19.18

In another study at Varanasi, effect of integrated nutrient management on growth and yield of greengram under guava based agri-horti system, guava + green-gram system with 100% RDF (60:40:30 NPK kg/ha) gave higher MCEY (6367 kg/ha), B:C ratio (6.1) and RWUE (24.29 kg/ha-mm) compared to other treatments (Table 3.36).

Mango + cowpea system

Mango + radish system

Table 3.36 : Effect of treatments on yield and economics of agri-horti system- Varanasi

Treatment	Yield (kg/ha)			MCEY (kg/ha)	Cost of cul-tivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop (Guava)	Intercrop (Greengram)	Stover/ stalk					
T_1: Control	15000	970	1870	5037	27000	173370	6.4	23.90
T_2: 100% FYM (10 t/ha)		1175	2090	6084	32000	178840	5.5	24.21
T_3: 100% vermicompost (5 t/ha)		1150	2070	5957	42000	167570	3.9	24.17
T_4: 100% RDF (60:40:30 kg/ha NPK)		1230	2170	6367	30000	183670	6.1	24.29
T_5: 50% RDF + 50% FYM		1210	2105	6260	31000	181605	5.8	24.26
T_6: 50% RDF + 50% vermicom-post		1170	2100	6060	36000	174600	4.8	24.20

3.1.7 Integrated farming systems

At Phulbani, an integrated farming system model of 1.2 ha was established in Dadupaju village, Phulbani block Khandmal district. In this IFS model, rice, horticultural crops (cauliflower, runner bean, brinjal, tomato, guava and papaya), buffalo, poultry (10 birds), pisciculture, vegetable seed production and nursery were added to the existing farming system and modified. From this IFS model, the farmer got net returns of Rs.90000 in the second year (2017) as against Rs 43850 with existing farming system (Table 3.37 & 3.38)

Guava + greengram system

Table 3.37 : Performance of existing farming system - Phulbani

Existing component	Cost incurred (Rs)	Gross income (Rs)	NMR (Rs)
Agricultural crops (Rice)	9500	14000	4500
Horticulture crops (brinjal, tomato, chilli)	41500	60000	18500
Horticulture crops (guava, mango)	-	15600	15600
Animal husbandry (buffalo)	-	5250	5250
Total	**51000**	**94850**	**43850**

Table 3.38 : Performance of integrated farming system model – Phulbani

Component	Interventions	Additional man-days generation/ year	Cost incurred (Rs.)	Gross income (Rs.)	NMR (Rs.)
Rice	HYV Naveen with improved practice	25	13000	21500	8500
Horticulture crops (cauliflower, runner bean, brinjal & tomato	Remunerative crops with improved practice	23	65000	110000	45000
Horticulture crops (guava and papaya)	Korg Honey dew papaya planted as avenue planting inside farm	15	2000	6000	4000
Animal husbandry (buffalo)	Balanced feed and healthcare		12000	30000	18000
Poultry	Local poultry birds for egg and meat purpose	12	1000	2500	1500
Pisciculture	Improved fingerlings released	5	2000	10000	8000
Nursery	Vegetable seed production	45	5000	10000	5000
Total		125	100000	190000	90000

At Varanasi, integrated animal based system (rice + three buffalo + two buffalo calf) gave highest net returns (Rs. 151677/ha) and employment generation was 160 man - days/ha/year with a rice grain yield of 2070 kg/ha and milk yield of 8130 liters/year. However, agri-horti system recorded net returns of Rs.27460/ha and employment generation was 300 man - days/ha/year with aonla yield of 6540 kg/ha (Table 3.39).

Table 3.39 : Performance of integrated farming system model – Varanasi

Farming system	Productivity (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Employment generation (man-days/ha/yr)
	Crop	Livestock	Any other enterprise				
Integrated animal based system	Rice (2070 kg/ha)	3 buffalo (8130 litre.) + 2 buffalo calf	-	124300	151677	2.2	160
Agri-horti-system	Aonla* (6240 kg/ha)	-	Sesame (370 kg/ha)	16000	27460	20.6	300

*26 Plants planted in 0.25 ha, Each plant produced 50-60 kg/plant

Amla based agri-horti system

Animal component - buffalo

3.2 Maize Based Production System

3.2.1 Rainwater management

At Arjia, in a study on catchment-storage-command relationship, a total rainfall of 644.1 mm with 13.51% runoff was recorded from June to December, 2017. Further, the highest runoff (356.0 m^3) with rainfall of 415.2 mm was recorded in July which was 80.9% of total runoff (440.0 m^3). The total runoff producing rainfall was 793.7 mm which contributed to 79.6% of the annual rainfall (Table 3.40).

Table 3.40 : Runoff from the small agricultural watershed - Arjia

Month	Rainfall (mm)		Runoff (m^3)	% runoff of monthly rainfall	% runoff producing rainfall
	Monthly	Runoff producing rainfall			
June	76.2	34.7	21.7	1.4	3.1
July	415.2	363.0	356.0	4.3	4.9
August	118.5	82.5	56.8	2.4	3.4
September	30.5	13.5	5.5	0.9	2.0
October	0.0	0.0	0.0	0.0	0.0
November	0.0	0.0	0.0	0.0	0.0
December	3.7	0.0	0.0	0.0	0.0
Total	**644.1**	**793.7**	**440.0**	**440.0**	**13.4**

At Ballowal Saunkhri, in a study on catchment-storage-command relationship and enhancing water productivity in a micro-watershed, the catchment-storage, catchment-command and storage command ratio of the water harvesting system were 12.7, 6.86 and 0.54, respectively for a catchment area of 3.43 ha which stored 0.27 ha-m water with command area of 0.5 ha (Table 3.41).

Table 3.41 : Catchment-storage-command relationship of farm pond – Ballowal Saunkhri

Catchment area (ha)	3.43	
Storage capacity, ha-m	0.27	
Command area, ha	0.5	
Catchment-storage ratio	12.7	
Storage command ratio	0.54	
Catchment command ratio	6.86	
Rainfall events (No.)	34 (*Kharif & Rabi*)	
Method of irrigation	Maize, okra & pea: Furrow, Wheat: Sprinkler	
No. of irrigations	01 each in *kharif* and *rabi*	
Amount of water applied (mm)	Maize & okra: 50 mm, Pea & wheat: 50 mm	
Details of pond water use		
Parameter	**Volume of water (cum)**	**% of harvested water**
Rainfall (689 mm)	4726	-
Evaporation (394 mm)	336	12.90
Water harvested	2612	-
Seepage losses	65	2.49
Used for irrigation	1080	41.35
Dead storage/ storage at the end of the season	254	9.72
Overflow	378	14.48

During *kharif* season, at Ballowal Saunkhri one supplemental irrigation in maize and okra gave 4251 kg/ha and 13400 kg/ha yield which was 48.4 and 42.5% higher over rainfed maize (2864 kg/ha) and okra (9400 kg/ha), respectively. During *rabi* season, one supplemental irrigation to wheat at CRI stage gave 83.7% higher yield (3762 kg/ha) over rainfed wheat (2048 kg/ha). While, in pea 5700 kg/ha of green pod yield was obtained with irrigation and under rainfed conditions pea could not be cultivated due to low soil moisture. Similarly the net returns, B:C ratio and RWUE were higher with one supplemental irrigation in all crops as compared to without supplemental irrigation (Table 3.42).

Wheat and pea with supplemental irrigation

Table 3.42 : Effect of supplemental irrigation on crop yield and economics - Ballowal Saunkhri

Crop (variety)	Yield (kg/ha)		Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C (Rs/ha)		RWUE (kg/ha-mm)	
	WSI	WOSI	WSI	WOSI	WSI	WOSI	WSI	WOSI	WSI	WOSI
C_1: Maize (PMH-1)	4251	2864	33016	30858	38995	17429	2.18	1.56	5.5	3.9
C_2: Okra (Punjab 8)	13400	9400	55926	49051	78074	44949	2.40	1.92	17.3	12.9
C_3: Wheat (PBW 660)	3762	2048	27607	26020	58205	20337	3.11	1.78	16.1	11.1
C_4: Pea (Matar Ageta-6)	5700	-	41299		55601		2.35		26.2	-

WSI: with supplemental irrigation; WOSI: without supplemental irrigation

At Ballowal Saunkhri, *in-situ* moisture conservation due to ridge planting, conservation furrows and bed planting resulted in significant increase in the grain yield of maize by 24, 21 and 15%, respectively over flat sowing. However, deep ploughing showed no significant increase in yield over flat sowing. Further, ridge planting of maize resulted in highest net returns (Rs. 28822/ha), B:C ratio (1.86) and RWUE (4.99 kg/ha-mm). The yield of succeeding wheat crop also improved significantly due to *in-situ* moisture conservation in maize. Ridge sowing and conservation furrows increased wheat yield by 21.6 and 18.5%, respectively compared to flat sowing. The highest net returns (Rs. 35071/ha) and B:C ratio (2.29) was obtained in ridge sowing followed by conservation furrows (Rs. 32839/ha and 2.21) (Table 3.43).

Table 3.43 : Effect of in-situ moisture conservation practices on yield and economics of maize (PMH-1) and wheat (PBW 660) - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	2017-18	Mean (2 yrs)					
Maize							
T_1: Deep ploughing	3163	3627	6372	4.35	32958	20855	1.63
T_2: Bed planting	3363	3786	6968	4.63	33114	24300	1.73
T_3: Ridge sowing	3622	4088	7803	4.99	33316	28822	1.86
T_4: Conservation furrow	3528	3996	7265	4.86	32932	27261	1.83
T_5: Flat sowing	2918	3347	6125	4.02	30900	18989	1.61
CD at 5%	413		833	0.57	321	6391	0.19
Wheat							
T_1: Deep ploughing	2294	2817	4297	11.3	27596	25600	1.96
T_2: Bed planting	2459	2977	4333	11.9	27769	28206	2.05
T_3: Ridge sowing	2779	3359	4908	11.4	28258	35071	2.29
T_4: Conservation furrow	2708	3217	4576	12.0	28024	32839	2.21
T_5: Flat sowing	2285	2712	4193	10.1	27375	25082	1.94
CD at 5%	396		494	NS	511	7007	0.24

At Ballowal Saunkhri, *in-situ* moisture conservation with ridge planting, conservation furrow, bed planting and deep ploughing resulted in storage of more soil moisture compared to flat sowing irrespective of growth stages of wheat and depth of soil sampling. Among different treatments ridge sowing closely followed by conservation furrow resulted in storage of higher soil moisture compared to all other planting methods during all growth stages sowing to harvest in all soil sampling depths 0-180 cm (Table 3.44).

Table 3.44 : Soil moisture at different stages of wheat – Ballowal Saunkhri

Treatment	Soil moisture storage (cm)															
	Sowing (8.11.17)								Crop stage 2 (18. 1. 17)							
	D1	D2	D3	D4	D5	D6	D7	T	D1	D2	D3	D4	D5	D6	D7	T
T_1	1.95	2.68	4.16	5.01	5.03	4.74	4.16	27.7	1.91	2.60	4.52	4.06	4.29	4.28	4.33	26.0
T_2	2.01	2.86	4.87	4.19	5.07	5.77	4.81	29.6	2.08	2.35	4.13	4.46	4.69	4.27	4.56	26.6
T_3	2.40	3.47	5.71	6.21	6.92	6.12	4.82	35.6	2.02	2.50	5.15	5.40	5.06	4.95	4.25	29.3
T_4	2.08	3.00	6.39	5.01	6.29	5.13	5.23	33.1	2.03	2.10	4.62	4.63	4.42	5.39	4.33	27.5
T_5	1.77	3.03	5.41	4.97	4.47	4.68	4.46	28.8	1.83	2.78	4.25	3.78	4.41	5.02	3.28	25.3
Mean	2.04	3.01	5.31	5.08	5.55	5.29	4.70	31.0	1.97	2.47	4.54	4.47	4.57	4.78	4.15	26.9

Soil depth: D1:0-15 cm; D2: 15-30 cm; D3: 30-60 cm; D4: 60-90 cm; D5: 90-120 cm, D6: 120-150, D7: 150-180, T:0-180 cm

Maize -ridge sowing

Maize -flat bed sowing

Residual effect of ridge sowing on wheat

Residual effect flat bed sowing on wheat

At Rakh Dhiansar, in an experiment on catchment-storage-command relationship for enhancing water productivity, the size of farm pond was 14 m x 14 m x 2 m with a capacity of 392 m^3. The pond was lined with cement concrete. Portable diesel operated 5 hp water pump was used as water lifting device with sprinkler method of irrigation. The rainfall-runoff relationship for the year 2017 is given in Fig. 3.1.

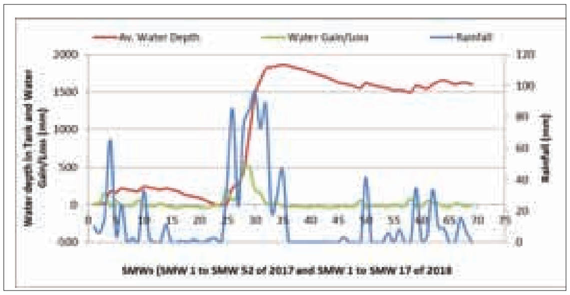


Fig. 3.1: Rainfall-runoff relationship during 2017-18 - Rakh Dhiansar

At Rakh Dhiansar, in an experiment on catchment-storage-command relationship for enhancing water productivity, during *kharif* the highest grain yield of maize (2430 kg/ha), net returns (Rs.28508/ ha), B:C ratio (2.33) and WUE (4.73 kg/ha-mm) was obtained with two life saving irrigations at critical stages and the lowest grain yield of (1850 kg/ha) was obtained in farmers practice of no supplemental irrigation (Table 3.45).

Table 3.45 : Effect of supplemental irrigation on maize yield and economics - Rakh Dhiansar

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs./ha)	B:C ratio	WUE (kg/ha-mm)
T_1: Farmers' practice (without irrigation)	1850	4500	19950	17170	1.86	3.60
T_2: One life saving irrigation at critical stage	2050	5450	20750	21310	2.03	3.99
T_3: Two life saving irrigations at critical stages	2430	6511	21450	28508	2.33	4.73

Similarly, during *rabi*, the highest grain yield of wheat (1667 kg/ha) was obtained with two life saving irrigations at critical stages and the lowest grain yield of (1156 kg/ha) was obtained in farmers' practice of no life saving irrigation. Highest net returns (Rs 17044/ha), B:C ratio (1.74) and WUE (18.48 kg/ha-mm) was also recorded with two life saving irrigation at critical stage compared to other treatments (Table 3.46).

Table 3.46 : Effect of supplemental irrigations on yield and economics of wheat - Rakh Dhiansar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Grain	Stover				
T_1: Farmers' practice (without irrigation)	1156	2108	19500	8578	1.44	12.81
T_2: One life saving irrigation at critical stage	1306	2421	20200	11678	1.58	14.47
T_3: Two life saving irrigations at critical stages	1667	2903	22900	17044	1.74	18.48

3.2.2 Cropping systems

At Arjia, Strip cropping of maize (grain) with 2/3 area + maize chari (fodder) with 1/3 area gave 26% higher maize grain equivalent yield (6130 kg/ha) compared to other treatments except maize (grain) 2/3 area + sorghum (f) 1/3 area (5778 kg/ha) with higher net returns (Rs.77400/ha) and B:C ratio (5.32) with highest RWUE (4.14 kg/ha-mm rainfall and in terms of rupee 130/ha-mm rainfall) (Table 3.47).

Maize (grain) in 2/3 area + Maize (chari) fodder in (1/3) area

Table 3.47 : Maize equivalent yield and economics as influenced by different strip cropping systems – Arjia

Treatment	Maize equivalent yield (kg/ha)		MGEY* (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE per ha/mm rainfall	
	Grain	Stover					kg grain	NMR
T_1: Maize (G)2/3 area + sorghum(f) 1/3 area	2287	22648	5778	14403	72271	5.02	3.86	121.89
T_2: Maize (G)2/3 area + maize chari (1/3) area	2454	23778	6130	14552	77400	5.32	4.14	130.54
T_3: Blackgram (G)2/3 area + sorghum (f) 1/3 area	1235	13833	3540	13680	39426	2.88	2.08	66.50
T_4: Blackgram (G)2/3 area + maize chari (f)1/3 area	1250	15678	3863	14362	43587	3.03	2.11	73.52
T_5: Blackgram (G) + sorghum (f) 2:2 ICS	625	25445	4644	15787	53871	3.41	1.05	90.86
T_6: Blackgram (G) + maize chari (f) 2:2 ICS	494	24495	4577	16009	52640	3.29	0.83	88.78
T_7: Maize (G) sole	3583	7685	4865	16885	56084	3.32	6.04	94.59
CD at 5%	267	2793	617					

*MGEY (grain + fodder yield)

At Ballowal Saunkhri, in a study on different slopes and strip width of maize and cowpea, cultivation of maize and cowpea in strips on 1% land slopes gave 7.3 & 13.3% higher maize equivalent yield (3331 kg/ha) as compared to 2% (3152 kg/ha) and 3% (2958kg/ha) slopes, respectively. Strip intercropping of maize and cowpea with strip width of 4.8 m: 1.2 m (4.8:1.2) gave significantly higher MEY (3862 kg/ha) with respective yield increase of 15.3, 32.0, 45.5 and 11.3% over maize: cowpea strip width of 3 m: 3m, 1.2 m: 4.8 m, sole cowpea and sole maize. Further, higher net returns (Rs. 37778/ha), B:C ratio (1.97) and RWUE of 6.27 kg/ha-mm was recorded with strip intercropping of maize and cowpea with strip width of 4.8 m:1.2 m (Table 3.48).

Maize: cowpea strip cropping (4.8 m: 1.2 m)

Table 3.48 : Effect of different slopes and strip width of maize and cowpea on yield and economics- Ballowal Saunkhri

Treatments	Yield (kg/ha)		MEY	LER	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha/mm)
	Main crop	Intercrop						
Slope								
S_1: 1%	2537	379	3331	1.23	29113	30525	1.99	5.33
S_2: 2%	2228	402	3152	1.27	28760	26509	1.90	4.94
S_3: 3%	2069	380	2958	1.26	28599	23039	1.81	4.62
CD at 5%	144	12.7	**101**	0.05	105	2402.6	0.07	0.22
Maize : cowpea strip width (m)								
W_1: 6:00	3139	-	3139	0.00	31702	29909	1.94	5.56
W_2: 4.8:1.2	3011	147	3862	1.34	33025	37778	1.97	6.27
W_3: 3:3	2001	322	3393	1.31	29963	29652	1.95	5.31
W_4: 1.2:4.8	962	459	2756	1.10	27057	20629	1.95	4.26
W_5: 0:6	-	621	2269	-	22374	15487	1.69	3.42
CD at 5%	166	14.7	130	0.06	136	3092.7	0.10	0.29

In a study on strip-intercropping of maize and cowpea under different land configurations on runoff and soil loss at Ballowal Saunkhri, the lesser slope (1%) recorded very less runoff (97 mm) and soil loss (3.2 t/ha) compared to 2% and 3% slopes with more runoff (114 and 133 mm) and soil loss (4.8 and 5.6 t/ha), respectively. Similarly, cowpea strip of 6 m width drastically reduced the runoff (74 mm) and soil loss (2.0 t/ha) compared to rest of the maize and cowpea strip width (1.2:4.8; 3:3, 4.8:1.2 and 6:0) (Table 3.49).

Table 3.49 : Effect of strip-intercropping of maize and cowpea under different land configurations on runoff and soil loss- Ballowal Saunkhri

Treatment	Runoff (mm)	Soil loss (t/ha)
Slope		
S_1: 1%	97	3.2
S_2: 2%	114	4.8
S_3: 3%	133	5.6
Maize : cowpea strip width (m)		
W_1: 6:0	116	4.7
W_2: 4.8:1.2	101	4.4
W_3: 3:3	97	3.6
W_4: 1.2:4.8	83	2.9
W_5 : 0:6	74	2.0

At Rakh Dhiansar, in an evaluation of maize-based intercropping systems under rainfed conditions, the highest maize equivalent yield (MEY) was obtained with maize + cowpea (1:1) intercropping system with the MEY and LER of 3638 kg/ha and 1.37, respectively with the highest net returns (Rs.41738/ha) and RWUE of 7.08 kg/ha-mm. However, highest B:C ratio (2.87) was recorded with sole maize (Table 3.50).

3.2.3 Nutrient management

At Arjia, in the experiment on effect of levels of potassium and magnesium on maize, application of 60 kg K_2O/ha was at par with 20 and 40 kg K_2O/ha and recorded significantly higher grain (2959 kg/ha) and stover (7099 kg/ha) yield compared to control. Similarly, application of 60 kg K_2O/ha recorded higher net returns (Rs.36159/ha), B:C ratio (2.01) and RWUE (4.29 kg/ha-mm). Among magnesium treatments, application of 45 kg $MgSO_4.7H_2O$/ha being at par with 15 and 35 kg $MgSO_4$/ha recorded significantly higher grain (2984 kg/ha) and stover yield (7402 kg/ha) with higher net returns (Rs.37968/ha). Whereas, application of 35 kg $MgSO_4$/ha recorded higher B:C ratio (2.15) and RWUE (4.17 kg/ha-mm) than other treatments (Table 3.51).

Table 3.50 : Evaluation of different maize-based intercropping system under rainfed conditions – Rakh Dhiansar

Treatment	MEY (kg/ha)	LER	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
$T_{1:}$ Maize	2887	-	37268	2.87	5.62
$T_{2:}$ Cowpea	2276	-	19948	2.36	4.43
$T_{3:}$ Rajmash	918	-	-13887	0.50	1.79
$T_{4:}$ Cucumber	1522	-	9640	1.71	2.96
$T_{5:}$ Blackgram	2243	-	17546	2.06	4.36
$T_{6:}$ Maize + cowpea (1:1)	3638	1.37	41738	2.68	7.08
$T_{7:}$ Maize + rajmash (1:1)	2615	1.13	24215	1.93	5.09
$T_{8:}$ Maize + cu-cumber(1:1)	2987	1.19	32641	2.34	5.81
$T_{9:}$ Maize + blackgram (1:1)	3215	1.19	35003	2.39	6.25
CD at 5%	354	-	-	-	-

Table 3.51 : Effect of potassium and magnesium application on yield and economics of maize -Arjia

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (3 years)					
K levels (kg/ha)							
T_1: K_0 (control)	2328	2153	5587	16771	27527	1.68	3.44
T_2: K_{20}	2660	2442	6382	17217	32550	1.92	3.90
T_3: K_{40}	2830	2590	6790	17662	35076	2.01	4.14
T_4 : K_{60}	2959	2690	7099	18108	36159	2.01	4.29
CD at 5%	474		1140				
Mg levels (kg/ha)							
T_1: Mg_0 (control)	2273	2080	5455	16877	25534	1.53	3.35
T_2: Mg_{15}	2569	2348	6164	17252	30524	1.79	3.80
T_3: Mg_{30}	2851	2616	6838	17627	35734	2.15	4.17
$T_{4:}$ Mg_{45}	2984	2798	7402	18002	37968	2.11	4.15
CD at 5%	474		1140	-	-	-	-

Different levels of potassium and magnesium had significant effect of soil K and Mg. Application of K at 60 kg/ha being at par with 40 kg/ha recorded higher soil K (400 kg/ha) than other treatments. Similarly application of Mg at 45 kg/ha being on par with other treatments recorded significantly highest Mg in soil (1.033 meq/100 g) compared to control (Table 3.52).

Table 3.52 : Availability of potassium and magnesium in soil under different treatments after harvest of maize - Arjia

Treatment	Available K_2O (kg/ha)	Exchangeable Mg (meq./100g soil)
K levels (kg/ha)		
T_1: K_0 (control)	329	0.880
T_2: K_{20}	359	0.973
T_3: K_{40}	396	0.942
T_4: K_{60}	400	0.944
CD at 5%	16.2	NS
Mg levels (kg/ha)		
T_1: Mg_0 (control)	361	0.806
T_2: Mg_{15}	371	0.926
T_3: Mg_{30}	376	0.974
T_4: Mg_{45}	376	1.033
CD at 5%	NS	0.128

Maize with application of K40 Mg30 kg/ha

Maize without K and Mg

At Arjia, in a study on long-term effect of integrated nutrient management in maize-blackgram cropping system, application of 25 kg N through FYM and 25 kg N through chemical fertilizer + 30 kg P_2O_5 gave higher grain yield of maize (3107 kg/ha) with higher net returns (Rs.45422/ha), B:C ratio (3.39) and RWUE (5.54 kg/ha-mm) (Table 3.53).

Table 3.53 : Effect of INM on yield and economics of blackgram - Arjia

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Haulm				
T_1: Control	1538	3569	14667	17322	2.18	2.74
T_2: 100% RD of NP (10:30 kg/ha)	2211	5126	16885	29097	2.72	3.94
T_3: 25 kg N through FYM and 25 kg N through IF + 30 kg P_2O_5/ha	3107	7137	19030	45422	3.39	5.54
T_4: 25 kg N through compost and 25 kg N through IF + 30 kg P_2O_5/ha	2932	6778	19530	41387	3.12	5.23
T_5: 25 kg N through crop residues and 25 kg N through IF + 30 kg P_2O_5/ha	2631	6096	21030	33674	2.60	4.69
T_6: 15 kg N through FYM + 10 kg N through crop residues and 25 kg N through IF + 30 kg P_2O_5/ha	2707	6372	19830	36710	2.85	4.83
T_7: 15 kg N through FYM + 10 kg N through compost and 25 kg N through IF + 30 kg P_2O_5/ha	2754	6366	19230	37994	2.98	4.91
T_8: 15 kg N through FYM + 10 kg N through greenleaf and 25 kg N through IF + 30 kg P_2O_5/ha	2797	6467	18570	39546	3.13	4.98
T_9: 100% recommended. N through IF without P	1875	4348	15606	23396	2.50	3.34
CD at 5%	170	358				

FYM – Farmyard manure, IF-Inorganic fertilizer

Soil bulk density was reduced in plots where organic matter (FYM, vermicompost or crop residues) was added. Further, the available nitrogen of the soil varied from 206.8 kg/ha (control) to 247.6 kg/ha in the treatment receiving 25 kg N through FYM and 25kg N through chemical fertilizer along with 30 kg P_2O_5/ha. Similarly, available phosphorous and potassium was significantly higher with INM treatments as compared to control. Copper and iron (23.78 and 1.95 ppm, respectively) were also higher in the plots under 25 kg N through FYM and 25 kg N through chemical fertilizer along with 30 kg P_2O_5/ha. Whereas, manganese, and zinc (12.68 and 1.85 ppm, respectively) were higher in the plots under 25 kg N through FYM and 25 kg N through IF + 30 kg P_2O_5/ha compared to other treatments (Table 3.54).

Table 3.54 : Effect of INM on soil properties (0-15 cm depth) after harvest of blackgram - Arjia

Treatment	**BD (Mg/m^3)**	**OC (%)**	**Available nutrients (kg/ha)**			**Micronutrients (ppm)**			
			N	**P**	**K**	**Fe**	**Cu**	**Mn**	**Zn**
$T_{1:}$ Control	1.52	0.350	206.8	28.0	336.9	9.10	0.76	7.18	0.84
$T_{2:}$ 100% RD of NP (10:30 kg/ha)	1.51	0.368	241.4	36.5	361.5	11.15	1.06	9.46	0.93
$T_{3:}$ 25 kg N through FYM and 25 kg N through IF + 30 kg P_2O_5/ha	1.48	0.405	245.8	39.9	373.7	23.33	1.92	12.68	1.85
$T_{4:}$ 25 Kg N through compost and 25 kg N through IF + 30 kg P_2O_5/ha	1.47	0.400	234.7	35.1	374.4	23.78	1.95	12.37	1.82
$T_{5:}$ 25 kg N through crop residues and 25 kg N through IF + 30 kg P_2O_5/ha	1.49	0.383	223.2	39.4	365.6	21.09	1.73	11.10	1.71
$T_{6:}$ 15 kg N through FYM + 10 kg N through crop residues and 25 kg N through IF + 30 kg P_2O_5/ha	1.50	0.393	231.9	37.4	375.2	21.70	1.84	11.88	1.77
$T_{7:}$ 15 kg N through FYM + 10 kg N through compost and 25 kg N through IF + 30 kg P_2O_5/ha	1.48	0.423	247.6	37.8	376.1	23.96	1.87	11.81	1.84
$T_{8:}$ 15 kg N through FYM + 10 kg N through greenleaf and 25 kg N through IF + 30 kg P_2O_5/ha	1.49	0.420	250.1	37.9	381.6	23.85	1.85	12.40	1.80
$T_{9:}$ 100% recommended. N through IF without P	1.50	0.361	238.9	32.8	359.4	10.72	1.02	9.36	0.89
CD at 5%	0.034	0.019	3.99	2.00	16.81	0.74	0.12	0.85	0.08

At Arjia, in a study on foliar spray of nutrients/chemicals for mitigating the dry spell stress in blackgram, foliar spray of soluble NPK (18:18:18 NPK) @ 2% at flower initiation and pod filling stages during dry spell produced higher blackgram seed yield (993 kg/ha), stalk yield (2339 kg/ha), which is at par with treatment foliar spray of NPK (18:18:18) @ 1%. Similarly, foliar spray of NPK soluble (18:18:18) @ 2% gave higher net returns (Rs.38271/ha), B:C ratio (2.08) and RWUE (1.67 kg/ha-mm) (Table 3.55).

Table 3.55 : Effect of foliar sprays of nutrients/chemicals on yield and economics of blackgram - Arjia

Treatment	**Yield (kg/ha)**		**Cot of cultivation (Rs/ha)**	**NMR (Rs/ha)**	**B:C ratio**	**RWUE (kg/ha-mm)**
	Seed	**Stalk**				
$T_{1:}$ Control (only RDF + foliar spray)	604	1326	16600	17574	1.06	1.02
$T_{2:}$ Water spray (no nutrient/chemical)	611	1361	16940	17685	1.04	1.03
$T_{3:}$ Foliar spray of KNO_3 @ 1%	791	1763	17300	27557	1.59	1.33
$T_{4:}$ Foliar spray of K_2SO_4 @ 1%	736	1833	17540	24749	1.41	1.24
$T_{5:}$ Foliar spray of KCl @ 1%	771	2076	17360	27393	1.58	1.30
$T_{6:}$ Foliar spray of DAP @ 2%	819	2305	17540	30330	1.73	1.38
$T_{7:}$ Foliar spray of NPK (18:18:18) @ 1%	972	2221	17660	37596	2.13	1.64
$T_{8:}$ Foliar spray of NPK (18:18:18) @ 2%	993	2339	18380	38271	2.08	1.67
CD at 5%	135	411	-	-	-	-

At Ballowal Saunkhri, a study on the effect of potassium and magnesium levels in maize indicated that application of 20, 30 and 40 kg K_2O/ha resulted in significant increase in maize grain yield as compared to control. There was no significant difference among 20, 30 and 40 kg K_2O/ha. However, the highest net returns (Rs. 28123/ha), B:C ratio (1.86) and RWUE (4.85 kg/ ha-mm) was recorded with application of 40 kg K_2O/ha. Among magnesium levels, magnesium sulphate application @ 30 kg/ha recorded significantly higher grain yield (3643 kg/ha) over control and $MgSO_4.7H_2O$ @ 15 kg/ha with higher net returns (Rs.29613/ha), B:C ratio (1.92) and RWUE of 4.93 kg/ha-mm over rest of the treatments. Further, data on mean grain yield (2014-2017) also revealed similar trend (Table 3.56a & 3.56b).

Table 3.56a : Effect of potassium and magnesium on the yield and economics of rainfed maize - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)		Stalk yield	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (4yrs)					
Potassium levels							
K_0: Control	3164	2689	6263	31005	20550	1.66	4.28
K_{20}: 20 kg K_2O/ha	3392	2924	6594	31836	25638	1.80	4.59
K_{30}: 30 kg K_2O/ha	3529	3103	7165	32269	27829	1.86	4.78
K_{40}: 40 kg K_2O/ha	3585	3205	6990	32639	28123	1.86	4.85
CD at 5%	210	133	404	164	3142	0.09	0.28
Magnesium levels							
Mg_0: Control	3174	2733	6221	31328	22501	1.72	4.30
Mg_{15}: 15 kg $MgSO_4$/ha	3407	2913	6760	31789	26079	1.82	4.61
Mg_{30}: 30 kg $MgSO_4$/ha	3643	3106	7227	32253	29613	1.92	4.93
Mg_{45}: 45 kg $MgSO_4$/ha	3446	3169	6804	32380	23946	1.74	4.67
CD at 5%	210	133	404	164	3142	0.09	0.28

Table 3.56b : Effect of potassium and magnesium on soil properties - Ballowal Saunkhri

Treatment	OC (%)	Available P (kg/ha)	Available K (kg/ha)	EC (dS/m)	pH
Potassium levels					
K_0: Control	0.39	32.1	219	0.16	7.84
K_{20}: 20 kg K_2O/ha	0.39	31.5	243	0.17	7.85
K_{30}: 30 kg K_2O/ha	0.38	29.3	250	0.18	7.82
K_{40}: 40 kg K_2O/ha	0.39	30.6	256	0.17	7.87
CD at 5%	NS	NS	13.5	NS	NS
Magnesium levels					
Mg_0: Control	0.39	32.7	227	0.17	7.86
Mg_{15}: 15 kg $MgSO_4$/ha	0.38	30.6	237	0.17	7.83
Mg_{30}: 30 kg $MgSO_4$/ha	0.38	29.8	245	0.17	7.85
Mg_{45}: 45 kg $MgSO_4$/ha	0.39	30.2	259	0.17	7.84
CD at 5%	NS	NS	13.5	NS	NS

At Ballowal Saunkhri, in a permanent manurial trial (initiated in 2009) on integrated nutrient management in rainfed maize, grain yield of maize improved significantly with all nutrient management practices as compared to control. During *kharif* 2017, significantly higher yield of maize (4505 kg/ha) was recorded with application of 125% NPK over rest of the treatments except 100% NPK + FYM 10 t/ha (4253 kg/ha). The highest net returns (Rs. 48601/ha), B:C ratio (2.54) and RWUE of 7.19 kg/ha-mm was also recorded with application of 125% NPK (Table 3.57).

Table 3.57 : PMT: Effect on yield and economics of maize - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)		Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	2017-18	Mean (4yrs)					
T_1: Control	1793	1831	3371	25713	6239	1.24	2.86
T_2: N (100% RDF) (80:40:20 kg NPK/ha)	2428	2398	4474	27211	15920	1.59	3.87
T_3: NP (100% RDF)	2604	2676	4717	28803	17333	1.60	4.16
T_4: NPK (100% RDF) (DAP)	3472	3086	6374	30053	31588	2.05	5.54
T_5: NPK (100% RDF (SSP)	3720	3202	6893	30996	35143	2.13	5.94
T_6: NPK (100% RDF) + $ZnSO_4$	3858	3253	6996	32484	35880	2.10	6.16
T_7: NPK (50% RDF) + FYM 10 t/ha	3707	3289	7034	39136	30020	1.77	6.23
T_8: NPK (100% RDF) + FYM 10 t/ha	4253	3616	7825	41036	34496	1.84	6.79
T_9: NPK (125% RDF)	4505	3535	8428	31616	48601	2.54	7.19
T_{10}: Organic (100% N through FYM)	3274	-	5957	42428	15618	1.37	5.22
T_{11} : Organic (100% N through FYM) + microbial consortia	3602	-	6615	45022	18930	1.42	5.75
CD at 5%	614	-	1106				

In wheat during *rabi* 2017-18, highest grain yield (2781 kg/ha) was recorded with application of 100% NPK + FYM 10 t/ha which was statistically at par with 100% NPK + $ZnSO_4$, 125% NPK, 50% NPK + FYM 10 t/ha and 100% NPK treatments. However, the net returns (Rs 36315/ha) and B:C ratio (2.56) was higher with 125% NPK treatment while RWUE (24.2 and 24.0 kg/ha-mm) was higher with NPK (100% RDF) + $ZnSO_4$, and NPK (100% RDF) + FYM 10 t/ha, respectively (Table 3.58).

Table 3.58 : PMT: Effect on yield and economics of wheat- Ballowal Saunkhri

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	2017-18	Mean (3years)					
T_1: Control	1757	1996	3363	21874	18524	1.85	15.6
T_2: N (100% RDF) (80:40:30 kg NPK/ha)	2150	2496	4185	23499	26144	2.11	19.0
T_3: NP (100% RDF)	2183	2658	4144	25550	24539	1.96	19.3
T_4: NPK (100% RDF) (DAP)	2412	2780	4652	26278	29285	2.11	21.3
T_5: NPK (100% RDF (SSP)	2483	2763	4526	26628	29781	2.12	22.0
T_6: NPK (100% RDF) + $ZnSO_4$	2735	2991	5252	28824	34111	2.18	24.2
T_7: NPK (50% RDF) + FYM 10 t/ha	2417	2753	4507	31472	23742	1.75	21.4
T_8: NPK (100% RDF) + FYM 10 t/ha	2781	3054	5133	37035	25128	1.68	24.0
T_9: NPK (125% RDF)	2561	2980	5119	23219	36315	2.56	22.7
T_{10}: Organic (100% N through FYM)	2295	-	4244	38825	18671	1.48	20.3
T_{11}: Organic (100% N through FYM) + microbial consortia	2506	-	4296	39132	16984	1.43	22.2
CD at 5%	485	-	814				

The nutrient uptake by the crop was similar to that of yield in maize and wheat crops. Significant differences were observed among treatments and higher uptake of nutrients in grain and straw was recorded with the application of 125% NPK in maize and 100% NPK + FYM 10 t/ha in wheat (Table 3.59).

Table 3.59 : PMT: Effect on nutrients uptake (kg/ha) in maize and wheat - Ballowal Saunkhri

Treatment	Maize						Wheat					
	N		P		K		N		P		K	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1: Control	22.0	23.1	7.7	8.9	7.7	23.3	21.3	26.0	7.2	8.9	6.7	23.4
T_2: N (100% RDF)	32.0	28.9	12.7	12.5	10.6	33.0	28.0	35.8	10.2	11.7	9.4	30.9
T_3: NP (100% RDF)	33.1	31.5	13.2	12.4	10.1	32.7	27.4	33.6	10.3	10.9	8.2	28.8
T_4: NPK (100% RDF) (DAP)	44.1	43.9	17.0	17.3	14.3	46.4	30.7	38.9	11.7	12.7	9.3	33.8
T_5: NPK (100% RDF (SSP)	48.4	48.2	19.6	18.9	15.1	50.3	32.0	38.9	12.6	12.4	10.1	33.1
T_6: NPK (100% RDF) + $ZnSO_4$	48.7	47.0	20.6	19.5	16.0	51.5	34.6	45.8	13.7	14.7	11.4	38.8
T_7: NPK (50% RDF) + FYM 10 t/ha	48.7	50.4	19.9	19.5	16.2	50.2	30.0	37.8	8.1	12.5	9.7	32.3
T_8: NPK (100% RDF) + FYM 10 t/ha	56.0	53.4	22.6	22.4	17.1	58.1	35.6	45.8	14.4	14.7	10.8	38.0
T_9: NPK (125% RDF)	57.8	55.8	22.8	24.1	19.0	61.0	32.7	43.8	12.0	14.6	10.5	37.1
T_{10}: Organic (100% N through FYM)	40.4	40.7	16.9	16.5	14.2	41.4	27.6	35.2	11.1	11.7	10.0	29.5
T_{11}: Organic (100% N through FYM)+ consortia	45.9	45.4	18.7	19.6	14.8	47.8	31.3	36.7	11.7	12.8	9.9	31.1
CD at 5%	6.8	8.7	4.4	2.9	3.7	6.7	5.9	7.7	NS	2.6	2.1	6.4

At Rakh Dhiansar, in a permanent manurial trial (initiated in 1995) in maize based cropping system, significantly higher grain yield of maize (1823 kg/ha) was obtained with application of 50% recommended NPK + 50% N through FYM compared to other treatments except 50% recommended NPK + 50% N crop residue (1717 kg/ha) and 100% NPK + 20 kg $ZnSO_4$/ha. Similar trend was observed in net returns (Rs.13745/ha) and RWUE (3.46 kg/ha-mm). However, B:C ratio was higher (1.63) with application of 100% NPK + 20 kg $ZnSo_4$/ha. The mean data for the last 15 years (2004-2017) revealed that recommended dose of NPK (60:40:20/ha) coupled with 20 kg $ZnSO_4$/ha recorded the highest mean grain yield of 2058 kg/ha followed by application of 50% recommended NPK + 50% N through FYM and 100% recommended dose of NPK with grain yield of 1930 and 1915 kg/ha, respectively (Table 3.60).

Table 3.60 : PMT: Effect on maize yield and economics - Rakh Dhiansar

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (15 years)					
T_1: Control	683	1003	2813	17600	-1592	0.91	1.30
T_2: 100% NPK (60:40:20 kg/ha)	1508	1915	4669	20740	11524	1.56	2.86
T_3: 50% NPK (30:20:10 kg/ha)	1122	1418	3521	19170	4921	1.26	2.13
T_4: 50% N (crop residue)	1002	1378	3191	20900	707	1.03	1.90
T_5: 50% N (FYM)	1055	1409	3331	23600	-902	0.96	2.00
T_6: 50% NPK + 50% N (crop residue)	1717	1803	5296	23570	13116	1.56	3.26
T_7: 50% NPK + 50% N (FYM)	1823	1930	5600	25170	13745	1.55	3.46
T_8: FYM @ 10 t/ha	1445	1606	4611	25600	5587	1.22	2.74
T_9: 100% NPK + 20 kg $ZnSo_4$/ha	1600	2058	4931	20940	13243	1.63	3.04
T_{10}: Farmers method (FYM @ 4 t/ha + 40 kg N/ha urea)	1438	1610	3604	21566	7500	1.35	2.73
CD at 5%	263	-	-	-	-	-	-

The soil pH of different treatments ranged from 6.35 to 6.49. The maximum organic carbon content (0.57%) was recorded with application of FYM @ 10 t/ha followed by 50% recommended NPK + 50% N through FYM (0.54%), and 50% recommended NPK + 50% N through crop residue (0.49%). Integration of 50% recommended NPK + 50% N through FYM recorded higher available nitrogen (211.6 kg/ha), phosphorus (17.1 kg/ha) and potassium (133.5 kg/ha) compared to other treatments (Table 3.61).

Table 3.61 : PMT: Effect on soil chemical properties - Rakh Dhiansar

Treatment	pH	OC (%)	Available nutrients (kg/ha)		
			N	P	K
T_1: Control	6.41	0.26	136.2	12.5	77.1
T_2: 100% NPK (60:40:20 kg/ha)	6.35	0.40	165.5	14.8	107.3
T_3: 50% NPK (30:20:10 kg/ha)	6.37	0.34	157.2	13.7	86.5
T_4: 50% N (crop residue)	6.35	0.38	161.3	15.2	95.9
T_5: 50% N (FYM)	6.38	0.39	173.9	15.7	101.6
T_6: 50% NPK + 50% N (crop residue)	6.46	0.49	194.9	16.6	131.7
T_7: 50% NPK + 50% N (FYM)	6.49	0.54	211.6	17.1	133.5
T_8: FYM @ 10 t /ha	6.41	0.57	207.4	16.7	131.7
T_9: 100% NPK + 20 kg $ZnSo_4$/ha	6.37	0.42	176.0	15.4	118.5
T_{10}: Farmers method (FYM @ 4 t/ha + 40 kg N/ha urea)	6.40	0.43	184.4	14.8	107.2

At Rakh Dhiansar, significantly higher sarson seed yield (470 kg/ha) was recorded with application of FYM @ 10 t/ha applied during *Kharif* compared to other treatments except application of 50% recommended NPK + 50% N through FYM (424 kg/ha). Similarly, the highest net returns (Rs.3384/ha), B:C ratio (1.22) and RWUE (2.84 kg/ha-mm) were also recorded with application of FYM @ 10 t/ha. The mean data of 15 years revealed that the highest seed yield (1063 kg/ha) was recorded with application of FYM @ 10 t/ha to maize followed by 50% NPK + 50% N (FYM) with seed yield of 995 kg/ha (Table 3.62).

Table 3.62 : PMT: Residual effect on gobhi sarson yield and economics- Rakh Dhiansar

Treatment	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs./ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (15 years)				
T_1: Control	173	484	15410	-8478	0.45	1.05
T_2: 100% NPK (60:40:20 kg/ha)	353	751	15410	-1305	0.92	2.13
T_3: 50% NPK (30:20:10 kg/ha)	258	659	15410	-5071	0.67	1.56
T_4: 50% N (crop residue)	320	657	15410	-2598	0.83	1.94
T_5: 50% N (FYM)	323	796	15410	-2501	0.84	1.95
T_6: 50% NPK + 50% N (crop residue)	391	873	15410	241	1.02	2.37
T_7: 50% NPK + 50% N (FYM)	424	995	15410	1540	1.10	2.56
T_8: FYM @ 10 t /ha	470	1063	15410	3384	1.22	2.84
T_9: 100% NPK + 20 kg $ZnSo_4$/ha	370	800	15410	-598	0.96	2.24
T_{10}: Farmers method (FYM @ 4 t/ha + 40 kg N/ha urea)	392	878	15410	290	1.02	2.37
CD at 5%	46	-	-	-	-	-

Treatments receiving organics alone or in combination with inorganic fertilizers in *kharif* evinced beneficial residual effect on soil properties. The maximum organic carbon content (0.45%) was recorded with application of FYM @ 10 t/ha (T_8) followed by intégration of 50% recommended NPK + 50% N through FYM (0.44%) and 50% recommended NPK + 50% N through crop residue (0.41%). Available N ranged from 125.7 to 213.7 kg/ha wherein maximum available N and P was recorded with application of FYM @ 10 t/ha in *kharif*. Available K was higher (127.2 kg/ha) with application of 50% recommended NPK + 50% N through FYM (T_7) (Table 3.63).

Table 3.63 : Effect of treatments on soil chemical properties after harvest of gobhi sarson - Rakh Dhiansar

Treatment	OC (%)	Available nutrients (kg/ha)		
		N	P	K
T_1: Control	0.24	125.7	11.3	65.5
T_2: 100% NPK (60:40:20 kg/ha)	0.30	161.3	14.6	96.4
T_3: 50% NPK (30:20:10 kg/ha)	0.27	153.0	13.4	80.9
T_4: 50% N (crop residue)	0.33	155.1	13.9	88.6
T_5: 50% N (FYM)	0.35	171.8	14.8	92.5
T_6: 50% NPK + 50% N (crop residue)	0.41	192.8	16.1	123.3
T_7: 50% NPK + 50% N (FYM)	0.44	205.3	16.1	127.2
T_8: FYM @ 10 t /ha	0.45	213.7	16.3	119.5
T_9: 100% NPK + 20 kg $ZnSo_4$/ha	0.31	171.8	15.1	100.2
T_{10}: Farmers method (FYM @ 4 t/ha + 40 kg N/ha urea)	0.30	169.7	13.8	96.4

In an evaluation of foliar application of nutrients on wheat at Rakh Dhiansar, significantly higher grain yield of 2147 kg/ha was obtained with foliar spray of 0.5% K (KCl) $_+$ foliar spray of 0.5% N (urea) during dry spells compared to other treatments except combined foliar spray of 0.5% K (KNO_3) + foliar spray of 0.5% N (urea) with grain yield of 2117 kg/ha. Similarly, highest net returns of Rs.27875/ha, B:C ratio of 2.37 and RWUE of 22.0 kg/ha-mm was obtained with treatment T_5 (Table 3.64).

Wheat with foliar application 0.5% each of K and N

Table 3.64 : Effect of foliar spray on wheat yield and economics – Rakh Dhiansar

Treatment	Yield (kg/ha)		Mean grain yield (kg/ha) (3 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw					
T_1: Control (no spray)	778	1153	889	18300	-467	0.97	8.0
T_2: Foliar spray of 0.5% K (KNO_3)	1775	2586	1772	20451	20068	1.98	18.2
T_3: T_2 + Foliar spray of 0.5% N (urea)	2117	2967	2043	20492	27358	2.34	21.7
T_4: Foliar spray of 0.5% K (KCl)	1842	2561	1850	20337	21216	2.04	18.9
T_5: T_4 + Foliar spray of 0.5% N (urea)	2147	2936	2198	20372	27875	2.37	22.0
T_6: Foliar spray of 0.5% N (urea)	1908	2592	1920	20312	22496	2.11	19.6
T_7: Foliar spray of water	1600	2233	1604	20271	15862	1.78	16.4
CD at 5%	410						

The soil available N ranged from 153.9 to 198.0 kg/ha and the highest N was recorded with foliar spray of 0.5% N (urea) and 0.5% K (KCl), followed by foliar spray of 0.5% N (urea) and 0.5% K (KNO_3) during dry spells. Similar trend was also observed in available P and K. The highest organic C content (0.31%) was recorded with foliar spray of 0.5% N (urea) and 0.5% K (KCl) (Table 3.65).

Table 3.65 : Effect of treatments on soil chemical properties - Rakh Dhiansar

Treatment	pH	OC (%)	Available nutrients (kg/ha)		
			N	P	K
T_1: Control (no spray)	6.64	0.23	153.9	11.3	85.2
T_2: Foliar spray of 0.5% K (KNO_3)	6.61	0.27	179.8	13.4	105.1
T_3: T_2 + Foliar spray of 0.5% N (urea)	6.62	0.29	189.2	15.0	110.7
T_4: Foliar spray of 0.5% K (KCl)	6.57	0.26	183.9	15.4	108.8
T_5: T_4 + Foliar spray of 0.5% N (urea)	6.56	0.31	198.0	15.5	115.0
T_6: Foliar spray of 0.5% N (urea)	6.53	0.27	187.2	15.3	106.9
T_7: Foliar spray of water	6.57	0.27	177.6	14.0	104.7

3.2.4 Energy management

At Arjia, in an experiment on farm mechanization in maize for improving the timeliness and precision in farm operations, sowing with bullock drawn implement + interculture with bullock drawn *kulpha* + harvesting manually, and sowing with tractor + interculture with tractor drawn weeder + harvesting by tractor drawn ripper were found at par with respect to grain yield of maize (2748 – 2813 kg/ha). However, sowing with tractor drawn seed drill + interculture with tractor drawn weeder + harvesting with ripper recorded highest net returns (Rs.39487/ha), B:C ratio (2.85) and maximum saving in time (82%). Whereas, sowing with tractor + interculture by power weeder + harvesting by ripper gave maximum saving in cost (47%) as compared to farmers' practice (Table 3.66 & 3.67).

Table 3.66 : Yield and economics under different farm mechanization operations in maize - Arjia

Treatment	Grain		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (2 years)					
T_1: Sowing bullock drawn + manual interculture + manual harvesting	2325	2084	4761	19045	24953	1.31	3.33
T_2: Sowing with two row bullock drawn seed drill + interculture with bullock drawn *kulpha* + manual harvesting	2813	2612	5523	15445	39389	2.55	4.17
T_3: Sowing with tractor drawn seed drill + interculture Arjia wheel hoe + manual harvesting	2419	2176	4693	14915	30729	2.06	3.48
T_4: Sowing with tractor drawn seed drill + interculture with power weeder + harvesting with ripper	2476	2299	5052	14045	34719	2.47	3.67
T_5: Sowing with tractor drawn seed drill + interculture with tractor drawn weeder + harvesting with ripper	2748	2543	5353	13845	39487	2.85	4.06
CD at 5%	321	683	-	-	-	-	-

Table 3.67 : Saving of time (hr) and cost (Rs) under different mechanization systems in maize - Arjia

Treatment	Sowing		Interculture		Harvesting		Total		Saving (%)	
	Time	Cost	Time	Cost	Time	Cost	Time	Cost	Time	Cost
T_1: Sowing bullock drawn + manual interculture + manual harvesting	13.5	1700	360	8900	64.0	1600	437.5	12200	-	-
T_2: Sowing with two row bullock drawn seed drill + interculture with bullock drawn *kulpha* + manual harvesting	6.5	1700	94	5300	64.0	1600	164.5	8600	64	30
T_3: Sowing with tractor drawn seed drill + interculture Arjia wheel hoe + manual harvesting	2.02	1400	200	5100	64.0	1600	266.2	8100	40	34
T_4: Sowing with tractor drawn seed drill + interculture with power weeder + harvesting with ripper	2.02	1400	90	3700	2.4	1200	94.4	6600	80	47
T_5 - Sowing with tractor drawn seed drill + interculture with tractor drawn weeder + harvesting with ripper	2.02	1400	82	4300	2.4	1200	86.4	7500	82	39

At Rakh Dhiansar, in an experiment on effect of different tillage and nutrient management practices in maize, there were significant differences among the tillage treatments and nutrient management. T_3 (50% CT + herbicide + interculture) in combination with application of 50% N (30 kg/ha) through organic manure + 50% N through inorganic fertilizer (F_2) recorded the highest grain yield of 2439 kg/ha followed by T_2 (50% CT + interculture) in combination with application of 50% N through organic manure + 50% N through inorganic fertilizer (F_2) with a grain yield of 2175 kg/ha (Table). T_3 (50% CT + herbicide + interculture) with application of 50% N (30 kg/ha) through organic manure + 50% N through inorganic fertilizer (F_2) also recorded higher net returns (Rs 25683/ha), B:C ratio (2.26) and RWUE (2.97 kg/ha-mm) compared to other treatments (Table 3.68).

Table 3.68 : Effect of treatments on maize yield and economics - Rakh Dhiansar

Treatment		Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Main treatment	**Sub treatment**	**Grain**	**Stover**				
T_1: Conventional tillage (CT) + interculture	F_1: 100% N (60 kg: organic manure)	1758	4600	20610	15312	1.74	1.90
	F_2: 50% N (inorganic + 50% N organic)	2092	5003	19760	22044	2.12	2.42
	F_3: 100% N (inorganic fertilizers)	1883	4739	18710	19390	2.04	2.10
	Mean	**1911**	**4781**	**19693**	**18916**	**1.96**	**2.14**
T_2: 50% CT + interculture	F_1: 100% N (60 kg: organic manure)	1842	4392	20400	16382	1.80	2.03
	F_2: 50% N (inorganic + 50% N organic)	2175	4906	19340	23532	2.22	2.56
	F_3: 100% N (inorganic fertilizers)	1981	4627	18590	20775	2.12	2.25
	Mean	**1999**	**4641**	**19443**	**20224**	**2.04**	**2.28**
T_3: 50% CT + herbicide + interculture	F_1: 100% N (60 kg: organic manure)	2092	4086	21400	18570	1.87	2.42
	F_2: 50% N (inorganic + 50% N organic)	2439	4475	20340	25683	2.26	2.97
	F_3: 100% N (inorganic fertilizers)	2064	4156	19590	20095	2.03	2.38
	Mean	**2198**	**4239**	**20443**	**21445**	**2.05**	**2.59**

At Rakh Dhiansar, in an experiment on effect of different tillage and nutrient management practices in wheat on resource conservation and improving soil quality, there were significant differences among tillage and nutrient management. The tillage treatment T_2 (50% CT + interculture) recorded the highest grain yield of wheat (1492 kg/ha) and among the nutrient management treatments, application of 100% N (inorganic fertilizers) recorded higher grain yield. The interactions of different tillage and nutrient management practices revealed that treatment combination T2F3 (50% CT + interculture and 100% N (inorganic fertilizers)) recorded highest grain yield (1729 kg/ha), compared to other treatments. Similar trend was observed in case of net returns, B:C ratio and RWUE (Table 3.69).

Table 3.69 : Effect of tillage and nutrient management on wheat yield and economics –Rakh Dhiansar

Treatment		Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs./ha)	B:C ratio	RWUE (kg/ha-mm)
Main treatment	**Sub treatment**	**Grain**	**Straw**				
T_1: Conventional tillage (CT) + interculture	F_1: 100% N (60 kg: organic manure)	1228	1663	22100	5428	1.25	13.61
	F_2: 50% N (inorganic + 50% N organic)	1265	2022	19500	10093	1.52	14.02
	F_3: 100% N (inorganic fertilizers)	1447	2571	18100	16783	1.93	16.04
	Mean	**1313**	**2085**	**19900**	**10766**	**1.54**	**14.56**

Treatment		Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs./ha)	B:C ratio	RWUE (kg/ha-mm)
Main treatment	**Sub treatment**	**Grain**	**Straw**				
T_2: 50% CT + interculture	F_1: 100% N (60 kg: organic manure)	1340	2103	19500	11692	1.60	14.86
	F_2: 50% N (inorganic + 50% N organic)	1407	2294	18000	15095	1.84	15.60
	F_3: 100% N (inorganic fertilizers)	1729	2326	16800	21897	2.30	19.17
	Mean	**1492**	**2241**	**18100**	**16228**	**1.90**	**16.54**
T_3: 50% CT + herbicide + interculture	F_1: 100% N (60 kg: organic manure)	1118	1690	20200	5566	1.28	12.39
	F_2: 50% N (inorganic + 50% N organic)	1361	2057	18700	12665	1.68	15.09
	F_3: 100% N (inorganic fertilizers)	1365	2233	17200	14937	1.87	15.13
	Mean	**1281**	**1994**	**18700**	**11058**	**1.59**	**14.21**

Maximum energy output (54491 MJ/ha) and energy use efficiency (7.6) was recorded in 50% conventional tillage + interculture + 100% N through inorganic fertilizer. However, the energy input was highest (7200 MJ/ha) with conventional tillage + interculture + 100% N through inorganic fertilizers compared to other treatments (Table 3.70).

Table 3.70 : Effect of tillage and nutrient management on energy use in wheat –Rakh Dhiansar

Treatment		Energy (MJ/ha)		Energy use efficiency
Main treatment	**Sub treatment**	**Input**	**Output**	
T_1: Conventional tillage (CT) + interculture	F_1: 100% N (organic manure)	6950	38839	5.6
	F_2: 50% N (inorganic + 50% N organic)	7050	43871	6.2
	F_3: 100% N (inorganic fertilizers)	7200	53408	7.4
	Mean	**7067**	**45369**	**6.4**
T_2: 50% CT + interculture	F_1: 100% N (organic manure)	6870	45986	6.7
	F_2: 50% N (inorganic + 50% N organic)	6970	49358	7.1
	F_3: 100% N (inorganic fertilizers)	7150	54491	7.6
	Mean	**6997**	**49945**	**7.1**
T_3: 50% CT + herbicide + interculture	F_1: 100% N (organic manure)	6910	37560	5.4
	F_2: 50% N (inorganic + 50% N organic)	7010	45719	6.5
	F_3: 100% N (inorganic fertilizers)	7180	47978	6.7
	Mean	**7033**	**43761**	**6.2**

3.2.5 Alternate land use systems

At Ballowal Saunkhri, in a study on evaluation of eucalyptus based agroforestry system under different spacings, eucalyptus planting geometry had no significant effect on its plant height and collar diameter. Grain yield of greengram and wheat was significantly higher in sole cropping as compared to eucalyptus based agroforestry systems. Eucalyptus planted at 4 m x 2 m, 8 m x 2 m and 8 m x 2 m paired rows had only 70, 87.5 and 75% area available for raising crops, respectively. There was no effect of eucalyptus on greengram and wheat during first year. System productivity of sole greengram - wheat system was significantly higher (6369 kg/ha) with higher net returns of Rs. 42631/ha and B:C ratio (1.76) as compared to eucalyptus based agroforestry systems and sole eucalyptus (Table 3.71).

Table 3.71 : Effect of eucalyptus planting geometry on eucalyptus growth and system productivity – Ballowal Saunkhri

Treatment	Eucalyptus		Yield (kg/ha)			System productivity (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Plant height (cm)	Collar diameter (cm)	Sole green gram	Sole wheat	Wheat straw				
T_1: Eucalyptus (4 m x 2 m) + greengram-wheat	230	1.97	394	2135	3562	4811	108195	-38786	0.64
T_2: Eucalyptus (8 m x 2 m) + greengram-wheat	197	1.85	469	2576	3879	5365	89928	-7803	0.91
T_3: Eucalyptus (8 m x 2 m) (paired row) + greengram-wheat	192	1.73	346	1972	3272	4369	98827	-35778	0.64
T_4: Sole eucalyptus (4 m x 2 m)	225	1.84	-	-	-	-	63195	-63195	0.00
T_5: Sole eucalyptus (8 m x 2 m)	199	1.67	-	-	-	-	40191	-40191	0.00
T_6: Sole eucalyptus (8 m x 2 m) (paired row)	210	1.79	-	-	-	-	54318	-54318	0.00
T_7: Sole greengram- sole wheat system	-	-	556	2965	4608	6369	53194	42631	1.76
CD at 5%	NS	NS	64.5	197	352	305	-	-	-

Eucalyptus + greengram

Eucalyptus + wheat

At Rakh Dhiansar, in an experiment on evaluation and development of alternate land use systems for rainfed conditions of Jammu, sole wheat grown under maize-wheat system (cereal-cereal) recorded higher wheat equivalent yield (2180 kg/ha), net returns (Rs.30212/ha), B:C ratio (2.40) and RWUE (28.31 kg/ha-mm). While, the lowest values of wheat equivalent yield was recorded with agri-horti-silvi-pastoral system (Guava + *Melia* + *Setaria* Spp.+ maize- Gobhi sarson) (1037 kg/ha) (Table 3.72).

Table 3.72 : Yield and economics of crops under different agri-horti-silvi-pastoral systems – Rakh Dhiansar

Treatment	Crop	Wheat equivalent yield (kg/ha)	NMR (Rs./ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Agri-horti-silvi-pastoral system: Guava + *Melia* + *Setaria* Spp. + maize-wheat	Wheat	1970	25065	2.16	25.58
T_2: Agri-horti-silvi-pastoral system: Guava + *Melia* + *Setaria* Spp. + maize- Gobhi sarson	Gobhi sarson	1037	2420	1.15	13.47
T_3: Agri-horti-silvi-pastoral system: Guava + *Melia* + *Setaria* Spp. + blackgram-wheat	Wheat	2020	26653	2.23	26.23
T_4: Agri-horti-silvi-pastoral system: Guava + *Melia* + *Setaria* Spp. + blackgram-Gobhi sarson	Gobhi sarson	1060	2821	1.18	13.77
T_5: Control (maize-wheat)	Wheat	2180	30212	2.40	28.31
CD at 5%	-	196	-	-	-

3.3 Nutritious Cereal Based Production System

3.3.1 Sorghum Based Production System

3.3.1.1 Rainwater management

At Vijayapura, in an experiment on catchment storage command area relationship for increasing water productivity in microwatershed to cope up with dry spells, one supplemental irrigation of 5 cm depth was given at the flowering stage of both chickpea + sorghum intercropping (2:4) and sole chickpea crops, through the MIS (sprinkler system) from the farm pond (Table 3.73). In the irrigated plot, an additional yield of 40.0 and 33.3% was recorded in sorghum + chickpea and chickpea crop respectively (Table 3.74).

Table 3.73 : Details of the farm pond used for supplemental irrigation - Vijayapura

Pond dimension (m)				Height (m)	Volume (m^3)	Side slope	Year of construction	Type of soil	Type of lining	Lifting pump
Top		Bottom								
L	W	L	W							
30	30	21	19	3	1800	2:1	1981	Black cotton	No lining	Solar pump 1.2 hp

Table 3.74 : Effect of supplemental irrigation on different crops – Vijayapura

Crop	Seed/grain yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (2008-17)				
T_1: Chickpea *(in sapota)**	770	634	9000	22570	2.51	3.6
T_2: Control	550	469	8000	14550	1.82	2.6
T_3: Chickpea + sorghum (4:2)* (SEY in *rabi)*	1102	1157	9000	18550	2.06	5.1
T_4: Control	828	830	8000	12700	1.59	3.8

*5 cm depth of irrigation water was applied at critical stages of chickpea and sorghum

The Table 3.75, depicts the relationship of rainfall, rainfall intensity and volume of water harvested during 2017. During the period, a total of 12 runoff events were recorded and 1350 cum of water was harvested.

Table 3.75 : Rainfall intensity and volume of water harvested – Vijayapura

Date	Rainfall	Rainfall intensity, * (mm/hr)		Volume of water harvested (cum)	Cumulative Volume of water harvested (cum)
		1	2		
15-08-2017	33.8	45.0	35.0	205	205
24-08-2017	23.6	12.0	55.2	58	263
25-08-2017	14.6	28.0	0.9	10	273
26-08-2017	15.0	1.6	-	14	287
07-09-2017	11.4	13.2	117.6	0	287
08-09-2017	51.4	26.4	20.8	74	387
14-09-2017	40.4	20.7	20.7	14	375
07-10-2017	16.6	26.4	20.8	39	414
10-10-2017	31.6	67.5	8.8	29	443
11-10-2017	24.8	27.1	-	93	536
12-10-2017	12.4	43.3	2.4	270	806
13-10-2017	36.8	45.0	-	544	1350

The details of the water balance components of farm pond (Table 3.76), revealed that 59.4% of water can be used for irrigation, 9.1% as seepage losses, 27.2% goes as evaporation and 6.9% harvested rainwater remained as dead storage which can be used as livestock drinking water and for nutrient/pesticide sprays during the cropping season.

Table 3.76 : Details of water balance components of farm pond – Vijayapura

Parameter	Year						Average (mm)	% harvested rain water
	2008	2009	2013	2014	2015	2017		
Rainfall (mm)	621.5	1196.3	711.1	736.8	654.5	746.9	777.8	-
Evaporation (mm)	790 (493.7 m^3)	970 (606 m^3)	1011 (710 m^3)	936 (585 m^3)	930 (575 m^3)	788 (489 m^3)	930 (578.5 m^3)	27.2
Water harvested (mm)	1560	2010	3107	2375	2401	1350	2133.8	-
Seepage losses (m^3)	156	198	200	190	210	200	192.3	9.1
Used for irrigation (m^3)	754	1050	2113	1444	1449	800	1268.3	59.4
Dead storage at the end of the season (m^3)	156	156	100	156	162	156	147.7	6.9

Sorghum + chickpea (2:4)

Rainwater harvested in farm pond

At Vijayapura, in a study for minimizing the evaporation losses in farm pond, the evaporation losses from stored rainwater (pilot study) were quantified for the period from April 2017 to March 2018 (Fig. 3.2). It was observed that least evaporation was recorded with application of steryl alcohol @ 2 ml/m^2 every fortnight (120.9 cm) followed by silicon oil @ 5 ml/m^2 (122.6 cm). The highest evaporation was observed in control (216.4 cm). The reduction in evaporation with alcohol containing chemicals was about 60-70% over the control, while it was 25% with organic retardants. The highest evaporation was recorded during April and May months, while least was observed during September and October months (Fig. 3.2).

The cost of different treatments and recommended doses of application and frequency of application is given in Table 3.77.

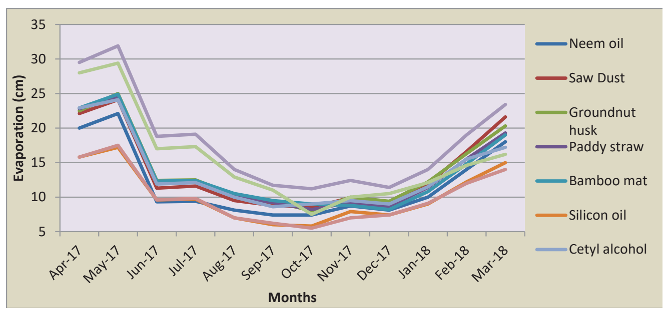


Fig. 3.2: Evaporation as influenced by different treatments - Vijayapura

Table 3.77 : Dose and cost of different evaporation retardants - Vijayapura

Treatment	Unit cost (Rs/lit)	Dose per application @ every fortnight (ml/sqm)	Cost of retardant for 100 Sqm*
Neem oil	200	10	1600
Saw Dust	15	Covering entire pond surface	1050
Groundnut husk	10	Covering entire pond surface	850
Paddy straw	5	Covering entire pond surface	550
Bamboo mat	50/sqm	Covering entire pond surface	-
Silicon oil	3000	5	12000
Cetyl alcohol	1300	2	2080
Steryl alcohol	875	2	1400
Polyvinyl alcohol	1700	2	2720

*It is assumed that water is available for four months, the total cost of retardants

Cetyl Alcohol

Saw dust

Paddy straw

At Vijayapura, in an evaluation of performance of solar pumpset for lifting of farm pond water, the solar pump installed to lift the farm pond water with a pump capacity was 1 KW (1.2 hp VFD), with1 KW capacity photo voltic solar panels. During the *rabi* season, the solar pump was successfully used to irrigate the chickpea and sorghum crops. During the peak sunshine hours, 8-10 numbers of sprinklers were run with the water spreading diameter of 12-15 m. The relationship between sunshine hours, radiation and frequency was established (Table 3.78).

Table 3.78 : Performance of solar pump during 2017-18 - Vijayapura

Date/time	Freq (Hz.)	Current (Ah)	No of sprinkler guns	Diameter (m)	Remarks
4/12/2017 10:30	38.7	4.1	10	12	
4/12/2017 12.23	34.8	3.7	10	1.5	Fixed sprinkler guns
4/12/2017 12.00	43..8	4.5	8	15.7	

Micro - irrigation (sprinkler) in chickpea + sorghum (4:2)

Micro - irrigation (sprinkler) in chickpea + sapota system

In another experiment on determination of crop management factor values at Vijayapura, pigeonpea was grown as test crop during *kharif* season. Eight runoff causing rainfall events (501 mm) occurred during the season and runoff recorded from cropped area was 18% and non-cropped area was 27.6%, the reduction in runoff was conserved in the soil which was evident from the soil moisture distribution (Fig. 3.3). The crop factor “C” for pigeonpea was calculated as 0.30 (Table 3.79). The pooled data from 2013 to 2017 revealed that the crop factor “C” for cucumber varied from 0.38-0.49, greengram 0.5, sorghum 0.67-0.86, sunflower 0.40 and pigeonpea 0.28-0.30 (Table 3.80).

Table 3.79 : Runoff, soil loss and crop factor values for pigeonpea - Vijayapura

Treatment	Rainfall (mm)	Runoff (m^3/ha)	Soil loss (kg/ha)	Crop factor
T_1: With crop	501.0	906.5	1154.7	0.3
T_2: Without crop	501.0	1380.7	3806.0	

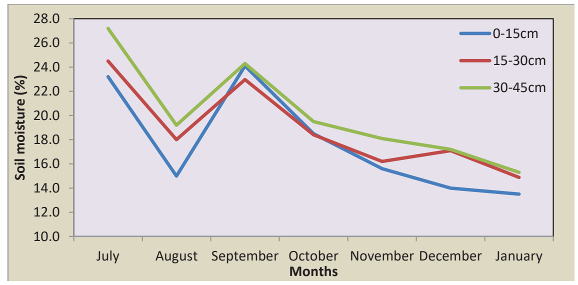


Fig. 3.3: Moisture distribution in plots under pigeonpea during kharif 2017 - Vijayapura

Table 3.80 : Crop management factor values of various crops (2013-2017) - Vijayapura

Year	Treatment	Crop	Runoff causing rainfall (mm)	Runoff (m^3/ha)	Soil loss (q/ha)	Crop management factor
Kharif						
2013	Cropped	Cucumber	143.2	102.7	2.40	0.49
	Fallow			172.1	4.86	
2015	Cropped	Green gram	9.8	5.97	0.74	0.5
	Fallow			7.45	1.47	
2015	Cropped	Cucumber	197.0	297	6.63	0.38
	Fallow			524.31	17.44	
Rabi						
2012	Cropped	Sorghum	59.8	33.7	2.5	0.86
	Fallow			39.3	2.9	
2013	Cropped	Sorghum	164.8	73.8	5.4	0.67
	Fallow			115.7	8.06	
2014	Cropped	Sorghum	75.6	234.4	25.70	0.73
	Fallow			253.03	35.30	
2015	Cropped	Sunflower	53.9	66.83	24.45	0.54
	Fallow			91.73	45.16	
Bi seasonal						
2016	Cropped	Pigeonpea	162.0	138.1	0.76	0.28
	Fallow			271.7	2.70	
2017	Cropped	Pigeonpea	501.0	906.5	11.54	0.3
	Fallow			1380	38.06	

Cucumber in runoff plots

Sunflower in runoff plots

Sorghum in runoff plots

In another experiment at Vijayapura on optimization of compartment bund size for increasing crop productivity, chickpea recorded the highest yield in compartment bund size 6 m × 6 m (624.1 kg/ha) with higher RWUE (2.9 kg/ha-mm) and net returns (Rs.13807/ha) using tractor drawn bund former compared to control (340 kg/ha) and 621.9 kg/ha using bullock drawn compartment bund former when compare to control 327.8 kg/ha (Table 3.81).

Table 3.81 : Yield and economics of chickpea as affected by compartmental bund - Vijayapura

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE
TT_1	624	1200	8035	13807.6	2.7	2.9
TT_2	454	800	8230	7674.20	1.9	2.11
TT_3	374	750	8350	4729.60	1.6	1.73
TT_4	402	784	8420	5657.80	1.7	1.87
BT_1	622	1250	9160	12604.8	2.4	2.89
BT_2	465	820	9536	6752.6	1.7	2.16
BT_3	392	740	9370	4357.8	1.5	1.82
BT_4	411	770	8610	5759.4	1.7	1.91
Control	340	650	7570	4330	1.6	1.58
CD at 5%	133	-	-	-	-	-

TT: Tractor drawn compartment bund; BT: Bullock drawn compartment bund; T_1: 6 m x 6 m compartment bund; T_2: 4.5 m x 4.5 m compartment bund; T_3: 3 m x 3 m compartment bund; T_4: 2 m x 2 m compartment bund

Bullock drawn compartment bund former

Tractor drawn compartment bund former

Chickpea with tractor drawn bund former

3.3.1.2 Cropping systems

At Vijayapura, a study on response of onion to crop geometry and nutrient management revealed that the crop geometry of 45 cm × 10 cm gave significantly higher bulb yield (2895 kg/ha), net returns (Rs.31762/ha), B:C ratio (2.48) and RWUE (14.7 kg/ha-mm) as compared to 30 cm × 10 cm and 30 cm criss cross sowing. Among the nutrient management, application of 93.8:37.5:93.8 kg N, P_2O_5 and K_2O/ha gave significantly higher bulb yield (2661 kg/ha) as compared to other nutrient levels except 62.5:25:62.5 kg N, P_2O_5 and K_2O/ha (Table 3.82). However, the later treatment gave higher net returns (Rs.31813/ha), B:C ratio (2.50) and RWUE (14.3 kg/ha-mm) than other treatments. Crop geometry of 45 cm × 10 cm with application of 62.5:25:62.5 kg N, P_2O_5 and K_2O/ha gave significantly higher bulb yield (6281 kg/ha) as compared to other treatment combinations (Table 3.83).

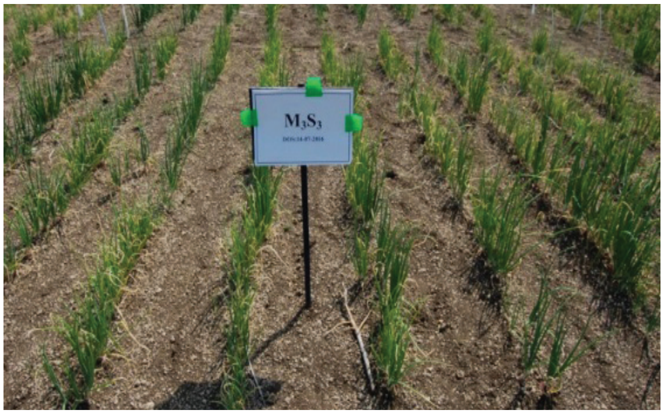
Table 3.82 : Effect of crop geometry and nutrient management on onion bulb yield and economics - Vijayapura

Treatment	Bulb yield (kg/ha) (2017-18)	Bulb yield (kg/ha) (3 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Crop geometry (CG)						
T_1: 30 cm with criss cross sowing	1754	4675	22006	19594	1.92	11.7
T_2: 30 cm × 10 cm	2792	5374	22006	27687	2.30	13.3
T_3: 45 cm × 10 cm	2895	5907	22006	31762	2.48	14.7
CD at 5%	207	226	-	2135	0.10	0.54
Nutrient management (N:P_2O_5: K_2O kg/ha) (NM)						
N_1: 125:50:125	2203	4921	24979	19233	1.77	12.3
N_2:93.75:37.5:93.75	2661	5229	22054	24206	2.05	13.1
N_3: 62.5:25:62.5	2622	5802	21242	31813	2.50	14.3
N_4: 30:10:30	2437	5323	19749	30139	2.61	13.1
CD at 5%	188	146	-	1508	0.07	0.35

Table 3.83 : Interaction effect of crop geometry and nutrient management on bulb yield - Vijayapura

Crop geometry (CG)	Nutrient management (N, P_2O_5 and K_2O kg/ha)				Mean
	125:50:125	93.75:37.5:93.75	62.5:25:62.5	30:10:30	
T_1: 30 cm with cris cross sowing	4192	4701	5248	4560	4675
T_2: 30 cm × 10 cm	4970	5196	5876	5452	5374
T_3: 45 cm × 10 cm	5602	5789	6281	5956	5907
Mean	4921	5229	5802	5323	-

For comparing the means of	S.Em ±	CD at 5%
Crop geometry (CG)	58	226
Nutrient management (NM)	49	146
NM at the same level of CG	85	213
CG at the same/different levels of NM	94	254



Onion with 45 cm × 10 cm and 30:10:30 kg N, P_2O_5 and K_2O/ha

Onion with 30 cm × 10 cm and 125:50:125 kg N, P_2O_5 and K_2O/ha

In another study on response of clusterbean genotypes to crop geometry at Vijayapura, among the planting geometry, 30 cm × 10 cm being on par with 45 cm × 10 cm and 45 cm × 15 cm gave significantly higher seed yield (498 kg/ha) compared to other treatments. Closer spacing (30 cm × 10 cm) also recorded higher net returns (Rs.65209/ha), B:C ratio (7.50) and RWUE (0.80 kg/ha-mm) than other treatments. Among the genotypes, RGC 1033 recorded significantly higher seed yield (444 kg/ha), net returns (Rs.55937/ha) and B:C ratio (6.5) compared to other genotypes except RGC 1038 (Table 3.84).

Table 3.84 : Effect of crop geometry on yield and economics of clusterbean genotypes - Vijayapura

Treatment	Seed yield (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (2 years)			
Spacing					
M_1: 30 cm × 10 cm	498	377	65209	7.5	0.8
M_2: 45 cm × 10 cm	494	369	63772	7.3	0.8
M_3: 45 cm × 15 cm	482	362	62248	7.2	0.7
M_4: 45 cm × 20 cm	340	269	43701	5.3	0.6
M_5: 60 cm × 10 cm	328	265	43026	5.3	0.6
M_6: 60 cm × 20 cm	286	239	37808	4.8	0.5
CD at 5%	29	27	3698	0.37	0.04
Genotype					
S_1: RGC 938	409	323	54548	6.4	0.7
S_2: RGC 1033	444	330	55937	6.5	0.7
S_3: RGC 1038	426	317	53243	6.3	0.6
S_4: RGC 1066	340	276	46781	5.6	0.6
CD at 5%	18	19	2041	0.20	0.02

Clusterbean - geometry of 30 cm × 10 cm with var. RGC 938

Clusterbean - geometry of 45 cm × 10 cm with var. RGC 938

In another study at Vijayapura on evaluation of chickpea genotypes under different crop geometry and nutrient levels, chickpea at a spacing of 45 cm × 20 cm being on par with 45 cm × 10 cm gave significantly higher seed yield (1716 kg/ha) with higher net returns (Rs.37399/ha) and B:C ratio (3.87) as compared to 30 cm × 10 cm and 60 cm × 10 cm. Among the genotypes, JG 11 and JAKI 9218 produced significantly higher seed yield of 1678 and 1644 kg/ha as compared to GBM 2 (1450 kg/ha), JG 11 also recorded higher net returns (Rs.35912/ha) and B:C ratio (3.63) than other varieties. There was significant difference in seed yield due to nutrient levels. Interaction effect among spacing and genotypes and nutrient levels revealed that, GBM 2 and JG 11 at spacing 45 cm × 10 cm gave significantly higher seed yields as compared to other treatments (Table 3.85).

Table 3.85 : Effect of crop geometry, genotypes and nutrient management on chickpea yield and economics - Vijayapura

Treatment	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (3 years)				
Crop geometry						
S_1: 30 cm × 10 cm	1416	1260	18373	24741	2.69	26.8
S_2: 45 cm × 10 cm	1698	1537	17673	36130	3.59	34.5
S_3: 45 cm × 20 cm	1716	1536	16372	37399	3.87	34.0
S_4: 60 cm × 10 cm	1594	1447	16873	33775	3.55	31.6
CD at 5%	87	48	-	1688	0.08	1.9
Genotype						
G_1: GBM 2	1450	1297	17573	27812	3.05	26.2
G_2: Jaki 9218	1644	1511	17572	35311	3.58	34.3
G_3: JG 11	1678	1528	17573	35912	3.63	34.6
CD at 5%	57	32	-	1086	0.08	1.5
Nutrient management (NPK kg/ha)						
F_1: 10:25:0	1587	1444	17227	33306	3.49	32.0
F_2: 15:37.5:0	1625	1447	17918	32717	3.36	31.4
CD at 5%	43	NS	-	NS	0.07	1.0

Chickpea Var. JG 11 with 45 cm × 10 cm + 10:25:0 kg N, P_2O_5:K_2O/ha

Chickpea Var. JG 11 with 30 cm × 10 cm + 10:25:0 kg N, P_2O_5:K_2O/ha

At Solapur, in a study on sorghum + fodder cowpea strip cropping systems, sole sorghum recorded highest yield (1525 kg/ha), net returns (Rs.28620/ha), B:C ratio (2.16) and RWUE (7.04 kg/ha-mm). Among strip crop combinations, sorghum + cowpea (4:4) system recorded maximum grain yield (1264 kg/ha), and RWUE (5.84 kg/ha-mm), while sorghum + cowpea (3:3) recorded higher net returns (Rs.23755/ha) compared to other intercrop combinations (Table 3.86).

Table 3.86 : Fodder yield and economics of sorghum + cowpea fodder strip cropping system - Solapur

Treatment	Sorghum yield (kg/ha)	Cowpea yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Sole sorghum	1525	-	28620	2.16	7.04
T_2: Sole cowpea	-	5811	-9972	0.58	0.0
T_3: Sorghum + cowpea (2:4)	659	2817	7106	1.28	3.04
T_4: Sorghum + cowpea (2:6)	985	3506	17248	1.70	4.58
T_5: Sorghum + cowpea (3:3)	1234	2640	23755	1.96	5.70
T_6: Sorghum + cowpea (4:4)	1264	2087	22514	1.91	5.84

Treatment	Sorghum yield (kg/ha)	Cowpea yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_7: Sorghum + cowpea (6:6)	970	2514	15914	1.64	4.48
T_8: Sorghum + cowpea (2:1)	1077	1565	14833	1.60	4.97
T_9: Sorghum + cowpea (2:1)	1052	1492	16029	1.65	4.85
CD at 5%	201	1264			

Sorghum + cowpea (2:6)

Sorghum + cowpea (4:4)

3.3.1.3 Nutrient management

At Vijayapura in the Permanent Manurial Trial (PMT), in *rabi* sorghum + chickpea (2:4) rotated with safflower every year, in sorghum + chickpea (2:4) intercropping system, significantly higher sorghum equivalent yield (2066 kg/ha) was recorded with 50% N through sunhemp + 50% N through inorganic sources, followed by 50% N through vermicompost + 50% N through inorganic sources (1655 kg/ha). Application of 50% N through sunhemp + 50% inorganic sources also recorded higher net returns (RS.27109/ha), B:C ratio (3.30) and RWUE (73.8 kg/ha-mm) compared to other treatments (Table 3.87). Different treatments had no significant effect on soil pH. The soil organic C and available N were highest (0.43% and 197 kg/ha) with application of 50% N through FYM + 50% N through inorganics compared to other treatments. Available P was higher (14.2 kg/ha) in plots under 50% N through vermicompost + 50% N through inorganic sources. Application of 50% N through FYM + 50% N through inorganic sources recorded maximum available K (414.7 kg/ha) compared to other treatments (Table 3.88).

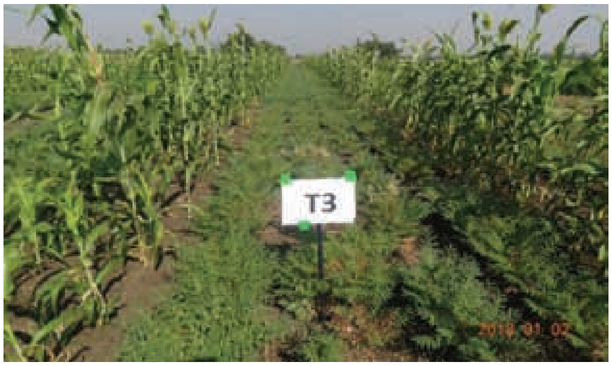
Table 3.87 : PMT: Effect on yield of crops and economics - Vijayapura

Treatment	Seed yield (kg/ha)		MCEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Rabi sorghum	Chickpea					
T_1: Control	370	570	1283	9200	16453	2.79	46.8
T_2: RPP	566	861	1943	12060	26803	3.22	70.9
T_3: 50% N through FYM + 50% N through inorganic sources	602	915	2066	19280	22031	2.14	75.4
T_4: 50% N through vermicompost + 50% N through inorganic sources	545	848	1902	18520	19520	2.05	69.4
T_5: 50% N through sunhemp + 50% N through inorganic sources	576	905	2023	13358	27109	3.03	73.8
T_6: 50% N through glyricidia loppings + 50% N through inorganic sources	463	786	1721	11392	23026	3.02	62.8
T_7: 50% N through crop residues + 50% N through inorganic sources	478	820	1790	14616	21181	2.45	65.3
CD at 5%	98	150	282	-	5636	0.43	10.3

MCEY: Main crop equivalent yield (*Rabi* sorghum); RPP: 50:25 kg NP/ha

Table 3.88 : PMT: Effect on soil chemical properties

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)		
			N	P	K
T_1: Control	7.94	0.41	181.3	12.9	389.0
T_2: RPP	7.92	0.42	189.7	13.4	384.7
T_3: 50% N through FYM + 50% N through ino ganic sources	7.97	0.43	197.0	14.1	414.7
T_4: 50% N through vermicompost + 50% N through inorganic sources	7.99	0.44	196.0	14.2	410.3
T_5: 50% N through sunhemp + 50% N through inorganic sources	7.96	0.42	193.0	14.0	413.3
T_6: 50% N through glyricidia loppings + 50% N through inorganic sources	7.95	0.43	192.3	13.7	395.3
T_7: 50% N through crop residues + 50% N through inorganic sources	7.96	0.41	188.7	13.6	399.0
CD at 5%	NS	NS	NS	0.57	14.5



50% N through FYM + 50% N through inorganic sources

Control (no fertilizer application)

Rabi sorghum + chickpea intercropping system (2:4)

In a study on effect of iron and zinc in chickpea at Vijayapura, application of 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha + RDF recorded significant increase in seed yield of chickpea (1782 kg/ha) during 2017-18 with higher net returns (Rs.45598/ha), B:C ratio (3.46) and RWUE (86.5 kg/ha-mm) compared to other treatments (Table 3.89).

The soil pH and organic C were significantly influenced by different treatments and highest organic C (0.52%) was recorded in the plots under RDF + 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha, with available N, P and K of 222.7, 14.55 and 392 kg/ha, respectively compared to other treatments (Table 3.90).

Table 3.89 : Effect of iron and zinc nutrition on chickpea yield and economics - Vijayapura

Treatment	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (3 years)				
T_1: Control (RDF) (10:25 kg NP/ha)	946	682	13514	20528	2.52	40.1
T_2: RDF + 10 kg $FeSO_4.7H_2O$/ha	1034	857	15755	21467	2.36	50.2
T_3: RDF + 15 kg $FeSO_4.7H_2O$/ha	1211	976	15910	27701	2.74	58.8
T_4: RDF + 10 kg $ZnSO_4.7H_2O$/ha	1435	1112	16255	35412	3.18	69.7
T_5: RDF + 15 kg $ZnSO_4.7H_2O$/ha	1358	1043	14657	34232	3.34	65.9
T_6: RDF + 10 kg each $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	1782	1397	18569	45598	3.46	86.5
T_7: RDF + 10 kg $FeSO_4.7H_2O$ + 15 kg $ZnSO_4.7H_2O$/ha	1721	1329	16962	44982	3.65	83.5
T_8: RDF + 15 kg $FeSO_4.7H_2O$ +10 kg $ZnSO_4.7H_2O$/ ha	1674	1279	17705	42573	3.40	81.3
T_9: RDF + 15 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	1644	1205	18105	41062	3.27	79.8

Treatment	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (3 years)				
T_{10}: Gypsum 6.1 kg/ha equivalent to sulphur content in 10 kg $FeSO_4.7H_2O$ /ha	965	778	15823	18899	2.19	46.8
T_{11}: Gypsum 9.0 kg/ha equivalent to sulphur content in 15 kg $FeSO_4.7H_2O$ /ha	959	750	16006	18527	2.16	44.9
T_{12}: Gypsum 5.8 kg/ha equivalent to sulphur content in 10 kg $ZnSO_4.7H_2O$/ha	972	823	16323	18677	2.14	47.2
T_{13}: Gypsum 8.7 kg/ha equivalent to sulphur content in 15 kg $ZnSO_4.7H_2O$/ha	1111	847	12508	27492	3.20	53.9
CD at 5%	224	269	-	8057	0.48	11.1

Chickpea with RDF + 10 kg each $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha

Chickpea under control (no fertilizer application)

Table 3.90 : Effect of treatments on soil chemical properties - Vijayapura

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)		
			N	P	K
T_1: Control (RDF) (10:25 kg NP/ha)	7.84	0.41	183.3	12.1	357.7
T_2: RDF + 10 kg $FeSO_4.7H_2O$/ha	8.08	0.44	195.0	13.0	369.3
T_3: RDF + 15 kg $FeSO_4.7H_2O$/ha	8.14	0.43	198.0	13.3	368.3
T_4: RDF + 10 kg $ZnSO_4.7H_2O$/ha	8.07	0.47	205.7	13.9	384.7
T_5: RDF + 15 kg $ZnSO_4.7H_2O$/ha	8.18	0.45	203.7	14.1	384.0
T_6: RDF + 10 kg each $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	8.10	0.52	222.7	14.6	392.3
T_7: RDF + 10 kg $FeSO_4.7H_2O$ + 15 kg $ZnSO_4.7H_2O$/ha	8.09	0.50	217.3	14.2	391.3
T_8: RDF + 15 kg $FeSO_4.7H_2O$ +10 kg $ZnSO_4.7H_2O$/ha	8.12	0.49	212.7	13.8	384.3
T_9: RDF + 15 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	8.08	0.47	208.7	14.1	379.7
T_{10}: Gypsum 6.1 kg/ha equivalent to sulphur content in 10 kg $FeSO_4.7H_2O$/ha	7.84	0.43	196.3	13.5	373.0
T_{11}: Gypsum 9.0 kg/ha equivalent to sulphur content in 15 kg $FeSO_4.7H_2O$/ha	7.89	0.42	189.3	13.6	369.3
T_{12}: Gypsum 5.8 kg/ha equivalent to sulphur content in 10 kg $ZnSO_4.7H_2O$/ha	7.88	0.44	197.7	13.6	362.0
T_{13}: Gypsum 8.7 kg/ha equivalent to sulphur content in 15 kg $ZnSO_4.7H_2O$/ha	7.87	0.46	200.7	13.2	373.0
CD at 5%	NS	NS	20.1	1.0	17.5

In another study at Vijayapura, on effect of zinc and iron application in *rabi* sorghum, significant increase in grain yield (1821 kg/ha), net returns (Rs. 24101/ha) and RWUE (96.6 kg/ha-mm) was recorded with application of RPP + 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ compared to control (100% RDF), 100% RDF + 10 kg $FeSO_4.7H_2O$/ha, 100% RDF + 20 kg $ZnSO_4.7H_2O$/ha and 100% RDF + 20 kg $FeSO_{4.}7H_2O$/ha + 10 kg $ZnSO_{4.}7H_2O$/ha (Table 3.91).

Table 3.91 : Effect of iron and zinc nutrition on rabi sorghum yield and economics - Vijayapura

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (2 years)					
T_1: Control (RPP) (50:25 kg NP/ha)	1317	912	1775	11264	15068	2.34	46.5
T_2: RPP + 10 kg $FeSO_4.7H_2O$/ha	1451	1086	1836	11505	17507	2.52	69.7
T_3: RPP + 20 kg $FeSO_4.7H_2O$/ha	1682	1510	2160	11660	21982	2.89	89.9
T_4: RPP + 10 kg $ZnSO_4.7H_2O$/ha	1713	1658	2253	12005	22254	2.85	74.2
T_5: RPP + 20 $ZnSO_4.7H_2O$/ha	1451	1310	2037	12407	16605	2.34	83.2
T_6: RPP + 10 kg each of $FeSO_4.7H_2O$ + $ZnSO_4.7H_2O$/ha	1821	1888	2191	12319	24101	2.96	96.6
T_7; RPP + 20 kg each of $FeSO_4.7H_2O$ + $ZnSO_4.7H_2O$/ha	1806	1792	2238	12712	23399	2.84	83.2
T_8; RPP+ 10 kg $FeSO_4.7H_2O$/ha + 20 kg $ZnSO_4.7H_2O$/ha	1667	1341	2160	12455	20878	2.68	78.7
T_9: RPP + 20 kg $FeSO_4.7H_2O$/ha + 10 kg $ZnSO_4.7H_2O$/ha	1574	1293	2052	12855	18626	2.45	67.4
CD at 5%	232	335	NS	-	4637	0.38	15.9

RPP: Recommended package of practices

The soil organic C was significantly influenced by different treatments and highest organic C (0.51%) was recorded with RPP + 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha, with available N content of 216.7, P 14.58 and K 405.3 kg/ha, respectively (Table 3.92). Application of RPP + 10 kg $FeSO_4.7H_2O$/ha + 20 kg $ZnSO_4.7H_2O$/ha recorded higher Zn (0.45 ppm) and Cu (0.67 ppm) compared to control.Similarly, higher Fe (2.15 ppm) and Mn (3.25 ppm) contents were recorded with RPP + 20 kg $FeSO_4.7H_2O$/ha + 10 kg $ZnSO_4.7H_2O$/ha, and RPP + 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$, respectively (Table 3.93).

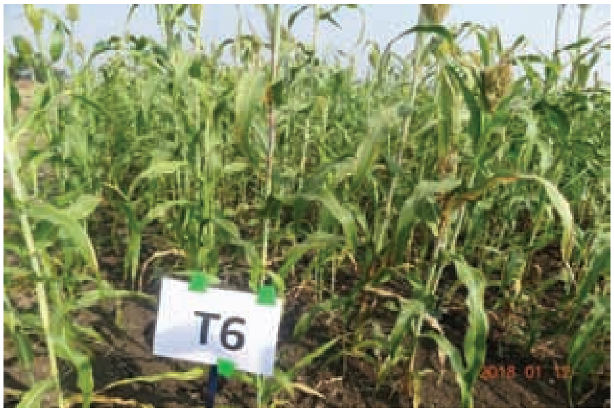
Table 3.92 : Effect of iron and zinc nutrition on soil chemical properties - Vijayapura

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)		
			N	P	K
T_1: Control (RPP)	7.83	0.43	189.7	11.9	366.7
T_2; RPP + 10 kg $FeSO_4.7H_2O$/ha	7.89	0.45	195.0	12.8	380.3
T_3: RPP + 20 kg $FeSO_4.7H_2O$/ha	7.93	0.46	201.0	12.7	387.3
T_4: RPP + 10 kg $ZnSO_4.7H_2O$/ha	8.03	0.47	209.7	13.7	391.3
T_5: RPP + 20 kg $ZnSO_4.7H_2O$/ha	8.09	0.50	213.7	13.9	393.0
T_6: RPP + 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	8.05	0.51	216.7	14.6	405.3
T_7: RPP + 20 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	8.01	0.48	212.0	14.2	399.3
T_8: RPP+ 10 kg $FeSO_4.7H_2O$ + 20 kg $ZnSO_4.7H_2O$/ha	8.02	0.45	210.0	13.5	380.7
T_9: RPP + 20 kg $FeSO_4.7H_2O$ + 10 kg $ZnSO_4.7H_2O$/ha	7.95	0.47	207.0	13.3	370.0
CD at 5%	NS	0.04	11.1	0.92	12.5

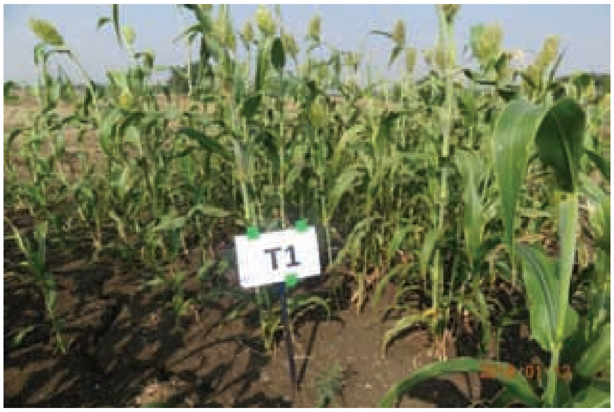
RPP: Recommended package of practices

Table 3.93 : Effect of iron and zinc nutrition on micronutrients (ppm) in the soil - Vijayapura

Treatment	Zn	Fe	Cu	Mn
T_1: Control (RPP)	0.34	1.82	0.65	2.71
T_2; RPP + 10 kg $FeSO_4.7H_2O$/ha	0.36	2.21	0.58	2.82
T_3: RPP + 20 kg $FeSO_4.7H_2O$/ha	0.38	2.44	0.56	3.01
T_4: RPP + 10 kg $ZnSO_4.7H_2O$/ha	0.50	1.87	0.67	2.92
T_5: RPP + 20 kg $ZnSO_4.7H_2O$/ha	0.56	1.91	0.68	2.99
T_6: RPP + 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	0.45	2.15	0.67	3.25
T_7: RPP + 20 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	0.53	2.16	0.63	3.04
T_8: RPP+ 10 kg $FeSO_4.7H_2O$ + 20 kg $ZnSO_4.7H_2O$/ha	0.54	2.08	0.64	3.07
T_9: RPP + 20 kg $FeSO_4.7H_2O$ + 10 kg $ZnSO_4.7H_2O$/ha	0.43	2.45	0.63	3.13
CD at 5%	0.08	0.29	NS	NS



***Rabi* sorghum with RDF + 10 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha**



***Rabi* sorghum under Control**

In the Permanent Manurial Trial (PMT) in *rabi* sorghum at Solapur (initiated in 1987), application of 25 kg N ha/ha-FYM + 25 kg N ha/ha urea gave significantly higher sorghum grain yield (871 kg/ha), stover yield (2532 kg/ha) and RWUE (7.28 kg/ha-mm), followed by 25 kg N/ha – crop residues (CR) + 25 kg N/ha - urea. However, application of 50 kg N/ha through urea recorded significantly higher net returns (Rs.10409/ha) compared to control, 25 kg N/ha through CR, 25 kg N/ha through FYM and 25 kg N/ha through *leucaena* loppings (Table 3.94).

Table 3.94 : PMT: Effect on yield and economics of rabi sorghum - Solapur

Treatment	Yield (kg/ha)		Mean yield (30 years) (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover	Grain	Stover			
T_1: 0 kg N/ha - control	424	1791	695	1937	2102	1.13	3.55
T_2: 25 kg N/ha - urea	761	2168	1004	2803	9963	1.56	6.36
T_3: 50 kg N/ha - urea	782	2226	1141	3057	10409	1.58	6.54
T_4: 25 kg N/ha - CR (crop residues)	662	1912	946	2476	4616	1.24	5.16
T_5: 25 kg N/ha - FYM	688	1987	1046	2811	3052	1.14	5.75
T_6: 25 kg N/ha - CR + 25 kg N/ha - urea	827	2377	1062	3080	10281	1.52	6.92
T_7: 25 kg N/ha - FYM + 25 kg N/ha - urea	871	2532	1225	3270	9485	1.42	7.28

Treatment	Yield (kg/ha)		Mean yield (30 years) (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover	Grain	Stover			
T_8: 25 kg N/ha - CR + 25 kg N/ha - *Leucaena* loppings	801	2428	1661	3399	8434	1.40	6.70
T_9: 25 kg N/ha - *Leucaena* loppings	694	2121	971	2445	6733	1.35	5.80
T_{10}: 25 kg N/ha - *Leucaena* loppings + 25 kg N/ha - urea	751	2253	1031	3031	9465	1.52	6.28
CD at 5%	61	170	-	-	2185	-	-

The soil organic C, available N, P and K were influenced by different treatments. The highest organic C (0.81%), available N (189 kg/ha), available P (25.9 kg/ha) and K (960 kg/ha) was recorded in the plots under application of 25 kg N/ha - CR + 25 kg N/ha - *Leucaena* loppings compared to other treatments (Table 3.95).

Table 3.95 : Effect of treatment on soil properties - Solapur

Treatment	Organic C (%)	Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
		At sowing	At harvesting	At sowing	At harvesting	At sowing	At harvesting
T_1: 0 kg N/ha – control	0.54	106	97	11.3	12.6	754	715
T_2: 25 kg N/ha – urea	0.64	144	156	17.2	18.5	802	821
T_3: 50 kg N/ha – urea	0.67	160	167	16.4	17.4	856	849
T_4: 25 kg N/ha – CR (crop residues)	0.66	144	168	14.2	16.7	868	873
T_5: 25 kg N/ha - FYM	0.71	162	170	17.4	18.3	854	866
T_6: 25 kg N/ha - CR + 25 kg N/ha - urea	0.70	154	172	16.2	17.7	869	876
T_7: 25 kg N/ha - FYM + 25 kg N/ha - urea	0.75	160	180	24.2	25.0	930	846
T_8: 25 kg N/ha - CR + 25 kg N/ha - *Leucaena* loppings	0.81	169	189	25.7	25.9	940	960
T_9: 25 kg N/ha - *Leucaena* loppings	0.74	159	170	14.6	20.3	925	844
T_{10}: 25 kg N/ha - *Leucaena* loppings + 25 kg N/ha - urea	0.72	161	170	20.7	21.7	895	915
Initial Values	0.61	154		-	-	-	-

Rabi sorghum with 25 kg N/ha - FYM + 25 kg N/ha urea

Rabi sorghum with 25 kg N/ha - CR + 25 kg N/ha - Leucaena loppings

3.3.1.4 Energy management

At Vijayapura, a study on effect of tillage and nutrient management in sunflower revealed that higher seed yield (591 kg/ha) and stalk yields (739 kg/ha) were recorded with conventional tillage (1 ploughing + 2 harrowings + 2 hoeings + 1 hand weeding), with higher net returns (Rs.6315/ha), B:C ratio (1.44) and RWUE (1.74 kg/ha-mm) as compared to other low tillage practices. Among different nutrient management treatments, farmer's practice + sunhemp green manuring recorded significantly higher seed (685 kg/ha) and stalk yield (806 kg/ha) compared to other treatments, with higher net returns (Rs.9619/ha) and RWUE (2.02 kg/ha-mm) (Table 3.96).

Table 3.96 : Effect of tillage and nutrient management on sunflower yield and economics - Vijayapura

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed 2017	Mean (6 years)	Stalk				
Tillage practice (T)							
T_1: Conventional tillage (CT) (1 ploughing + 2 harrowings + 2 hoeings + 1 HW)	591	794	739	14335	6315	1.44	1.74
T_2: Low till (LT_1) (2 harrowings + 1 hoeing + 1 HW)	517	745	774	13210	4850	1.36	1.52
T_3: Low till (LT_2) (1 harrowing + 1 hoeing + weedicide)	455	747	825	12915	3010	1.23	1.34
CD at 5%	NS	74.1	18.0	-	-	-	-
Nutrient supply (N)							
N_1: Sunhemp incorporation @ 5 t/ha		520	744	11250	1427	1.12	1.07
N_2: Sunhemp incorporation @ 2.5 t/ha + 50% RDF through fertilizer	589	818	811	13847	6752	1.48	1.74
N_3: 100% RDF through inorganic fertilizer	452	849	781	13845	1986	1.14	1.33
N_4: Farmer's practice	517	718	755	13800	4291	1.31	1.52
N_5: Farmer's practice + sunhemp green manuring	685	905	806	14345	9619	1.67	2.02
CD at 5%	93.4	68.1	16.0	-	-	-	-

CT + N5 (farmers practice + sunhemp green manuring)

Control

In another experiment at Vijayapura, the performance of farm machinery used for pigeonpea production was evaluated, in mechanized farming system recorded seed yield of 1130 kg/ha, net returns of Rs.55655/ha, B:C ratio (4.6), RWUE (1.9 kg/ha-mm) with energy use efficiency of 22.0. Whereas traditional farming method recorded seed yield of 1052 kg/ha (Table 3.97) with energy use efficiency of 18.0 (Table 3.98).

Table 3.97 : Performance of farm machinery in pigeonpea yield and economics - Vijayapura

Treatment	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (2 years)				
T_1: Farmers practice	1052	1171.5	15230	47890	3.1	1.77
T_2: Mechanization	1130	1179	12145	55655	4.6	1.9

Table 3.98 : Energy input, output and field efficiency in pigeonpea - Vijayapura

Treatment	Field efficiency (hr/ha)	Energy (MJ/ha)		Energy use efficiency
		Input	Output	
T_1: Farmers practice	38.1	4349.4	75526.1	18.0
T_2: Mechanization	3.02	3623.9	78554.4	22.0

Bullock drawn seed drill

Tractor drawn seed drill

Intercultivation with bullock drawn implement

Intercultivation along with fertilizer application with tractor drawn implement

At Solapur, in a study on tillage and residue retention for resource conservation in improving soil quality and productivity, the reduced tillage (RT) recorded significantly higher grain (1097 kg/ha) and stover yield (3300 kg/ha) compared to conventional and zero tillage. RWUE was in the order RT>CT>LT. Among residue management treatments, blackgram green manuring (S2), recorded significantly higher grain (1068 kg/ha) and stover yield (3103 kg/ha) than rest of residue management treatments (S1 and S3). The interaction effects were significant for *rabi* sorghum grain and stover yields. Blackgram for green manuring (S2) with reduced tillage (RT) recorded significantly higher grain yield (1084 kg/ha) and stover yield (3069 kg/ha) than other treatments (Table 3.99). Due to very low rainfall (1.2 mm) during crop growth period and terminal drought the yields were below average.

Table 3.99 : Yield and economics of kharif black gram- rabi sorghum sequence as influenced by tillage and residue management - Solapur

Treatment	Yield (kg/ha)		NMR (Rs/ha)	B:C Ratio	RWUE (kg/ha-mm)
	Grain	Stover			
Tillage (T)					
T_1: Conventional tillage(CT)	1028	2984	3724	1.09	8.59
T_2: Reduced tillage (RT)	1097	3300	9434	1.27	9.17
T_3: Zero tillage (ZT)	964	2718	9004	1.30	8.06
CD at 5%	44	95	-		-
Residue management (S)					
S_1: *Kharif* fallow	1033	3014	4127	1.13	8.64
S_2: Blackgram- green manuring	1068	3103	4201	1.13	8.93
S_3: Blackgram- grain	987	2885	13834	1.40	8.26
CD at 5%	16	74	-		-

Conventional tillage + blackgram – green manuring

Reduced tillage + blackgram – grain

The effect of tillage on nutrient uptake by *rabi* sorghum was found significant in respect of N, P and K (Table 3.100). Reduced tillage (RT) recorded higher uptake of N (38.1 kg/ha), P (8.6 kg/ha) and K (54.6 kg/ha). In case of residue management, black gram- green manuring (S_2) recorded significantly higher nutrient uptake of N (37.2 kg/ha), P (8.3 kg/ha) and K (51.4 kg/ha) and was significantly superior over S_1 and S_3 treatments.

Table 3.100 : Nutrient uptake by rabi sorghum as influenced by tillage systems and residue management - Solapur

Treatment	Nutrient uptake (kg/ha)		
	N	P	K
Tillage (T)			
T_1: Conventional tillage (CT)	35.72	7.94	49.70
T_2: Reduced tillage (RT)	38.13	8.59	54.63
T_3: Zero tillage (ZT)	33.60	7.01	44.26
CD at 5%	0.99	0.49	2.11
Residue management (S)			
S_1: *Kharif* fallow	35.41	6.87	50.02
S_2: Blackgram- green manuring	37.22	8.34	51.40
S_3: Blackgram- grain	34.82	8.33	47.17
CD at 5%	0.58	0.31	1.22

The tillage system had significant effect on soil organic carbon and available phosphorus. Conventional tillage being on par with reduced tillage recorded significantly higher organic C (0.35%) compared to zero tillage while reduced tillage recorded significantly higher available P (27.8 kg/ha) than other treatments. In case of residue management, green manuring (S_2) recorded significantly higher soil organic carbon (0.37%) and available N and K compared to other treatments (Table 3.101).

Table 3.101 : Soil properties as influenced by tillage systems and residue management - Solapur

Treatment	Organic C (%)	Nutrient uptake (kg/ha)		
		N	P	K
Tillage (T)				
T_1: Conventional tillage(CT)	0.35	118	24.9	853
T_2: Reduced tillage (RT)	0.34	117	27.8	869
T_3: Zero tillage (ZT)	0.32	107	22.1	847
CD at 5%	0.01	NS	2.28	NS
Residue management (S)				
S_1: *Kharif* fallow	0.32	115	24.1	814
S_2: Blackgram- green manuring	0.37	121	25.9	895
S_3: Blackgram- grain	0.33	107	24.8	855
CD at 5%	0.01	4.6	NS	18.4

3.3.1.5 Evaluation of improved varieties

In an evaluation of 14 genotypes of horsegram at Vijayapura, VGH44 (BL 44) recorded significantly higher seed yield of 60 kg/ha over the checks KBHG 01 (465 kg/ha) and GPM 06 (525 kg/ha) . The entry VHG 44 (BL 44), a high yielding selection from GPM 06 is proposed for farm trial in Zone 3 and 8. The genotype gave 20.1% higher yield over GPM 06 and 27% higher yield over KBHG 01 (627 kg/ha) across 3 years (2015-16 to 2017-18) and 11 locations of Zone 3 and 8. It also recorded on par performance with check CRHG 19 (565 kg/ha) in AICRP trials (Table 3.102 & 3.103).

Table 3.102 : Yield of horsegram genotypes (kg/ha) at different locations - Vijayapura

Entry	Zone 3			Zone 8			Overall mean
	ANG	VJP	Mean	BLH	DWD	Mean	
CRHG 09	329	447	388	289	348	318	353
CRHG 22	463	225	344	283	448	365	355
CRHG 23	407	246	326	858	387	623	475
AK 52	443	124	283	870	476	673	478
ICC 100935	517	485	501	662	445	554	527
AK 44	430	453	442	948	437	693	567
BL 15	445	503	474	850	446	648	561
VHG 44 (BL 44)	507	557	532	898	477	688	610
BHG 13-01	466	270	368	780	373	577	472
DHG 01	349	497	423	834	355	595	509
GPM 06	417	547	482	700	437	568	525
KBHG 01	378	533	456	543	403	473	465
CD at 5%	104	107		184	99		

Table 3.103 : Performance of VHG 44 across 2015, 2016 and 2017 in multi-location trials - Vijayapura

Entry	Zone 8 2015	Zone 8 2016	Zone 8 2017	Mean over years	% SUP	Zone 3 2015	Zone 3 2016	Zone 3 2017	Mean over years	% SUP	Grand mean	% SUP
VHG-44 (BL 44)	1057	919	688	888		690	892	532	705		796	
Checks												
GPM-06	865	681	568	705	26.0	623	747	482	617	14.1	661	20.4
KBHG-1	930	719	473	707	25.5	639	542	456	546	29.1	627	27.0

In another trial on evaluation of mothbean entries at Vijayapura, RMM-12 recorded significantly highest seed yield (509 kg/ha), followed by BGMBG-11 (479 kg/ha). Other advanced lines produced lower seed yield when compared to BGMBG-11 (Table 3.104).

Table 3.104 : Performance of mothbean genotypes - Vijayapura

Entry	Plant height (cm)	Number of branches/plant	Number of pods/ plant	Number of seeds/ pod	Seed yield (kg/ha)
BGMBG-10	25.4	2.6	23.4	4.2	334
Mannur local-7	23.1	2.6	18.0	3.9	454
BGMB-08	26.3	3.0	19.1	4.0	352
HM-61	24.2	2.7	15.8	4.4	451
CGM-18	25.9	2.7	19.3	4.0	287
MBG-09	25.5	2.6	18.4	4.1	347
KBMB-1	25.1	2.7	19.3	4.0	341
Pato line	26.0	2.9	19.5	4.2	345
RMB-101	28.0	2.6	20.2	4.3	285
CZM-3	27.3	2.7	16.6	4.2	345
MB-16	27.5	2.6	20.9	4.4	348
RMB-408	26.1	2.6	19.8	4.2	373
BGMB-07	26.5	2.8	19.1	4.2	275
RMB-141	26.4	2.5	18.7	4.2	440
BGMBG-16	26.8	2.6	19.5	4.4	410
BGMB-11	25.9	2.8	19.7	4.4	376
RMB-108	27.2	2.5	23.4	4.0	405
GMO-310	24.2	2.6	18.0	4.0	285
BGMBG-11	25.9	3.0	19.1	4.4	479
Kavalagi local	25.5	2.7	15.8	4.0	348
BGMBG-13	25.1	2.7	19.3	4.1	373
BGMBG-14	26.0	2.6	18.4	4.0	275
BGMB-14	28.0	2.6	19.3	4.2	440
RMM-102	27.3	2.8	19.5	4.3	410
BGMBG-06	27.5	2.5	20.2	4.2	376
BGMBG-04	26.1	2.6	16.6	4.4	405
RMM-12	26.5	3.0	20.9	4.2	509
RMB-1005	26.4	2.7	19.8	4.2	433
MNL-1	26.8	2.7	19.1	4.2	469
RMO-435	27.2	2.6	18.7	4.3	410
CD at 5%	7.1	0.22	8.3	0.5	119.7

In an initial varietal trial on clusterbean (*kharif*) at Vijayapura, the genotypes Gr-13 (926 kg/ha), Gr-11 (912 kg/ha) and Gr-9 (833 kg/ha) gave significantly higher seed yields compared to other genotypes. The height of first pod formation in these genotypes ranged from 29.9-37.3 cm from soil surface (Table 3.105).

Table 3.105 : Performance of clusterbean genotypes in IVT + AVT 1 trial - Vijayapura

Genotype	Seed yield (Kg/ha)	Plant height (cm)	No. of branches /plant	Pods/ plant	100 Seed wt. (g)
Gr-1	831	43.0	2.47	26.4	2.92
Gr-2	795	35.5	2.60	23.5	2.98
Gr-4	806	32.6	2.53	21.3	3.02
Gr-5	783	35.0	2.67	25.6	2.89
Gr-6	842	31.4	2.73	29.4	3.22
Gr-7	811	36.2	2.47	29.9	3.04
Gr-8	751	38.7	2.73	23.3	2.91
Gr-9	833	37.3	2.87	25.0	3.06
Gr-10	786	34.8	2.60	24.9	3.44
Gr-11	912	31.1	2.47	22.5	3.45
Gr-12	825	34.0	2.60	26.7	3.26
Gr-13	926	29.9	2.73	32.9	3.25
Gr-14	688	36.7	2.67	28.6	3.08
GM	815	35.1	2.63	26.2	3.12
CD at 5%	174.7	6.4	0.4	4.6	0.3

Clusterbean varietal trial

In a study at Vijayapura to find out the suitability of chickpea genotypes for mechanical harvesting, the entries C-1988 (1780 kg/ha), C-2002 (1767 kg/ha) and C-2005 (1748 kg/ha) gave significantly higher seed yields compared to other genotypes. The height of first pod formation in these genotypes ranged from 46.1 -48.1 cm from soil surface (Table 3.106).

Table 3.106 : Performance of chickpea genotypes in Initial Varietal Trial (IVT-MH) - Vijayapura

Entry (Code No.)	Seed yield (kg/ha)	50% flowering (days)	Plant height (cm)	Height of first pod (cm)	100 seed weight (g)
C-1975	1516	49.0	48.7	29.0	26.1
C-1976	1716	49.0	45.7	22.7	29.2
C-1977	1461	47.3	52.0	29.3	26.9
C-1980	1707	50.0	47.3	24.1	29.3
C-1981	1651	49.0	45.4	23.4	29.2
C-1982	1581	50.7	51.0	25.1	27.6
C-1983	1589	48.0	48.8	23.7	31.6
C-1984	1568	47.7	47.9	25.4	27.4
C-1985	1609	47.7	45.6	21.5	26.7
C-1988	1780	50.0	48.1	22.6	30.7
C-1989	1544	50.3	47.5	24.4	24.9
C-1990	1502	49.0	45.6	21.9	30.8
C-1991	1503	50.0	52.5	24.0	29.6
C-1992	1506	49.0	44.1	23.3	26.9
C-1993	1654	48.3	49.2	21.6	27.7
C-1996	1505	53.0	46.8	21.0	26.0
C-1997	1517	50.0	48.0	22.7	25.9
C-1998	1516	52.3	49.6	24.7	27.6
C-1999	1518	48.0	48.9	23.5	27.3
C-2001	1433	50.0	46.5	23.5	27.3
C-2002	1767	49.0	49.2	25.3	26.6
C-2003	1511	49.0	47.3	24.9	27.0
C-2004	1627	49.0	49.8	30.2	28.6
C-2005	1748	49.0	46.1	24.2	29.5
C-2006	1662	48.0	45.5	22.8	29.4
C-2007	1521	51.7	50.1	25.3	27.0
C-2008	1461	50.7	49.3	23.5	29.3
CD at 5%	319	-	-	-	-

Chickpea - IVT trial for mechanical harvesting

At Solapur, in an experiment on screening and evaluation of horsegram germplasm, the entries HG 3 (793 kg/ha) and HG 7 (788 kg/ha) recorded significantly higher seed yield over the local check Phule Sakas (627 kg/ha) (Table). The genotype HG-3 also recorded maximum number of pods/plant (56) and number of seeds/pod (6). Whereas, the entry HG 7 recorded higher 100 seed weight (3.12 g). Phule Sakas (local check) was earlier for 50% flowering (31 days) and days to maturity (97 days) among the entries tested (Table 3.107).

Table 3.107 : Seed yield and ancillary characters of horsegram genotypes in Advance Varietal Trial - Solapur

Entry	Seed yield (kg/ ha)	Days to		Plant height (cm)	No. of branches /plant	No. of pods /plant	No. of seeds /pod	100 grain wt.(g)
		50% flowering	Maturity					
HG 1	633	38	110	28	4	35	5	2.80
HG 2	538	45	115	31	7	41	5	2.65
HG 3	793	40	105	41	7	56	6	3.10
HG 4	616	36	110	38	3	48	5	3.10
HG 5	542	45	111	35	5	35	5	2.88
HG 6	624	33	101	45	4	45	5	2.80
HG 7	788	46	125	38	6	55	5	3.12
HG 9	331	38	124	22	6	22	4	2.80
HG 10	494	42	120	26	7	28	5	2.59
HG 11	596	38	110	30	5	39	5	3.10
HG 13	599	45	115	29	6	35	5	2.65
HG 14	301	42	122	37	6	22	5	2.75
HG 15	494	50	125	25	5	28	5	2.74
HG 16	542	51	112	31	5	34	5	2.89
P.Sakas (c)	627	31	97	32	6	41	5	2. 90
CD at 5%	144							

In a large scale yield trial of horsegram germplasm, entries SHG-1601 (870 kg/ha) and SHG1606 (807 kg/ha) recorded significantly higher grain yield over check variety Phule Sakas (678 kg/ha). Genotype SHG-1602 was earlier for flowering and maturity (30 and 95 days) while, genotype SHG 1601 recorded higher number of pods/plant (66) and 100 seed weight (3.32 g) (Table 3.108).

Table 3.108 : Grain yield and ancillary characters of horsegram genotypes in large scale yield trial - Solapur

Entry	Seed yield (kg/ha)	Days to		Plant height (cm)	No. of branches/plant	No. of pods/plant	No. of seeds/pod	100 seed wt. (g)
		50% flowering	Maturity					
SHG 1601	870	42	120	34	7	66	6	3.32
SHG 1602	374	30	95	41	6	35	5	2.65
SHG 1603	419	38	112	28	6	36	5	2.72
SHG 1604	574	38	109	36	7	48	5	2.86
SHG 1605	683	34	104	38	6	53	6	2.98
SHG 1606	807	35	105	25	8	58	5	2.98
SHG 1607	437	38	110	32	6	33	5	2.87
SHG 1608	452	36	110	38	5	43	5	3.01
SHG 1609	452	39	102	37	5	52	6	3.10
SHG 1610	794	37	106	44	7	61	6	2.45
SHG 1611	476	47	108	40	8	30	4	2.99
SHG 1612	459	46	108	39	9	28	5	2.90
Maan (c)	483	37	98	40	8	48	6	2.78
P.Sakas (C)	678	32	96	38	7	53	5	2.80
CD at 5%	128							

In another study at Solapur on collection, screening and evaluation of mothbean germplasm, genotypes MB 8 (565 kg/ha) and MB 9 (546 kg/ha) recorded significantly higher seed yield over the check MBS 27 (387 kg/ha). Genotype MB 2 was earlier for days to 50% flowering (23 days) and maturity (75 days) compared to check MB 27 (60 and 135 days). Genotype MB 8 recorded higher number of pods (171/plant) while higher 100 seed weight was recorded by MB 5 (2.23 g) (Table 3.109).

Table 3.109 : Seed yield and ancillary characters of mothbean in initial varietal trial, (IVT) - Solapur

Entry	Seed yield (kg/ha)	Days to		Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ pod	100 grain wt. (g)
		50% flowering	Maturity					
MB 1	255	25	76	22	4	28	4	2.10
MB 2	221	23	75	28	4	24	5	1.98
MB 3	231	27	80	23	6	20	5	2.23
MB 4	258	28	84	19	4	22	4	1.98
MB 5	358	48	124	45	6	150	5	2.23
MB 6	269	24	80	24	7	35	6	1.65
MB 7	451	54	128	40	7	155	5	1.75
MB 8	565	58	122	38	8	171	6	1.61
MB 9	546	49	124	45	7	168	6	1.56
MBS 27	387	60	135	38	6	149	5	1.44
CD at 5%	86	-	-	-	-	-	-	-

Performance of mothbean genotype MB 8

3.3.1.6 Alternate land use system

In a study at Vijayapura on tamarind based horti-pasture system, the fruit yield of tamarind was significantly higher with planting geometry of 10 m x 6 m (610 kg/ha) with higher net returns (Rs.59494/ha), B:C ration (14.1) and RWUE (0.84 kg/mm-ha) compared to other treatments. There was no significant difference in the production of green fodder due to the planting geometry of tamarind. Guinea grass recorded significantly higher green fodder yield (3633 kg/ha) than signal grass (2439 kg/ha) (Table 3.110).

Table 3.110 : Performance of tamarind based horti-pasture system on yield and economics - Vijayapura

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Tamarind fruit	Grass	Tamarind equivalent yield				
Planting geometry of tamarind							
T_1: 10 m × 3 m	444	3035	474	5172	42236	9.2	0.62
T_2: 10 m × 6 m	610	3040	640	4538	59494	14.1	0.84
T_3: 10 m × 9 m	541	3034	571	4324	52807	13.2	0.75
CD at 5%	47	NS	47	-	4712	1.1	0.06
Grass							
G_1: Guinea grass	565	3633	601	4678	55410	13.0	0.79
G_2: Signal grass	499	2439	523	4678	47615	11.3	0.68
CD at 5%	40	23	40	-	3983	0.8	0.05

Tamarind based horti-pasture system with 10 m × 6 m - Guinea grass

Tamarind based horti-pasture system with 10 m × 6 m - Signal grass

3.3.2 Pearlmillet Based Production System

3.3.2.1 Rainwater management

At Hisar, during *Kharif* 2017, a total rainfall of 461 mm was received against the normal of 320 mm. There were two dry spells of 10 and > 30 days during the growing season which affected the crop growth at vegetative and reproductive stage. The monsoon withdrew on 7th September, 2017. Thereafter, only 21.0 mm rainfall was received in 2 rainy days. The rainwater was harvested in a farm pond of 1257 m^3 (27.1 m x 23.1 m x 1.98 m). The evaporation and seepage losses accounted for 23 and 70%, respectively and 7% of harvested rainwater was used for providing protective irrigation in *kharif* and *rabi* crops (Table 3.111).

Table 3.111: Evaporation and seepage losses from farm pond - Hisar

Parameter	Volume of water (cum)	% of harvested water
Rainfall (mm)	482	-
Evaporation	456	23
Water harvested	1999	100
Seepage losses	1403	70
Used for irrigation	140	7
Dead storage/storage at the end of the season	118	-

At Hisar, pearlmillet equivalent yield was significantly higher (2177 kg/ha) with supplemental irrigation (25 mm) from harvested rain water in farm pond compared to without supplemental irrigation (1976 kg/ha). Similarly, greengram recorded significantly higher pearlmillet equivalent yield (2133 kg/ha) than pearlmillet (2020 kg/ha). However, mean data over 3 years indicated that pearlmillet performed better than greengram. The economics also showed similar trend (Table 3.112).

Table 3.112: Effect of supplemental irrigation on yield and economics of crops during *kharif* - Hisar

Treatment	PEY (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Mean (3 yrs)					
Irrigation							
I_1: Supplemental irrigation	2177	1662	5661	18550	17704	1.95	10.78
I_2: No supplemental irrigation	1976	1283	5235	18300	14740	1.81	11.16
CD at 5%	98	-	-	-	-	-	-
***Kharif* crop**							
C_1: Pearlmillet (HHB 67 improved)	2020	1567	5049	18300	15025	1.82	10.66
C_2: Greengram (Sattya)	2133	1377	5738	19700	16106	1.82	11.26
CD at 5%	109	-	-	-	-	-	-

PEY: Pearl millet equivalent yield, Water harvested in farm pond: 1999 m^3, harvested rainwater used for irrigation: 140 m^3

Pearlmillet with supplemental irrigation

Pearlmillet without supplemental irrigation

During *rabi*, mustard equivalent yield (MEY) was significantly higher (1883 kg/ha) under supplemental irrigation (50 mm) with harvested rain water in farm pond than without supplemental irrigation (1607 kg/ha). Further, MEY was higher with mustard (2111 kg/ha) than chickpea (1379 kg/ha). The mean yield over 2 years also showed similar trend (Table 3.113).

Table 3.113 : Effect of supplemental irrigation on crops yield and economics during *rabi* season - Hisar

Treatment	MEY (kg/ha)		Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Mean (2 yrs)					
Irrigation							
I_1: Supplemental irrigation	1883	2147	4896	23000	48369	3.10	26.52
I_2: No supplemental irrigation	1607	1656	4339	22400	38758	2.73	76.54
CD at 5%	70	-	-	-	-	-	-
***Rabi* crop**							
C_1: Mustard (RH 30)	2111	2316	5552	22400	57709	3.58	45.90
C_2: Chickpea (C 235)	1379	1487	3544	17075	35135	3.06	29.98
CD at 5%	102	-	-	-	-	-	-

MEY: Mustard equivalent yield

Farm pond with harvested rainwater

At Hisar, in a study on the effect of foliar spray on yield and economics of pearlmillet during *kharif* to cope with midseason drought, spraying of thiourea @ 250 g/ha (twice) recorded maximum grain and stover yield (2102 and 5528 kg/ha) with higher net returns (Rs.11792/ha), B:C ratio (1.51) and RWUE (1.51 kg/ha-mm) compared to all other treatments (Table 3.114) During *rabi*, foliar spray of 1% KNO_3 recorded maximum seed and stalk yield of mustard (2076 and 5383 kg/ha) closely followed by spray of thiourea @ 250 g/ha (2068 kg/ha) and 1% KCl (2014 kg/ha). However, spray of thiourea resulted in highest net returns (Rs.54798/ha), B:C ratio and RWUE(11.88 kg/ha-mm) over rest of the treatments. However, there was no significant difference among the treatments in yield of pearlmillet and mustard. The mean yield of 3 years also showed similar trend (Table 3.115).

Table 3.114 : Effect of foliar spray on yield and economics of pearlmillet (HHB–67) - Hisar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Mean (3 yrs)	Stover				
T_1: RDF + no spray	2053	1709	5147	22400	11493	1.51	11.60
T_2: RDF + water spray (twice)	2072	1782	5195	23000	11215	1.49	11.71
T_3: RDF + 1% KNO_3 (twice)	2093	1920	5460	28880	5996	1.21	11.82
T_4: RDF + 1% KCl (twice)	2097	1907	5346	29080	5675	1.20	11.85
T_5: RDF + thiourea @ 250 g/ha (twice)	2102	1997	5528	23300	11792	1.51	11.88
CD at 5%	NS	-	-	-	-	-	-

RDF: 40:20 kg NP/ha

Table 3.115 : Effect of foliar spray on yield and economics of mustard (RH-30) - Hisar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Mean (3 yrs)	Stalk				
T_1: RDF + no spray	1968	1767	5057	22400	52086	3.33	93.7
T_2: RDF + water spray (two)	1944	1847	5011	23000	50624	3.20	92.6
T_3: RDF + 1% KNO_3 (twice)	2076	1999	5383	28880	49767	2.72	98.8
T_4: RDF + 1% KCl (twice)	2014	1932	5143	29080	47111	2.62	95.9
T_5: RDF + thiourea @ 250 g/ha (twice)	2068	2022	5190	23300	54798	3.35	98.5
CD at 5 %	NS	-	-	-	-	-	-

RDF: 40:20 kg NP/ha

No foliar spray *Foliar spray with Thiourea @ 250 g/ha*

Performance of pearlmillet

No foliar spray *Foliar spray with Thiourea @ 250 g/ha*

Performance of mustard

3.3.2.2 Cropping systems

At Hisar, a study on *sesbania* + pearlmillet intercropping system indicated that *sesbania* sole at 60 cm recorded significantly higher *sesbania* yield (1090 kg/ha) being at par with *sesbania* sole at 45 cm (1050 kg/ha) compared to other treatments. Pearlmillet sole at 45 cm also recorded significantly higher grain yield (1737 kg/ha) compared to all other treatments. The results revealed that seed yield of *sesbania* and pearlmillet in intercropping system were low resulting in negative net returns due to excessive vegetative growth of *sesbania*. Highest net returns (Rs.3683/ha) and B:C ratio (1.24) was obtained from *sesbania* sole at 60 cm followed by *sesbania* sole at 45 cm (Rs.2677/ha and 1.17) (Table 3.116).

Table 3.116 : Performance of sesbania + pearlmillet intercropping system - Hisar

Treatment	Yield (kg/ha)		MCEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pearlmillet	*Sesbania*					
T_1: Pearlmillet sole at 45 cm spacing	1737	-	1737	20210	1499	1.07	9.65
T_2: *Sesbania* sole at 45 cm spacing	-	1050	1480	15794	2677	1.17	8.22
T_3: *Sesbania* sole at 60 cm spacing	-	1090	1540	15505	3683	1.24	8.55
T_4: *Sesbania* at 90 cm spacing + 1 row of pearlmillet	443	620	1320	17418	-936	0.95	7.33
T_5: Paired row of *Sesbania* at 45 : 90 + 1 row of pearlmillet	338	510	1050	17622	-4459	0.75	5.83
T_6: *Sesbania* at 120 cm spacing + 1 row of pearlmillet	381	480	1060	17833	-4538	0.75	5.88
T_7: *Sesbania* at 120 cm spacing + 2 row of pearlmillet	603	620	1480	18306	141	1.01	8.22
T_8: Paired row of *Sesbania* at 45 : 120 cm + 2 rows of pearlmillet	446	470	1110	17783	-3914	0.78	6.16
T_9: Paired row of *Sesbania* at 60 : 120 cm + 2 rows of pearlmillet	408	470	1070	17828	-4430	0.75	5.94
T_{10}: Paired row of *Sesbania* at 60 : 120 cm + 1 row of pearlmillet	228	530	970	17266	-5118	0.70	5.38
CD at 5%	89	68	-	-	-	-	-

At Hisar, in an assessment of pearlmillet + *sesbania* intercropping system over 4 years, it was found that pearlmillet mean grain yield was significantly highest with pearlmillet sole at 45 cm spacing compared to all other treatments. Further, mean grain yield of *sesbania* as intercrop was highest in *sesbania* sole at 60 cm being at par with *sesbania* sole at 45 cm compared to all other treatments. Mean pearlmillet equivalent yield and RWUE was also highest with pearlmillet sole at 45 cm while intercropping of 2 rows of pearlmillet in *sesbania* crop at 120 cm spacing gave highest net returns (Rs. 4147/ha) and B:C ratio (1.23) followed by pearlmillet sole at 45 cm spacing with net returns of Rs.3635/ha and B:C ratio of 1.18 (Table 3.117).

Table 3.117 : Performance of pearlmillet + *sesbania* intercropping system (2013-2017) - Hisar

Treatments	Yield (kg/ha)*		MCEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pearlmillet	*Sesbania*					
T_1	1753	-	1753	20167	3635	1.18	8.31
T_2	-	892	1300	15751	1607	1.10	6.28
T_3	-	901	1309	15462	1434	1.09	6.35
T_4	699	530	1478	17375	1288	1.07	6.95
T_5	587	458	1266	17579	340	1.02	5.92
T_6	626	426	1255	17790	530	1.03	5.90
T_7	929	502	1667	18263	4147	1.23	7.80
T_8	754	480	1465	17740	2268	1.13	6.83
T_9	705	434	1349	17785	843	1.05	6.29
T_{10}	447	495	1177	17223	112	1.01	5.54
CD at 5%	71	74	-	-	-	-	-

Pearlmillet + sesbania intercropping system

3.3.2.3 Nutrient management

At Agra, in an experiment on effect of nutrient management on productivity of mustard under rainfed conditions, mean data of 4 years revealed that combined application of nutrients i.e. 100% NP (60 & 40 kg NP/ha) + 50 kg K as basal + foliar spray of 2.0% water soluble NPK (19:19:19) at siliquae formation recorded higher seed yield of mustard (1664 kg/ha) as compared to other treatments with higher net returns (Rs.56321/ha), B:C ratio (3.68) and RWUE (11.85 kg/ha-mm) (Table 3.118).

Table 3.118 : Effect of nutrient management on yield and economics of mustard - Agra

Treatment	Seed yield (kg/ha)		Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (4 years)					
T_1: Control (60 kg N+ 40 kg P_2O_5/ha)	1510	1226	3301	19358	42973	3.22	10.23
T_2: 100% RDF (60:40:40 kg/ha NPK)	1684	1441	3873	20177	49624	3.46	11.04
T_3: 100% NP + 75 kg K/ha basal	1802	1561	4168	20999	53729	3.56	11.35
T_4: 100% NP + 50 kg K/ha basal dose	1766	1543	4036	20373	52789	3.59	11.29
T_5: T-3 + 2.0% KCl spray before flowering	1810	1592	4268	20788	54394	3.62	11.34
T_6: T4 + 2.0% KCl spray before flowering	1832	1599	4181	20788	55099	3.65	11.40
T_7: T3 + 2.0% NPK spray (19:19:19) at siliquae formation	1850	1626	4583	21649	55525	3.56	11.49
T_8: T4 + 2.0% NPK spray (19:19:19) at siliqua formation	1915	1664	4620	21023	56321	3.68	11.85
CD at 5%	277	--	877	---	---	---	---

Mustard with RDF (60 + 40 kg NP/ha)

Mustard with RDF + 50 kg/ha K as basal + 2% KCl spray

At Agra, in the Permanent Manurial Trial (PMT) in pearlmillet initiated in 1984, significantly higher grain yield (1200 kg/ha) was recorded with application of 50% N through fertilizer + 50% N through FYM compared to other treatments except 50% N through fertilizer + 50% N through crop residue, and RDF (60:40 kg NP/ha) + Zn @ 25 kg $ZnSO_4$/ha (Table). Application of 50% N through fertilizer + 50% N though FYM also recorded higher net returns (Rs.5247/ha), B:C ratio (1.30) and RWUE (7.32 kg/ha-mm) compared to other treatments (Table 3.119).

Table 3.119 : PMT: Effect on pearlmillet yield and economics - Agra

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha) (2017)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (33 years)					
T_1: Control	452	1089	1546	13244	(-)4484	0.66	2.76
T_2: RDF (60 kg N + 40 kg P_2O_5/ha)	970	2470	3193	15749	2863	1.18	5.91
T_3: 50% RDF	672	1789	1995	14496	(-)1928	0.87	4.10
T_4: 50% RDN through crop reside	710	1816	2343	15044	(-)1412	0.91	4.33
T_5: 50% RDN through FYM	726	1883	2403	15144	(-)1194	0.92	4.43
T_6: 50% RDN through fertilizer + 50% RDN through crop residue	1136	2569	3612	17549	4057	1.23	6.93
T_7: 50% RDN through fertilizer + 50% RDN through FYM	1200	2800	3864	17649	5247	1.30	7.32
T_8: RDF + 25 kg $ZnSO_4$/ha	1094	2688	3413	17399	3310	1.19	6.67
T_9: Farmer's practice (10/15 kg N/ha)	656	1456	2184	13375	(-)751	0.94	4.00
CD at 5%	208	---	756	-	-	-	--

Pearlmillet with 50% RDN through fertilizer + 50% RDN through FYM

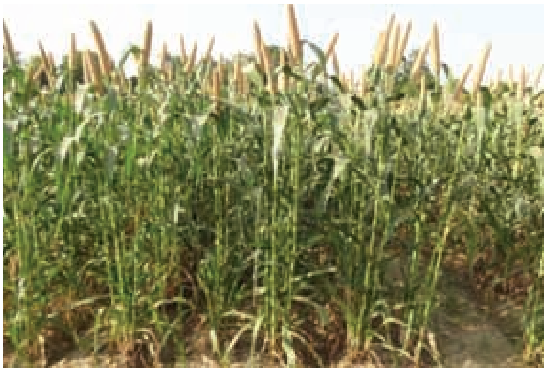
Pearlmillet under control

At Agra, in an experiment on direct and residual effect of potassium on pearlmillet-mustard-pearlmillet sequence, application of RDF + 60 kg K_2O/ha gave higher grain yield of pearlmillet (1170 kg/ha), which was at par with the all other treatments except control. Similarly, application of RDF + 60 kg K_2O/ha gave higher net returns of Rs.5685/ha, B:C ratio of 1.32 and RWUE of 7.13 kg/ha-mm compared to other treatments (Table 3.120).

Table 3.120 : Effect of K levels on yield and economics of pearlmillet - Agra

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2017)	Mean grain (2 years)	Stover				
T_1: Control (RDF) 60 kg N + 40 kg P_2O_5/ha	905	1636	2910	15749	1512	1.09	5.52
T_2: RDF + 15 kg K_2O/ha	1010	1804	3418	16173	3346	1.23	6.16
T_3: RDF + 30 kg K_2O/ha	1080	1919	3945	16597	4710	1.28	6.58
T_4: RDF + 45 kg K_2O/ha	1130	1999	4249	17021	5455	1.32	6.89
T_5: RDF + 60 kg K_2O/ha	1170	2034	4305	17445	5685	1.32	7.13
T_6: RDF + 75 kg K_2O/ha	1155	2029	4326	17869	5079	1.28	7.04
CD at 5%	205	---	1137	---	---	---	---

Pearlmillet with 60 + 40 + 45 NPK kg/ha



Pearlmillet with 60 + 40 kg NP/ha

Similarly in mustard, application of potassium along with RDF (60 & 40 kg NP/ha) had significant effect on seed and stalk yield of mustard. The seed yield increased with increase in the level of potassium up to 75 kg/ha. Application of RDF + 75 kg K_2O/ha gave significantly higher seed yield of 1915 kg/ha, net returns (Rs.59072/ha) and RWUE (11.77 kg/ha-mm), whereas, B:C ratio (3.84) was higher with RDF + 60 kg K_2O/ha compared to other treatments (Table 3.121).

Table 3.121 : Effect of K levels on yield, RWUE and economics of mustard - Agra

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2017-18)	Mean seed (2 years)	Stalk				
T_1: Control (RDF) 60 kg N + 40 kg P_2O_5/ha	1480	1820	3357	19358	41997	3.17	10.22
T_2: RDF + 15 kg K_2O/ha	1652	2032	4031	19835	48987	3.47	10.85
T_3: RDF + 30 kg K_2O/ha	1765	2160	4439	20142	53586	3.66	11.28
T_4: RDF + 45 kg K_2O/ha	1843	2255	4740	20449	56695	3.77	11.41
T_5: RDF + 60 kg K_2O/ha	1901	2301	4922	20758	58865	3.84	11.68
T_6: RDF + 75 kg K_2O/ha	1915	2322	4977	21163	59072	3.79	11.77
CD at 5%	244	--	1301	---	---	---	---

Mustard with 60+40 kg NP/ha

Mustard with 60+40+45 kg NPK/ha

At Hisar, during *kharif*, 2017, application of RDF (40:20:0 kg NPK/ha) was being on par with N equivalent through vermicompost recorded significantly higher grain yield of pearlmillet (1190 kg/ ha) compared to all other treatments. Further, application of RDF also recorded higher net returns (Rs.5777/ha), B:C ratio (1.30) and RWUE (6.72 kg/ha-mm) over rest of the treatments. Mean grain yield of pearlmillet over 3 years also showed similar trend (Table 3.122).

Table 3.122 : Effect of long term nutrient management on yield and economics of pearlmillet - Hisar

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (3 yrs)					
T_1: Control	827	846	2390	17500	260	1.01	4.67
T_2: RDF (40:20:0 kg NPK/ha)	1190	1198	3167	19100	5777	1.30	6.72
T_3: N equivalent through FYM	1073	1061	3045	18800	4102	1.22	6.06
T_4: N equivalent through vermicompost	1110	1108	3110	19000	4595	1.24	6.27
CD at 5%	108		168	-			

Similarly during *rabi*, at Hisar, application of RDF (40:20:0 kg NPK/ha) being on par with application of N equivalent through vermicompost recorded significantly higher seed and stalk yield of mustard (1943 and 4410 kg/ha) compared to other treatments. Further, application of RDF (40:20:0 kg NPK/ha) also recorded higher net returns (Rs.61030/ha), B:C ratio (3.89) and RWUE (92.52 kg/ha-mm) over rest of the treatments (Table 3.123).

Table 3.123 : Effect of long-term nutrient management on yield and economics of mustard - Hisar

Treatment	Seed yield (kg/ha)		Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017-18	Mean (3 yrs)					
T_1: Control	1102	981	2564	19500	27144	2.39	52.48
T_2: RDF (40:20:0 kg NPK/ha)	1943	1769	4410	21100	61030	3.89	92.52
T_3: N equivalent through FYM	1537	1306	3692	20800	44372	3.13	73.20
T_4: N equivalent through vermicompost	1632	1460	3830	21000	48110	3.29	77.71
CD at 5%	321	-	590	-	-	-	-

Application of N equivalent through vermicompost and FYM had higher soil moisture compared to application of recommended dose of fertilizers (RDF) and control (Table). Further, the profile soil moisture also increased from 12.5 mm to 48.2 mm under 0-15 cm to 90-120 cm at sowing and 3.3 mm to 27.2 mm in vermicompost, 3.1 mm to 26.6 mm in plots under FYM (Table 3.124).

Table 3.124 : Effect of treatments on profile soil moisture (mm/120 cm) - Hisar

Soil depth (cm)	At sowing	At harvest			
		Control	RDF (40:20:0 kg NPK/ha)	N equivalent through FYM	N equivalent through vermicompost
0-15	12.5	2.5	3.0	3.1	3.3
15-30	18.2	3.2	4.0	4.7	5.0
30-60	34.1	4.9	4.8	5.8	5.9
60-60	35.6	5.2	5.3	6.0	6.0
90-120	48.2	6.5	6.8	7.0	7.0

Soil organic carbon (OC) improved over initial OC (0.11%) status in the plots treated with vermicompost (0.16%) and FYM (0.15%) compared to RDF (0.08%) and control (0.09). However, the available N was reduced in all treatments where as available P and K decreased in control plots and improved in other plots over initial status (Table 3.125).

Table 3.125 : Effect of treatments on soil properties - Hisar

Treatment	pH	EC (dS/m)	OC (%)	Available nutrients (kg/ha)		
				N	P	K
Initial values	7.9	0.12	0.11	67	12	218
T_1: Control	7.9	0.12	0.09	56	11.2	202
T_2: RDF @ 40:20 kg of NP/ha	7.8	0.12	0.08	62	13.1	229
T_3: N equivalent through FYM	7.8	0.14	0.15	60	15.7	245
T_4: N equivalent through vermicompost	7.9	0.12	0.16	62	15.9	249

At SK Nagar, in permanent manurial trial (PMT) on pearlmillet/clusterbean/castor rotation initiated in 1988, application of 50% recommended dose of N (RDN) through urea + 50% RDN through FYM registered significantly higher seed yield (310, 1036 and 1143 kg/ha) straw yield (1416, 2672 and 1257 kg/ha) and RWUE (1.17, 1.11 and 0.55 kg/ha-mm) in pearlmillet, clusterbean and castor, respectively. Whereas, application of 100% RDN through urea gave higher net returns (Rs.14876/ha) in pearlmillet while in clusterbean and castor, 50% RDN (urea) + 50 % RDN (FYM) recorded higher net returns compared to other treatments (Table 3.126).

Table 3.126 : PMT: Effect on yield and economics of different crops – SK Nagar

Treatment	Yield (kg/ha)		Mean yield (kg/ha) (28 years)		Cost of cultivation (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Straw	Seed	Straw				
Pearlmillet								
T_1: Control	173	906	467	1406	5500	5963	2.08	0.58
T_2: 100% RDN–urea	244	1134	869	2662	6611	14876	3.25	1.07
T_3: 50% RDN–urea	207	1080	695	2245	6056	11533	2.90	0.86
T_4: 50% RDN–FYM	228	1115	651	2024	13500	2697	1.20	0.80
T_5: 50% RDN-(urea) + 50% RDN-(FYM)	310	1416	950	2971	14056	9642	1.69	1.17
T_6: Farmers method	216	1084	467	1406	11500	4184	1.36	0.79
CD at 5%	46	147	95	308	-	-	-	-
Clusterbean								
T_1: Control	610	1441	308	727	5800	20846	4.59	0.66
T_2: 100% RDN–urea	750	1650	451	1039	6078	26622	5.38	0.81
T_3: 50% RDN–urea	710	1810	418	1000	5939	25141	5.23	0.76

Treatment	Yield (kg/ha)		Mean yield (kg/ha) (28 years)		Cost of cultivation (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Straw	Seed	Straw				
T_4: 50% RDN–FYM	862	2202	489	1175	7800	29936	4.84	0.93
T_5: 50% RDN-(urea) + 50% RDN-(FYM)	1036	2672	588	1377	7939	37427	5.71	1.11
T_6: Farmers method	680	1590	416	1046	5800	23895	5.12	0.73
CD at 5%	114	315	80	194				
Castor								
T_1: Control	622	686	468	444	6500	18740	4.18	0.30
T_2: 100% RDN–urea	971	1061	785	683	7333	32035	5.66	0.47
T_3: 50% RDN–urea	838	931	681	622	6917	27088	5.29	0.40
T_4: 50% RDN–FYM	886	971	677	634	12500	23415	3.1	0.43
T_5: 50% RDN-(urea) + 50% RDN-(FYM)	1143	1257	871	772	12917	33429	3.84	0.55
T_6: Farmers method	750	821	585	535	6500	23913	5.04	0.36
CD at 5%	114	182.5	223	166.8	143.7			

100% RDN: 80 kg/ha in pearlmillet; 20 kg/ha in clusterbean; 60 kg/ha in castor

At SK Nagar, higher values of available N (163 kg/ha), P_2O_5 (59.3 kg/ha) and K_2O (239 kg/ha) in soil were recorded with 50% RDN through urea + 50% RDN through FYM compared to other treatment (Table 3.127).

Table 3.127 : Effect of different nitrogen sources on soil properties after harvest of castor – SK Nagar

Treatment	Available nutrients (kg/ha)		
	N	P_2O_5	K_2O
T_1: Control	117	36.5	156
T_2: 100% RDN - urea	142	42.7	170
T_3: 50% RDN - urea	132	40.0	164
T_4: 50% RDN - FYM	147	51.1	214
T_5: 50% RDN-(urea) + 50% RDN-(FYM)	163	59.3	239
T_6: Farmers method	123	42.3	195
CD at 5%	23.3	8.4	25.5

Castor with 30 kg N (urea) + 30 kg N (FYM)/ha

Castor (no fertilizer application)

At SK Nagar, in an experiment on integrated nitrogen management in castor-clusterbean crop rotation under rainfed condition, during *kharif*, seed and stalk yields of castor differed significantly due to different treatments. Application of 50% RDN (60 kg/ha) through chemical fertilizer + 50% RDN through vermicompost + *Azotobactor* (Azo-8) + PSB registered significantly higher seed yield (1333 kg/ha), stalk yield (2872 kg/ha) and RWUE (2.28 kg/ha.mm), while higher net returns (Rs.38123/ha) and B:C ratio (5.99) was registered with 100% RDN through chemical fertilizer (50% as basal + 50% at 30-40 DAS) (Table 3.128).

Table 3.128 : Yield and economics of castor as influenced by integrated nitrogen management – SK Nagar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
T_1: Control	964	1863	6800	30774	5.53	1.65
T_2: 100% RDN through chemical fertilizer (50% as basal + 50% at 30-40 DAS)	1172	2452	7635	38123	5.99	2.01
T_3: 50% RDN through chemical fertilizer + 50% RDN through FYM	1017	2219	16217	23541	2.45	1.74
T_4: 50% RDN through chemical fertilizer + 50% RDN through castor cake	1125	2420	11312	32653	3.89	1.93
T_5: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	1032	2353	17217	23174	2.35	1.77
T_6: 50% RDN through chemical fertilizer + 25% RDN through FYM + *Azotobactor* (Azo-8) + PSB	1239	2746	11767	36677	4.12	2.12
T_7: 50% RDN through chemical fertilizers + 50% RDN through castor cake + *Azotobactor* (Azo-8) + PSB	1241	2682	11362	37143	4.27	2.12
T_8: 50% RDN through chemical fertilizer + 50% RDN through vermicompost + *Azotobactor* (Azo-8) + PSB	1333	2872	17267	34824	3.02	2.28
CD at 5%	239	593				

100% RDN: 60 kg/ha

Soil moisture content did not differed significantly due to different treatments. However significantly the higher values of soil available N (177.6 kg/ha), P_2O_5 (40.16 kg/ha) and K_2O (228.8 kg/ha) in soil after harvest of castor were recorded with application of 50% RDN through chemical fertilizers (TD) + 50 % RDN through vermicompost + seed inoculation with *Azotobactor* (*Azo*8) + PSB compared to other treatments (Table 3.129).

Table 3.129 : Effect of INM on soil properties - SK Nagar

Treatment	Soil moisture (%)	OC%	Available nutrients (kg/ha)		
			N	P_2O_5	K_2O
T_1: Control	2.78	0.28	149.0	29.15	174.1
T_2: 100% RDN through chemical fertilizer (50% as basal + 50% at 30-40 DAS)	2.73	0.35	151.3	33.36	195.3
T_3: 50% RDN through chemical fertilizer + 50% RDN through FYM	2.94	0.40	164.0	37.00	217.3
T_4: 50% RDN through chemical fertilizer + 50% RDN through castor cake	2.78	0.38	168.2	35.10	214.8
T_5: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	3.01	0.40	170.2	37.15	221.9
T_6: 50% RDN through chemical fertilizer + 25% RDN through FYM + *Azotobactor* (Azo-8) + PSB	3.00	0.39	175.5	37.83	222.4
T_7: 50% RDN through chemical fertilizers + 50% RDN through castor cake + *Azotobactor* (Azo-8) + PSB	2.96	0.38	174.3	36.83	225.0
T_8: 50% RDN through chemical fertilizer + 50% RDN through vermicompost + *Azotobactor* (Azo-8) + PSB	3.04	0.41	177.6	40.16	228.8
CD at 5%	NS	0.05	17.2	4.33	NS

During *rabi*, seed and stalk yields of clusterbean differed significantly due to different treatments. Application of 50% (10 kg/ha) RDN through chemical fertilizer + 50% RDN through vermi compost + *Azotobacter* (Azo-8) + PSB registered significantly higher seed yield (315 kg/ha), stalk yield (614 kg/ha) and RWUE (0.15 kg/ha-mm), however it was found at par with other treatments except control. However net returns (Rs. 2932/ha) and B:C ratio (1.41) was registered with 100% RDN through chemical fertilizer (50% as basal + 50% at 30-40 DAS) compared to other treatments (Table 3.130).

Table 3.130 : Yield and economics of clusterbean as influenced by integrated nitrogen management – SK Nagar

Treatment	Yield(kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
T_1: Control	208	414	6800	1292	1.19	0.10
T_2: 100% RDN through chemical fertilizer (50% as basal + 50% at 30-40 DAS)	254	541	7078	2932	1.41	0.12
T_3: 50% RDN through chemical fertilizer + 50% RDN through FYM	262	544	9939	334	1.03	0.13
T_4: 50% RDN through chemical fertilizer + 50% RDN through castor cake	267	571	8304	2213	1.27	0.13
T_5: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	277	603	10272	679	1.07	0.13
T_6: 50% RDN through chemical fertilizer + 25% RDN through FYM + *Azotobacter* (Azo-8) + PSB	283	610	8456	2708	1.32	0.14
T_7: 50% RDN through chemical fertilizer s + 50% RDN through castor cake + *Azotobacter* (Azo-8) + PSB	260	591	8321	2030	1.24	0.13
T_8: 50% RDN through chemical fertilizer + 50% RDN through vermicompost + *Azotobacter* (Azo-8) + PSB	315	614	10289	1959	1.19	0.15
CD at 5 %	61.9	105.1	-	-	-	-

100% RDN: 20 kg/ha

Soil moisture content was not affected significantly due to different treatments after harvest of crop. However significantly higher values of available N (184 kg/ha), P_2O_5 (39.2 kg/ha) and K_2O (233.5 kg/ha) in soil after harvest of clusterbean were recorded with 50% RDN through chemical fertilizers + 50% RDN through vermicompost + seed inoculation with *Azotobacter* (*Azo*-8) + PSB and was found at par with rest of the treatments except 100% RDN through chemical fertilizers (50% RDN as basal + 50% RDN at 30-40 DAS (TD) and control (Table 3.131).

Table 3.131 : Effect of INM on soil properties - SK Nagar

Treatment	Soil moisture (%)	OC (%)	Available nutrients (kg/ha)		
			N	P_2O_5	K_2O
T_1: Control	2.69	0.27	145	28.3	169
T_2: 100% RDN through chemical fertilizer (50% as basal + 50% at 30-40 DAS)	2.76	0.36	153	33.7	198
T_3: 50% RDN through chemical fertilizer + 50% RDN through FYM	3.02	0.42	168	38.0	223
T_4: 50% RDN through chemical fertilizer + 50% RDN through castor cake	2.88	0.39	174	36.2	222
T_5: 50% RDN through chemical fertilizer + 50% RDN through vermicompost	2.97	0.42	176	38.4	229
T_6: 50% RDN through chemical fertilizer + 25% RDN through FYM + *Azotobacter* (Azo-8) + PSB	3.06	0.41	179	38.5	226
T_7: 50% RDN through chemical fertilizer s + 50% RDN through castor cake + *Azotobacter* (Azo-8) + PSB	2.98	0.40	175	37.4	226
T_8: 50% RDN through chemical fertilizer + 50% RDN through vermicompost + *Azotobacter* (Azo-8) + PSB	2.96	0.43	184	39.2	234
CD at 5 %	NS	0.05	17.2	4.33	28.4

Control

50% RDN through chemical fertilizer + 50% RDN through vermicompost + Azotobacter (Azo-8) + PSB

Control

50% RDN through chemical fertilizer + 50% RDN through vermicompost + Azotobacter (Azo-8) + PSB

Performance of castor and clusterbean

3.3.2.4 Energy management

In a tillage and residue management experiment at Hisar, the grain yield of pearlmillet was significantly higher under conventional tillage (1090 kg/ha) compared to zero tillage (75 kg/ha) and low tillage (578 kg/ha). Further, harvesting the crop at 30 cm and spreading of remaining residue as mulch produced significantly higher grain yield (649 kg/ha) compared to other two treatments. However, the net returns were negative in all the treatments due to very low yields (Table 3.132).

Table 3.132 : Effect of tillage and residue management on yield and economics of pearlmillet - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Tillage						
T_1: Zero tillage	75	455	17300	-15660	0.09	0.42
T_2: Low tillage (one cultivator + two interculture)	578	1530	17800	-8134	0.54	3.27
T_3: Conventional tillage (one harrowing + one cultivator + two interculture)	1090	2814	18300	-187	0.99	6.16
CD at 5%	343					
Harvesting height from ground						
H_1: Harvesting at ground level	513	1423	17800	-9126	0.49	2.90
H_2: Harvesting at 15 cm and spreading of remaining residue	581	1452	17800	-8218	0.54	3.28
H_3: Harvesting at 30 cm and spreading of remaining residue	649	1459	17800	-7184	0.60	3.67
CD at 5%	81					

3.3.2.5 Evaluation of improved varieties

In FYT (Early) trials at Hisar, among 14 pearlmillet hybrids, hybrid 1 x 434 (2905 kg/ha) and 71 x 494 (2835 kg/ha) recorded the highest grain yields over best check HHB 223 (2807 kg/ha). However higher stover yield was recorded with 1 x 319 (8449 kg/ha) followed by 71 x 494 (7407 kg/ha), 1 x 434 (7176 kg/ha) and 101 x 319 (7074 kg/ha). Plant height ranged from 113 cm (311 x 564) to 167 cm (HHB 197); total tillers from 3.3-4.9; spike length from 19.2-25.9 cm and spike girth from 2.9-4.0 cm (Table 3.133).

At Hisar, in IVT (RF) trials in pearlmillet hybrids, only hybrid 36 x 544 recorded significantly higher grain yield (3437 kg/ha) over the best check hybrid HHB-197 (2951 kg/ha). Further, the hybrids 195 x 200 (3342 kg/ha) and 197 x 200 (2995 kg/ha) also produced higher yield over best check hybrid HHB-197 but not significant. Stover yield was highest for hybrid 195 x 200 (12847 kg/ha) followed by hybrid 197 x 199 (12500 kg/ha) and 196 x 198 (12153 kg/ha) (Table 3.134).

Final yield trial (Early) in pearlmillet

Table 3.133 : Performance of pearlmillet entries in FYT (early) trial - Hissar

Hybrid pedigree	Plant height (cm)	Tillers/ plant	Yield (kg/ha)		RWUE (kg/ha-mm)
			Grain	Stover	
1 x 319	150	3.4	2665	8449	15.06
1 x 434	158	4.0	2905	7176	16.41
36 x 564	159	4.2	2778	7023	15.69
71 x 359	131	3.8	2531	5403	14.30
71 x 494	155	4.1	2835	7407	16.02
101 x 319	145	4.2	2205	7074	12.46
101 x 364	162	5.0	1628	6944	9.20
286 x 494	157	4.2	2366	7060	13.37
301 x 494	161	4.6	2487	6829	14.05
311 x 359	163	3.9	2021	6829	11.42
311 x 564	113	3.3	2284	5403	12.90
775 x 319	159	4.9	2590	6097	14.63
823 x 359	141	4.7	2087	6134	11.79
823 x 564	153	3.4	1979	5634	11.18
HHB 223 ©	150	4.6	2807	5787	15.86
HHB 67 Imp.(c)	162	4.1	2014	4759	11.38
HHB 226 ©	157	5.1	2584	6829	14.60
HHB 197 ©	167	4.6	2598	6944	14.68
CD at 5%	17.45	1.05	344.42	1024.2	-

Table 3.134 : Performance of pearlmillet entries in IVT (RF) trials -Hisar

Hybrid pedigree	Plant height (cm)	Tillers/plant	Grain yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)
36 x 534	172	3.1	2622	10417	14.81
36 x 544	170	4.1	3437*	11285	19.42
195 x 200	168	3.8	3342	12847	18.88
HHB 197 ©	155	3.8	2951	10417	16.67
196 x 198	153	3.8	2969	12153	16.77
196 x 199	160	4.1	2743	11285	15.50
196 x 200	156	3.5	2873	10590	16.23
HHB 226 ©	169	3.9	2812	11285	15.89
197 x 198	174	3.7	2925	11979	16.53
197 x 199	182	4.4	2543	12500	14.37
197 x 200	150	4.6	2995	6972	16.92
HHB 223 ©	152	4.7	2595	9896	14.66
CD at 5%	18.30	0.87	459.17	2329.04	-

In a multi-location trial (MLT) at Hisar, among 20 genotypes of greengram, seven genotypes *viz*. MH 1315 (1242 kg/ha), MH 1323 (1217 kg/ha) and MH 1320 (1215 kg/ha), MH 1344 (1192 kg/ha), MH 1314 (1167 kg/ha), MH 1142 (1090 kg/ha) and MH 1317 (1065 kg/ha) recorded significantly higher seed yield over the best check MH 421 (926 kg/ha). RWUE varied from 1.43 (MH 1303) to 7.02 kg/ha-mm (MH 1315) (Table 3.135).

Greengram - Multilocation trial

Table 3.135 : Performance of greengram genotypes in multi-location trial (MLT) -Hisar

Genotype	Days to maturity	Plant height (cm)	Branches /plant	Pods/ plant	Pod length (cm)	Seeds/ pod	Seed yield (kg/ha)	RWUE (kg/ha-mm)
MH 1129	57.7	45.7	4.5	15.2	7.8	8.9	440	2.49
MH 1142	59.0	44.2	5.1	25.7	7.6	9.1	1090	6.16
MH 1302	60.7	49.6	4.5	17.3	7.8	9.1	486	2.75
MH 1303	57.7	45.4	5.1	12.3	8.0	9.5	253	1.43
MH 1305	59.7	49.8	5.1	21.5	7.6	8.1	822	4.64
MH 1314	54.3	44.1	4.8	24.8	7.8	8.5	1167	6.59
MH 1315	58.3	47.6	4.8	29.4	8.1	8.9	1242	7.02
MH 1317	57.3	53.6	5.4	26.7	8.0	8.9	1065	6.02
MH 1320	58.0	52.2	4.9	28.3	7.9	8.5	1215	6.86
MH 1323	54.3	50.6	5.4	25.4	8.1	8.3	1217	6.88
MH 1324	59.0	54.9	5.1	21.0	7.3	8.7	822	4.64
MH 1327	57.7	48.9	4.9	21.3	7.6	9.0	683	3.86
MH 1329	55.0	49.1	4.9	13.0	8.1	9.1	440	2.49
MH1332	59.0	45.3	5.3	19.1	8.1	8.9	382	2.16
MH 1344	59.3	45.9	5.3	26.1	7.8	8.5	1192	6.73
MH 1346	61.7	44.9	4.3	13.4	7.6	8.9	382	2.16
MH 1347	56.7	49.3	4.7	20.8	7.2	8.9	694	3.92
MH 1353	57.7	46.3	4.7	18.1	8.1	8.7	579	3.27
MH 1354	64.0	50.8	4.9	25.3	7.6	9.1	903	5.10
MH 1359	59.0	48.0	4.9	15.2	7.6	8.4	556	3.14
Sattya ©	69.7	53.4	4.8	18.9	7.3	8.1	856	4.84
Basanti ©	68.0	58.3	4.9	16.0	7.5	7.8	775	4.38
MH 421 ©	59.7	46.8	3.9	23.3	8.1	9.4	926	5.23
MH 318 ©	57.7	50.7	5.1	25.1	8.1	8.5	856	4.84
CD at 5%	2.37	5.47	0.61	3.33	N/A	N/A	119.57	-

At Hisar, in FYT-1 trial, among 15 genotypes of raya, two genotypes RH 1885 (4521 kg/ha) and RH 1529 (4514 kg/ha) recorded higher seed yield over the best check RH-0406 (4365 kg/ha). Plant height ranged from 190 cm (RH-1529) to 227 cm (RH-11599-36) and siliqua/plant from 518 (RH-0761) to 740 (RH-1592) (Table 3.136).

Raya - Final yield trial - 1

Table 3.136 : Performance of raya genotypes in FYT-1- Hisar

Genotype	Plant height (cm)	Branches/plant	Pods/plant	Seeds/pod	Seed yield (kg/ha)
RH 0761	199	6.1	518	12.5	3198
RH 1424	195	7.0	569	13.2	3626
RH 1430	203	5.8	567	12.6	3840
RH 1499-7	220	6.3	642	13.7	4041
RH 1515	202	5.9	640	12.9	4313
RH 1518	209	6.5	664	13.7	4140
RH 1519	203	6.0	591	13.5	4319
RH 1529	190	6.0	596	13.3	4514
RH 1550	198	5.2	591	13.5	4247
RH 1555	207	6.5	715	13.3	4241
RH 1584	225	5.9	698	12.9	4329
RH 1885	207	5.9	627	13.0	4521
RH 1592	219	7.0	740	13.9	4283
RH 1599-36	227	5.1	628	13.1	4280
RH 0406 ©	198	5.3	653	12.9	4365

In a multi-location trial (MLT) at Hisar, among 16 genotypes of chickpea, only one genotype, H 15-27 produced marginally higher seed yield (3090 kg/ha) over the best national check BG 372 (3021 kg/ha). However, three genotypes, H 15-13, H 15-03 and H 15-05 were also found promising (>2700 kg/ha). Days to maturity ranged from 148 days (H 15-11) to 153 days (H 14-13); plant height from 65.1 (GNG 1581) to 76.7 cm (H 15-05) and test weight from 14.1 g (HC 15-02) to 19.9 g (H-14-13) (Table 3.137).

Table 3.137 : Performance of chickpea genotypes in multi-location trial - Hisar

Genotypes	Plant height (cm)	Branches/ plant	Pods/ plant	Seeds/ pod	100 seed wt.(g)	Days to maturity	Seed yield (kg/ha)
H 14-13	72.5	4.9	110.6	1.6	19.90	153	1910
H 14-14	73.5	5.2	121.3	1.7	15.96	152	2257
H 15-02	74.8	5.8	132.4	1.7	14.08	152	2292
H 15-03	74.3	5.7	85.4	1.7	17.31	150	2847
H 15-04	73.2	5.6	96.3	1.7	19.68	149	2431
H 15-05	76.7	6.5	93.9	1.8	18.15	152	2708
H 15-06	71.9	8.9	86.3	1.8	18.21	150	2361
H 15-11	73.6	5.8	119.9	1.6	17.74	148	2569
H 15-13	75.5	8.5	145.5	2.0	17.71	150	2882
H 15-18	70.2	5.8	80.0	1.8	17.10	152	2396
H 15-20	68.8	6.0	118.8	1.9	18.87	148	2691
H 15-21	69.7	6.5	135.1	1.7	18.48	150	2292
H 15-23	80.3	6.3	140.5	1.9	17.93	150	2014
H 15-24	71.8	6.1	134.0	1.7	18.99	151	1597
H 15-25	67.1	6.4	119.0	1.8	15.23	149	2361
H 15-27	72.2	6.2	106.2	1.9	17.33	148	3090
HC 1 ©	61.6	5.4	96.8	2.0	17.05	151	2361
HC 5 ©	73.5	6.8	153.8	2.0	17.89	153	2917
BG 372 ©	70.5	6.6	102.3	1.7	14.98	150	3021
CSJ 515 ©	61.7	6.3	133.8	1.9	15.36	151	2396
GNG 1581©	65.1	6.1	96.4	1.9	15.42	150	2604

3.3.2.6 Alternate land use system

In an experiment on evaluation of drumstick based agri-horti system at SK Nagar, drumstick equivalent yield differed significantly due to different drumstick based agri-horticultural systems. Among different systems, drumstick + castor system recorded significantly higher drumstick equivalent yield (1371 kg/ha), net returns (Rs.40873/ha) and RWUE (0.66 kg/ha-mm). Whereas, drumstick + greengram recorded higher B:C ratio (4.78) compared to other systems (Table 3.138).

Table 3.138 : Yield and economics of drumstick based agri-horti systems – SK Nagar

Treatment	Drumstick pod yield (kg/ha)	Intercrop yield (kg/ha)		MCEY	Cost of cultivation (Rs./ha)	NMR (Rs/ha)	B: C ratio	RWUE (kg/ha-mm)
		Seed	Fodder/ stover					
T_1: Drumstick sole	353	-	-	241	4580	4560	1.00	0.12
T_2: Greengram sole	-	416	757	1144	7650	35840	4.68	0.55
T_3: Pearlmillet sole	-	484	1029	467	9150	8599	0.94	0.23
T_4: Fodder sorghum sole	-	3243	-	486	8500	9984	1.17	0.24
T_5: Castor sole	-	1021	1547	1059	11760	28493	2.42	0.51
T_6: Drumstick + greengram	330	272	506	1085	7130	34095	4.78	0.53
T_7: Drumstick + pearlmillet	324	383	815	694	8630	17737	2.06	0.34
T_8: Drumstick + fodder sorghum	319	-	2593	708	7980	18909	2.37	0.34
T_9: Drumstick + castor	321	1014	1420	1371	11240	40873	3.64	0.66
CD at 5%	-	-	-	190.9	-	-	-	-

Greengram sole

Drumstick + greengram system

3.3.3 Fingermillet Based Production System

3.3.3.1 Rainwater management

At Bengaluru, in a field experiment on long term effect of polymers on fingermillet, the grain and straw yield of fingermillet with application of different levels of polymers were statistically non-significant. However, application of polymer aquapod once in 2 years recorded higher mean grain yield (2001 kg/ha) with net returns of Rs. 14080/ha, B:C ratio of 1.37 and RWUE of 3.41 kg/ha-mm compared to other treatments (Table 3.139).

Table 3.139 : Long-term effect of polymers on yield and economics of fingermillet - Bengaluru

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (4 yrs)					
T_1: Polymer aquasorb once in 2 years	2281	1915	3134	82106	-31791	0.61	3.32
T_2: Polymer aquasorb once in 3 years	2126	1830	2871	63356	-16521	0.74	3.09
T_3: Polymer aquasorb once in 4 years	2216	1873	2991	53981	-5176	0.90	3.22
T_4: Polymer aquasorb once in 5 years	2130	1838	2968	48356	-1305	0.97	3.10
T_5: Polymer aquapod once in 2 years	2347	2001	3168	37606	14080	1.37	3.41
T_6: Polymer aquapod once in 3 years	2158	1898	2956	33689	13914	1.41	3.14
T_7: Polymer aquapod once in 4 years	2286	1949	3086	31731	18611	1.59	3.32
T_8: Polymer aquapod once in 5 years	2317	1961	3128	30556	20485	1.67	3.37
Control	2353	1922	3111	25856	25870	2.00	3.42
CD at 5%	NS	-	NS	-	-	-	-

In a study on live barriers at Bengaluru, *Nase* grass recorded higher mean fingermillet grain and straw yield (3225 and 3966 kg/ha), net returns (Rs.44824/ha), B:C ratio (2.75) and RWUE (5.15 kg/ha-mm) compared to *khus* grass (2575 and 3671 kg/ha). Among the land position of vegetative barriers, downside plot performed better than upper side (Table 3.140).

Live barrier with Nase grass

Live barrier with Khus grass

Table 3.140 : Fingermillet yield and economics as influenced by live barriers - Bengaluru

Treatment		Grain yield (kg/ha)		Straw yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
		2017	Mean (5 yrs)				
Khus grass	Upper	2530	1778	3541	30288	2.18	4.04
	Lower	2620	1872	3799	32474	2.27	4.19
Mean		2575	1825	3671	31381	2.22	4.11
Nase grass	Upper	2810	1953	3746	36195	2.41	4.49
	Lower	3640	2503	4186	53454	3.09	5.81
Mean		3225	2228	3966	44824	2.75	5.15
Control		2100	1502	2662	20369	1.79	3.35

During 2017, the total rainfall received was 1113.30 mm. The details of catchment area of different farm ponds, no. of days water available in farm ponds, quantity of rainwater harvested and efficiency utilized are given in Table. It was observed that the pond 1 which was connected to roof water harvesting from the office building recorded water for maximum duration (231 days). Regarding rainwater harvesting, stone slab lining (pond 5) recorded maximum duration of water availability (228 days) followed by pond 3 (222 days) and pond 4 with brick (1 m^2) and soil + cement (8:1) lining with 221 days of water availability (Table 3.141).

Table 3.141 : Amount of water stored and used in different farm ponds - Bengaluru

Pond	Catch-ment area (ha)	No. days water available	Runoff events	Total water harvested (m^3)	Water used (m^3)
1	0.594	231	33	184.0	3.14
2	0.561	141	19	130.9	17.19
3	0.612	222	25	382.8	10.63
4	0.561	221	30	413.7	22.55
5	0.594	228	27	269.4	2.40
6	0.594	147	26	92.3	1.60
7	0.594	220	25	256.1	18.85
Total			**185**	**1729.1**	**57.51**

The date on rainfall-runoff relationship and seepage losses from farm ponds with different lining materials used are presented in (Table 3.142). In general, the seepage and percolation losses were 87% and evaporation losses were 8.9% of total water harvested in different farm ponds. The seepage and percolation losses were highest (90.5%) from farm pond 3 with evaporation losses of 25.4 m^3.

Table 3.142 : Rainfall-runoff relationship and seepage losses from farm ponds with different lining materials - Bengaluru

Pond	Total water harvested (cum)	Balance water after the season (cum)	Outflow from the pond (cum)	% runoff	Water used for protective irriga-tion (cum)	Evaporation (cum)	Seepage + per-colation (cum)
1	184.0	0	118.0	27.0	3.1	24.7	156.1
2	130.9	0	0	11.7	17.2	23.3	90.3
3	382.8	0.7	177.6	50.1	10.6	25.4	346.0
4	413.7	0.6	62.3	42.5	22.6	23.3	367.1
5	269.4	0.4	21.2	26.0	2.4	25.4	241.1
Total	**1380.8**	**1.7**	**379.1**	-	**55.9**	**122.3**	**1200.8**

In double cropping of forage crops followed by chickpea, the fodder yield of giant bajra was comparatively higher (31893 kg/ha) followed by fodder maize (SA tall) (23820 kg/ha). Significantly higher main crop equivalent yield was recorded in fodder bajra-chickpea system (39003 kg/ha). There was no significant difference with respect to different varieties of chickpea and levels of fertilizer (Table 3.143).

Table 3.143 : Double cropping of forage crops followed by chickpea under rainfed situation with protective irrigation - Bengaluru

Treatment	Yield (kg/ha)		MCEY	Cost of cultivation (Rs/ha)		System cost of cultiva-tion (Rs/ha)	NMR (Rs/ha)		System (Rs/ha)	B:C ratio		System B:C ratio	RWUE (kg/ha-mm)	
	Crop 1	Crop 2		Crop 1	Crop 2		Crop 1	Crop 2		Crop 1	Crop 2		Crop 1	Crop 2
Forage crop (M)														
M_1:South African maize (SA Tall)	23820	716	31844	23100	25579	48679	12630	17357	29986	1.6	1.7	1.61	118.3	3.55
M_2:Sweet sorghum	14818	511	16909	18593	25579	44172	3633	5058	8691	1.2	1.2	1.20	73.61	2.54
M_3: Giant bajra	31893	670	39003	20855	25579	46434	26985	14613	41598	2.3	1.6	1.93	158.4	3.33
CD at 5%		115.7	6730											
Chickpea variety (V)														
V_1: Annigeri-1		605	28755		25579	46428		10694			1.42	1.55		3.00
V_2: JG-11		660	29749		25579	46428		13992			1.55	1.61		3.28
CD at 5%		NS	NS											
Fertilizer (F)														
100% RDF		657	29968		26013	46862		13386			1.51	1.60		3.26
75% RDF		607	28535		25144	45993		11300			1.45	1.56		3.02
CD at 5%		NS	NS											

MCEY: Main crop equivalent yield (forage crop)

Giant bajra

3.3.3.2 Cropping systems

In an experiment on conservation agriculture, among different tillage practices, conventional tillage recorded significantly higher fingermillet equivalent yield (2565 kg/ha) and straw yield (4014 kg/ha) compared to reduced tillage (2316 and 3492 kg/ha) and zero tillage (1802 and 2380 kg/ha). Higher net returns (Rs.34430/ha), B:C ratio (2.12) and RWUE (3.74 kg/ha-mm) was also recorded with conventional tillage compared to reduced and zero tillage (Table 3.144). Growing of horsegram as cover crop recorded significantly higher fingermillet grain equivalent yield (2635 kg/ha) compared to field bean (2094 kg/ha) and control (1953 kg/ha). Further horsegram as cover crop also recorded significantly higher straw yield (3928 kg/ha), net returns (37607 kg/ha), B:C ratio (2.28) and RWUE (3.84 kg/ha-mm) compared to field bean and no cover crop. Interaction between tillage and cover crops showed that conventional tillage with horsegram grown as cover crop also recorded significantly higher fingermillet equivalent yield (3106 kg/ha), net returns (47728 kg/ha), B:C ratio (2.55) and RWUE (4.53 kg/ha-mm).

Table 3.144 : Yield and economics as influenced by conservation agriculture practices in fingermillet + pigeonpea intercropping (8:2) - Bengaluru

Treatment	Yield (kg/ha)				NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Fingermillet (grain)	Straw	Pigeonpea (seed)	Fingermillet equivalent			
Tillage							
M_1: Conventional tillage	2338	4014	130	2565	34430	2.12	3.74
M_2: Reduced tillage	2113	3492	117	2316	28755	1.97	3.38
M_3: Zero tillage	1644	2380	91	1802	19039	1.73	2.63
CD at 5%	169	826	27	201	-	-	-
Cover crop							
C_1: Control	1776	2827	102	1953	20667	1.71	2.85

Treatment	Yield (kg/ha)				NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Fingermillet (grain)	Straw	Pigeonpea (seed)	Fingermillet equivalent			
C_2: Field bean (HA-4)	1910	3131	106	2094	23951	1.83	3.05
C_3: Horsegram	2409	3928	130	2635	37607	2.28	3.84
CD at 5%	113	584	16	134	-	-	-
Interaction							
M_1C_1	2094	3473	126	2313	28096	1.93	3.37
M_1C_2	2077	3895	115	2276	27468	1.89	3.32
M_1C_3	2844	4675	150	3106	47728	2.55	4.53
M_2C_1	1971	2748	109	2160	24345	1.83	3.15
M_2C_2	1803	3255	100	1976	20445	1.68	2.88
M_2C_3	2566	4472	141	2811	41475	2.39	4.10
M_3C_1	1264	2260	70	1386	9558	1.37	2.02
M_3C_2	1851	2243	103	2030	23941	1.92	2.96
M_3C_3	1817	2637	100	1990	23618	1.90	2.90
CD at 5%	194	NS	NS	231	-	-	-

Tillage practice *viz.*, conventional, reduced and zero tillage showed non-significant results with respect to soil physical properties except bulk density. Similarly growing of cover crops also did not show significant results with pH and EC. However, growing of horsegram as cover crop showed significantly higher organic carbon (0.47%) compared to control (0.43%) but was on par with field bean (0.46%). Interaction effect between different tillage and cover crops was found to be non-significant (Table 3.145).

Table 3.145 : Soil physical parameters as influenced by conservation agriculture practices in fingermillet + pigeonpea intercropping (8:2) - Bengaluru

Treatment	Bulk density	Particle density	MWHC	Porosity
	(Mg/m³)		(%)	
Tillage				
M_1 :Conventional tillage	1.40	3.10	30.49	54.85
M_2 : Reduced tillage	1.45	3.11	29.85	53.44
M_3 :Zero tillage	1.55	3.23	28.77	52.08
CD at 5%	0.07	NS	NS	NS
Cover crop				
C_1: Control	1.47	3.19	29.54	53.50
C_2: Field bean (HA-4)	1.46	3.16	29.21	53.69
C_3: Horsegram	1.45	3.06	30.35	53.18
CD at 5%	NS	NS	NS	NS

Among different tillage practices, no-significant results were observed in soil available N, P and K. Significantly higher available N (225.6 kg/ha) was recorded with growing of horsegram as cover crop compared to control (196.4 kg/ha) but was on par with field bean (210.2 kg/ha). Interaction between tillage and cover crops was also found non-significant (Table 3.146).

Table 3.146 : Soil chemical parameters as influenced by conservation agriculture practices in fingermillet + pigeonpea intercropping (8:2) - Bengaluru

Treatment	pH	EC (dS/m)	OC (%)	Available nutrients (kg/ha)		
				N	P_2O_5	K_2O
Tillage						
M_1: Conventional tillage	5.05	0.01	0.46	221.5	127.8	90.6
M_2: Reduced tillage	5.05	0.01	0.45	225.9	124.3	79.8
M_3: Zero tillage	5.13	0.01	0.45	184.8	124.3	86.5
CD at 5%	NS	NS	NS	NS	NS	NS
Cover crop						
C_1: Control	5.11	0.01	0.43	196.4	121.5	84.1
C_2: Field bean (HA-4)	5.07	0.01	0.46	210.2	124.3	83.4
C_3: Horsegram	5.05	0.01	0.47	225.6	130.7	89.4
CD at 5%	NS	NS	0.03	22.8	NS	NS

Available secondary and micronutrients in soil showed non-significant results with respect to different tillage practices, cover crops and also their interaction with each other (Table 3.147).

Table 3.147 : Available secondary and micronutrients in soil as influenced by conservation agriculture practices in fingermillet + pigeonpea intercropping (8:2) - Bengaluru

Treatment	Exch. (meq/100 g)		Available nutrients (ppm)				
	Ca	Mg	S	Zn	Mn	Fe	Cu
Tillage							
M_1: Conventional tillage	1.63	1.18	10.61	0.36	6.95	4.94	0.42
M_2: Reduced tillage	1.62	1.10	9.59	0.32	6.50	4.50	0.37
M_3: Zero tillage	1.52	1.02	9.55	0.35	6.57	4.42	0.35
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Cover crop							
C_1: Control	1.54	1.12	9.35	0.35	6.51	4.57	0.41
C_2: Field bean (HA-4)	1.58	1.08	9.52	0.33	6.51	4.64	0.35
C_3: Horse gram	1.64	1.10	10.89	0.36	7.00	4.65	0.38
CD at 5%	NS	NS	NS	NS	NS	NS	NS

Soil biological parameters *viz.*, dehydrogenase, acid phosphatase, alkaline phosphatase and urease enzyme activity was found non-significant with different tillage practices, cover crops and their interaction (Table 3.148).

Table 3.148 : Soil biological parameters as influenced by conservation agriculture practices in fingermillet + pigeonpea intercropping (8:2) - Bengaluru

Treatment	Dehydrogenase (µg TPF/g soil/24 hr)	Acid phosphatase µg PNP/g soil)	Alkaline phosphatase µg PNP/g soil)	Urease (µg NH_4/g soil/hr)
Tillage				
M_1: Conventional tillage	27.44	25.01	20.71	18.70
M_2: Reduced tillage	33.75	29.19	27.19	25.75
M_3: Zero tillage	27.31	25.65	21.15	19.31
CD at 5%	NS	NS	NS	NS
Cover crop				
C_1: Control	28.45	24.72	22.45	20.45
C_2: Field bean (HA-4)	28.67	26.55	21.80	19.93
C_3: Horse gram	31.37	28.58	24.79	23.37
CD at 5%	NS	NS	NS	NS

Conventional tillage

Zero tillage

Performance of fingermillet + pigeonpea intercropping system (8:2)

3.3.3.3 Nutrient management

In a study on levels of potassium and magnesium at Bengaluru, application of 150% rec. K_2O (56.3 kg/ha) recorded significantly higher grain yield of pigeonpea (1079 kg/ha), but there was no significant effect among different levels of magnesium on seed yield of pigeonpea and its interaction with K levels. Further, application of 150% rec. K_2O recorded higher net returns (Rs 8358/ha), B:C ratio (1.28) and RWUE (1.29 kg/ha-mm) compared to other treatments (Table 3.149).

Table 3.149 : Yield and economics of pigeonpea as influenced by levels of potassium and magnesium - Bengaluru

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
K_1: No K	641	2562	28390	-5939	0.79	0.77
K_2: 100% rec. K (37.5 kg/ha)	697	2537	29062	-4667	0.84	0.84
K_3: 125% rec. K	744	2322	29230	-3195	0.89	0.89
K_4: 150 % rec. K	1079	2495	29398	8358	1.28	1.29
CD at 5%	218	NS	-	-	-	-
M_1: No Mg	690	2178	28900	-4746	0.84	0.83
M_2: Magnesium@15 kg/ha	783	2533	29020	-1610	0.94	0.94
M_3: Magnesium @ 30 kg/ha	898	2725	29140	2273	1.08	1.08
CD at 5%	NS	NS	-	-	-	-

Different levels of potassium and magnesium application did not differ significantly with respect to pH, EC, organic C and available N (Table). Different levels of potassium application recorded significantly higher available K_2O (151.8 kg/ha) and exchangeable Ca (3.13 meq/100 g) and Mg (2.27 meq/100 g) with application of 150% recommended K compared to control. Further, application of magnesium @ 30 kg/ha recorded significantly higher exchangeable Ca (2.95 meq/100 g) and Mg (2.28 meq/100 g) as compared to other treatments (Table 3.150).

Table 3.150 : Soil chemical properties after the harvest of pigeonpea as influenced by levels of potassium and magnesium - Bengaluru

Treatment	pH	EC (dS/m)	OC (%)	Available nutrient (kg/ha)			Exch. nutrient (meq/100g)	
				N	P_2O_5	K_2O	Ca	Mg
K_1:No K	5.53	0.03	0.44	188.9	35.1	109.1	2.21	1.70
K_2:100% rec. K	5.46	0.03	0.45	202.6	37.8	141.6	2.77	2.26
K_3:125% rec. K	5.71	0.03	0.48	187.5	41.3	144.4	3.02	2.24
K_4: 150 % rec. K	5.69	0.03	0.44	188.9	41.5	151.8	3.13	2.27
CD at 5 %	NS	NS	NS	NS	4.2	14.1	0.42	0.22
M_1: No Magnesium	5.51	0.03	0.45	189.3	37.6	130.5	2.51	1.86
M_2: Magnesium @ 15.0 kg/ha	5.66	0.03	0.45	188.9	39.3	138.8	2.89	2.22
M_3: Magnesium @ 30.0 kg/ha	5.62	0.03	0.46	195.6	39.8	140.8	2.95	2.28
CD at 5%	NS	NS	NS	NS	NS	NS	0.36	0.19

Pigeonpea with 150% rec. K + 30 kg magnesium

Pigeonpea with no K application

In the permanent manurial trial (PMT) at Bengaluru, in the 40th year under mono-cropping of fingermillet, the grain and straw yield was found to be significantly higher (1860 and 3011 kg/ha, respectively) with application of FYM @ 10 t/ha + 100% rec. NPK, compared to application of rec. N, P_2O_5 and K_2O alone (1032 and 1635 kg/ha, respectively). Further, application of FYM @ 10 t/ha with 100% Rec. NPK recorded higher net returns (Rs. 16481/ha), B:C ratio (1.65), RWUE (2.46 kg/ha-mm) and SYI (0.70) compared to rest of the treatments. Similar trends were also noticed under maize residue (MR) series (Table 3.151).

Table 3.151 : Effect of long term use of FYM/maize residues (MR) and fertilizers on productivity and economics of fingermillet monocropping (40th year) - Bengaluru

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)	SYI
	2017	Mean (40 yrs)						
FYM series								
T_1: Control	266	669	521	13610	-7508	0.45	0.35	-0.08
T_2: FYM (10 t/ha)	1113	2267	1790	21740	3205	1.15	1.47	0.44
T_3: FYM (10 t/ha) + 50% N, P_2O_5 and K_2O	1110	2714	1774	23492	1369	1.06	1.47	0.58
T_4: FYM (10 t/ha) + 100% N, P_2O_5 and K_2O	1860	3069	3011	25236	16481	1.65	2.46	0.70
T_5: Rec. N, P_2O_5 and K_2O	1032	1963	1635	17106	4487	1.26	1.37	0.34
CD at 5%	248	-	637	-	-	-	-	-
Maize residue series								
T_1: Control	109	589	134	13610	-11229	0.17	0.14	-0.06
T_2: MR (5 t/ha)	544	982	659	21740	-9871	0.55	0.72	0.10
T_3: MR (5 t/ha) + 50% N, P_2O_5 and K_2O	1024	1862	1188	23492	-1230	0.95	1.36	0.46
T_4: MR (5 t/ha) + 100% N, P_2O_5 and K_2O	1497	2419	2441	25236	8366	1.33	1.98	0.70
T_5: Rec. N, P_2O_5 and K_2O	1088	1826	1595	17106	7047	1.41	1.44	0.45
CD at 5%	243	-	858	-	-	-	-	-

Rec. NPK: 50:40:25 kg/ha

In the 13th cycle of rotation with groundnut under FYM series, the fingermillet grain and straw yield was found to be significantly higher (2538 and 3483 kg/ha) with application of FYM @ 10 t/ha + 100% rec. NPK compared to application of Rec. N, P_2O_5 and K_2O (1045 and 1758 kg/ha, respectively). Also, higher RWUE (3.36 kg/ha-mm) was recorded with application of FYM @ 10 t/ha + 100% Rec. NPK and lowest was with control (0.28 kg/ha-mm). Similar trends were also observed under maize residue (MR) series (Table 3.152).

Table 3.152 : Influence of long term use of FYM/MR and fertilizers on productivity and economics of fingermillet under rotation (13th year) - Bengaluru

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha) (2017)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio	RWUE (kg/ha-mm)	SYI
	2017	Mean (13 yrs)						
FYM Series								
T_1: Control	214	681	344	13610	-8814	0.35	0.28	-0.13
T_2: FYM (10 t/ha)	1507	2759	2290	21740	11835	1.54	2.00	0.44
T_3: FYM (10 t/ha) + 50% N, P_2O_5 and K_2O	2122	3339	3483	23492	24173	2.03	2.81	0.60
T_4: FYM (10 t/ha) + 100% N, P_2O_5 and K_2O	2538	3645	3988	25236	31506	2.25	3.36	0.68

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha) (2017)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio	RWUE (kg/ha-mm)	SYI
	2017	Mean (13 yrs)						
T_5: Rec. N, P_2O_5 and K_2O	1045	2353	1758	17106	6431	1.38	1.38	0.33
CD at 5%	627.31	-	937.8	-	-	-	-	-
Maize residue series								
T_1: Control	75	486	138	13610	-11903	0.13	0.10	-0.17
T_2: MR (5 t/ha)	521	1150	843	21740	-10055	0.54	0.69	0.05
T_3: MR (5 t/ha) + 50% N, P_2O_5 and K_2O	1667	2351	2767	23492	13999	1.60	2.21	0.46
T_4: MR (5 t/ha) + 100% N, P_2O_5 and K_2O	2102	2923	3569	25236	22158	1.88	2.78	0.66
T_5: Rec. N, P_2O_5 and K_2O	1169	2281	2262	17106	9667	1.57	1.55	0.44
CD at 5%	650.51	-	850.66	-	-	-	-	-

Rec. NPK: 50:40:25 kg/ha

Under fingermillet monocropping (FYM series), the soil pH and EC decreased significantly in control treatment compared to NPK/INM treatment. Higher organic carbon content, available N, P and K was observed in plots under FYM (10 t/ha) + 100% N, P_2O_5 and K_2O compared to control. Similar results were recorded with maize residue application (Table 3.153).

Table 3.153 : Soil properties as influenced by continuous application of FYM, MR and NPK fertilizers under fingermillet monocropping - Bengaluru

Treatment	pH	EC (dS/m)	OC (%)	Available nutrient (kg/ha)			Exch. nutrient (meq/100 g soil)		Available S (ppm)
				N	P_2O_5	K_2O	Ca	Mg	
FYM series									
Initial	5.00	-	0.40	169.5	9.0	160.0	-	-	-
T_1: Control	4.78	0.01	0.24	99.5	7.1	41.5	1.1	0.68	4.78
T_2: FYM (10 t/ha)	5.92	0.02	0.47	196.4	17.4	63.8	2.6	1.30	5.92
T_3: FYM (10 t/ha) + 50% N, P_2O_5 and K_2O	5.90	0.03	0.53	223.8	36.7	64.5	3.7	1.47	5.90
T_4: FYM (10 t/ha) + 100% N, P_2O_5 and K_2O	5.89	0.03	0.58	245.1	67.4	90.4	4.1	2.30	5.89
T_5: Rec. N, P_2O_5 and K_2O	4.93	0.02	0.25	106.0	23.7	63.5	2.4	1.25	4.93
CD at 5%	0.63	0.01	0.14	58.6	7.6	18.2	0.63	0.20	0.63
Maize residue series									
T_1: Control	4.77	0.01	0.30	127.9	7.9	35.4	0.94	0.67	4.77
T_2: MR (5t/ha)	5.95	0.02	0.54	226.0	18.9	69.8	2.52	1.15	5.95
T_3: MR (5 t/ha) + 50% N, P_2O_5 and K_2O	5.71	0.03	0.43	178.6	35.2	59.8	3.37	1.45	5.71
T_4: MR (5 t/ha) + 100% N, P_2O_5 and K_2O	5.77	0.03	0.53	223.9	34.2	76.0	3.47	2.35	5.77
T_5: Rec. N, P_2O_5 and K_2O	5.36	0.02	0.39	165.4	25.3	60.7	2.04	1.75	5.36
CD at 5%	0.44	0.003	0.06	23.7	5.8	14.1	0.56	0.50	0.44

Under rotation system (FYM series), the soil pH and EC increased with FYM / INM treatment compared to control. Significantly lower organic carbon was observed in control and NPK alone compared to FYM (10 t/ha) + 100% N, P_2O_5 and K_2O. The available N, P and K also followed similar trend as that of organic carbon. Similar trends of results were also observed in maize residue series (Table 3.154).

Table 3.154 : Soil properties as influenced by continuous application of FYM, MR and NPK fertilizers under fingermillet-groundnut rotation - Bengaluru

Treatment	pH	EC dS/m	OC (%)	Available nutrient (kg/ha)			Exch. nutrient meq/100g Soil		Available S (ppm)
				N	P_2O_5	K_2O	Ca	Mg	
FYM series									
T_1: Control	4.82	0.01	0.34	142.1	6.2	53.7	1.02	0.55	4.82
T_2: FYM (10 t/ha)	5.85	0.03	0.54	228.2	32.7	81.1	1.95	1.32	5.85
T_3: FYM (10 t/ha) + 50% N, P_2O_5 and K_2O	5.78	0.02	0.55	230.3	45.5	67.3	3.50	1.92	5.78
T_4: FYM (10 t/ ha) + 100% N, P_2O_5 and K_2O	5.65	0.03	0.56	236.8	52.2	118.7	4.01	2.45	5.65
T_5: Rec. N, P_2O_5 and K_2O	4.78	0.02	0.40	170.1	23.8	58.9	2.18	1.25	4.78
CD at 5%	0.58	0.01	0.05	19.6	7.6	10.3	0.51	0.26	0.58
Maize residue series									
T_1: Control	4.70	0.01	0.32	132.8	9.5	46.1	0.85	0.51	4.70
T_2: MR (5 t/ha)	5.42	0.01	0.50	212.1	20.6	67.6	1.50	1.33	5.42
T_3: MR (5 t/ha) + 50% N, P_2O_5 and K_2O	5.57	0.01	0.53	220.6	34.6	57.3	2.73	1.85	5.57
T_4: MR (5 t/ha) + 100% N, P_2O_5 and K_2O	5.46	0.02	0.53	222.8	36.1	75.6	3.63	2.43	5.46
T_5: Rec. N, P_2O_5 and K_2O	5.23	0.01	0.42	177.8	18.3	60.9	2.25	1.28	5.23
CD at 5%	0.18	0.003	0.05	21.1	6.4	11.1	0.47	0.35	0.18

Nutrient uptake of groundnut was significantly influenced by continuous application of FYM, MR and NPK fertilizers under fingermillet-groundnut rotation as well as monocropping. The uptake of N, P and K was significantly higher in NPK and INM treatment. Almost similar results were recorded with maize residue application (Table 3.155).

Table 3.155 : Nutrient uptake by fingermillet as influenced by continuous application of FYM, MR and fertilizers under fingermillet-groundnut rotation and monocropping - Bengaluru

Treatment	Nutrient uptake (kg/ha)					
	Fingermillet-groundnut rotation			Monocropping		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
FYM series						
T_1: Control	3.20	1.37	3.14	4.32	1.54	3.85
T_2: FYM (10 t/ha)	30.30	13.65	25.03	21.76	8.30	16.60
T_3: FYM (10 t/ha) + 50% N, P_2O_5 and K_2O	49.61	23.74	49.63	25.19	9.76	22.10
T_4: FYM (10 t/ ha) + 100% N, P_2O_5 and K_2O	60.89	31.64	66.22	44.06	18.93	43.50
T_5: Rec. N, P_2O_5 and K_2O	25.46	8.74	19.74	15.41	4.26	10.39
CD at 5%	4.83	4.17	7.34	6.26	1.39	7.98
Maize residue series						
T_1: Control	1.21	0.41	1.27	1.14	0.39	1.26
T_2: MR (5 t/ha)	11.23	4.42	8.68	9.13	3.12	6.36
T_3: MR (5 t/ha) + 50% N, P_2O_5 and K_2O	37.78	17.08	31.38	18.20	7.00	13.27
T_4: MR (5t/ha) + 100% N, P_2O_5 and K_2O	52.78	22.94	46.07	36.80	12.85	27.65
T_5: Rec. N, P_2O_5 and K_2O	32.09	9.80	22.17	24.16	6.22	15.06
CD at 5%	14.22	5.77	9.25	6.07	2.76	5.72

FYM (10 t/ha) + 100% N, P2O5 and K2O *Control*

Fingermillet under rotation

FYM (10 t/ha) + 100% N, P_2O_5 and K_2O *Control*

Fingermillet under monocropping

3.3.3.4 Alternate land use system

At Bengaluru, in amla based agri-horti system, significantly higher amla equivalent yield was recorded in intercropping of amla with fingermillet (1427 kg/ha) which was on par with amla + cowpea (1355 kg/ha). However fingermillet proved to be better intercrop in amla based agri-horti system with higher net returns (Rs. 29446/ha) than sole amla (Rs.24053/ha). However, B:C ratio was higher (3.16) in amla sole crop compared to all other treatments (Table 3.156).

Table 3.156 : Yield and economics of amla based agri-horti systems - Bengaluru

Treatment	Amla yield (kg/ha)	Intercrop yield (kg/ha)	AEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Amla + fingermillet	699	1324	1427	29446	2.07	2.09
T_2: Amla + cowpea	858	398	1355	28737	2.13	1.98
T_3: Amla + horsegram	739	221	932	24332	2.88	1.36
T_4: Amla + field bean	867	308	1290	25212	1.96	1.89
T_5: Amla + fodder maize	730	13902	1251	27824	2.25	1.83
T_6: Amla + grain amaranth	716	261	1108	18501	1.72	1.62
T_7: Amla	879	-	879	24053	3.16	1.29
T_8: Fingermillet	-	2033	1118	18227	1.69	1.64
T_9: Cowpea	-	808	1010	16056	1.66	1.48
T_{10}: Horsegram	-	405	354	2343	1.20	0.52
T_{11}: Field bean	-	557	766	5388	1.21	1.12
T_{12}: Fodder maize	-	18974	474	-2115	0.90	0.69
T_{13}: Grain amaranth	-	349	523	-3779	0.85	0.77
CD at 5%	NS	-	176	28737	2.13	1.98

AEY: Amla equivalent yield

Growth parameters of amla such as plant height (cm), more number of branches, stem diameter (cm), canopy spread and biomass yield were statistically on par among the different intercrop treatments and sole amla (Table 3.157).

Table 3.157 : Growth parameters of amla as influenced by intercrops - Bengaluru

Treatment	Plant height (cm)	Number of branches	Canopy spread (cm^2)	Stem diameter (cm)	Biomass (kg/tree)
T_1: Amla + fingermillet	345	2.67	349	44.7	395
T_2: Amla + fodder maize	359	2.67	307	42.7	367
T_3: Amla + field bean	500	2.00	404	46.7	409
T_4: Amla + grain amaranth	329	2.33	318	42.0	362
T_5: Amla + cowpea	439	3.33	362	43.0	373
T_6: Amla + horsegram	476	2.33	346	47.3	419
T_7: Amla sole	452	2.33	396	43.0	380
CD at 5%	105	NS	38.7	NS	NS

Biomass=2.994* (Collar diameter)$^{1.285}$

Amla + fingermillet system

Amla + fodder maize system

At Bengaluru, in custard apple based agri-horti system, significantly higher custard apple equivalent yield was recorded with fodder maize (2346 kg/ha) followed by finger millet intercropping (1628 kg/ha) as compared to other intercrops. Intercropping of fodder maize registered higher net returns (Rs.119672/ha), B:C ratio (6.67) and RWUE of 3.43 kg/ha-mm (Table 3.158).

Table 3.158 : Yield and economics of custard apple based systems - Bengaluru

Treatment	Custard apple yield (kg/ha)	Intercrop yield (kg/ha)	CEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: CA + fingermillet (GPU-28)	840	2149	1628	68129	3.31	2.38
T_2: CA + fodder maize (SA Tall)	794	62078	2346	119672	6.67	3.43
T_3: CA + field bean (HA-4)	890	347	1209	47282	2.87	1.77
T_4: CA + niger (No. 71)	661	186	847	32040	2.70	1.24
T_5: CA + green chilli (Samrudhi)	618	2860	1333	48800	2.56	1.95
T_6: CA + cowpea (IT 38956-1)	679	375	992	35222	2.45	1.45
T_7: CA + foxtail millet (RS-118)	650	397	848	29839	2.42	1.24
T_7: Custard apple (CA)	724	353	724	24248	2.26	1.06

Treatment	Custard apple yield (kg/ha)	Intercrop yield (kg/ha)	CEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_8: Fingermillet	-	4400	1613	70294	3.65	2.36
T_9: Fodder maize	-	101957	1699	80868	4.83	2.49
T_{10}: Field bean	-	727	666	14713	1.58	0.97
T_{11}: Niger	-	289	289	-1457	0.92	0.42
T_{12}: Green chilli	-	4157	1039	31170	2.00	1.52
T_{13}: Cow pea	-	837	698	17586	1.72	1.02
T_{14}: Foxtail millet	-	813	406	3328	1.16	0.59
CD at 5%	NS	-	674.3	-	-	-

CA: Custard apple; CEY: Custard apple equivalent yield

Custard apple + fingermillet system

Custard apple + fodder maize system

3.4 Oilseed Based Production System

3.4.1 Groundnut Based Production System

3.4.1.1 Rainwater management

At Ananthapuramu, maximum runoff of 468.0 and 590.4 m^3 was collected during October and November months. However due to sufficient rainfall during the crop period at critical stages, supplemental irrigation was not given to groundnut.

Harvested rainwater in farm pond with cement + soil (1:3) lining

At Ananthapuramu, results of earlier experiments revealed that the life of lining materials viz., soil + cement (8:1) and soil + cement (6:1) with 5 cm thickness was up to 2 years. Hence, the Centre initiated work on evaluation of sand + cement in 6:1 ratio as lining material for controlling seepage losses. It was observed that the seepage loss was less (72 $l/m^2/day$) with sand + cement lining (6:1) as compared to other treatments. The cost of lining of farm pond including labour charges with different lining materials (Table 3.159).

Table 3.159 : Cost of lining and seepage losses from different farm ponds - Ananthapuramu

Sl. No.	Pond size (m^3)	Lining material	Cost of lining (sides and floor) (Rs.)	Seepage loss ($l/m^2/day$)
1.	250	Soil + cement (8:1)	8280	154.0
2.	250	Soil + cement (6:1)	10260	132.0
3.	250	Sand + cement (6:1)	12760	72.0

At Ananthapuramu, in an experiment on minimizing the evaporation losses using different materials in small cement structures, 5 g of cetyl alcohol and steryl alcohol and 5 ml of Silicon oil and Neem oil was spread on 1 m^2 surface area of water. The spreading of chemicals was done manually. Among different treatments, bamboo mat was found effective in preventing evaporation losses. Among different chemicals, cetyl alcohol was found effective in minimizing evaporation losses followed by steryl alcohol. All the chemicals were found effective for a period of one week, later on their efficiency decreased (Table 3.160).

Experiment on minimization of evaporation losses

Table 3.160 : Effect of different materials on evaporation (cm) from farm pond - Ananthapuramu

Treatment	Dose (kg or l/100 m^2	Cost/100 m^2	3 days	5 days	10 days	15 days	20 days
T_1: Control	-	-	3.1	4.6	9.8	14.5	22.4
T_2: Cetyl alcohol	1.0	280	1.6	2.8	6.5	11.6	15.2
T_3: Steryl alcohol	1.0	240	2.0	3.5	8.2	12.4	17.6
T_4: Silicon oil	1.0	800	2.4	3.7	8.6	13.5	20.4
T_5: Neem oil	1.0	500	2.8	4.1	9.1	14.1	21.8
T_6: Bamboo sheet	-	1200	1.0	2.4	5.3	8.4	12.4

In an experiment on subsoiling at Ananthapuramu, subsoiling at 1 m distance recorded higher pigeonpea equivalent yield (PEY) (669 kg/ha), net returns (Rs.11780/ha), B:C ratio (1.06) and RWUE (1.24 kg/ha-mm) compared to subsoiling at 2 m distance and no subsoiling in pigeonpea, castor, clusterbean and pearlmillet. Among the crops, castor recorded higher pigeonpea equivalent yield (913 kg/ha), net returns (Rs.16312/ha) and RWUE (1.69 kg/ha-mm). However, pigeonpea recorded higher B:C ratio (2.16) compared to other crops (Table 3.161). Maximum soil moisture content was recorded in plots with subsoiling at 1 m distance followed by subsoiling at 2 m distance.

Subsoiling with chisel plough

Table 3.161 : Pigeonpea equivalent yield and economics of dryland crops as influenced by subsoiling – Ananthapuramu

Treatment	PEY (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (3 years)				
Sub-soiling						
T_1: No sub-soiling	557	341	12733	8999	1.05	1.03
T_2: Sub-soiling at 1 m distance	669	410	15230	11780	1.06	1.24
T_3: Sub-soiling at 2 m distance	618	383	13982	10332	1.05	1.14
CD at 5%	60.9	-	-	-	-	-
Crops						
C_1: Pigeonpea	722	445	13296	15407	2.16	1.33
C_2: Castor	913	531	18395	16312	1.89	1.69
C_3: Clusterbean	547	293	12735	9597	1.01	1.01
C_4: Pearlmillet	275	289	11504	167	1.75	0.51
CD at 5%	45.3	-	-	-	-	-

At Ananthapuramu, in a study on in-*situ* moisture conservation through conservation furrows in groundnut + pigeonpea intercropping (8:1), opening of conservation furrow after every row of groundnut 30 DAS produced higher groundnut pod equivalent yield (3140 kg/ha), net returns (Rs.98945/ha), B:C ratio (4.72) and RWUE of 5.80 kg/ha-mm followed by opening of furrow after every 2nd row of groundnut (Table 3.162).

Table 3.162 : Yield and economics of groundnut + pigeonpea intercropping (8:1) as influenced by *in-situ* moisture conservation - Ananthapuramu

Treatment	Yield (kg/ha)			GEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Groun-dnut	pigeon-pea	Ground nut haulm					
T_1: Control (no CF)	1760	597	3657	2328	28375	64705	3.28	4.30
T_2: CF after every row	2269	915	4143	3140	26575	98945	4.72	5.80
T_3: CF after every 2nd row	2173	809	4085	2941	26575	91105	4.43	5.43
T_4: CF after every 4th row	2071	744	4029	2777	27575	83545	4.03	5.13
T_5: CF after every 8th row	2036	673	3943	2675	27250	79750	3.93	4.94
T_6: CF after every 12th row	1907	640	3886	2515	27250	73350	3.69	4.64

CF: conservation furrow; GEY: Groundnut pod equivalent yield

Control (no conservation furrow)

Formation of conservation furrow in every row

Performance of groundnut + pigeonpea intercropping (8:1)

3.4.1.2 Cropping systems

At Ananthapuramu, in an evaluation of different fodder crops under late onset of monsoon situation (24th August), highest green fodder yield was produced with fodder sorghum and fodder pearlmillet yield (2560 and 2560 kg/ha, respectively) followed by sunhemp (2470 kg/ha). Pooled data of 3 years showed that higher green fodder yield was produced with fodder pearlmillet (1680 kg/ha) than other crops (Table 3.163). However, all crops except fodder pearlmillet (Rs 5067/ha), fodder sorghum (Rs 967/ha) and cowpea (Rs 378/ha) recorded negative net returns.

Table 3.163 : Green fodder yield and dry fodder yield of different fodder crops – Ananthapuramu

Treatment	Green fodder yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	2017	Mean (3 years)			
C_1: Fodder sorghum	2560	1320	12233	967	1.08
C_2: Fodder maize	2150	1240	12983	-583	0.96
C_3: Fodder pearlmillet	2560	1680	11733	5067	1.43
C_4: Clusterbean	1190	600	11411	-5411	0.53
C_5: Cowpea	1530	930	8922	378	1.04
C_6: Fieldbean	1960	990	10330	-430	0.96
C_7: Foxtail millet	1820	1230	12411	-111	0.99
C_8: Horsegram	1520	880	11728	-2928	0.75
C_9: Sunhemp	2470	1160	12228	-628	0.95
CD at 5%	276	510	-	-	-

Evaluation of fodder crops

At Rajkot, among different intercropping systems studied, cotton + sesame (1:1) intercropping recorded significantly higher seed cotton equivalent yield (2967 kg/ha) compared other treatments except cotton + cowpea (1:1), cotton + greengram (1:1), cotton + groundnut (1:1) intercropping systems. Similarly, higher net returns (Rs.115317/ha) and B:C ratio (4.19) was recorded under cotton + sesame (1:1) intercropping system. The highest RWUE (2.03 kg/ha-mm) was recorded with cotton + cowpea intercropping system. Pooled results of two years also revealed that significantly higher seed cotton equivalent yield (2508 kg/ha) was recorded with cotton + sesame (1:1) system than other treatments (Table 3.164).

Table 3.164 : Performance of cotton based intercropping systems - Rajkot

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop	CEY	Mean CEY (2 years)				
T_1: Sole cotton	1998	-	1998	1795	35229	66773	2.90	1.50
T_2: Cotton + groundnut (1:1)	2053	608	2539	2210	38197	103827	3.72	2.00
T_3: Cotton + greengram (1:1)	2041	520	2537	2301	37214	92952	3.50	1.93
T_4: Cotton + blackgram (1:1)	2066	456	2409	2205	37276	86262	3.31	1.90
T_5: Cotton + gumguar (1:1)	890	1778	2206	1783	36447	79520	3.18	2.01
T_6: Cotton + sesame (1:1)	2032	583	2967	2508	36135	115317	4.19	1.97
T_7: Cotton + soybean (1:1)	1688	839	2143	1904	37504	76534	3.04	1.90
T_8: Cotton + cowpea (1:1)	1951	741	2656	2292	36964	98985	3.68	2.03
CD at 5%	-	-	419	-	-	-	-	-

3.4.1.3 Nutrient management

In the Permanent Manurial Trial (PMT) (initiated in 1985) in groundnut at Ananthapuramu, application of 50% RDF (10:20:20 kg N, P_2O_5, K_2O/ha) along with FYM @ 4 t/ha recorded higher pod yield (2202 kg/ha), followed by recommended dose of fertilizers (20:40:40 N, P_2O_5, K_2O kg/ha) (2053 kg/ha). In depletion studies, non-significant yields were observed. However, higher groundnut mean pod yield (986 kg/ha), net returns (Rs.77976/ha) and RWUE (4.38 kg/ha-mm) was recorded with application of 50% RDF + FYM @ 4 t/ha. Whereas higher B:C ratio (3.99) was recorded with application of 100% RDF (Table 3.165) (Fig. 3.4).

Application of 50% recommended dose of fertilizer (10:20:20 kg NP_2O_5, K_2O/ha) along with FYM @ 4 t/ha recorded higher soil organic carbon (0.6%). Marginal increase in soil pH towards neutral was observed in treatments applied with organics alone or in combination of organics along with inorganics (Table 3.166). Higher soil available nitrogen (184 kg/ha) and available K (395 kg/ha) in plots under 50% RDF along with FYM @ 4 t/ha and higher phosphorous (89 kg/ha) was recorded with 100% RDF + $ZnSO_4$ @ 50 kg/ha. Higher content of available micronutrients was recorded in treatments applied with either organics alone or in combination with inorganics compared to inorganics alone (Table 3.167).

Similarly, stability in soil moisture status in surface soils was noticed in treatments applied with either organics or in combination with inorganics compared to inorganics alone (Fig. 3.5). The soil organic carbon stocks were higher in the plots under 50% RDF + FYM @ 4 t/ha (13.42 Mg/ha) followed by FYM@ 4 t/ha (12.66 Mg/ha) compared to other treatments (Table 3.168).

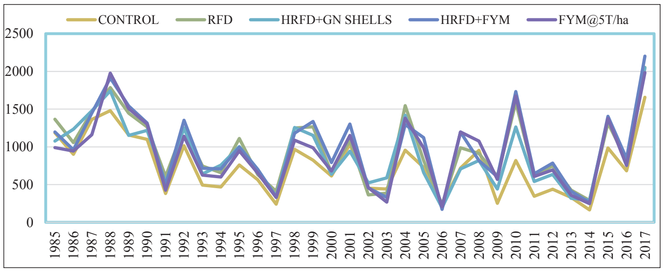


Fig. 3.4: Long-term effect of nutrient management on groundnut pod yield (kg/ha) - Ananthapuramu

Table 3.165 : Permanent manurial trial in groundnut: Effect on yield, economics and RWUE- Ananthapuramu

Treatment	Pod yield (kg/ha)				Haulm Yield (kg/ha)		Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio		RWUE (kg/ha-mm)	
	2017		Mean (33 years)											
	T	D	T	D	T	D	T	D	T	D	T	D	T	D
T_1: Control	1657		749	645	2268		21375		57726		3.70		3.29	
T_2: RDF (20:40:40 NPK kg/ha)	2053	1714	963	716	3050	2520	24681	21375	73804	60795	3.99	3.84	4.08	3.41
T_3: 50% RDF	1837	1636	894	677	2923	2415	23028	21375	65483	57075	3.84	3.67	3.65	3.25
T_4: Groundnut shells @ 4 t/ha	1891	1713	872	705	3007	2280	24175	21375	66934	60270	3.67	3.82	3.76	3.41
T_5: FYM @ 4 t/ha	1944	1650	921	724	3200	2138	26175	21375	67705	57151	3.73	3.67	3.87	3.28
T_6: 50% RDF + ground-nut shells @ 4 t/ha	2048	1583	900	686	3115	2342	25828	21375	72562	54544	3.81	3.55	4.07	3.15
T_7: 50% RDF + FYM @ 4 t/ha	2202	1682	986	712	3357	2557	27828	21375	77976	59429	3.94	3.78	4.38	3.34
T_8: RDF + $ZnSO_4$ @ 50 kg/ha	2007	1790	942	693	3060	2248	24681	21375	71754	63671	3.91	3.98	3.99	3.56
T_9: FYM @ 5 t/ha	1984	1743	919	717	3015	2524	27375	21375	67935	62108	3.61	3.91	3.94	3.47
T_{10}: RDF + groundnut shells @ 4 t/ha	2037	1721	-	-	2794	2188	27481	21375	69772	60446	3.67	3.83	4.05	3.42
CD @ 5%	175	NS	-	-	287	250	-	-	-	-	-	-	-	-

T: Treated; D: Depleted

Table 3.166 : Permanent manurial trial (PMT): Effect on chemical properties of soil (after 33 years) - Ananthapuramu

Treatment	pH		EC (dS/m)		OC (%)		Av. N (kg/ha)		Av. P_2O_5 (kg/ha)		Av. K_2O (kg/ha)	
	T	D	T	D	T	D	T	D	T	D	T	D
T_1: Control	6.30		0.03		0.20		132		28		184	
T_2: RDF (20:40:40 NPK kg/ha)	6.17	6.11	0.02	0.01	0.49	0.35	169	152	95	34	360	223
T_3: 50% RDF	6.19	6.15	0.01	0.02	0.45	0.35	165	152	56	36	252	237
T_4: Groundnut shells @ 4 t/ha	6.10	6.18	0.03	0.02	0.42	0.32	160	147	44	32	322	216
T_5: FYM @ 4 t/ha	6.33	6.20	0.03	0.02	0.55	0.30	177	145	45	33	388	246
T_6: 50% RDF + groundnut shells @ 4 t/ha	6.28	6.17	0.03	0.01	0.47	0.35	167	151	71	35	386	200
T_7: 50% RDF + FYM @ 4 t/ha	6.51	6.29	0.02	0.02	0.60	0.29	184	144	76	38	395	252
T_8: RDF + $ZnSO_4$ @ 50 kg/ha	6.11	6.17	0.05	0.03	0.40	0.27	158	142	89	30	350	176
T_9: FYM @ 5 t/ha	6.48	6.02	0.02	0.03	0.51	0.35	172	152	56	38	337	234
T_{10}: RDF + groundnut shells @ 4 t/ha	6.20	6.36	0.04	0.03	0.42	0.34	160	150	82	57	351	327
Initial values	6.60	-	0.02	-	0.30	-	131	-	20	-	154	-
CD at 5%	0.308	NS	NS	NS	0.179	NS	22.76	NS	8.58	NS	63.60	NS

T: Treated; D: Depleted

Table 3.167 : Permanent manurial trial (PMT): Effect on soil micronutrients (ppm) (after 33 years) - Ananthapuramu

Treatment	Manganese		Zinc		Copper		Iron	
	T	D	T	D	T	D	T	D
T_1: Control	7.56		0.65		0.98		5.33	
T_2: RDF (20:40:40 NPK kg/ha)	10.29	7.71	0.83	0.74	1.18	1.12	8.26	6.48
T_3: 50% RDF	9.66	7.53	0.72	0.57	1.30	0.97	8.18	5.60
T_4: Groundnut shells @ 4 t/ha	10.02	6.46	0.93	0.73	1.40	1.25	7.45	4.80

Treatment	Manganese		Zinc		Copper		Iron	
	T	D	T	D	T	D	T	D
T_5: FYM @ 4 t/ha	10.69	6.58	1.02	0.63	1.07	1.02	9.94	4.70
T_6: 50% RDF + groundnut shells @ 4 t/ha	14.03	7.52	0.99	0.68	1.37	1.10	10.23	5.98
T_7: 50% RDF + FYM @ 4 t/ha	12.74	7.89	1.07	0.63	1.22	0.99	11.29	5.39
T_8: RDF + $ZnSO_4$ @ 50 kg/ha	12.42	8.15	0.85	0.77	1.14	1.10	11.64	6.39
T_9: FYM @ 5 t/ha	11.01	5.28	1.08	0.80	1.11	1.15	12.09	4.18
T_{10}: RDF + groundnut shells @ 4 t/ha	10.53	6.86	0.93	0.91	1.28	1.27	8.75	7.26
CD at 5%	2.25	NS	0.18	0.17	NS	NS	3.25	NS

T: Treated; D: Depleted

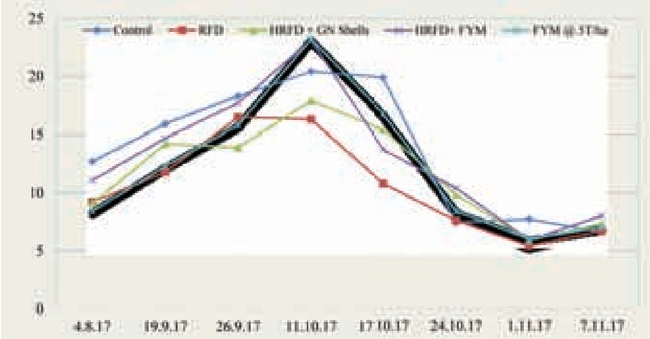


Fig. 3.5: Effect of long-term application of manures and fertilizers on soil moisture (% volume basis) at 0-15 cm depth during crop growth – Ananthapuramu

Table 3.168 : Permanent manural trial: Effect on organic carbon stocks (0-15 cm depth) in soil during *kharif* 2017-Ananthapuramu

Treatment	Organic carbon stocks (Mg/ha)	
	Treated	Depleted
T_1: Control	4.50	
T_2: RDF (20:40:40 NPK kg/ha)	11.14	11.14
T_3: 50% RDF	10.03	10.03
T_4: Groundnut shells @ 4 t/ha	9.63	9.63
T_5: FYM @ 4 t/ha	12.66	12.66
T_6: 50% RDF + groundnut shells @ 4 t/ha	10.38	10.38
T_7: 50% RDF + FYM @ 4 t/ha	13.42	13.42
T_8: RDF + $ZnSO_4$ @ 50 kg/ha	9.42	9.42
T_9: FYM @ 5 t/ha	11.04	11.04
T_{10}: RDF + groundnut shells @ 4 t/ha	10.26	10.26
CD at 5%	0.22	0.22

Groundnut under 50% RDF + FYM @ 4 t/ha

Groundnut under control

At Ananthapuramu, in a satellite experiment on the effect of integrated nutrient management (INM) and soil test based fertilizer (STBF) application on yield and economics of rainfed groundnut in *alfisols*, application of recommended dose of fertilizers (20:40:40 N, P_2O_5, K_2O kg/ha) recorded higher pod yield (1828 kg/ha) which was closely followed with soil test based fertilizer application (1764 kg/ha) and half recommended fertilizer dose (HRFD) + FYM @ 4 t/ha (INM) (1752 kg/ha) (Table 3.169).

Table 3.169 : Groundnut yield and economics under different treatments - Ananthapuramu

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	Shelling (%)	RWUE (kg/ha-mm)	B:C ratio
T_1: Control	1433	2270	72	2.852	3.70
T_2: INM	1752	2382	79	3.405	3.94
T_3: STBF	1764	2439	78	3.511	3.89
T_4: RFD	1828	2480	78	3.633	3.99
CD at 5%	89.1	73.8	2.2		

Performance of groundnut under RFD (left) and control (right)

3.4.1.4 Energy management

At Ananthapuramu, in a study on development and evaluation of clusterbean planter, seed yield (368 kg/ha), net returns (Rs.2990/ha), B:C ratio (1.3), RWUE (1.46 kg/ha-mm), higher field efficiency (2.5 hr/ha), higher output energy (11547.6 MJ/ha) and energy use efficiency (9.52) was recorded due to sowing with clusterbean planter.

In another experiment at Ananthapuramu, on development and evaluation of intercrop planter, a planter was designed and developed for sowing groundnut and pigeonpea in 8:1 row ratio. The yield of groundnut and pigeonpea was 1759 and 625 kg/ha, respectively, with net returns of Rs.84513/ha, B:C ratio (4.33) and RWUE (4.8 kg/ha-mm), with higher field efficiency (1.3 hr/ha), higher output energy (13516.4 MJ/ha) and energy use efficiency (9.62).

Sowing with clusterbean planter

Groundnut + pigeonpea (8:1) intercropping planter

At Anantapuramu, mini tractor drawn Ananta planter and Kisan planters were designed and developed with suitable seed metering devices for sowing of groundnut. From the calibration results of these two planters, it was found that the seed rate of Kisan planter (103 kg/ha) was less than that of Ananta planter (110 kg/ha).

Mini -tractor drawn Ananta planter

Mini -tractor drawn Kisan planter

3.4.1.5 Evaluation of improved varieties

At Ananthapuramu, among 14 entries of groundnut, MLTG (SB)-17-6 recorded highest seed and haulm yield (1194 & 1813 kg/ha, respectively), net returns (Rs.50757 kg/ha), B:C ratio (2.49) and RWUE (2.49 kg/ha-mm) followed by MLTG (SB) 17-8 (1035 kg/ha) (Table 3.170).

Table 3.170 : Performance of groundnut genotypes in multi-location trial– Ananthapuramu

Entry	Yield (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Haulm			
MLTG(SB) -17 -6	1194	1813	50757	2.49	2.49
MLTG(SB) -17 -8	1035	1685	41849	2.05	2.16
MLTG(SB) -17 -3	965	1288	36224	1.78	2.01
MLTG(SB) -17 -5	710	1140	22224	1.09	1.48
MLTG(SB) -17 -9	649	1192	19312	0.95	1.35
K-6 (C)	614	1795	20507	1.01	1.28
MLTG(SB) -17 -2	606	970	15966	0.78	1.27
MLTG(SB) -17 -13	598	1099	16195	0.79	1.25
MLTG(SB) -17 -7	583	902	14430	0.71	1.22
MLTG(SB) -17 -12	552	1150	14058	0.69	1.15
MLTG(SB) -17 -1	497	1097	10933	0.54	1.04
MLTG(SB) -17 -11	357	655	1443	0.07	0.75
MLTG(SB) -17 -4	344	772	1352	0.07	0.72
MLTG(SB) -17 -10	321	758	86	0.004	0.67
CD at 5%	192	799	-	-	-

Cost of cultivation : Rs. 20396/ha

In an evaluation of 14 entries of horsegram in IVT at Ananthapuramu, HG-9 was superior with significantly higher seed yield of 1094 kg/ha followed by HG-13 (977 kg/ha). Similarly, higher net returns (Rs.30624/ha), B:C ratio (4.37) and RWUE (2.38 kg/ha-mm) were also recorded with HG-9 entry of horsegram (Table 3.171).

Table 3.171 : Performance of horsegram entries - Ananthapuramu

Entry	Yield (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Dry haulm			
HG-9	1094	1201	30624	4.37	2.38
HG-13	977	1465	28170	4.02	2.13
HG-1	836	1413	23732	3.39	1.82
HG-3	833	1324	23286	3.33	1.81
HG-6	786	1121	21064	3.01	1.71
HG-8	784	1048	20712	2.96	1.71
HG-11	778	968	20212	2.89	1.69
HG-7	768	1069	20316	2.90	1.67
ATPHG-11 ©	754	1010	19660	2.81	1.64
HG-5	623	958	15522	2.22	1.36
HG-14	592	841	14124	2.02	1.29
HG-12	558	625	12240	1.75	1.22
HG-10	552	814	12816	1.83	1.20
HG-2	446	635	8920	1.27	0.97
CD at 5%	67	155	-	-	-

At Ananthapuramu, in an evaluation of 14 entries of clusterbean (guar) for seed, GR-8 recorded significantly higher seed yield (939 kg/ha), net returns (Rs.16900/ha), B:C ratio (1.50) and RWUE (1.83 kg/ha-mm) followed by GR-1 (838 kg/ha) net returns of Rs. 13891/ha, B:C ratio (1.23) and RWUE (1.64 kg/ha-mm) (Table 3.172).

Table 3.172 : Performance of clusterbean (guar) entries – Ananthapuramu

Entry	Seed yield kg/ha	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
GR-8	939	16900	1.50	1.83
GR-1	838	13891	1.23	1.64
GR-7	816	13222	1.17	1.59
GR-14	773	11920	1.06	1.51
GR-5	709	10021	0.89	1.39
GR-12	707	9937	0.88	1.38
RGC-936 ©	703	9835	0.87	1.37
GR-6	664	8647	0.77	1.30
GR-13	660	8554	0.76	1.29
GR-9	650	8239	0.73	1.27
GR-11	595	6601	0.59	1.16
GR-10	576	6025	0.54	1.13
GR-4	546	5125	0.46	1.07
GR-2	490	3448	0.31	0.96
CD at 5%	118	-	-	-

At Ananthapuramu, in a cowpea initial varietal trial (IVT) with 14 entries, CP-17 recorded highest seed yield (754 kg/ha) net returns (Rs.18902/ha), B:C ratio (1.68) and RWUE (1.47 kg/ha-mm) followed by CP-6 and CP-18 (655 & 646 kg/ha) respectively compared to other entities (Table 3.173).

Table 3.173 : Performance of cowpea entries in Initial Varietal Trial (IVT) – Ananthapuramu

Entry	Seed yield kg/ha	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
CP-17	754	18902	1.68	1.47
CP-6	655	14942	1.33	1.28
CP-18	646	14582	1.30	1.26
CP-12	631	13982	1.24	1.23
CP-3	620	13542	1.20	1.21
CP-10	602	12822	1.14	1.18
CP-8	602	12822	1.14	1.18
CP-14	567	11422	1.01	1.11
CP-15	567	11422	1.01	1.11
CP-2	511	9182	0.82	1.00
CP-13	499	8702	0.77	0.97
CP-4	446	6582	0.58	0.87
CP-16	407	5022	0.45	0.79
CP-9	396	4582	0.41	0.77
CD at 5%	105	-	-	-

Cowpea - Initial varietal trial

3.4.1.6 Alternate land use system

At Ananthapuramu, among various agroforestry systems evaluated in class IV lands, fodder sorghum (MP Chari) recorded higher green fodder yield (1404 kg/ha) as sole crop, followed by fodder sorghum in custard apple as intercrop (1283 kg/ha) compared with other agroforestry systems. Similarly, fodder cowpea (EC 4216) recorded higher green fodder yield (1046 kg/ha) as sole crop, followed by simarouba + fodder sorghum (1003 kg/ha). Both fodder crops sorghum and cowpea recorded lowest green fodder yield when intercropped with subabul (Table 3.174 & 3.175).

Table 3.174 : Green fodder yield of different fodder crops in various agroforestry systems - Ananthapuramu

Treatment	Plant height (cm)	Green fodder yield (kg/ha)		
		1st cut	2nd cut	Total
T_1: Fodder sorghum alone	169	1215	189	1404
T_2: Fodder cowpea alone	85	905	141	1046
T_3:Amla + fodder sorghum	164	590	92	682
T_4: Subabul + fodder sorghum	166	405	63	468
T_5:Simarouba + fodder sorghum	166	868	135	1003
T_6: Custard apple + fodder sorghum	167	1111	172	1283
T_7: Amla + fodder cowpea	74	567	88	656
T_8: Subabul + fodder cowpea	75	359	56	415
T_9: Simarouba + fodder cowpea	85	775	121	896
T_{10}: Custard apple + fodder cowpea	78	613	96	709
CD at 5%	7	114	15	129

Table 3.175 : Effect of treatments on growth parameters in agroforestry system – Ananthapuramu

Tree species	Plant height (m)	Stem girth (m)	Plant spread (m)	
			E-W	N-S
Simarouba	3.65	0.46	4.36	4.57
Custard apple	2.25	0.25	2.02	1.99
Amla	3.76	0.42	3.45	3.79
Subabul	4.94	0.34	3.19	4.01

Experiment on agroforestry system

3.4.2. Soybean Based Production System

3.4.2.1 Rainwater management

At Indore, in a study on catchment-storage-command relationship for enhancing water productivity in a micro-watershed, four double cropping systems were evaluated using harvested rainwater in farm pond for supplemental irrigation during critical crop growth stages. Among different cropping systems, soybean-chickpea system was found more remunerative with net returns of Rs.61478/ha and B:C ratio 2.86 followed by soybean-pea for vegetable (Rs. 56886/ha with B: C ratio of 2.26). Further, sweet corn (Sugar-75) grown for green cobs during rainy season recorded net return of Rs.24931/ha and tomato (*Hy*. Laxmi) grown during *rabi* gave net returns of Rs. 3148/ha. The total net return from sweet corn-tomato was Rs. 28079/ha with B:C ratio of 1.40. Similarly, total net return from sweet corn-sweet corn cropping system was Rs. 31412/ha with B: C ratio 1.63 (Table 3.176).

Table 3.176 : Yield and economics of different cropping systems with supplemental irrigation -Indore

Cropping sequence	Crop	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	System NMR (Rs/ha)	System B:C ratio
Sweet corn-tomato	Sweet corn (Suger-75) (K)	2497	25000	24931	28079	1.40
	Tomato (Hy.Laxmi) (R)	2407	45000	3148		
Sweet corn-sweet corn	Sweet corn (K)	2497	25000	24931	31412	1.63
	Sweet corn (R)	1574	25000	6481		
Soybean - pea (vegetable)	Soybean (JS 20-29) (K)	1406	20000	29211	56886	2.26
	Pea(Pea-10) (R)	1756	25000	27675		
Soybean-chickpea	Soybean (K)	1406	20000	29211	61478	2.86
	Chickpea (JG - 412) (R)	905	13000	32267		

Farm pond with harvested rainwater

Sweet corn - Sugar 75

Soybean - JS 20-29

Chickpea- JG 412

At Rewa, in an experiment on performance of different cropping systems under various *in-situ* moisture conservation treatments, soybean + pigeonpea intercropping (4:2) sown in ridge and furrow system recorded higher soybean equivalent yield (2231 kg/ha), net returns (Rs.57924/ha), B:C ratio (3.60) and RWUE (2.63 kg/ha-mm) compared to other treatments. Occurrence of dry spells during crop growth and reproductive stages adversely affected seed yield and net returns (Table 3.177).

Soybean + pigeonpea intercropping (4:2) sown on ridge and furrows system

Table 3.177 : Effect of *in-situ* moisture conservation on yield and economics of cropping systems - Rewa

Treatment	Yield (kg/ha)				SEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed		Stalk						
	Soybean	Inter crop	Soybean	Inter crop					
M_1C_1	197	179	444	403	453	20755	-4249	0.80	0.53
M_1C_2	287	54	645	121	394	20755	-6250	0.70	0.46
M_1C_3	340	538	766	1210	1261	20755	24792	2.19	1.48
M_1C_4	430	0	968	0	430	20500	-4479	0.78	0.51
M_2C_1	269	287	605	645	679	22300	2373	1.11	0.80
M_2C_2	358	134	806	302	627	22300	611	1.03	0.74
M_2C_3	448	1039	1008	2339	2231	22300	57924	3.60	2.63
M_2C_4	717	0	1613	0	718	20500	6202	1.30	0.84
M_3C_1	72	90	161	202	198	20240	-12988	0.36	0.23
M_3C_2	108	43	242	97	193	20240	-13175	0.35	0.23
M_3C_3	143	358	323	806	756	20240	7009	1.35	0.89
M_3C_4	215	0	484	0	215	20500	-12489	0.39	0.25
CD at 5%					82				

M_1: Broad bed and furrow; M_2: Ridge and furrow; M_3: Flat bed; C_1: Soybean + greengram (4:2); C_2: Soybean + cowpea (4:2); C_3: Soybean + pigeonpea (4:2); C_4: Soybean sole

3.4.2.2 Cropping systems

At Rewa, in an evaluation of chickpea and lentil based intercropping systems after *kharif* paddy under zero till condition, very low chickpea equivalent yields (CEY) were recorded due to low rainfall in October (20.2 mm) followed by no rainfall during November and December months. About 7.4 mm was received in January and there was no rainfall till crop harvest. A CEY of 673 kg/ha was recorded from sole lentil with net returns of Rs.20890/ha and B:C ratio of 2.24 followed by chickpea + linseed (4:2) with CEY of 549 kg/ha, net returns of Rs.19953/ha and B:C ratio of 2.35 (Table 3.178).

Table 3.178 : Yield and economics of different rabi cropping systems under zero tillage condition – Rewa

Treatment	Yield (kg/ha)				CEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Seed		Stalk					
	Main crop	Inter crop	Main crop	Inter crop				
T_1: Sole linseed	378	-	427	-	302	19600	-4073	0.79
T_2: Sole chickpea	838	-	1094	-	838	16000	26994	2.68
T_3: Sole lentil	530	-	1355	-	583	12100	18405	2.52
T_4: Sole mustard	259	-	373	-	181	10350	-927	0.91
T_5: Chickpea + linseed (4:2)	747	245	865	281	943	15850	32446	3.04

Treatment	Yield (kg/ha)				CEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Seed		Stalk					
	Main crop	Inter crop	Main crop	Inter crop				
T_6: Chickpea + mustard (4:2)	683	178	717	380	807	14950	26497	2.77
T_7: Lentil + linseed (4:2)	331	223	1260	471	542	14050	14781	2.05
T_8: Lentil + mustard (4:2)	422	175	643	230	586	13150	17023	2.29
CD at 5%					**32.6**			

CEY: Chickpea equivalent yield

3.4.2.3 Nutrient management

In a permanent manurial trial (PMT) (initiated in 1992) at Indore, significantly higher soybean (JS 95-60) seed yield (908 kg/ha) was recorded with application of FYM @ 6 t/ha+ 20 kg N and 13 kg P/ha over all other treatments except application of residues @ 5 t/ha + 20 kg N and 13 kg P/ha (805 kg/ha) and residues alone @ 5 t/ha (772 kg/ha). Similarly, the mean seed yield of soybean for last 26 years also revealed that application of FYM @ 6 t ha + 20 kg N and 13 kg P/ha gave the highest yield (1934 kg/ha) compared to rest of the treatments. Further, application of FYM @ 6 t/ha + 20 kg N and 13 kg P/ha gave the highest net returns (Rs.13991/ha), B:C ratio (0.68) and RWUE (1.45 kg/ha-mm) compared to other treatments (Table 3.179).

Table 3.179 : PMT: Effect of treatments on seed yield and economics of soybean- Indore

Treatment	Soybean yield (kg/ha)		Mean seed yield (26 yrs)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk					
T_1: Control	450	979	1166	16300	798	0.05	0.72
T_2: N20 P13	549	982	1485	16700	4163	0.25	0.88
T_3: N30 P20	674	1355	1641	16900	8715	0.52	1.07
T_4: N40 P26	685	1464	1740	17200	8838	0.51	1.09
T_5: N60 P35	683	1421	1808	18400	7572	0.41	1.09
T_6: FYM 6 t/ha + T_2	908	1811	1934	19700	13991	0.68	1.45
T_7: Residues 5 t/ha + T_2	805	1574	1683	20300	10301	0.51	1.28
T_8: FYM 6 t /ha	645	1169	1733	20000	4796	0.24	1.03
T_9: Residues 5 t/ha	772	1590	1589	20200	9148	0.45	1.23
CD at 5%	177	490	-	-	-	-	-

At the time of sowing of soybean, higher mean weight diameter (MWD) was recorded with application of FYM + N20 P13 (1.69 mm) and minimum (0.74 mm) in control. In general, FYM and crop residue addition gave higher MWD compared to chemical fertilizer alone. Addition of organic manures alone and along with inorganic fertilizer also reduced the soil bulk density. The lowest bulk density of 1.15 Mg/m^3 was obtained with FYM @ 6 t/ha + N20 P13. Due to higher MWD and reduced bulk density, the porosity of soil was also increased in organic amendment treated plots. The porosity ranged from 44.55% to 56.25% in different treatments and was highest (56.6%) with FYM @ 6 t/ha + N20 P13. Similar results were obtained after harvest of soybean (Table 3.180).

Table 3.180 : PMT: Effect of treatments on soil physical properties before and after harvest of Soybean - Indore

Treatment	Before sowing of soybean			After harvest of soybean		
	Mean wt. diameter (mm)	Bulk Density (Mg/m^3)	Porosity (%)	Mean wt. diameter (mm)	Bulk Density (Mg/m^3)	Porosity (%)
T_1:N0 P0 -Control	0.74	1.47	44.5	0.44	1.49	43.8
T_2:N20 P13	1.03	1.46	44.9	0.73	1.47	44.5
T_3: N30 P20	1.05	1.41	46.8	0.81	1.43	46.1

Treatment	Before sowing of soybean			After harvest of soybean		
	Mean wt. diameter (mm)	Bulk Density (Mg/m^3)	Porosity (%)	Mean wt. diameter (mm)	Bulk Density (Mg/m^3)	Porosity (%)
T_4:N40 P26	1.10	1.38	47.9	0.89	1.38	47.9
T_5:N60 P35	1.13	1.38	47.9	0.91	1.39	47.6
T_6:FYM 6 t/ ha + T_2	1.69	1.15	56.6	1.91	1.14	57.0
T_7:Residues 5 t/ha+T_2	1.68	1.17	55.8	1.89	1.16	56.2
T_8:FYM 6 t/ha	1.65	1.16	56.2	1.83	1.70	35.9
T_9:Residues 5 t/ha	1.62	1.26	52.5	1.80	1.29	51.3

Application of FYM and crop residue resulted in a positive balance of soil fertility particularly available N, P_2O_5, K_2O, S and organic carbon content in plough layer compared to inorganic fertilizers. However, the highest soil organic C (0.79), P_2O_5 (21.7 kg/ha), K_2O (647.0 kg/ha) and S (18.4 kg/ha) was recorded with application of FYM 6 t/ha + T_2 compared to rest of the treatments (Table). Further, the application of organic manures reduced the electrical conductivity (EC) and marginally increased pH of soil compared to other treatments (Table 3.181).

Table 3.181 : PMT: Effect of treatments on soil chemical properties - Indore

Treatment	OC (%)	Available nutrients (kg/ha)				pH (2:1)	EC (dS/m)
		N	P_2O_5	K_2O	S		
T_1: N0 P0- Control	0.28	180	8.4	472	6.8	7.77	0.56
T_2: N20 P13	0.38	241	10.9	525	6.1	6.94	0.52
T_3: N30 P20	0.47	215	12.4	542	7.1	7.48	0.42
T_4: N40 P26	0.53	209	13.4	552	7.8	7.81	0.53
T_5: N60 P35	0.59	217	14.4	585	8.2	7.72	0.42
T_6: FYM 6 t/ha + T_2	0.79	289	21.7	647	18.4	7.90	0.21
T_7: Residues 5 t/ha + T_2	0.75	290	18.3	637	15.1	8.09	0.22
T_8: FYM 6 t/ha	0.74	288	15.5	607	16.1	8.25	0.22
T_9: Residues 5 t/ha	0.64	253	14.5	607	17.1	7.99	0.25

The uptake of N, P, K and S by soybean seed and stalk and total uptake of these nutrients in relation to different treatments was mainly governed by biomass yield. Application of FYM 6 t/ha + T_2 recorded higher uptake of N, P, K and S as compared to all other treatments (Table 3.182).

Table 3.182 : PMT: Effect of treatments on nutrient uptake by soybean - Indore

Treatment	Nutrient uptake by soybean (kg/ha)								Total nutrient uptake (kg/ha)			
	Seed				Stalk							
	N	P	K	S	N	P	K	S	N	P	K	S
T_1: N0 P0- Control	21.5	1.7	5.7	1.1	5.4	0.4	1.3	1.2	18.2	2.1	7.0	2.3
T_2: N20 P13	29.6	2.5	7.2	1.4	6.7	0.4	1.3	1.6	21.6	2.9	8.4	3.0
T_3: N30 P20	35.1	2.8	8.9	1.9	9.7	0.8	3.0	1.9	27.3	3.6	11.9	3.7
T_4: N40 P26	40.0	3.0	8.7	2.1	11.3	0.8	3.4	2.0	36.6	3.8	12.0	4.1
T_5: N60 P35	40.0	3.3	9.6	2.1	13.1	0.9	3.4	2.4	36.2	4.2	13.0	4.5
T_6: FYM 6 t/ha + T_2	56.4	5.7	14.2	3.2	17.4	1.3	4.4	2.8	49.8	7.0	18.7	5.9
T_7: Residues 5 t/ha+T_2	42.3	4.4	11.0	1.9	13.1	0.9	3.5	2.6	33.3	5.3	14.6	4.5
T_8: FYM 6 t/ha	36.1	2.7	8.9	1.8	9.9	0.7	2.5	1.4	31.4	3.4	11.4	3.2
T_9: Residues 5 t/ha	44.8	3.2	10.3	2.0	11.7	0.9	3.4	2.3	37.7	4.1	13.7	4.3

Soybean under control

Soybean under FYM 6 t/ha + N 20 P 13

In PMT, during *rabi* 2017-18 after harvest of soybean, rainfed chickpea crop grown on residual moisture gave highest chickpea seed yield (1131 kg/ha), net returns (Rs. 27855/ha) and B:C ratio (1.60) with application of FYM @ 6 t/ha + 20 kg N and 13 kg P/ha compared to other treatments (Table 3.183).

Table 3.183 : PMT: Residual effect of treatments on seed yield and economics of chickpea - Indore

Treatment	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
T_1: N0 P0- Control	350	250.08	15000	(-) 995	(-) 0.07
T_2: N20 P13	396	283.15	15900	(-) 44	0.00
T_3: N30 P20	694	496.03	16200	11578	0.71
T_4: N40 P26	793	566.30	16500	15213	0.92
T_5: N60 P35	978	698.58	16800	22320	1.33
T_6: FYM 6 t/ha + T_2	1131	808.12	17400	27855	1.60
T_7: Residues 5 t/ha + T_2	929	663.44	17800	19353	1.09
T_8: FYM 6 t/ha	747	533.23	17200	12661	0.74
T_9: Residues 5 t/ha	825	589.04	17000	15986	0.94
CD at 5%	221	-	-	-	-

In a PMT started in 1999 at Rewa, among different combinations of N sources in rice-wheat; blackgram-chickpea and rice + blackgram - wheat + chickpea systems in separate blocks, application of 100% N through compost was superior in all cropping systems (Table 3.184 & 3.185). During *kharif* 2017, very poor yield of blackgram was obtained due to occurrence of dry spells. However, in rice-wheat system, the highest yield of rice (1554 kg/ha) with net returns of Rs.8584/ha and B:C ratio of 1.43 were recorded with 100% N through compost compared to other treatments. During *rabi*, no rainfall was recorded and due to lack of moisture very poor yields were recorded. Among all treatment combinations, application of 100% N through compost gave higher chickpea equivalent yield (388 kg/ha), net returns (Rs.972/ha) and B:C ratio (1.05) compared to other treatments (Table 3.186).

Table 3.184 : PMT: Effect of source and levels of N on yield and economics of rice-wheat system – Rewa

Treatment	Yield (kg/ha)						Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio	
	Rice			Wheat								
	Grain yield	Mean (19 years)	Straw	Grain	Mean (18 years)	Straw	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1: Control (no nitrogen)	817	1154	2476	242	670	1594	16400	17733	-852	-709	0.95	0.96
T_2: 100% N fertilizer (f)	1353	1817	3378	307	973	1955	18963	21525	6064	-197	1.32	0.99
T_3: 100% N through compost (c)	1554	2121	3810	376	1050	2065	20090	21525	8584	3279	1.43	1.15
T_4: 50% N (f) + 50% N (c)	1238	1808	3098	320	940	1945	19526	21525	3380	335	1.17	1.02

Treatment	Yield (kg/ha)						Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio	
	Rice			Wheat								
	Grain yield	Mean (19 years)	Straw	Grain	Mean (18 years)	Straw	Rice	Wheat	Rice	Wheat	Rice	Wheat
$T_{5:}$ 50% N (f) + 25% N (c)	967	1498	2466	309	859	1935	18604	21525	-666	-189	0.96	0.99
$T_{6:}$ 25% N (f) + 50% N (c)	1013	1412	2737	331	909	1955	18911	21525	34	859	1.00	1.04
$T_{7:}$ 50% N (f) + 25% N (c) + *Azotobacter*	1233	1552	3388	320	940	1975	18706	21628	4410	353	1.24	1.02
$T_{8:}$ 25% N (f) + 50% N (c) + *Azotobacter*	1348	1754	3509	343	936	1905	19014	21628	6063	1085	1.32	1.05
$T_{9:}$ 50% N (f) + 50% N (c) + *Azotobacter*	1504	2028	3679	346	948	1925	19629	21628	8114	1297	1.41	1.06

100% N: 60 kg/ha; f: Fertilizer; c: compost

Table 3.185 : PMT: Effect of source and levels of N on yield and economics of the blackgram-chickpea system- Rewa

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio	
	Blackgram		Chickpea							
	2017	Mean (19 years)	2017	Mean (19 years)	Black-gram	Chickpea	Black-gram	Chickpea	Black-gram	Chickpea
T_1: Control (no nitrogen)	104	761	256	732	5500	17220	-3754	-4256	0.32	0.75
T_2: 100% N through fertilizer	163	1162	297	858	6500	21013	-3779	-5979	0.42	0.72
T_3: 100% N through compost	217	1541	391	1120	7300	21013	-3690	-1617	0.49	0.92
T_4: 50% N (fert) + 50% N (compost)	169	1186	325	926	6800	21013	-3958	-4643	0.42	0.78
T_5: 50% N (fert) + 25% N (compost)	134	962	307	889	6400	21013	-4143	-5519	0.35	0.74
T_6: 25% N (fert) + 50% N (compost)	148	1048	338	964	6600	21013	-4135	-4051	0.37	0.81
T_7: 50% N (fert) + 25% N (compost) + *Rhizobium*	142	956	333	954	6600	21115	-4225	-4373	0.36	0.79
T_8: 25% N (fert) + 50% N (compost) + *Rhizobium*	152	1052	352	1009	6700	21115	-4160	-3557	0.38	0.83
T_9: 50% N (fert) + 50% N (compost)+ *Rhizobium*	188	1221	355	1004	7000	21115	-3869	-3365	0.45	0.84

Table 3.186 : PMT: Effect of different treatments on yield and economics of rice + blackgram - wheat + chickpea systems - Rewa

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)		NMR (Rs/ha		B:C ratio	
	Rice + blackgram (equivalent to rice)		Wheat + chickpea (equivalent to chickpea)		Rice + black-gram	Wheat + chickpea	Rice + black-gram	Wheat + chickpea	Rice + black-gram	Wheat + chickpea
	2017	Mean (19 years)	2017	Mean (19 years)						
T1:Control (no nitrogen)	403	916	228	916	7500	17600	495	-4034	1.07	0.77
T2: 100% N through fertilizer	744	1464	290	1464	8600	21400	5235	-4090	1.61	0.81
T_3: 100% N through compost	854	1747	388	1747	9800	21400	5559	972	1.57	1.05
T_4: 50% N (fert) + 50% N (compost)	701	1491	324	1491	9000	21400	4211	-2134	1.47	0.90
T_5: 50% N (fert) + 25% N (compost)	604	1166	314	1166	8600	21400	2135	-2606	1.25	0.88

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)		NMR (Rs/ha		B:C ratio	
	Rice + blackgram (equivalent to rice)		Wheat + chickpea (equivalent to chickpea)		Rice + black-gram	Wheat + chickpea	Rice + black-gram	Wheat + chickpea	Rice + black-gram	Wheat + chickpea
	2017	Mean (19 years)	2017	Mean (19 years)						
T_6: 25% N (fert) + 50% N (compost)	648	1266	337	1266	8700	21400	3121	-1614	1.36	0.92
T_7: 50% N (fert) + 25% N (compost) + *Azotobacter/Rhizobium*	693	1172	330	1172	8600	21500	3940	-1926	1.46	0.91
T_8: 25% N (fert) + 50% N (compost) + *Azotobacter/ Rhizobium*	729	1321	345	1321	8900	21500	4779	-1552	1.54	0.93
T_9: 50% N (fert) + 50% N (compost) + *Azotobacter/ Rhizobium*	814	1603	354	1603	9300	21500	5360	-860	1.58	0.96
CD at 5%	20	-	39	-	-	-	-	-	-	-

3.4.2.4 Energy management

In a long-term study on tillage and nutrient management in soybean at Indore, low tillage (LT) + 4 t/ha straw + hand weeding (HW) recorded statistically highest seed yield of 593 kg/ha over all tillage practices except LT + 4 t/ha compost + HW (536 kg/ha) and LT + 2 t/ha *glyricidia* green leaves + HW (490 kg/ha). Further, the highest net returns of Rs. 9627/ha, B:C ratio (0.75) and RWUE (0.95 kg/ha- mm) was obtained under LT + 4 t/ha straw + HW and the lowest (Rs. 2198 /ha) in T_1 (Table). The mean seed yield of 19 years indicated that the highest soybean seed yield of 1416 kg/ha was recorded with LT + 4 t/ha straw + HW closely followed by CT + RF (+OT) + HW (1413 kg/ha) and the lowest in LT + 2 t/ha *glyricidia* green leaves + Hb (987kg/ha). All the treatment combinations having herbicide application had lower seed yield than hand weeding (Table 3.187).

Table 3.187 : Effect of tillage and nutrient management on yield and economics of soybean - Indore

Treatment	Seed yield (kg/ha)	Mean seed yield (19 years) (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: CT + RF (-OT) + HW	350	1300	11100	2198	0.20	0.56
T_2: CT + RF (+OT) + HW	335	1413	12600	142	0.01	0.53
T_3: LT + 4 t/ha straw + HW	593	1416	12900	9627	0.75	0.95
T_4 : LT + 4 t/ha straw + Hb	396	1074	13700	1341	0.10	0.63
T_5 : LT + 4 t ha compost + HW	536	1354	13900	6466	0.47	0.85
T_6 : LT + 4 t/ha compost + Hb	363	1176	12800	982	0.08	0.58
T_7: LT + 2 t/ha *glyricidia* green leaves + Hb	402	987	12400	2858	0.23	0.64
T_8: LT + 2 t/h *glyricidia* green leaves + HW	490	1258	12800	5829	0.46	0.78
CD at 5%	113	215	-	-	-	-

The input, output and energy balance under different treatments indicated that the highest energy balance was recorded under the treatment T_5 closely followed by T_6 and T_7. Input energy is lower under low till treatments than that of T_1 and T_2. The highest output energy was recorded T_5 followed by T_6, T_7, T_3, T_2, T_1, T_8 and lowest in T_4 (Fig. 3.6).

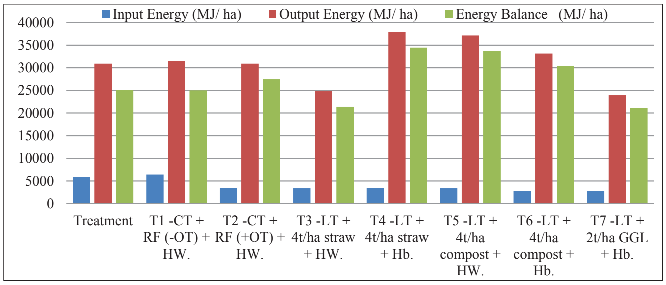


Fig. 3.6: Input , output and energy balance under LTE - Indore

The highest organic carbon content (0.67%) was recorded in plots under LT + 4 t/ha straw+ HW and minimum (0.41%) in CT + RF (+OT) + HW. Available nutrients N, P_2O_5, K_2O and S was higher in plots under LT + 4 t/ha straw + HW. The available N ranged from 205 to 291, available P 15.5 to 21.6; available K 619 to 670 and 13.73 to 17.45 in case of available S in different treatments (Table 3.188).

Table 3.188 : Effect of tillage and nutrient management on soil chemical properties - Indore

Treatment	OC (%)	Nutrient status of soil (kg/ha)				pH (1:2.5)	EC (dS/m)
		N	P_2O_5	K_2O	S		
T_1: CT + RF (-OT) + HW	0.44	229	16.0	662	13.7	7.75	0.32
T_2: CT + RF (+OT) + HW	0.41	205	15.5	619	14.3	7.75	0.34
T_3: LT + 4 t/ha straw + HW	0.67	291	21.6	670	17.5	7.85	0.31
T_4: LT + 4 t/ha straw + Hb	0.51	247	17.7	621	16.1	7.78	0.33
T_5: LT + 4 t ha compost + HW	0.60	277	18.7	642	16.6	7.75	0.34
T_6: LT + 4 t/ha compost + Hb	0.48	241	16.2	611	17.3	7.65	0.31
T_7: LT + 2 t/ha *glyricidia* green leaves + Hb	0.49	229	15.8	603	16.3	7.75	0.31
T_8: LT + 2 t/h *glyricidia* green leaves + HW	0.57	254	16.7	604	16.4	7.70	0.30

CT: Conventional tillage; LT: Low tillage; OT: Offseason tillage; Hb: Herbicide; HW: Hand weeding

The lowest bulk density (1.205 Mg/m^3) was recorded in plots under LT + 4 t/ha straw + HW and the maximum (1.33 Mg/m^3) was in CT + RF (-OT) + HW. The soil porosity was highest (53.98%) in LT + 4 t/ha straw + HW closely followed by LT + 4 t/ha compost + HW. The mean weight diameter (MWD) was the parameter which was affected mostly due to different treatments. It was highest (4.97 mm) in plots under LT + 4 t/ha straw + HW and closely followed by LT + 4 t/ha compost + HW and the minimum in CT + RF (+OT) + HW (Table 3.189).

Table 3.189 : Effect of tillage and nutrient management in soybean on soil physical properties - Indore

Treatment	Bulk density (Mg/m^3)	Porosity (%)	MWD (mm)
T_1: CT + RF (-OT) + HW	1.33	50.20	2.40
T_2: CT + RF (+OT) + HW	1.32	50.95	1.29
T_3: LT + 4 t/ha straw + HW	1.21	53.98	4.97
T_4: LT + 4 t/ha straw + Hb	1.27	51.91	3.57
T_5: LT + 4 t ha compost + HW	1.23	53.28	4.27
T_6: LT + 4 t/ha compost + Hb	1.29	52.26	2.88
T_7: LT + 2 t/ha *glyricidia* green leaves + Hb	1.25	51.35	2.66
T_8: LT + 2 t/h *glyricidia* green leaves + HW	1.23	52.56	3.99

3.4.2.5 Evaluation of improved varieties

At Indore, eight pigeonpea entries were tested along with two checks *viz.,* JKM –189 and JA 4 (medium maturing varieties *i.e.,* 170-175 days). Three dry spells were experienced at early vegetative stage and pre-flowering to maturity phase of the crop. The short duration (166 days) entry C-11 recorded highest seed yield of 2173 kg/ha followed by ICP 8863 08-40 (1961 kg/ha) and ICP 8863 08-41 (1925 kg/ha) as against the check entries JKM-189 (1692 kg/ha) and JA- 4 (1988 kg/ha) (Table 3.190). Entry C-11 also recorded higher net returns (Rs.97342/ha), B:C ratio (3.41) and RWUE (5.87 kg/ha-mm) than other entries.

Table 3.190 : Performance of pigeonpea entries under dryland conditions - Indore

Entry	Seed yield (kg/ha)	NMR (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
JKE-114E	1470	59380	2.31	3.97
ICP 8863-08-40	1961	85894	3.08	5.29
ICP 8863-08-41	1925	83950	3.02	5.20
ICP 8863-08-39	1597	66238	2.51	4.31
JA 4 08-20	1632	68128	2.56	4.41
JKM 189 (check)	1692	71368	2.66	4.57
JA- 4 (check)	1988	87352	3.12	5.37
TJT 501	1446	58084	2.27	3.90
C-11	2173	97342	3.41	5.87
PUSA 992	857	26278	1.35	2.31
CD at 5%	4.7	206.94	-	-

Cost of cultivation: Rs.20000/ha

At Indore, among 20 chickpea varieties evaluated under residual soil moisture, entry IG 593 recorded highest seed yield (1300 kg/ha) with net returns of Rs. 38500/ha and B:C ratio (2.93) followed by Vishal (1280 kg/ha) and JG 16 (1215 kg/ha) as compared to other varieties. Check variety Ujjain 21 recorded seed yield of 1036 kg/ha seed yield (Table 3.191).

Table 3.191 : Performance of chickpea genotypes - Indore

Entry	Maturity (days)	Seed yield (kg/ha)	NMR (Rs/ha)	B:C ratio
Ujjain 21	118	1036	26625	2.33
JG 14	118	742	13375	1.67
JG 218	121	988	24463	2.22
VISHAL	117	1281	37625	2.88
IG 593	120	1300	38500	2.93
RVS 203	116	1011	25513	2.28
JG 322	120	1158	32125	2.61
JG 6	121	1058	27625	2.38
RVG 201	120	1128	30763	2.54
JG 16	120	1215	34688	2.73
JG 130	118	1206	34250	2.71
JG 370	120	1072	28250	2.41
JG 338	118	1070	28129	2.41
JAKI 9218	120	1089	29008	2.45
KAK 2	120	904	20667	2.03
JG 412	115	1019	25845	2.29
JG 12	121	981	24125	2.21
RVG 202	119	1133	31000	2.55
JG 11	120	1010	25450	2.27
CD at 5%	3.30	142.5	-	-

Cost of cultivation: Rs.20000/ha

3.5 Cotton Based Production System

3.5.1 Rainwater management

At Kovilpatti, during *rabi* 2017-18, the total rainfall received was 421.4 mm in 17 rainy days as against the normal rainfall of 398.6 mm in 21 rainy days. There were six runoff events during the cropping period (Table 3.192). Further, about 21% of harvested rainwater (56 m^3) was lost through seepage while 39% of water was lost through evaporation.

Table 3.192 : Details of pond water used - Kovilpatti

Parameter	Volume of water	% of harvested water
Rainfall (mm)	421.4 mm	-
Evaporation*	105 m^3	39.37
Water harvested	268 m^3	-
Seepage losses	56 m^3	20.89
Used for irrigation	101 m^3	37.74
Dead storage/ storage at the end of the season	6 m^3	2.00

The runoff water collected from one hectare catchment (268 m^3) can be used for giving supplemental irrigation in an area of 0.4 ha (Table 3.193). Supplemental irrigation to a depth of 2.5 cm using raingun from the harvested rainwater in farm pond during flowering stage resulted in 12.6% increased yield in cotton and 15.3% in sorghum compared to rainfed crop, with higher net returns of Rs. 10954/ha, B:C ratio (1.36) and RWUE of 2.34 kg/ha-mm (Table 3.194).

Table 3.193 : Details of rainfall events and amount of water stored in farm pond - Kovilpatti

Date	Rainfall (mm)	Depth of water in farm pond (mm)	Volume of water stored (m^3)
13.10.2017	29.5	145	47.1
18.10.2017	58.6	145	47.1
27.10.2017	32.2	100	32.5
08.11.2017	27.9	145	47.1
01.12.2017	112	145	47.1
08.12.2017	22.2	145	47.1
Total			**268.0**

Table 3.194 : Effect of supplement irrigation on crops yield and economics - Kovilpatti

Treatment	Seed cotton/ grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
Cotton					
T_1: Rainfed	876	30000	6792	1.23	2.08
T_2: Supplemental irrigation through raingun	987	30500	10954	1.36	2.34
Sorghum					
T_1: Rainfed	1098	22000	-2236	0.90	2.60
T_2: Supplemental irrigation through raingun	1267	22500	306	1.01	3.00

Among different tillage methods evaluated in cotton at Kovilpatti, rotovator recorded the highest seed cotton yield (965 kg/ha) of cotton (KC3) which was 12% higher than the conventional tillage, with higher net returns of Rs. 9530/ha, B:C ratio (1.31) and RWUE of 2.29 kg/ha-mm (Table 3.195).

Table 3.195 : Effect of tillage methods on yield and economics of cotton - Kovilpatti

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton	Stalk				
T_1: Conventional tillage	863	2082	30500	5746	1.19	2.05
T_2: Rotovator	965	2418	31000	9530	1.31	2.29
T_3: Conservation tillage	817	1817	28000	6314	1.23	1.94
T_4: Chiesel ploughing	904	2134	29750	8218	1.28	2.15
CD at 5%	22.7	53.8	-	-	-	-

Tillage in cotton with rotovator

Cotton with conventional tillage

The highest soil moisture content was recorded in conservation tillage method in 0-15 cm, 15-30 cm and 30-45 cm soil depths compared to other tillage methods (Table 3.196).

Table 3.196 : Effect of treatments on soil moisture (%) at different stages of cotton - Kovilpatti

Treatment	Sowing			Flowering			Maturity		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
T_1: Conventional tillage	23.7	25.4	20.3	31.4	31.8	32.3	16.9	18.7	16.1
T_2: Rotovator	22.8	26.5	21.7	31.9	31.6	33.1	16.5	17.9	16.5
T_3: Conservation tillage*	25.2	27.9	22.6	32.7	32.5	33.5	17.6	18.2	19.3
T_4: Chiesel ploughing	22.3	26.2	21.8	31.6	33.3	33.9	16.3	19.3	18.7

*Conservation tillage: Minimum tillage + retention of crop residues on the surface + crop rotation

At Parbhani, during 2017, 9 rainfall events contributed to 480.3 m^3 of runoff water to farm pond from the catchment area of 1 ha. During the year, total 4 fillings of farm pond (20 m x 20 m x 30 m) was observed during June, August, September and October which contributed to large volume of runoff (432.3 m^3) from a catchment area of 1 ha. The seasonal evaporation and seepage loss from the farm pond during 15th June to 31st December, 2017 was 904.1 mm and 2339.4 mm, respectively (Table 3.197 & 3.198).

Table 3.197 : Runoff events during 2017 at experimental site-Parbhani

Date	Rain-fall (mm)	Runoff (mm)	Runoff from 1.0 ha area (m^3)	No of fill-ings of farm pond
07 June	87.4	54.2	542	
13 June	72.2	49.4	494	1st filling
14 July	33.8	06.2	62	
20 August	90.4	74.6	746	2nd filling
21 August	58.4	46.4	464	
09 September	73.4	52.8	528	3rd filling
13 September	67.0	50.2	502	
08 October	49.1	26.1	261	
10 October	81.2	72.4	724	4th filling
Total		432.3	480.3	

Table 3.198 : Seasonal evaporation and seepage losses from farm pond - Parbhani

Month	Evaporation (mm)	Seepage (mm)
June	102.7	248.5
July	137.7	244.3
August	130.7	201.7
September	130.8	420.2
October	138.7	311.5
November	136.0	507.8
December	127.5	405.4
Total	904.1	2339.4
	Farm pond dried	

The water from farm pond was provided through supplemental irrigation to soybean in *kharif* season and safflower in *rabi* season. During the dry spell in the month of July to mid-August, one protective irrigation given from harvested water in farm pond to soybean increased the seed yield by 43.1% (1837 kg/ha) as against 1284 kg/ha with no protective irrigation. During *rabi* season, application of two protective irrigations at branching and flowering stages resulted in increased safflower yield by 43.85% (1089 kg/ha) followed by one protective irrigation 29.98% (984 kg/ha) as against no protective irrigation (757 kg/ha).

Protective irrigation in safflower

At Parbhani, *in-situ* moisture conservation through broad bed and furrow system (BBF) recorded significantly higher soybean seed yield (1936 kg/ha) and net returns (Rs.40488/ha) as compared to all other treatments except opening of furrow after every 4 rows, and conservation furrow at 2.7 m distance. Further, broad bed and furrow system recorded significantly higher B:C ratio (3.18) as compared to all other treatments. Similarly, BBF recorded higher RWUE (3.04 kg/ha-mm) followed by opening of furrow after every 4 rows (2.77 kg/ha-mm) (Table 3.199).

Table 3.199 : Soybean yield and economics as affected by various *in-situ* moisture conservation practices – Parbhani

Treatment	Seed yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Opening of furrow after every 4 rows	1765	35272	2.90	2.77
T_2: Dead furrow after 10 m each	1632	31516	2.72	2.56
T_3: Tied ridging after every 4 rows	1690	32731	2.76	2.66
T_4: Conservation furrow at every 2.7 m distance	1742	34571	2.86	2.74
T_5: BBF	1936	40488	3.18	3.04
T_6: Flat bed	1282	22541	2.36	2.01
CD at 5%	243	4995		

The mean monthly soil moisture content as influenced by different treatments revealed that all soil moisture conservation practices conserved more moisture as compared to flatbed treatment (Table 3.200).

Table 3.200 : Monthly soil moisture status (%) as influenced by *in-situ* moisture conservation practices – Parbhani

Month	Opening of furrow after every 4 rows	Dead furrow after 10 m	Tied ridging	CF at 2.7 m distance	BBF	Flat bed
June	30	29	30	30	32	
July	32	31	32	31	32	28
August	30	28	29	30	31	27
September	31	30	30	31	33	28
October	30	28	31	31	33	28

The highest runoff of 427.5 mm was produced in flat bed and minimum runoff of 211 mm in BBF which was 49% lesser than the flat bed treatment. Further, all moisture conservation practices recorded less runoff as compared to flatbed system which indicate that moisture conservation practices were effective in reducing surface runoff and thus higher in *in-situ* rainwater conservation (Table 3.201).

Table 3.201 : Storm-wise rainfall–runoff (mm) as influenced by various treatments - Parbhani

Date	Rainfall (mm)	Opening of furrow after every 4 rows	Dead furrow after 10 m	Tied ridging after every 4 rows	CF at 2.7 m distance	BBF	Flat bed
07 June	87.4	28.6	34.4	28.2	27.8	22.5	49.2
13 June	72.2	24.8	26.3	24.5	22.4	19.6	45.7
16 June	31.0	6.5	7.2	6.3	6.8	4.6	10.2
14 July	33.8	3.8	4.1	3.7	3.8	3.1	11.2
20 Aug	90.4	41.2	46.8	40.5	40.5	35.2	67.2
21 Aug	58.4	20.6	21.9	19.8	20.5	18.4	37.5

Date	Rainfall (mm)	Opening of furrow after every 4 rows	Dead furrow after 10 m	Tied ridging after every 4 rows	CF at 2.7 m distance	BBF	Flat bed
26 Aug	30.8	3.6	3.9	3.2	3.5	2.8	08.5
09 Sept	73.4	28.7	30.5	27.6	28.9	25.3	48.6
13 Sept	67.0	22.8	24.8	21.7	22.9	21.7	44.9
08 Oct	49.1	15.7	16.9	14.8	15.9	14.2	24.1
10 Oct	81.2	39.2	41.8	38.6	39.7	36.8	65.9
11 Oct	30.0	7.6	8.8	7.1	7.9	6.8	14.5
Total		**243.1**	**267.4**	**236**	**240.6**	**211**	**427.5**

At Parbhani, during the 2017, the highest soil loss of 7.83 t/ha was recorded in the treatment of flat bed and minimum soil loss of 3.53 t/ha was in BBF. Further, all moisture conservation practices recorded less soil loss as compared to flatbed treatment (Table 3.202).

Table 3.202 : Storm-wise soil loss as influenced by various treatments - Parbhani

Date	Rainfall (mm)	Soil loss (t/ha)					
		Opening of furrow after every 4 rows	Dead furrow after 10 m	Tied ridging after every 4 rows	CF at 2.7 m distance	BBF	Flat bed
07 June	87.4	0.80	0.85	0.82	0.82	0.60	0.90
13 June	72.2	0.62	0.65	0.64	0.64	0.42	0.89
16 June	31.0	0.30	0.28	0.27	0.31	0.24	0.52
14 July	33.8	0.25	0.30	0.26	0.26	0.21	0.35
20 Aug	90.4	0.72	0.75	0.63	0.62	0.38	1.39
21 Aug	58.4	0.70	0.75	0.73	0.71	0.47	1.08
26 Aug	30.8	0.22	0.29	0.25	0.23	0.12	0.40
09 Sept	73.4	0.37	0.42	0.40	0.39	0.28	0.50
13 Sept	67.0	0.30	0.36	0.33	0.31	0.21	0.40
08 Oct	49.1	0.22	0.28	0.24	0.22	0.15	0.35
10 Oct	81.2	0.64	0.68	0.66	0.62	0.40	0.85
11 Oct	30.0	0.12	0.13	0.10	0.12	0.05	0.20
Total		**5.26**	**5.74**	**5.33**	**5.25**	**3.53**	**7.83**

At Parbhani, all the evaporation minimization treatments were found to be effective in reducing evaporation as compared to control. The cumulative evaporation in control was 402.2 mm during winter (October to December, 2017) for 92 days and 536.7 mm during summer (January to March, 2018). Among the treatments, application of cetyl alcohol was found to be significantly superior over neem and vegetable oil treatments and reduced the cumulative evaporation by 46 to 52% while neem and vegetable oil reduced evaporation to the tune of 27 to 31% over control. Similarly during summer, cetyl alcohol application reduced cumulative evaporation by 48 to 55% while neem and vegetable oil reduced evaporation by 24 to 28% compared to control (Table 3.203 & 3.204). The mean data across 3 years also showed similar results (Table 3.205).

Table 3.203 : Reduction in evaporation (mm) as influenced by various treatments - Parbhani

Treatment	Winter		Summer	
	Mean evaporation	% reduction	Mean evaporation	% reduction
T_1: Neem oil @ 50 ml/m^2 every 15 days	276	31.4	386	28.1
T_2: Neem oil @ 50 ml/m^2 every 30 days	292	27.4	402	25.1
T_3: Vegetable oil @ 50 ml/m^2 every 15 days	302	24.9	391	27.2
T_4: Vegetable oil @ 50 ml/m^2 every 30 days	295	26.7	397	26.0
T5: Cetyl alcohol @ 10 mg/m^2 every 5 days	212	47.3	279	48.0
T_6: Cetyl alcohol @ 15 mg/m^2 every 5 days	195	51.5	252	53.0
T_7: Cetyl alcohol @ 20 mg/m^2 every 10 days	214	46.8	274	48.9
T_8: Cetyl alcohol @ 30 mg/m^2 every 10 days	194	51.8	241	55.1
T_9: Control	402	-	537	-
CD at 5%	-	-	64.8	-

Table 3.204 : Mean reduction in evaporation (mm) as influenced by various treatments during October to December (winter) - Parbhani

Treatment	2015	2016	2017	Mean	% reduction
T_1	409.4	223.9	276	303.1	29.03
T_2	421.3	230.8	292	314.7	26.36
T_3	433.3	235.9	302	323.7	24.26
T_4	416.2	230.2	295	313.8	26.57
T_5	295.6	159.2	212	222.3	47.98
T_6	272.9	143.6	195	203.8	52.32
T_7	293.4	159.5	214	222.3	47.98
T_8	270.1	149.2	194	204.4	52.17
T_9	568.6	311.5	402.2	427.4	-
CD at 5 %	-	-	-	72.0	-

Table 3.205 : Mean reduction in evaporation (mm) as influenced by various treatments during January to March (summer) - Parbhani

Treatment	2016	2017	2018	Mean	% reduction
T_1	478	625	386	496	28.01
T_2	492	652	402	515	25.25
T_3	506	634	391	510	25.97
T_4	492	638	397	509	26.12
T_5	345	441	279	355	48.47
T_6	322	402	252	325	52.83
T_7	344	443	274	354	48.62
T_8	317	384	241	314	54.42
T_9	666	863	537	689	-
CD at 5 %	-	-	-	67	-

At Parbhani, based on the trials conducted under controlled condition, the best treatment i.e. application of cetyl alcohol @ 30 mg/m^2 at 10 days interval was done in farm pond constructed at Sorghum Research centre, VNMKV Parbhani and the farm pond of dryland research centre was kept as control. On-farm evaluation of performance of cetyl alcohol indicated that 51.3% of water loss can be avoided (1 to 1.5 lakh litres of water) compared to control (Table 3.206).

Table 3.206 : Comparison of change in water level as influenced by evapo-retardants - Parbhani

Date and month	Depth of water level in farm pond (m)		% saving of water due to application of cetyl alcohol
	Application of cetyl alcohol @ 30 mg/m^2 after every 10 days	Control	
October 1st, 2017	2.92	2.90	-
November 1st, 2017	2.42	1.95	19.4
December 1st, 2017	1.95	0.95	51.3
January1st, 2018	1.05	0	100.0
February 1st, 2018	0.45	0	100.0
March 1st, 2018	0.30	0	100.0

The cost of treatments involving cetyl alcohol was very less as compared to neem oil and vegetable oil (Table 3.207).

Table 3.207 : Cost of evaporation control agents for four months duration in farm pond

Treatment	Interval and no. of applications	Treatment cost (Rs)	
		farm pond 30 m x 30 m (900 m^2)	farm pond 20 m x 20 m (400 m^2)
Neem oil	15 days- 8 applications	50400	22400
	30 days- 4 applications	25200	11200
Vegetable oil	15 days- 8 applications	25200	11200
	30 days- 4 applications	12600	5600
Cetyl alcohol	10 mg/m^2 5 days - 24 applications	7560	3360
	15 mg /m^2 5 days - 24 applications	11232	4992
	20 mg/$m^2$10 days - 12 applications	7560	3360
	30 mg/m^2 10 days - 12 applications	11232	4992

At Parbhani, the effect of nanoclay polymer a super absorbent (NCPC) on soybean yield was found to be significant. Application of NCPC @15 kg/ha significantly improved the soybean seed yield (2536 kg/ha) compared to other to treatments except NCPC @ 10 kg/ha (2351 kg/ha). Further, the effect of fertilizer levels on soybean yield was found to be significant. Application of RDF + $ZnSO_4$ @ 20 kg/ha being at par with 100% RDF recorded significantly higher soybean yield (2651 kg/ha) over rest of the treatments (Table 3.208).

Application of NCPC @ 15 kg/ha recorded highest net returns (Rs.36366/ha), B:C ratio (1.88) and RWUE (3.98 kg/ha-mm). Similarly, application of RDF + $ZnSO_4$ @ 20 kg/ ha recorded higher net returns (Rs. 42173/ha), B:C ratio (2.08) and RWUE (4.16 kg/ha-mm) than other treatments.

Table 3.208 : Soybean yield and economics as influenced by different treatments - Parbhani

Treatment	Seed yield (kg/ha)	Mean seed yield (2 yrs)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
NCPC levels					
T_1: NCPC @ 0 kg/ha (Control)	2028	2052	28395	1.84	3.18
T_2: NCPC @ 5 kg/ha	2220	2140	31736	1.88	3.49
T_3: NCPC @ 10 kg/ha	2351	2231	33242	1.86	3.69
T_4: NCPC @ 15 kg/ha	2536	2352	36366	1.88	3.98
CD at 5%	282	-	8604	--	-
Fertilizer levels					
F_1: 50% RDF	1978	1801	24582	1.68	3.11
F_2: 75% RDF	2072	1956	26466	1.72	3.25
F_3: 100% RDF	2433	2355	36519	1.96	3.82
F_4: RDF + $ZnSO_4$ @ 20 kg/ha	2651	2663	42173	2.08	4.16
CD at 5%	281	-	8579	--	-

100% RDF: 30:60:30 kg NPK/ha

At Parbhani, data on soil properties revealed that the application of NCPC showed non significant changes in terms of soil nutrient availability. Whereas, nutrient management treatments showed improvement in nutrient availability (Table 3.209).

Table 3.209 : Effect of NCPC and nutrient management on soil properties in soybean - Parbhani

Treatment	pH	EC (dS/m)	OC %	Available nutrients (kg/ha)		
				N	P	K
NCPC levels						
T_1: NCPC @ 0 kg/ha i.e. Control	7.92	0.36	0.44	224	12	542
T_2: NCPC @ 5 kg/ha	7.90	0.34	0.44	230	14	568
T_3: NCPC @ 10 kg/ha	7.88	0.35	0.46	248	15	550
T_4: NCPC @ 15 kg/ha	7.85	0.35	0.48	254	17	587
CD at 5%	NS	NS	NS	6.72	2	NS
Fertilizer levels						
F_1: 50% RDF	7.91	0.34	0.43	196	13	552
F_2: 75% RDF	7.93	0.34	0.44	215	15	560
F_3: 100% RDF	7.95	0.36	0.45	234	15	594
F_4: RDF + $ZnSO_4$ @ 20 kg/ha	7.95	0.35	0.45	247	16	591
CD at 5%	NS	0.02	NS	9.39	2	27.8
Interaction effect (N x F)						
CD at 5%	NS	NS	NS	14.86	3.60	NS

100% RDF: 30:60:30 kg NPK/ha

3.5.2 Cropping systems

At Akola, in a study on cotton based intercropping systems and fertility levels, sole cotton sowing at 90 cm x 20 cm spacing recorded significantly higher seed cotton yield (554 kg/ha) compared to other treatments except intercropping treatments of cotton + cowpea (1:1) and cotton + clusterbean (1:2). Cotton + okra intercropping in 1:1 and 1:2 row proportion recorded lowest seed cotton yield. Different of fertility levels did not show any significance differences in seed cotton yield. During 2017-18, intercropping of cotton + cowpea and cotton + clusterbean in 1:1 and 1:2 row proportions being at par, recorded significantly higher cotton equivalent yield than sole cotton and rest of the treatments. Cotton + okra in 1:1 and 1:2 row proportions recorded lowest cotton equivalent yield. Among fertility levels, application of 125% and 100% RDF had no significant effect during the year 2017-18. While in pooled results, higher fertility levels (125% RDF) recorded significantly higher cotton equivalent yield than 100% RDF (Table 3.210).

Table 3.210 : Yield of cotton based intercropping systems as influenced by various treatments – Akola

Treatment	Seed cotton yield (kg/ha)		Intercrop yield (kg/ha)		Cotton equivalent yield (kg/ha)	
	2017-18	Pooled (3 years)	2017-18	Pooled (3 years)	2017-18	Pooled (3 years)
T_1: Sole cotton	554	1354	-	-	554	1354
T_2: Cotton + cowpea (1:1)	550	1329	1143	2543	1019	2373
T_3: Cotton + cowpea (1:2)	492	1086	1221	2622	993	2163
T_4: Cotton + clusterbean (1:1)	520	1310	1119	2528	988	2347
T_5: Cotton + clusterbean (1:2)	518	1077	1133	2561	983	2128
T_6: Cotton + okra (1:1)	423	890	963	1788	818	1624
T_7: Cotton + okra (1:2)	358	733	1077	1817	800	1479
CD at 5%	62.8	76.2	-	-	88.5	94.5
Fertility levels						
F_1: 100% RDF	483	1067	1091	1921	867	1855
F_2: 125% RDF	495	1156	1127	2039	892	1992
CD at 5%	NS	40.7	-	-	NS	50.5

100% RDF: 60:30:30 kg NPK/ha

Cotton + cowpea (1:1)

Cotton + clusterbean (1:1)

Sole cotton (90 cm x 20 cm)

Application of 125 and 100% RDF recorded non-significant results in terms of net returns and RWUE. Whereas, pooled data of 3 years revealed that 125% RDF recorded significantly higher net returns (Rs.50317/ha) and RWUE (3.07 kg/ha-mm) compared to 100% RDF. Cotton + okra intercropping (1:1) recorded higher B:C ratio (1.17) followed by cotton + clusterbean in 1:1 and 1:2 row proportion (1.12). However, pooled data showed that cotton + cowpea and cotton + clusterbean with 1:1 row proportion recorded significantly higher B:C ratio (2.34 and 2.24 respectively) than rest of the treatments. The RWUE being at par in cotton + cowpea and cotton + clusterbean in 1:1 and 1:2 row proportion was significantly superior than sole cotton and cotton + okra in 1:1 and 1:2 row proportions during the year 2017-18. (Table 3.211).

Table 3.211: Economics of different intercropping systems - Akola

Treatment	Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio		RWUE (kg/ha-mm)	
	2017-18	Pooled (3 years)	2017-18	Pooled (3 years)	2017-18	Mean (3 years)	2017-18	Pooled (3 years)
T_1: Sole cotton	27672	31669	-4365	33514	0.84	1.93	1.27	2.15
T_2: Cotton + cowpea (1:1)	40722	51300	2967	62622	1.06	2.10	2.34	3.62
T_3: Cotton + cowpea (1:2)	45312	55102	-3067	48646	0.93	1.70	2.28	3.32
T_4: Cotton + clusterbean (1:1)	37357	48027	4412	64907	1.12	2.13	2.27	3.58
T_5: Cotton + clusterbean (1:2)	37281	48752	4592	55604	1.12	1.99	2.26	3.28
T_6: Cotton + okra (1:1)	29884	36343	5189	41409	1.17	1.96	1.88	2.55
T_7: Cotton + okra (1:2)	31517	36757	2869	30560	1.09	1.76	1.84	2.31
CD at 5%	-	-	3605	4182	-	-	0.21	0.15
Fertility levels								
F_1: 100% RDF	35170	42794	1648	46043	1.05	1.90	1.99	2.87
F_2: 125% RDF	36186	44620	1743	50317	1.06	1.95	2.05	3.07
CD at 5%	-	-	NS	2235	-	-	NS	0.08

At Akola, in a study on conservation agriculture in soybean-chickpea system, in general the yield of soybean was poor due to frequent dry spells and deficit rainfall by 34% during the crop season. Reduced tillage (RT) – Broad bed and furrow every year + pre- and post-emergence herbicide application+crop residue (T_3) recorded significantly higher seed yield (838 kg/ha) and RWUE (1.62 kg/ha-mm) over other treatments (Table 3.212).

Table 3.212 : Performance of soybean as influenced by different treatments- Akola

Treatment	Number of pods/plant	Seed weight (g/plant)	Seed yield (kg/ha)	RWUE (kg/ha-mm)
T_1	20.3	6.63	733	1.41
T_2	18.9	6.54	718	1.38
T_3	23.0	7.81	838	1.62
T_4	18.0	6.09	688	1.33
T_5	17.4	5.73	643	1.24
CD at 5%	1.9	1.22	118	-

T_1: Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowings + One hand weeding + Opening of furrow with hoe in each row at 30-35 DAS + Crop residue mulch; T_2: Conventional tillage (CT) - Ploughing once in 3 years + 2 pre-sowing harrowings + One hand weeding + Opening of furrow with hoe in each row at 30-35 DAS without crop residue mulch; T_3: Reduced tillage (RT) – Broad bed and furrow every year + Pre and post emergence herbicide application + crop residue; T_4: Zero tillage + crop residue; T_5: Permanent BBF furrow after every 4 rows + crop residue mulch

Sowing with BBF planter

Soybean under RT + herbicide + crop residue

Soybean under ZT + crop residue

Soybean under BBF + crop residue

At Kovilpatti, the yield and yield parameters of cotton (cv. TCH-1819) were significantly influenced by crop geometry. Among the crop geometry, 45 cm x 15 cm recorded significantly higher number of bolls and seed cotton yield (1242 kg/ha) with higher net returns (Rs.26931/ha) and B:C ratio (1.93) compared to 45 cm x 10 cm. Wider spacing also recorded more number of monopodia than closer spacing. Among the moisture conservation practices, broad bed furrow recorded significantly more number of bolls, seed cotton yield (1206 kg/ha), net income (Rs. 25202/ha), B:C ratio (1.87) and RWUE (2.86 kg/ha-mm) than compartmental bunding. Earlier boll formation and uniform boll bursting and more number of sympodia were recorded with 100% RDF than high fertility level. However, more number of bolls, boll weight and seed cotton yield (1245 kg/ha) were recorded under 125% fertility level than that under 100 and 150% levels (Table 3.213).

Table 3.213 : Effect of crop geometry, fertility levels and moisture conservation practices on growth, yield and economics of cotton - Kovilpatti

Treatment	Plant height (cm)	No. of sympodia / plant	No. of bolls/ plant	Boll weight (g)	Seed cotton yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha -mm)
Crop geometry									
P_1 : 45 cm x 15 cm	120.5	13.9	7.7	4.6	1242	28969	26931	1.93	2.95
P_2 : 45 cm x 10 cm	106.1	13.7	6.4	3.7	980	28719	15391	1.53	2.33
CD at 5%	9.0	NS	0.8	0.5	161	-	-	-	-
Moisture conservation									
M_1:Compartmental bunding	107.2	13.7	6.1	3.7	1006	28661	19032	1.66	2.52
M_2 - Ridges and furrows	113.6	14.0	7.3	4.2	1122	28811	19249	1.67	2.53
M_3 - Broad bed furrow	119.8	13.8	7.7	4.6	1206	29061	25202	1.87	2.86
CD at 5%	11.0	NS	1.0	0.5	165	-	-	-	-
Fertility levels: NPK (kg/ha)									
F_1: 100% RDF (40:20:40)	110.7	13.8	6.1	3.8	987	28226	16166	1.57	2.34
F_2: 125% RDF (50:25:50)	116.6	14.0	8.0	4.4	1245	28844	27181	1.94	2.95
F_3: 150% RDF (60:30:60)	113.3	13.7	7.0	4.3	1102	29461	20136	1.68	2.62
CD at 5%	4.2	NS	1.0	0.3	95	-	-	-	-

In an experiment on the effect of *in-situ* green manuring on cotton (*Gossypium* spp.) at Kovilpatti under rainfed vertisols, the intercrops such as sunnhemp, daincha and fodder cowpea were sown under paired row intercropping system with cotton. The intercrops were incorporated at 35 days after sowing. On an average of 5 - 6 t/ha of green manure biomass was incorporated in sunnhemp and daincha plots, whereas the fodder cowpea produced upto 7 to 8 t/ha of green biomass. All the intercropping systems completely arrested the monopodial branching in cotton whereas in sole cotton more number of monopodia was present. Among the fertility levels, 100% RDF recorded significantly more number of bolls/plant (8.1), boll weight (3.2 g) and higher seed cotton yield (1006 kg/ha), net returns (Rs. 19100/ha), B:C ratio (1.82) and RWUE (2.23 kg/ha-mm) over rest of the treatments except that it was at par with 75% RDF. Among the intercropping systems, daincha, sunnhemp and cowpea reduced the weed growth. Further, cotton + sunnhemp system (899 kg/ha) being at par with cotton + dhaincha produced significantly higher seed cotton yield (924 kg/ha), net returns (Rs.18031/ha), B:C ratio (1.78) and RWUE (2.17 kg/ha-mm) compared to cotton + cowpea and sole cotton (Table 3.214).

Table 3.214 : Effect of *in-situ* green manuring and fertility levels on cotton yield, economics and weeds - Kovilpatti

Treatment	Plant height (cm)	No. of bolls/ plant	Boll weight (g)	Seed cotton yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)	Weed density (No/m^2)	Weed dry weight (g/m^2)
Fertility level (NPK kg/ha)										
F_1: Control	89.4	4.4	2.7	694	23358	7625	1.30	1.63	15.1	12.1
F_2: 100% RDF (40:20:40)	101.9	8.1	3.2	1006	25826	19100	1.82	2.23	27.4	17.4
F_3: 75% RDF (30:15:30)	97.8	7.9	3.0	841	25209	14094	1.61	1.97	21.3	15.3
F_4: 50% RDF (20:10:20)	91.8	5.1	2.9	760	24592	10888	1.47	1.80	17.9	12.6
CD at 5%	6.8	1.0	0.4	128	-	-	-	-	2.1	1.8

Treatment	Plant height (cm)	No. of bolls/ plant	Boll weight (g)	Seed cotton yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)	Weed density (No/m^2)	Weed dry weight (g/m^2)
Intercropping system										
S_1: Sole cotton (KC 3)	88.4	6.0	2.8	754	24580	10438	1.45	1.77	31.1	21.7
S_2: Cotton + sunhemp (CO1)	97.4	8.1	3.2	924	24788	18031	1.78	2.17	20.2	12.3
S_3: Cotton + dhaincha (Local)	98.8	7.0	3.1	899	24834	16344	1.70	2.09	18.0	11.5
S_4: Cotton + cowpea (CO(FC)8)	95.8	4.5	2.8	725	24768	6894	1.30	1.59	10.5	8.3
CD at 5%	3.7	0.6	0.2	67	-	-	-	-	1.5	1.3

Interaction effect between fertility level and *in-situ* green manuring on yield of cotton revealed that higher yield was recorded with 100% RDF with cotton + sunnhemp green manuring system (1120 kg/ha) followed by 100% RDF with cotton + dhaincha (1085 kg/ha) over rest of the treatment combinations (Table 3.215).

Table 3.215 : Interaction between fertility level and *in-situ* green manuring on yield of cotton (kg/ha) -Kovilpatti

Treatment	Sole cotton	Cotton + sunnhemp	Cotton + dhaincha	Cotton + cowpea
T_1: Control	640	795	740	600
T_2: 100% RDF	985	1120	1085	835
T_3: 75% RDF	740	920	905	800
T_4: 50% RDF	650	860	865	665
		CD at 5%		
F at S		155		
S at F		112		

Cotton + Sumhemp

Cotton + Dhaincha

Cotton + cowpea

Sole cotton

At Parbhani, sub soiling in every year recorded significantly higher soybean seed (2895 kg/ha) and stalk yield (3674 kg/ha) than rest of the treatments except that stalk yield was found at par with sub soiling in alternate year (Table). Similarly, sub soiling at every 2.25 m horizontal distance recorded significantly higher soybean seed (2951 kg/ha) and stalk yield (3757 kg/ha) than rest of the treatments except that stalk yield was found at par with sub soiling at every 4.5 m and 6.75 m horizontal distance. Further, it was observed that sub soiling in every year with 2.25 m horizontal distance recorded significantly higher net returns (Rs.74912 and 75975/ha) respectively than rest of the treatments (Table). Further, sub soiling in every year with 2.25 m horizontal distance resulted in highest B:C ratio (1.91 and 1.88) and RWUE (4.55 and 4.64 kg/ha-mm) closely followed by sub soiling in alternate year with 4.5 m horizontal distance (Table 3.216).

Table 3.216 : Soybean (MAUS 162) yield and economics as influenced by different treatments - Parbhani

Treatment	Yield (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk			
Sub soiling					
S_1: Sub soiling in every year	2895	3674	74912	1.91	4.55
S_2: Sub soiling in alternate year	2474	3372	58785	1.50	3.89
S_3: Sub soiling once in three years	2334	3220	53355	1.36	3.67
CD at 5%	259	421	1702	-	-
Sub soiling horizontal spacing					
D_1: No sub soiling	2219	3115	50920	1.38	3.49
D_2: Sub soiling at every 2.25 m	2951	3757	75975	1.88	4.64
D_3: Sub soiling at every 4.5 m	2672	3555	65552	1.64	4.20
D_4: Sub soiling at every 6.75 m	2590	3406	63068	1.61	4.07
D_5: Sub soiling at every 9.0 m	2409	3280	56242	1.45	3.79
CD at 5%	296	427	5387	-	-
Interaction effect (S x D)					
CD at 5%	369	828	8653	-	-

At Parbhani, intercropping system of soybean + pigeonpea (4:2) produced significantly higher soybean equivalent yield (2891 kg/ha) and gross returns (Rs.88185/ha) which was at par with soybean + pigeonpea strip of 3.6 m (8 & 4 rows/strip), 5.4 m (12 & 9 rows/strip) and 7.2 m (16 & 8 rows/strip) and found significantly superior over rest of the treatments. Similarly, significantly higher net returns (Rs.54553/ha) was recorded with soybean + pigeonpea strip of 3.6 m (8 & 4 rows/strip) which was at par with soybean + pigeonpea strip of 5.4 m (12 & 9 rows/strip) and intercropping system of soybean + pigeonpea (4:2). Further, soybean + pigeonpea intercropping system recorded higher RWUE (4.55) whereas highest B:C ratio was recorded with soybean + pigeonpea strip of 3.6 m (8 & 4 rows/strip) (2.62) (Table 3.217).

Table 3.217 : Soybean yield and economics as influenced by different treatments - Parbhani

Treatment	SEY (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Soybean sole	2080	31720	24528	1.63	3.27
T_2: Pigeonpea sole	2551	38913	43302	2.26	4.01
T_3: Soybean + pigeonpea strip of 3.6 m each (8 & 4 rows/strip)	2838	86567	54553	2.70	4.46
T_4: Soybean + pigeonpea strip of 5.4 m each (12 & 9 rows/strip)	2755	84036	52022	2.62	4.33
T_5: Soybean + pigeonpea strip of 7.2 m each (16 & 8 rows/strip)	2676	81608	49594	2.55	4.21
T_6: Soybean + pigeonpea strip of 10.8 m each (24 & 12 rows/strip)	2555	77914	45900	2.43	4.02

Treatment	SEY (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_7: Soybean + pigeonpea strip of 14.4 m each (32 & 16 rows/strip)	2412	73555	41541	2.30	3.79
T_8: Soybean + pigeonpea strip at 4 rows intercropping system	2891	88185	51861	2.43	4.55
CD at 5%	334	9870	4923	--	--

SEY: Soybean equivalent yield

3.5.3 Nutrient management

At Akola, ina permanent manurial trial (PMT) initiated in 1987 in cotton + greengram intercropping (1:1) system, application of 50 % RDN through organic source (FYM) in combination with 50% N + 100% P_2O_5 + 100% K_2O/ha through inorganics recorded higher yield of crops, RWUE (0.68 kg/ha-mm) and was on par with the application of 50% N through gliricidia + 50% N + 100% P_2O_5 + 100% K_2O/ha through fertilizers. However, in case of greengram grain yield, the application of 50% N through fertilizers + 50% N/ha through FYM + 100% P_2O_5 + 100% K_2O/ha through fertilizers was found to be significantly superior over other treatments. The pooled data (31 years) also indicated the same trend (Table 3.218.). Higher net returns (Rs.48120/ha) were recorded with application of 50% N each through FYM and fertilizer + 100% P_2O_5 + 100% K_2O/ha through inorganics, and followed by application of 50% N through gliricidia + 50% N through inorganics + 100% P_2O_5 + 100% K_2O/ha through fertilizers. However, higher B:C ratio (2.31) was recorded in latter treatment. Integrated application of FYM/gliricidia along with chemical fertilizers resulted in higher RWUE. The nutrient content was 0.7% N, 0.07% P and 0.50% K in gliricidia, 0.60% N, 0.22% P and 0.57% K in FYM.

Table 3.218 : PMT: Effect on yield and economics of cotton + greengram (1:1) intercropping system - Akola

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha mm)
	Seed cotton/ seed yield (2017-18)	Mean seed cotton/ seed yield (31 years)	Stalk/ (2017-18)				
T_1: Control	65 (146)	506 (372)	133 (85)	22938	25634	1.96	0.15 (0.44)
T_2: 100% RDF	219 (241)	744 (487)	427 (130)	29713	39772	2.21	0.49 (0.73)
T_3: 50% RDF	151 (198)	669 (458)	295 (118)	26853	35464	2.18	0.34 (0.60)
T_4: 50% N/ha through gliricidia	99 (167)	636 (449)	193 (97)	25656	31504	2.07	0.22 (0.51)
T_5: 50% N/ha through FYM	109 (164)	681 (478)	222 (97)	30940	29332	1.82	0.25 (0.50)
T_6: 50% N through fertilizers + 50% N through gliricidia +100% P_2O_5 + 100% K_2O/ha through fertilizers	276 (321)	806 (508)	567 (187)	32810	46994	2.31	0.62 (0.97)
T_7: 50% N through fertilizers + 50% N through FYM + 100% P_2O_5+ 100% K_2O/ha through fertilizers	302 (384)	871 (561)	629 (208)	37365	48120	2.19	0.68 (1.16)
T_8: 100% N through gliricidia + 100% P_2O_5+ 100% K_2O/ha through fertilizers	127 (256.61)	751 (498)	276 (139)	29677	41938	2.27	0.28 (0.78)
CD at 5%	48 (51)	32 (23)	78 (23)	-	4968	-	-

Figures in parenthesis are for greengram; 100% RDF: 60:30:30 kg NPK/ha

Cotton + greengram with 50% N through fertilizers + 50% through N through FYM + 100% P_2O_5 + 100% K_2O/ha

Control (no ferterlizer application)

The long-term application of 50% RDN through FYM in combination with 50% N + 100% P_2O_5 + 100% K_2O/ha through inorganics recorded lower bulk density (1.39 Mg/m^3), higher hydraulic conductivity (1.09 cm/hr) and was found on par with the treatment 50% N through fertilizers + 50% N through gliricidia + 100% P_2O_5 + 100% K_2O/ha through inorganics (Table 3.219). The significant improvement in physical properties of soil indicates the vital role of conjunctive application of organics with inorganics. Similar trend was observed in case of moisture content at FC, PWP and AWC.

Table 3.219 : PMT: Effect on soil properties - Akola

Treatment	BD (Mg/m^3)	HC (cm/hr)	FC (%)	PWP (%)	AWC (%)
T_1: Control	1.46	0.80	25.84	13.41	12.43
T_2: 100% RDF	1.45	0.93	34.90	18.21	16.69
T_3: 50% RDF	1.44	0.86	30.34	15.07	15.26
T_4: 50% N/ha through gliricidia	1.44	0.96	34.58	16.89	17.68
T_5: 50% N/ha through FYM	1.43	0.97	34.61	16.91	17.70
T_6: 50% N through fertilizers + 50% N through gliricidia +100% P_2O_5 + 100% K_2O/ha through fertilizers	1.40	1.09	46.51	23.80	22.71
T_7: 50% N through fertilizers + 50% N through FYM + 100% P_2O_5+ 100% K_2O/ha through fertilizers	1.39	1.09	47.70	24.81	22.89
T_8: 100% N through gliricidia + 100% P_2O_5+ 100% K_2O/ha through fertilizers	1.40	1.05	43.29	22.12	21.17
CD at 5%	0.03	0.03	2.62	3.43	5.44

The highest soil organic carbon (0.69%) was recorded in treatment 50% N through fertilizers + 50% N through FYM + 100% P_2O_5+ 100% K_2O/ha through fertilizers followed by 50% N fertilizers + 50% N through gliricidia +100% P_2O_5+ 100% K_2O/ha through fertilizers (0.68%) and 100% N/ha through gliricidia + 100% P_2O_5+ 100% K_2O/ha through fertilizers through (0.67%) which were found to be on par with each other. Significantly higher available N (255.1 kg/ha) was recorded in plots under 50% N through fertilizers + 50% N/ha through FYM + 100% P_2O_5 + 100% K_2O/ha through fertilizer which was on par with application of 50% N through fertilizers + 50% N through gliricidia +100% P_2O_5+ 100% K_2O/ha through fertilizers (253.0 kg/ha), while the lowest (204.9 kg/ha) available nitrogen was observed in absolute control. The highest available phosphorus (15.8 kg/ha) was recorded in treatment 50% N through fertilizers + 50% N/ha through FYM + 100% P_2O_5+ 100% K_2O/ha fertilizers. While the lowest available

P (10.5 kg/ha) was observed in control treatment. The available K was significantly higher (373.3 kg/ha) in plots under 50% N through fertilizers + 50% N/ha through FYM + 100% P_2O_5+ 100% K_2O/ha through fertilizers, followed by application of 50% N + 100% P_2O_5 + 100% K_2O/ha through fertilizers in combination with 50% N/ha through gliricidia lopping (371.5 kg/ha) compared to other treatments. The available iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were higher in plots under 50% N through fertilizers + 50% N/ha through FYM + 100% P_2O_5/ha through fertilizers and 50% N through fertilizers + 50% N/ha through gliricidia +100% P_2O_5 (Table 3.220).

Table 3.220 : PMT: Effect on chemical properties of soil - Akola

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P	K	Zn	Fe	Cu	Mn
T_1: Control	8.10	0.45	204.9	10.5	294.9	0.57	7.19	1.97	9.03
T_2: 100% RDF	8.07	0.61	232.1	13.4	321.1	0.63	8.50	2.90	11.00
T_3: 50% RDF	8.05	0.53	227.9	12.7	319.2	0.61	7.39	2.47	10.34
T_4: 50% N/ha through gliricidia	7.99	0.60	227.9	12.4	321.1	0.65	8.53	2.69	12.73
T_5: 50% N/ha through FYM	8.00	0.61	223.7	12.5	324.8	0.65	9.09	2.97	14.34
T_6: 50% N through fertilizers + 50% N through gliricidia +100% P_2O_5 + 100% K_2O/ha through fertilizers	7.99	0.68	253.0	15.5	371.5	0.75	9.37	3.21	15.40
T_7: 50% N through fertilizers + 50% N through FYM + 100% P_2O_5+ 100% K_2O/ha through fertilizers	7.98	0.69	255.1	15.8	373.3	0.76	9.71	3.38	16.58
T_8: 100% N through gliricidia + 100% P_2O_5+ 100% K_2O/ha through fertilizers	8.00	0.67	240.4	15.3	354.7	0.73	9.68	3.18	15.24
CD at 5%	0.06	0.07	13.3	0.6	11.9	0.04	0.47	0.30	2.20
Initial values	8.2	0.46	214.0	12.97	316.8	-	-	-	-

In another study at Akola on potash management through gliricidia green leaf manuring in cotton, significantly higher seed cotton and stalk yield (440 and 827 kg/ha) was recorded with application of 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia compared to other treatments except 100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia. The pooled results also followed the similar trend. (Table 3.221). Application of 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia being on par with 100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia also recorded higher net returns (Rs. 27192/ha) and B:C ratio (1.82) compared to other treatments.

Table 3.221 : Effect of potash management through gliricidia on cotton yield and economics - Akola

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton (2017-18)	Mean seed cotton (3 years)	Stalk (2017-18)				
T_1: Control	126	612	246	19706	7807	1.31	0.28
T_2: 100% RDF (60:30:30 NPK kg/ha)	338	985	626	26424	17736	1.58	0.76
T_3: 100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia	382	1187	713	28297	24938	1.77	0.86
T_4: 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia	440	1253	827	28915	27192	1.82	0.99

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha·mm)
	Seed cotton (2017-18)	Mean seed cotton (3 years)	Stalk (2017-18)				
T_5: 100% NP + 30 kg K through gliricidia	285	1042	527	28088	18710	1.56	0.64
T_6: 75% N +100% P + 15kg K(inorganic) + 15kg K through gliricidia	257	1015	475	27071	18399	1.57	0.58
T_7: 75% N +100% P+30 kg K through gliricidia	224	907	414	27087	13579	1.54	0.50
T_8: 50% N +100% P+30 kg K through gliricidia	149	819	275	25640	11090	1.34	0.33
T_9: 100% K through gliricidia	139	692	256	22352	8791	1.30	0.28
CD at 5%	70	104	126	-	4509	-	-

The bulk density of soil was lowest (1.40 Mg/m^3) with the application of 100% NP + 30 kg K through gliricidia. The lower values of bulk density and hydraulic conductivity in gliricidia treated plots may be due to better aggregation of soil particles and stability of aggregates leading to increase the total pore space in soil. The higher value of bulk density (1.47 Mg/m^3) was found in control plots. The hydraulic conductivity was highest (0.90 cm/hr) with application of 100% NP + 10 kg K (inorganic) + 20 kg K/ha through gliricidia and it was found to be on par with application of 100% NP + 15 kg K (inorganic) +15 kg K/ha through gliricidia (0.88 cm/hr), 100 % NP + 30 kg K/ha through gliricidia (0.82 cm/hr) and 100% K/ha through gliricidia (0.85 cm/hr). The moisture retention at FC, PWP and AWC were also found to be higher with the application of 100% NP + 10 kg K (inorganic) + 20 kg K/ha through gliricidia followed by 100% NP + 15 kg K (inorganic) + 15 kg K/ha through gliricidia (Table 3.222).

Table 3.222 : Effect of potash management through gliricidia green leaf manuring on soil physical properties - Akola

Treatment	BD (Mg/m^3)	HC (cm/hr)	FC (%)	PWP (%)	AWC (%)
T_1: Control	1.47	0.74	26.01	11.41	13.93
T_2: 100% RDF (60:30:30 NPK kg/ha)	1.46	0.78	32.52	16.74	15.77
T_3: 100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia	1.43	0.88	37.35	17.06	20.30
T_4: 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia	1.41	0.90	39.63	18.35	21.28
T_5: 100% NP + 30 kg K through gliricidia	1.40	0.85	32.66	16.29	16.37
T_6: 75% N +100% P + 15kg K(inorganic) + 15kg K through gliricidia	1.42	0.82	31.47	15.15	16.32
T_7: 75% N +100% P+30 kg K through gliricidia	1.42	0.80	31.09	16.60	14.49
T_8: 50% N +100% P+30 kg K through gliricidia	1.44	0.80	30.06	15.82	14.24
T_9: 100% K through gliricidia	1.44	0.85	30.64	16.16	14.48
CD at 5%	0.03	0.07	3.33	3.28	3.81
Initial values	1.48	0.74	-	-	-

Cotton under control

Cotton under 100% NP + 10 kg K (inorganic) +20 kg K through gliricidia

Significantly higher soil organic carbon (0.63%), available N (213.8 kg/ha) and available K (362.8 kg/ha) was recorded with application of 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia while the available P (17.6 kg/ha) was significant in 100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia. The available Fe, Mn, Zn and Cu were and higher with application of 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia and was on par with application of 100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia. In general, the INM treatments (T_4 & T_3) which received gliricidia loppings in combination with fertilizers showed better performance in respect of available nutrients over all other treatments (Table 3.223).

Table 3.223 : Effect of potash management through gliricidia green leaf manuring on soil chemical properties - Akola

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P	K	Zn	Fe	Cu	Mn
T_1	8.10	0.46	181	13	319	0.63	7.06	2.19	11.80
T_2	8.09	0.56	192	17	333	0.66	8.30	2.47	13.35
T_3	7.96	0.60	210	18	350	0.71	9.00	3.29	15.12
T_4	7.95	0.63	214	18	363	0.77	8.51	3.30	16.29
T_5	7.96	0.60	205	16	349	0.69	7.93	3.08	14.27
T_6	7.97	0.57	203	16	341	0.65	7.71	2.44	13.88
T_7	7.98	0.54	197	16	330	0.67	7.68	2.37	13.29
T_8	7.99	0.55	197	16	323	0.65	7.70	2.26	12.69
T_9	7.99	0.51	193	16	322	0.62	7.15	2.24	12.60
CD at 5%	0.07	0.05	9	1	20	0.06	0.58	0.15	2.52
Initial values	8.2	0.51	186	15	322	0.63	6.59	2.14	9.97

In another experiment on potash management through gliricidia green leaf manuring in soybean at Akola, significantly higher soybean seed and stalk yield (1442 & 1828 kg/ha) was recorded with application of 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia except 100% RDF (30:75:30 NPK kg/ha). Application of 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia resulted in higher RWUE (3.76 kg/ha-mm) compared to all other treatments. Higher net returns were obtained with application of 100% RDF (30:75:30 NPK kg/ha) and was found on par with 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia. However, slightly higher B:C ratio was recorded in treatment T_2 followed by T_3 (Table 3.224).

Table 3.224 : Effect of potash management through gliricidia green leaf manuring on yield and economics of soybean - Akola

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2017-18)	Mean seed (3 years)	Stalk (2017-18)				
T_1: Control	877	847	1052	24367	1177	1.03	2.28
T_2: 100% RDF (30:75:30 NPK kg/ha)	1372	1369	1746	30711	10595	1.33	3.58
T_3: 75% N +100% P + 15 kg K (inorganic) +15 kg K through gliricidia	1442	1317	1828	31193	8402	1.26	3.76
T_4: 75% N +100% P + 30 kg K through gliricidia	1335	1201	1680	31668	4513	1.13	3.48
T_5: 50% N +100% P + 30 kg K through gliricidia	1251	1069	1574	31362	947	1.02	3.26
T_6: 100% K through gliricidia	1128	985	1427	26747	2970	1.10	2.94
CD at 5%	312	129	330	-	3688	-	-

Soybean under control

Soybean under 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia

The lowest bulk density (1.45 Mg/m^3) was recorded with application of 75% N + 100% P + 30 kg K through gliricidia and application of 75% N +100% P + 15 kg K (inorganic) + 15 kg K through gliricidia (1.45 Mg/m^3) when compared to control. Significantly highest (0.93 cm/h) hydraulic conductivity was recorded with application of 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia and was on par with application of 75% N + 100% P + 30 kg K through gliricidia (0.92 cm/hr) compared to control. Significantly higher moisture retention at FC, PWP and AWC were also higher with application of 75% N + 100% P + 30 kg K through gliricidia followed by 75% N + 100% P + 15 kg K (inorganic)+15 kg K through gliricidia compared to other treatments (Table 3.225).

Table 3.225 : Effect of potash management through gliricidia green leaf manuring on soil physical properties - Akola

Treatment	BD (Mg/m^3)	HC (cm/hr)	FC (%)	PWP (%)	AWC (%)
T_1: Control	1.48	0.83	24.05	10.98	13.06
T_2: 100% RDF (30:75:30 NPK kg/ha)	1.47	0.85	31.06	15.35	15.71
T_3: 75% N +100% P+15 kg K (inorganic)+15 kg K through gliricidia	1.45	0.93	38.63	16.86	21.77
T_4: 75% N +100% P+30 kg K through gliricidia	1.45	0.92	40.30	17.46	22.84
T_5: 50% N +100% P+30 kg K through gliricidia	1.46	0.87	32.64	16.18	16.46
T_6: 100% K through gliricidia	1.47	0.88	30.23	14.77	15.45
CD at 5%	0.02	0.03	4.49	2.75	5.03
Initial values	1.48	0.83	-	-	-

Significantly higher soil organic carbon (0.62%) was recorded with application of 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia compared to other treatments except 100% RDF (30:75:30 NPK kg/ha) (0.61%) and in 75% N + 100% P + 30 kg K through gliricidia (0.61%). Significantly higher available nitrogen (213.0 kg/ha) was recorded with application of 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia compared to other treatments except 100% RDF (30:75:30 NPK kg/ha) (210.1 kg/ha) and 75% N + 100% P + 30 kg K through gliricidia (206.7 kg/ha) However, significantly higher available phosphorus (16.6 kg/ha) was recorded with application of 100% RDF (30:75:30 NPK kg/ha) compared to other treatment except 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia. Significantly higher available potassium (338.5 kg/ha) was recorded with application of 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia compared to the control and 100 % K through gliricidia but was on par with other treatments. Higher available iron (8.93 mg/kg), available manganese (12.11 mg/kg), available copper (3.07 mg/kg) and available zinc (0.73 mg/kg) was recorded with application of 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia followed by 75% N + 100% P + 30 kg K through gliricidia (Table 3.226).

Table 3.226 : Effect of potash management through gliricidia green leaf manuring on soil chemical properties - Akola

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P	K	Zn	Fe	Cu	Mn
T_1: Control	8.15	0.47	173	14	312	0.63	6.61	2.15	9.93
T_2: 100% RDF (30:75:30 NPK kg/ha)	8.13	0.61	210	17	335	0.66	8.08	2.49	10.90
T_3: 75% N +100% P+15 kg K (inorganic)+15 kg K through gliricidia	8.05	0.62	213	16	338	0.73	8.93	3.07	12.11
T_4: 75% N +100% P+30 kg K through gliricidia	8.01	0.61	207	16	331	0.69	8.51	2.92	11.45
T_5: 50% N +100% P+30 kg K through gliricidia	8.08	0.53	194	15	329	0.66	7.83	2.61	10.68
T_6: 100% K through gliricidia	8.09	0.51	185	14	324	0.64	7.65	2.54	10.44
CD at 5%	0.09	0.012	11	0.4	11	0.06	0.46	0.33	1.15
Initial values	8.2	0.51	185	14	321	0.63	6.59	2.14	9.97

In a permanent manurial trial (PMT), initiated in 2011, on cotton under rainfed deep black soils (*Typic Haplusterts*) at Kovilpatti, application of 100% RDF + 25 kg $ZnSO_4$/ha (T_6) registered higher number of bolls/plant (12.8), seed cotton yield (1229 kg/ha), stalk yield (3072 kg/ha), net returns (Rs.28661/ha), B:C ratio (2.02) and RWUE (2.92 kg/ha-mm) followed by 50% inorganic N + 50% organic N (FYM) + P (50%) + K (50%) (Table 3.227).

Table 3.227 : PMT: Effect on yield attributes, yield and economics of cotton (KC 3) - Kovilpatti

Treatment	Sympodial branches /plant (No)	No. of bolls/ plant	Yield (kg/ha)		COC (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			Seed cotton	Stalk				
T_1: Control	10.2	11.4	664	1660	23358	7352	1.31	1.58
T_2:100% RDF (40:20:40 NPK kg/ha)	12.0	12.4	1142	2855	28168	24647	1.87	2.71
T_3: 50% RDF (20:10:20 NPK kg/ha)	10.9	12.6	1155	2886	31255	23851	1.76	2.74
T_4 :50% N (FYM)	12.8	11.8	1183	2959	29804	24930	1.84	2.81
T_5: 50% Inorganic N+ 50% organic N (FYM) + P (50%) + K (50%)	10.0	12.0	1191	2979	26934	26465	1.98	2.83
T_6: 100 % RDF + 25 kg $ZnSO_4$/ha	10.7	12.8	1229	3072	28168	28661	2.02	2.92
T_7: FYM - 12.5 t/ha	12.6	12.0	1162	2905	38200	15551	1.41	2.76
CD at 5%	0.09	0.49	71.0	89.0	-	-	-	-

Different treatments had no significant effect on soil pH. However, application of 100% RDF + 25 kg $ZnSO_4$/ha (T_6) recorded higher available N (142 kg/ha), P (17.1 kg/ha) and K (551 kg/ha) compared to other treatments (Table 3.228).

Table 3.228 : PMT: Effect on soil properties- Kovilpatti

Treatment	pH	Av. nutrients (kg/ha)		
		N	P	K
T_1: Control	8.23	120	10.2	10.2
T_2:100% RDF (40:20:40 NPK kg/ha)	8.19	128	14.6	527
T_3: 50% RDF (20:10:20 NPK kg/ha)	8.15	125	15.1	495
T_4 :50% N (FYM)	8.21	132	16.2	528
T_5: 50% Inorganic N+ 50% organic N (FYM) + P (50%) + K (50%)	8.29	138	16.8	532
T_6: 100 % RDF + 25 kg $ZnSO_4$/ha	8.27	142	17.1	551
T_7: FYM - 12.5 t/ha	8.12	131	15.9	508
CD at 5%	NS	5.9	0.97	26.8

At Parbhani, in the permanent manurial trial (initiated in 2011), the cropping system of soybean + pigeonpea (4:2) produced significantly higher seed cotton equivalent yield (1990 kg/ha), gross returns (Rs.79990/ha) and net returns (Rs.42544/ha) compared to cotton + pigeonpea (6:1) intercropping system. The B:C ratio (2.13) and RWUE (3.13 kg/ha-mm) were also higher under soybean + pigeonpea intercropping system (Table 3.229).

Under different nutrient levels, application of 75% RDF + 5 t/ha FYM recorded significantly higher CEY (2343 kg/ha), gross returns (Rs.94226/ha) and net returns (Rs.52341/ha) over rest of the treatments except that CEY was at par with application of FYM 10 t/ha + 50% RDF for cotton and FYM 7.5 t/ha + 50% RDF for soybean (2049 kg/ha). The B:C ratio (2.24) and RWUE (3.68 kg/ha-mm) were also higher with 75% RDF + 5 t/ha FYM (Table). Interaction effect of cropping systems and nutrient levels revealed that soybean + pigeonpea (4:2) intercropping system with application of FYM 5 t/ha + 75% RDF (C_2N_3) recorded significantly higher cotton equivalent yield (2761 kg/ha), gross returns (Rs.111005/ha) and net returns (Rs.71022/ha) over rest of the treatment combinations.

Table 3.229 : PMT: Effect on cotton yield and economics - Parbhani

Treatment	CEY (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Cropping system					
C_1 : Cotton + pigeonpea (6:1)	1417	56997	14072	1.35	2.23
C_2 : Soybean+ pigeonpea (4:2)	1990	79990	42544	2.13	3.13
CD at 5%	233	11736	3373	--	--
Nutrient level					
N_1: FYM 15 t/ha for cotton FYM 10 t/ha for soybean	1433	57597	9529	1.26	2.25
N_2 : FYM 10 t/ha + 50% RDF for cotton FYM 7.5 t/ha + 50% RDF for soybean	2049	82389	38898	1.89	3.22
N_3 : FYM 5 t/ha + 75% RDF for cotton FYM 5 t/ha + 75% RDF for soybean	2343	94226	52341	2.24	3.68
N_4 : RDF 100% (100:50:50 NPK kg/ha for cotton, RDF 100% (30:60:30 NPK kg/ha for soybean	1863	74910	37511	2.01	2.92
N_5 : Absolute control for cotton and soybean	829	33369	3261	1.10	1.30
CD at 5%	295	8469	5238	--	--
Interaction effect (C x N)					
CD at 5%	334	9687	4393	--	--

Soybean: MAUS 81, Pigeonpea: BDN 711, Cotton Bt Ajit 155

There were no significant changes in soil nutrient status due to cropping systems cotton + pigeonpea (6:1) and soybean+ pigeonpea (4:2). Integrated nutrient management involving organic inputs improved soil organic carbon and available nitrogen, phosphorus, potassium and sulphur. Highest organic carbon (0.76%) was observed in treatment N_1 followed by N_2 (0.69%) and N_3 (0.59%) (Table 3.230).

Table 3.230 : PMT: Effect on soil properties - Parbhani

Treatment	pH	EC (dS/m)	Organic C (%)	Available nutrients (kg/ha)			S (ppm)
				N	P	K	
Cropping system							
C_1 : Cotton + pigeonpea (6:1)	7.64	0.31	0.60	245	21	539	15.31
C_2 : Soybean+ pigeonpea (4:2)	7.65	0.39	0.59	247	20	543	15.33
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Nutrient level							
N_1: FYM 15 t/ha for cotton FYM 10 t/ha for soybean	7.36	0.21	0.76	259	16	509	14.11
N_2 : FYM 10 t/ha + 50% RDF for cotton FYM 7.5 t/ha + 50% RDF for soybean	7.62	0.26	0.69	266	23	575	16.31
N_3 : FYM 5 t/ha + 75% RDF for cotton FYM 5 t/ha + 75% RDF for soybean	7.68	0.37	0.59	284	26	609	18.39
N_4 : RDF 100% (100:50:50 NPK kg/ha for cotton, RDF 100% (30:60:30 NPK kg/ha for soybean	7.73	0.37	0.55	242	21	516	15.04
N_5 : Absolute control for cotton and soybean	7.84	0.39	0.42	181	15	496	12.76
CD at 5%	0.052	0.02	0.038	1.26	0.8	8.03	0.347

3.5.4 Energy management

At Parbhani, in a long-term study on tillage and nutrient management on fixed site with biennial cropping sequence of cotton + soybean (1:1) and soybean + pigeonpea (4:2), conventional tillage (T_1) recorded significantly higher soybean seed equivalent yield (3307 kg/ha), gross and net returns (Rs.100863 and 73287/ha) B:C ratio (3.66) and RWUE (5.19 kg/ha-mm) compared to other tillage methods. Among nutrient sources, application of RDF (50%) + FYM (N_3) being at par with RDF (N_5) recorded significantly higher soybean seed equivalent yield (3665 kg/ha), net returns (Rs.84206/ha) with higher B:C ratio (4.05) and RWUE (5.76 kg/ha-mm) compared to other nutrient sources (Table 3.231).

Soybean + pigeonpea (4:2) under conventional tillage

Table 3.231 : Soybean + pigeonpea yield and economics as affected by tillage methods and nutrient sources - Parbhani

Treatment	Yield (kg/ha)		SEY (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Soybean	Pigeonpea					
Tillage method (T)							
T_1: Conventional tillage	1215	1171	3307	100863	73287	3.66	5.19
T_2: Reduced tillage+ interculture	939	1133	2963	90371	62795	3.28	4.65
T_3: Reduced tillage + herbicide	905	1087	2847	86833	59557	3.18	4.47
CD at 5%	-	-	239	4326	3663	0.24	-

Treatment	Yield (kg/ha)		SEY (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Soybean	Pigeonpea					
Nutrient sources (N)							
N_1: FYM @ 5 t/ha	1371	1033	3180	96990	69414	3.52	4.99
N_2: Vermicompost @ 3 t/ha	987	1047	2858	87169	59593	3.16	4.49
N_3: RDF (50%) + FYM (2.5 t/ha)	1448	1241	3665	111782	84206	4.05	5.76
N_4: RDF (50%) + vermicompost (1.5 t/ha)	1295	1224	3217	98118	70542	3.56	5.05
N_5: RDF	1308	1048	3482	106201	78925	3.85	5.47
CD at 5%	-	-	261	5841	5487	0.39	-
Interaction T X N							
CD at 5%	-	-	258	5508	4596	0.18	-

SEY: Soybean equivalent yield

On an average, maximum infiltration rate of 10.02 cm/hr was observed in plots under conventional tillage and minimum of 7.86 cm/hr was in reduced tillage + herbicide. Among nutrient sources, maximum infiltration rate of 9.8 cm/hr was observed in plots under RDF + FYM and minimum of 7.5 cm/hr in RDF treatment. Among tillage methods, maximum bulk density of 1.31 Mg/cm^3 was recorded in plots conventional tillage and minimum of 1.28 Mg/m^3 was recorded in reduced tillage + interculture and reduced tillage and herbicide treatment (Table 3.232).

Table 3.232 : Infiltration rate and bulk density as affected by tillage methods and nutrient sources -Parbhani

Treatment	FYM	Vermi-compost	RDF + FYM	RDF + vermi-compost	RDF
Infiltration rate (cm/hr)					
Conventional tillage	10.5	9.9	11.9	9.6	8.2
Reduced tillage + interculture	9.5	8.2	9.4	8.2	7.3
Reduced tillage + herbicide	8.5	7.6	8.2	7.9	7.1
Bulk density (Mg/m^3)					
Conventional tillage	1.35	1.29	1.34	1.29	1.29
Reduced tillage + interculture	1.28	1.23	1.31	1.28	1.29
Reduced tillage + herbicide	1.27	1.28	1.29	1.28	1.28

Among tillage methods, highest moisture use efficiency of Rs. 157.93/ha-mm was recorded with conventional tillage while the highest moisture use of 466 mm was recorded with RDF compared to other treatments (Table 3.233).

Table 3.233 : Soil moisture use and moisture use efficiency (Rs/mm-ha) as affected by tillage methods and nutrient sources - Parbhani

Treatment	FYM	Vermi-com-post	RDF+ FYM	RDF+ vermin-compost	RDF
Soil moisture use (mm)					
Conventional tillage	467	455	460	458	487
Reduced tillage + interculture	450	442	440	442	462
Reduced tillage + herbicide	448	438	433	432	450
Moisture use efficiency (Rs/mm-ha)					
Conventional tillage	155.52	147.80	167.15	156.40	162.76
Reduced tillage + interculture	147.20	139.55	158.89	148.16	154.51
Reduced tillage + herbicide	144.49	136.77	156.19	145.38	151.73

Among the tillage practices, reduced tillage + interculture recorded highest available N, P and K as well as soil organic carbon (0.48%). Among the nutrient sources, RDF (50%) + vermicompost (1.5 t/ha) recorded highest N, P and K as well as organic carbon followed by RDF (50%) + FYM (2.5 t/ha) compared to other treatments (Table 3.234).

Table 3.234 : Soil chemical properties as influenced by various treatments - Parbhani

Treatment	pH	EC (ds/m)	OC (%)	$CaCO_3$ (%)	Available nutrients (kg/ha)		
					N	P	K
Tillage method (T)							
T_1: Conventional tillage	7.97	0.28	0.37	3.0	165	8.2	408
T_2: Reduced tillage + interculture	7.98	0.33	0.40	3.6	199	10.0	525
T_3 :Reduced tillage + herbicide	7.97	0.31	0.38	3.3	160	9.1	479
Nutrient sources (N)							
N_1: FYM @ 5 t/ha	7.98	0.31	0.40	3.0	197	9.2	511
N_2: Vermicompost @ 3 t/ha	8.00	0.38	0.45	3.2	203	11.7	533
N_3: RDF (50%) + FYM (2.5 t/ha)	8.01	0.40	0.49	3.2	204	12.1	619
N_4:RDF (50%) + vermicompost (1.5 t/ha)	8.01	0.39	0.55	3.8	219	13.1	603
N5: RDF	797	0.29	0.41	3.5	212	10.1	525

At Parbhani, among various mechanization practices in soybean, full mechanization recorded significantly highest soybean yield (2861 kg/ha) over rest of the treatments. Similarly, soybean yield (2568 kg/ha) under partial mechanization was found significantly superior over no mechanization treatment. Soybean seed yield (2744 kg/ha) recorded under BBF (S_1) was significantly superior over flatbed (2179 kg/ha) but it was at par with soybean sown on ridges and furrow method (2625 kg/ha). Full mechanization recorded significantly higher gross and net returns over rest of the treatments. Partial mechanization was also significantly superior over no mechanization with respect to monitory returns. Similarly, soybean planted on BBF (S_1) recorded significantly higher gross and net returns than in flatbed and at par with soybean sown on ridges and furrow method. The highest B:C ratio (2.93) and RWUE (4.49) was observed with full mechanization practices followed by T_2. Similarly, the highest B:C ratio (2.93) and RWUE (4.31) was observed with BBF method followed by ridges & furrow method (2.77) (Table 3.235).

Table 3.235 : Soybean yield and economics as influenced by different treatments - Parbhani

Treatment	Seed yield (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Mechanization					
T_1 : Full mechanization	2861	87260	57531	2.93	4.49
T_2 : Partial mechanization	2568	78324	49293	2.72	4.04
T_3 : Zero mechanization (Farmer's practice)	2248	68564	40969	2.48	3.53
CD at 5%	291	6887	6154	--	--
Land configuration					
S_1 : BBF	2744	83692	55153	2.93	4.31
S_2 : Ridges & furrow	2625	80062	51204	2.77	4.12
S_3 : Flat bed	2179	66459	37800	2.31	3.42
CD at 5%	235	6127	5987	--	--
Interaction effect (T x S)					
CD at 5%	280	7236	4988	--	--

Similarly, full mechanization recorded the highest safflower seed yield (1068 kg/ha) which was found significantly superior over rest of the treatments. Similarly, safflower yield (984 kg/ha) under partial mechanization was found significantly superior over no mechanization treatment. The safflower yield recorded with BBF (1021 kg/ha) was significantly superior over flatbed treatment and at par with safflower sown under ridges and furrow (951 kg/ha). Similar trend was also recorded in case of GMR, NMR and B:C ratio (Table 3.236).

Table 3.236 : Safflower seed yield and economics as influenced by different treatments - Parbhani

Treatments	Seed yield (kg/ha)	NMR (Rs/ha)	B:C ratio
Main plot			
T_1: Full mechanization	1068	28788	2.92
T_2: Partial mechanization	984	23344	2.37
T_3: Zero mechanization (Farmer's practice)	767	11447	1.57
CD at 5%	81	5235	
Sub plot			
S_1: BBF	1021	24361	2.39
S_2: Ridges & furrow	951	21901	2.25
S_3: Flat bed	757	15037	1.94
CD at 5%	117	4455	

Under partial mechanization, the highest energy input (6901 MJ/ha) was required followed by fully mechanization while no mechanization required less energy input. However, under full mechanization, highest energy output (70722 MJ/ha) was obtained followed by partial mechanization compared to no mechanization (42110 MJ/ha). The energy output to input ratio was found to be highest (10.2) under full mechanization followed by partial mechanization (Table 3.237).

Table 3.237 : Total energy input, output & output-input ratio as influenced by different treatments - Parbhani

Treatment	Input energy (MJ/ha)	Output energy (MJ/ha)	Energy output-input ratio
T_1: Full mechanization - BBF	6876	70722	10.2
T_2: Partial mechanization - Ridges & furrow	6901	66729	9.6
T_3: No mechanization - Flat bed	6368	42110	6.6

3.5.5 Alternate land use system

In an experiment at Akola on evaluation of continuous contour trenches for perennial plantations, higher yield of custard apple (208 kg/ha) and greengram (317 kg/ha) and custard apple equivalent yield (472 kg/ha) was recorded in the CCTs treated catchment as compared to untreated catchment. The RWUE, net returns and B:C ratio was also found to be higher in CCTs treatment (0.96, Rs.15999/ha and 1.80, respectively) as compared to untreated catchment (Table 3.238).

Table 3.238 : Effect of CCT treatments on crop yield and economics - Akola

Treatment	Yield (kg/ha)			Custard apple equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ ha)	B:C ratio	RWUE (kg/ ha-mm)
	Main crop	Inter crop	stalk yield					
T_1: Untreated micro-catchment	124	205	263	295	15853	2165	1.14	0.60
T_2: CCT treated micro-catchment	208	317	375	472	15999	12800	1.80	0.96

The hydrological water balance components for the year 2017 (Fig 3.7). revealed that for annual rainfall of 518 mm, less surface runoff + losses, more recharge and more evapotranspiration losses were recorded in CCTs treated micro-catchment when compared to untreated catchment.

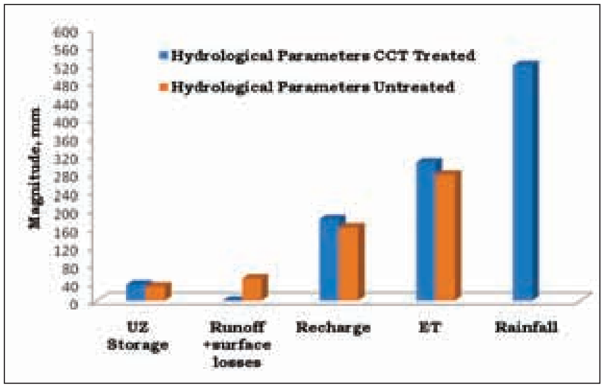


Fig. 3.7: Hydrological water balance components for CCT treated and untreated micro-catchment during 2017

Custard apple + greengram system without CCTs

Custard apple + greengram system with CCTs

At Akola, in a study on ber based agri-horti system during 2017-18, difference treatments had no significant effect on cotton equivalent yield. However ber + cotton system recorded higher net returns (Rs 6637/ha), B:C ratio (1.22) and RWUE (1.94 kg/ha-mm) than other treatments (Table 3.239).

Table 3.239 : Performance of ber based agri-horti system- Akola

Treatment	Yield (kg/ha)			MCEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE kg/ha-mm)
	Ber	Cotton	Soybean					
T_1: Sole cotton	17	828	0	828	29681	6637	1.22	1.94
T_2: Sole soybean	17	0	1128	796	35207	-354	0.99	1.87
T_3: Cotton + soybean (1:1)	17	412	584	824	36372	118	1.00	1.93
T_4: Cotton + soybean (3:3)	17	498	488	842	36761	167	1.00	1.98
CD at 5%	-	-	-	NS		-	-	-

MCEY: Main crop equivalent yield (cotton)

In aonla based agri-horti system at Kovilpatti aonla with greengram system recorded higher greengram yield of (685 kg/ha), net returns (Rs 14325/ha) and B:C ratio (1.61), followed by aonla + pearlmillet system (Rs 7150/ ha with B:C ratio of 1.33) compared to other treatments (Table 3.240).

Table 3.240: Effect of treatments on crop yield and economics - Kovilpatti

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Intercrop	Stover/ stalk yield				
T_1: Aonla*	-	-	-	-	-	-
T_2: Aonla + pearlmillet	2200	4175	21450	7150	1.33	5.22
T_3: Aonla + sorghum	950	2234	22500	-9200	0.60	2.25
T_4: Aonla + greengram	685	1507	23350	14325	1.61	1.63

*Fruiting was not observed in main crop (Aonla)

The study on effect of intercrops on growth parameters of aonla indicated that the greengram and pearlmillet produced positive effect on number of branches per plant (24 each) and greengram on collar diameter (20 cm). Further, plant height and canopy spread was reduced due to intercropped aonla crop compared to sole aonla (Table 3.241).

Table 3.241 : Effect of intercropping treatments on growth parameters of aonla - Kovilpatti

Treatment	Plant height (cm)	No. of branches	Collar diameter (cm)	Canopy spread (cm)	
				N-S	E-W
T_1: Aonla	262	22	16	226	214
T_2: Aonla + pearlmillet	223	24	15	211	213
T_3: Aonla + sorghum	234	20	12	204	242
T_4: Aonla + greengram	246	24	20	214	209

In a study on custard apple based agri-horti systems at Kovilpatti, custard apple + greengram system recorded higher net returns (Rs 11875/ha) as compared to other systems and also recorded high B:C ratio of 1.50 followed by custard apple with pearlmillet system (1.42) (Table 3.242).

Table 3.242 : Performance of custard apple based agri-horti system - Kovilpatti

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Inter crop	Stover/ stalk yield				
T_1: Custard apple	-	-	-	-	-	-
T_2: Custard apple + pearl millet	2120	4800	20960	8720	1.42	5.03
T_3: Custard apple + sorghum	985	6150	21350	-8545	0.60	2.34
T_4: Custard apple + greengram	655	2540	24150	11875	1.50	1.55

*Fruiting was not observed in main crop

The study on effect of intercrops on growth parameters of custard apple indicated that the greengram produced positive effect due to legume crop and recorded higher plant height (192 cm) and canopy spread (155 cm in N-S and 137 cm in E-W) compared to sole custard apple with lesser plant height (166 cm) and canopy spread (135 cm in N-S and 119 cm in E-W) (Table 3.243).

Table 3.243 : Effect of intercrop treatments on growth parameters of custard apple - Kovilpatti

Treatment	Plant height (cm)	No. of branches	Collar diameter (cm)	Canopy spread (cm)	
				N-S	E-W
T_1: Custard apple	166	15	19	135	119
T_2: Custard apple + pearl millet	177	12	17	142	107
T_3: Custard apple + sorghum	185	13	20	171	116
T_4: Custard apple + greengram	192	11	18	155	137

At Parbhani in drumstick based agri–horti system, drumstick + green manuring (1:6) recorded significantly highest drumstick equivalent yield (14920 kg/ha) net returns (Rs.119367/ha), B:C ratio (5.01) and RWUE (23.45 kg/ha-mm) closely followed by drumstick + greengram (1:6) and drumstick + soybean (1:6) systems (Table 3.244).

Table 3.244 : Effect of alternate land use systems on crop yield and economics - Parbhani

Treatment	Drumstick yield (kg/ha)	Intercrop yield (kg/ha)	System yield (kg/ha)	COC (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
C_1: Drumstick sole (3 m x 3 m)	10725	-	10725	25334	81916	4.23	16.86
C_2: Drumstick + greengram (1:6)	4482	804	14398	37304	106676	3.85	22.63
C_3 : Drumstick + soybean (1:6)	5627	1845	14052	51685	88835	2.71	22.09
C_4: Drumstick + *kharif* sorghum (1:6)	4177	2017	12367	42670	81000	2.85	19.44
C_5: Drumstick + green manuring (1:6)	14920	3745	14920	29834	119367	5.01	23.45
CD at 5%	937	-	-	-	-	-	-

The soil pH and EC was not affected significantly due to different drumstick based agri-horti systems. Whereas, significantly highest organic carbon (0.66%) was recorded due to drum stick + green manuring (C_5) with higher available nitrogen (264.8 kg/ha), phosphorus (19.7 kg/ha) and potassium (596.5 kg/ha) compared to other treatments (Table 3.245).

Table 3.245 : Soil nutrient status under drumstick based cropping system - Parbhani

Treatment	pH	EC (dS/m)	OC (%)	Available nutrients (kg/ha)		
				N	P	K
C_1: Drumstick sole (3 m x 3 m)	8.01	0.40	0.42	193.3	10.3	567.2
C_2: Drumstick + greengram (1:6)	7.86	0.28	0.57	235.2	17.4	592.2
C_3: Drumstick + soybean (1:6)	7.97	0.40	0.48	203.8	12.2	581.5
C_4: Drumstick + *kharif* sorghum (1:6)	7.97	0.38	0.51	218.8	13.7	577.6
C_5: Drumstick + green manuring (1:6)	7.75	0.30	0.66	264.8	19.7	596.5
CD at 5%	NS	NS	0.19	10.4	3.4	11.0

3.6 Voluntary Centre

3.6.1 Aklera

3.6.1.1 Nutrient management

At Aklera, in a study on effect of nutrient management on soybean (RKS-45) based double cropping systems, application of 50% RDF (inorganic) + 50% N through FYM + sulphur @ 10 kg/ha gave maximum soybean seed and stalk (1497 and 2993 kg/ha) yield which was at par with application of 50% RDF (inorganic) + 50% N through FYM (1462 and 2925 kg/ha), respectively. Similarly, maximum net returns were recorded with application of 50% RDF (inorganic) + 50% N through FYM + sulphur @ 10 kg/ha (Rs. 34627/ha), but was at par with application of 50% RDF (inorganic) + 50% N through FYM (Rs. 33856/ha). The B:C ratio (1.67) was similar with application of 50% RDF (inorganic) + 50% N through FYM + sulphur @ 10 kg/ha and 50% RDF (inorganic) + 50% N through FYM. During *rabi* chickpea gave higher seed yield (1863 kg/ha), net returns (Rs. 57085/ha) and B:C ratio (2.70) compared to coriander and linseed. Among nutrient management, application of 50% RDF (inorganic) + 50% N through FYM + sulphur @ 10 kg/ha being at par with 50% RDF (inorganic) + 50% N through FYM recorded significantly higher yield (1335 kg/ha), net returns (Rs. 50572/ha) and B:C ratio (2.45) than other treatments (Table 3.246).

Soybean with 50% RDF (inorganic) + 50% N through FYM + sulphur @ 10 kg/ha

Table 3.246 : Effect of nutrient management on soybean (RKS-45) based double cropping system yield and economics - Aklera

Treatment	*Kharif*				*Rabi*		
	Seed yield (kg/ha)	**Stalk yield (kg/ha)**	**NMR (Rs/ha)**	**B:C ratio**	**Yield (kg/ha)**	**NMR (Rs/ha)**	**B:C ratio**
Cropping system							
T_1: Soybean - chickpea(GNG-469)	1319	2638	29428	1.51	1863	57085	2.70
T_2: Soybean - coriander (RCR 436)	1317	2634	29360	1.51	875	48621	2.58
T_3: Soybean - linseed (KBA-3)	1332	2664	29913	1.54	922	30483	1.74
CD at 5%	NS	NS	NS	NS	36	2081	0.11
Nutrient management							
N_1: 100 % RDF (inorganic)	1167	2335	25191	1.40	1117	40978	2.27
N_2: 100 % RDF (inorganic) + sulphur @ 10 kg/ ha	1195	2390	25707	1.39	1144	41962	2.27
N_3: 75% RDF (inorganic) + 25% N through FYM	1299	2597	28926	1.51	1194	44054	2.30
N_4: 75% RDF (inorganic) + 25% N through FYM + sulphur @ 10 kg/ha	1317	2634	29096	1.48	1229	45657	2.32
N_5: 50% RDF (inorganic) + 50% N through FYM	1462	2925	33856	1.67	1302	49157	2.43
N_6: 50% RDF (inorganic) + 50% N through FYM + sulphur @ 10 kg/ha	1497	2993	34627	1.67	1335	50572	2.45
CD at 5%	106	211	3904	0.20	49	2282	0.11

3.6.1.2 Energy management

At Aklera, in a study on an evaluation of different tillage and moisture conservation practices on soybean yield and economics, the yield of soybean was significantly influenced due to effect of different tillage as well as moisture conservation practices. Further, deep summer ploughing + harrowing + cultivator (T_2) and subsoiler (once in 3 years) + deep summer ploughing + harrowing (T_3) being at par with each other recorded significantly higher soybean yield of 1703 and1647 kg/ha, respectively over summer disc harrowing + cultivator (T_1). Deep summer ploughing + harrowing + cultivator (T_2) also recorded significantly higher net returns of Rs.38231/ha and B:C ratio (1.65) over rest of tillage treatments. Similarly, under moisture conservation, BBF(C_2) and flatbed sowing + dead furrows at 5 m interval (C_3) being at par with each other recorded significantly higher soybean yield (1654 and 1630 kg/ha) and net returns (Rs. 36755 and 34453/ha), respectively compared to flatbed sowing (1535 kg/ha and Rs.31588/ ha). However, the B:C ratio was significantly superior with BBF (1.67) over rest of the treatments (Table 3.247).

Soybean under BBF system

Table 3.247 : Effect of different tillage and moisture conservation treatments on yield and economics of soybean (JS 95-60) - Aklera

Treatment	Seed yield (kg/ha)	NMR (Rs/ha)	B:C ratio
Tillage			
T_1: Summer disc harrowing + cultivator	1468	29377	1.30
T_2: Deep summer ploughing + harrowing + cultivator	1703	38231	1.65
T_3: Subsoiler (once in 3 years) + deep summer ploughing + harrowing	1647	35188	1.49
CD at 5%	70	2835	0.12
Moisture conservation			
C_1: Flat bed sowing	1535	31588	1.37
C_2: Broad bed and furrow (BBF)	1654	36755	1.67
C_3: Flat bed sowing + dead furrows at 5 m interval	1630	34453	1.40
CD at 5%	58	2348	0.10

3.6.2 Darsi

3.6.2.1 Rainwater management

At voluntary centre Darsi, during 2017 the onset of monsoon was June 1st week and annual rainfall of 614.7 mm was received against mean annual rainfall of 726 mm. In *kharif,* 414.2 mm and in *rabi,* 107.4 mm was received against the normal rainfall of 412 and 191.6 mm, respectively. In a study on the effect of *in-situ* moisture conservation and supplemental irrigation on growth and yield of pigeonpea (LRG-41) and castor (GCH-4), supplemental irrigation significantly improved the castor yield (2333 kg/ha) over the conservation furrow at 3.6 m, sub soiling at 1.8 and 2.7 m distance with B:C ratio of 3.1. Whereas, in pigeonpea supplemental irrigation was significantly superior over conservation furrow at 3.6 m interval but it was on par with sub-soiling at 1.8 and 2.7 m distance (Table 3.248).

Table 3.248 : Effect of *in-situ* moisture conservation and supplemental irrigation on yield and economics of pigeonpea and castor - Darsi

Treatment	Plant height (cm)		No of branches/ plant		100 seed weight (g)		Seed yield (kg/ha)		B:C ratio	
	Castor	Pigeon-pea	Castor	Pigeon-pea	Castor	Pigeon-pea	Castor	Pigeon-pea	Castor	Pigeon-pea
S_1: Sub-soiling at 1.8 m distance	174.6	109.9	4.75	7.25	21.3	11.00	1729	312	2.2	0.7
S_2: Sub-soiling at 2.7 m distance	177.5	113.9	5.00	7.5	21.73	11.13	2069	361	2.5	0.8
S_3:Supplemental irrigation	190.6	115.9	5.5	8.00	22.83	11.35	2333	410	3.1	1.0
S_4: Conservation furrow at 3.6 m	172.6	109.3	4.50	7.20	20.53	10.78	1316	299	1.8	0.8
CD at 5%	4.00		0.16		NS		173		-	

3.6.2.2 Cropping systems

At Darsi, in an evaluation of suitable millet-pulse based cropping sequences, among millets grown during *kharif,* foxtail millet produced higher pigeonpea equivalent yield (571 kg/ha) while during *rabi* cowpea grown in sequence with pearlmillet also recorded higher pigeonpea equivalent yield (827 kg/ha) compared to other pulses. Similarly, pearlmillet-cowpea sequence recorded the highest system productivity (1335 kg/ha), gross returns (Rs. 66772/ha) and B:C ratio (2.39) fallowed by foxtail millet-greengram sequence with system yield of 1255 kg/ha, gross returns of Rs. 62729/ha and B:C ratio of 2.06 (Table 3.249).

Table 3.249 : Yield and economics of millet-pulse based cropping sequences - Darsi

Treatment	Yield (kg/ha)		PPEY (kg/ha)		System productivity (kg/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
	kharif	*rabi*	*kharif*	*rabi*				
T_1: Foxtail millet-greengram	164	644	546	709	1255	30450	62729	2.06
T_2: Foxtail millet-cowpea	162	720	545	504	1049	27895	52437	1.88
T_3: Foxtail millet-blackgram	239	586	571	633	1204	32750	60210	1.84
T_4: Pearlmillet-greengram	56	653	509	653	1162	30450	58082	1.91
T_5: Pearlmillet-cowpea	56	1181	509	827	1335	27895	66772	2.39
T_6: Pearlmillet-blackgram	47	464	506	510	1016	32750	50806	1.55
T_7:Pigeonpea + foxtail millet (1:5)	266 (FM) + 443 (PP)	-	533	-	533	29000	26665	0.92
T_8: :Pigeonpea + pearlmillet (1:2)	301 (PM) + 367 (PP)	-	546	-	546	29000	27286	0.94
T_9: Sole pigeonpea	490	-	490	-	490	19000	24500	1.29
CD at 5%	44	173	-	-	-	-	-	-

PPEY: Pigeonpea equivalent yield; Varieties: pigeonpea- LRG-41, pearlmillet & foxtail millet-local, Blackgram: GBG-1, Greengram- LGG-460 and cowpea-local

3.6.2.3 Alternate land use system

At Darsi, in an evaluation of subabul based silvi-pastoral systems among different silvi-pastoral systems, subabul + bajra napier hybrid + *Desmanthus virgatus* (1:3:1) recorded significantly higher fresh fodder yield of 4966 kg/ha compared to other treatment. Subabul + bajra napier hybrid + *Stylosanthus hamata*in the row ratio of 1:3:1 (3792 kg/ha) followed by subabul + bajra napier hybrid in the row ratio of 1:4 (3262 kg/ha) were found to be next best subabul based silvi-pastoral systems (Table 3.250).

Table 3.250 : Fresh fodder yield and economics of subabul based silvi-pastoral system - Darsi

Treatment	Fresh fodder yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
T_1: Subabul sole	-	71622	0	0.00
T_2: Subabul + BNH (1:4)	3262	73400	6525	0.09
T_3: Subabul + BNH + *Stylosanthushamata*(1:3:1)	3792	75437	7585	0.10
T_4: Subabul + BNH + *Desmathus virgatus*(1:3:1)	4966	74956	9932	0.13
T_5: Subabul + *Desmathus* (1:4)	1665	56511	3330	0.06
T_6: Subabul + *Stylosanthus hamata* (1:4)	1876	73400	3751	0.05
T_7: Subabul + pearlmillet + horsegram (1:2:1)	2195	73489	4391	0.06
T_8: Subabul + sorghum + horsegram (1:2:1)	1378	74200	2755	0.04
CD at 5%	657	-	-	-

BNH- Bajra Napier Hybrid: Sorghum variety: CSH-27

3.6.3 Imphal

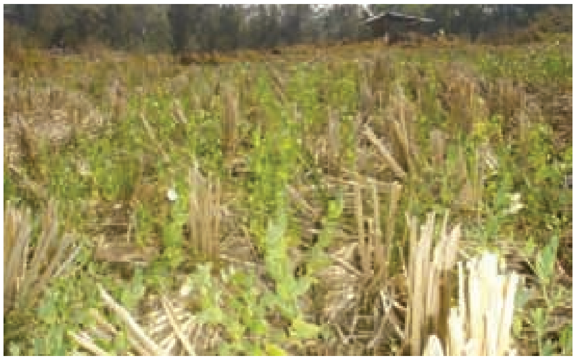
3.6.3.1 Cropping systems

At Imphal, in a study on relay cropping of field pea in rice under rainfed medium low land situation, sowing of field pea at rice harvest with 150% seed rate and mulching with paddy straw recorded significantly higher rice equivalent yield (1395 kg/ha) over rest of the treatments. However, relay cropping of field pea 15 days before rice harvest with 150% seed rate with mulching was on par with sowing of field pea at rice harvest with 100% seed rate with mulching (1229 kg/ha) and relay cropping of field pea at 150% seed rate without mulching (1180 kg/ha) and recorded significantly higher rice equivalent yield (1238 kg/ha) compared to T_1, T_2, T_3 and T_5 treatments. Similarly, there was no significant difference between relay cropping with field pea at 100 and 150% seed rate without mulching. Sowing of field pea at rice harvest with 100% seed rate + mulching also recorded higher net returns (Rs. 69632/ha) and B:C ratio (1.21) compared to other treatments (Table 3.251).

Table 3.251 : Yield and economics of rice-field pea relay cropping system - Imphal

Treatment	Grain/Seed Yield(kg/ha)		MCEY (kg/ha)	COC (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Rice	Field pea					
T_1: Sowing of field pea 15 days before rice harvest with 100% seed rate	6900	341	796	56443	62402	1.11	0.48
T_2: Sowing of field pea 15 days before rice harvest with 150% seed rate	6900	434	1013	59743	63287	1.06	0.61
T_3: Sowing of field pea at rice harvest with 100% seed rate	6900	473	1104	57343	67457	1.18	0.66
T_4: Sowing of field pea at rice harvest with 150% seed rate	6900	506	1180	60643	65612	1.08	0.71
T_5: Sowing of field pea 15 days before rice harvest with 100% seed rate with mulching	6900	476	1110	57568	67337	1.17	0.67
T_6: Sowing of field pea 15 days before rice harvest with 150% seed rate with mulching	6900	531	1238	60868	66512	1.09	0.75
T_7: Sowing of field pea at rice harvest with 100% seed rate with mulching	6900	527	1229	57568	69632	1.21	0.74
T_8: Sowing of field pea at rice harvest with 150% seed rate with mulching	6900	598	1395	61993	68402	1.10	0.84
CD at 5%	-	49.5	115.6	-	-	-	0.07

MCEY: Main crop rice equivalent yield



Field pea sown at rice harvest with 100% seed rate without mulching

Field pea sown at rice harvest with 100% seed rate with mulching

3.6.3.2 Alternate land use system

At Imphal, in a study on mango based agri-horti systems, blackgram being on par with cowpea recorded significantly higher yield (720 kg/ha) compared to other intercrops (Table). Significantly higher fruit yield of mango was recorded in treatments involving legumes as intercrops such as blackgram (3737 kg/ha), greengram (3707 kg/ha) and cowpea (3730 kg/ha) which were on par with each other. However, mango in rice (3247 kg/ha) and maize (3177 kg/ha) intercropped area recorded significantly lower yield. Further, due to higher cost of cultivation and lower yield of intercrops different agri-horti systems were less remunerative compared to sole mango with B:C ratio of 2.7. It could be due to the poor fertility status of soils and more sloppy lands which led to higher cost of cultivation due to more labour. However, higher RWUE was recorded with mango intercropped with pulses (4.1-4.0 kg/ha-mm) (Table). Similarly, significantly higher mango equivalent yield was recorded in mango intercropped with legumes such as blackgram (5357 kg/ha), cowpea (5238 kg/ha), greengram (5192 kg/ha) and groundnut (5039 kg/ha) which were on par with each other. However, mango intercropped with rice and maize recorded significantly lower mango equivalent yield of 4084 and 3390 kg/ha, respectively (Table 3.252).

Table 3.252 : Yield and economics of mango based agri-horti systems - Imphal

Treatment	Yield (kg/ha)			MEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Mango fruit	Grain/ seed	Stover					
T_1: Mango sole	3550	-	-	3550	34502	36499	1.06	2.7
T_2: Mango + blackgram	3737	720	1740	5357	61465	45669	0.74	4.1
T_3: Mango + greengram	3707	660	1540	5192	62365	41469	0.66	4.0
T_4: Mango + cowpea	3730	670	1630	5238	63215	41535	0.66	4.0
T_5: Mango + ricebean	3573	0	1900	3573	62715	8752	0.14	2.8
T_6: Mango + soybean	3420	450	1350	4433	65440	23210	0.35	3.4
T_7: Mango + pigeon pea	3453	340	1330	4218	63190	21177	0.34	3.3
T_8: Mango + groundnut	3577	650	1520	5039	65740	35044	0.53	3.9
T_9: Mango + rice	3247	930	1460	4084	67114	14566	0.22	3.2
T_{10}: Mango + maize	3177	170	710	3390	65249	2551	0.04	2.6
CD at 5%	185	58	108	189.3	-	-	-	0.15

MEY: Mango equivalent yield

Groundnut

Cowpea

Blackgram

Performance of intercrops in mango based agri-horti systems

3.6.4 Munger

At Munger, an annual rainfall of 778.9 mm was received which was deficit by 367.1 mm compared to normal (1146 mm). During *kharif*, a rainfall of 691.0 mm was received against a normal rainfall of 986 mm. The rainfall during *rabi* was deficit by 64.2 mm compared to normal rainfall of 106.7.

3.6.4.1 Rainwater management

At Munger, in a study on *in-situ* moisture conservation practices in maize based double cropping systems under upland rainfed conditions, maize-*rabi* crops sown on raised beds produced significantly higher maize equivalent yield (9448 kg/ha), net returns (Rs.113378/ha) and RWUE (12.88 kg/ha-mm) followed by ridge and furrow system (8914 kg/ha, Rs.106965/ha and 12.15 kg/ha-mm, respectively) (Table 3.253). Among the cropping systems, maize-mustard sequence produced significantly higher maize equivalent yield (9722 kg/ha) and net returns (Rs.116663/ha) compared to other crop sequences.

Table 3.253 : Yield and economics of crops as influenced by *in-situ* moisture conservation and cropping systems - Munger

Treatment	Yield (kg/ha)				System NMR (Rs/ha)	B:C ratio	System RWUE (kg/ha-mm)
	Maize	*Rabi* crop	MEY	Mean MEY (2 yrs)			
Moisture conservation							
M_1: Flat bed	3669	757	6261	6659	75135	1.51	8.54
M_2: Ridge and furrow	5486	961	8914	9189	106965	2.03	12.15
M_3: Raised bed	5954	978	9448	9715	113378	2.15	12.88
CD at 5%	425	021	086	-	4179	0.02	0.46
Cropping system							
C_1: Maize-linseed	5000	605	6764	7351	81167	1.58	9.22
C_2: Maize-mustard	4824	1679	9722	9433	116663	2.28	13.25
C_3: Maize-lentil	5072	629	7694	8158	92322	1.70	10.49
C_4: Maize-chick pea	5248	681	8652	9144	103819	2.03	11.79
CD at 5%	232	040	081	-	2897	0.05	0.33

MEY: Maize equivalent yield

Maize-mustard cropping sequence under raised bed system produced significantly higher maize equivalent yield (10914 kg/ha) closely followed by maize-mustard sequence under ridge and furrow system (10192 kg/ha) compared to other treatment combinations (Table 3.254).

Maize on raised bed system

Table 3.254 : Effect of *in-situ* moisture conservation and cropping systems on maize equivalent yield (kg/ha) - Munger

Treatment	Maize-linseed	Maize-mustard	Maize-lentil	Maize-chickpea	Mean
M_1: Flat bed	4776	8061	5868	6340	6261
M_2: Ridge and furrow	7574	10192	8371	9519	8914
M_3: Raised bed	7942	10914	8841	10096	9448
Mean	6764	9722	7694	8652	
		CD at 5%	-	-	-
Factor A (Moisture conservation)		348	-	-	-
Factor B (Cropping system)		241	-	-	-
Factor(B) at same level of A		467	-	-	-
Factor(A) at same level of B		497	-	-	-

3.6.4.2 Nutrient management

At Munger, in an experiment on integrated nutrient management in pigeonpea based intercropping systems, pigeonpea + blackgram intercropping (1:2) gave significantly higher pigeonpea equivalent yield (PEY) (2156 kg/ha), net returns (Rs.129377/ha), B:C ratio (2.78) and RWUE (1.43 kg/ha-mm) compared to other cropping systems. Among nutrient management, application of level 75% RDF + 25% N through FYM + PSB + *Rhizobium* produced significantly higher pigeonpea equivalent yield (1993 kg/ha), net returns (Rs.119570/ha) and RWUE (2.28 kg/ha-mm) compared to 100% RDF + PSB + *Rhizobium* (1915 kg/ha) (Table 3.255).

Table 3.255 : Effect of intercropping and INM on crop yield and economics of pigeonpea- Munger

Treatment	PEY(kg/ha)		NMR (Rs/ha)	RWUE (kg/ha-mm)	LER
	2017	Mean (2 yrs)			
Cropping system					
T_1: Sole pigeonpea	1817	2070	108990	2.34	1.0
T_2: Sole fingermillet	507	506	30454	0.65	1.0
T_3: Sole sorghum	1236	1249	74181	1.59	1.0
T_4: Sole blackgram	1097	1140	65790	1.41	1.0
T_5: Pigeonpea + fingermillet (1:2)	1803	2044	108165	2.32	1.40
T_6: Pigeonpea + fodder sorghum (1:1)	1896	2271	113735	2.44	1.22
T_7: Pigeonpea + blackgram (1:2)	2156	2439	129377	2.78	1.43
T_8: Pigeonpea + fodder sorghum (FP)	1955	2330	117299	2.52	1.28
CD at 5%	89	-	5346	0.12	-
Nutrient management					
F_1: 100% RDF + PSB + *Rhizobium/Azotobacter*	1523	1719	104404	1.96	-
F_2: 75% RDF + 25 % N through FYM + PSB + *Rhizobium/Azotobacter*	1594	1794	109308	2.05	-
CD at 5%	NS	-	585	0.01	-

PEY: Pigeonpea equivalent yield; FP: Farmers' practice

Performance of pigeonpea + blackgram (1:2) and pigeonpea + fingermillet (1:2) intercropping systems under 75% RDF + 25% N through FYM + PSB + Rhizobium

3.6.5 Raichur

3.6.5.1 Rainwater management

At Raichur, the onset of monsoon was early (7th June) compared to normal onset of monsoon (20th June). The total rainfall received during 2017 was 828.2 mm in 53 rainy days as compared to normal rainfall of 736 mm in 41 rainy days received during last 107 years. The crop seasonal rainfall of 635.4 mm was received against normal of 486.2 mm during *kharif* season. During *rabi* season, 193.5 mm rainfall was received against normal of 124.5 mm. A square shaped farm pond of size 18 m x 18 m top width 10 m x 10 m bottom width with a depth of 2.7 m and side slope of 1.5:1 was excavated in the year 2016-17. The total capacity of the pond is about 547.0 m^3. The catchment and command area were delineated as 8 and 1 ha, respectively. The subsoil at the pond site was sandy loam which resulted in high seepage losses hence the farm pond was lined with RCC concrete to prevent seepage losses from the pond (Table 3.256).

Table 3.256 : Details of the farm pond - Raichur

Pond size				Height (m)	Volume (cum)	Slope (%)	Year of construction	Soil type	Lining	Lifting pump
Top (m)		Bottom (m)								
18	18	10	10	2.7	547.77	1.5:1	2016-17	Red soil	Concrete	Diesel pump

During the year 2017, in a study on catchment, storage and command relationship and recycling of the harvested water for increasing the water productivity in micro-watersheds, 828.2 mm annual rainfall with 53 rainy days was recorded, out of which, six runoff causing rainfall events occurred and the pond overflowed four times after exceeding its fullest capacity of 547.0 m^3. Most of the runoff events occurred during the months of September and October. The August, September and October months received good amount of rainfall (197.6, 248.4 and 193.5 mm, respectively). Due to continuous rainfall in these months, the sorghum crop did not germinate properly. The water balance of the pond was revealed that 143.42 m^3 of water was lost through evaporation and seepage losses together during the period from 10-10-2017 to 10-01-2018 (3 months). The remaining 404.34 m^3 of water available in the pond as on 11-01-2018 was used for supplemental irrigation to groundnut (Var. K9) with an irrigation depth of 4 cm for one hectare area which amounted to 400 m^3, using low head sprinkler irrigation system and groundnut pod yield of 615 kg/ha was recorded with net returns of Rs. 10399/ha and B:C ratio of 1.79 (Table 3.257).

Table 3.257 : Water balance of farm pond during 2017 - Raichur

Parameter	Volume of water
Rainfall (mm)	849
Evaporation & seepage losses (m^3)	143.4
Water harvested (m^3)	547.8
Used for irrigation (m^3)	404.3
Dead storage/storage at the end of the season	Nil

Harvested raintwater in farm pond with lifting pump

Supplemental irrigation (sprinkler) in groundnut

At Raichur, adoption of ridges and furrow system of planting for *in-situ* rainwater conservation recorded significantly higher seed cotton yield (2209 kg/ha) as compared to broad bed and furrows (1964 kg/ha) and flat bed system (1587 kg/ha). Similarly, application of 90:45:45 NPK kg/ha (50% N through organic) being on par with 90:45:45 NPK kg/ha (1945 kg/ha) and produced significantly higher seed cotton yield (2101 kg/ha) over other nutrient management treatments. Pooled analysis of two years data also showed similar trend of results. Among the treatment combinations adoption of ridges and furrows along with application of 90:45:45 NPK kg/ha (50% N through organic) performed better over rest of the treatment combinations (Table 3.258).

Table 3.258 : Yield and economics of Bt. cotton as influenced by *in-situ* moisture conservation and nutrient management - Raichur

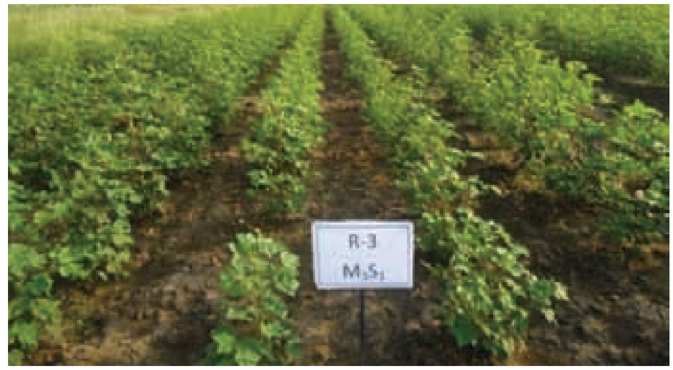
Treatment	Seed cotton yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	2016	2017	Mean			
***In-situ* moisture conservation**						
M_1: Broad bed & furrows	2222	1964	2093	40012	75370	2.89
M_2: Ridges and furrows	2403	2209	2306	40012	87107	3.17
M_3: Flatbed	1743	1587	1665	37512	54291	2.45
CD at 5%	154.9	169	139		7658	0.20
Nutrient management						
S_1: 60: 30: 30 NPK kg/ha	1937	1773	1855	36356	65878	2.80
S_2: 90:45:45 NPK kg/ha	2148	1945	2046	37286	75522	3.02
S_3: 60: 30: 30 NPK kg/ha (50% through organic)	2097	1863	1980	40141	69005	2.71
S_4: 90:45:45 NPK kg/ha (50% through organic)	2308	2101	2205	42930	78619	2.82
CD at 5%	159.8	185	116	-	6399	0.17

Ridges and furrow system

Flat bed system

***In-situ* moisture conservation**

Cotton under ridges & furrows + 60:30:30 kg NPK/ha



Cotton under flat bed + 60:30:30 kg NPK/ha

3.6.5.2 Alternate land use system

At Raichur, in a study on neem (*Melia dubia* L.) based agroforestry systems in shallow black soils, pigeonpea performed better as intercrop and recorded higher seed yield of 933, 1039 and 1223 kg/ha in neem plant spacing of 5 m × 3 m, 5 m × 4 m and 5 m × 5 m respectively, compared to foxtail millet and pearlmillet. Further the plant to plant and row to row spacing of 5 m × 5 m geometry of neem was most suitable for taking intercrops compared to 5 m × 3 m and 5 m × 4 m (Table 3.259). Planting of neem with a spacing of 5 m × 5 m recorded higher plant height (424 cm), no of branches (4.80) and girth (8.55 cm) while canopy spread was higher under plant spacing of 5 m × 3 m (Table 3.260).

Table 3.259 : Effect of treatments on crop yield and economics - Raichur

Melia dubia geometry	Intercrop	Intercrop yield (kg/ha)
T_1: 5 m × 3 m	Pigeonpea	933
T_2: 5 m × 3 m	Foxtailmillet	744
T_3: 5 m × 3 m	Pearlmillet	921
T_4: 5 m × 4 m	Pigeonpea	1039
T_5: 5 m × 4 m	Foxtailmillet	818
T_6: 5 m × 4 m	Pearlmillet	970
T_7: 5 m × 5m	Pigeonpea	1223
T_8: 5 m × 5m	Foxtailmillet	863
T_9: 5 m × 5m	Pearlmillet	1088
-	Pigeonpea	1417
-	Foxtailmillet	1154
-	Pearlmillet	1273

Pigeonpea Var. TS-3R; Foxtailmillet Var. HMT–101; Pearlmillet Var. ICTP-8203

Table 3.260 : Effect of treatments on growth parameters of Melia dubia - Raichur

Treatment (Planting geometry)	Plant height (cm)	No. of branches	Collar diameter (cm)	Canopy spread (m)	
				N-S	E-W
5 m × 5 m	424	4.80	8.55	1.35	1.29
5 m × 4 m	389	4.56	8.12	1.28	1.31
5 m × 3 m	402	4.60	8.18	1.41	1.63

Melia dubia + pearlmillet

Melia dubia + foxtailmillet

Melia dubia + pigeonpea

4. Operational Research Project

OPERATIONAL RESEARCH PROJECT

During 2017-18, the on-farm assessment/demonstration of technologies/practices were conducted in the following adopted villages of ORP centres (Table 4.1).

Table 4.1 : Details of ORP villages

ORP Centre	Village	Block/Tehsil/Mandal	District	State	Operational area (ha)
Ananthapuramu	Yerraguntlapalli	Peapully	Kurnool	Andhra Pradesh	142
Arjia	Newariya	Rashmi	Chittorgarh	Rajasthan	465
Ballowal Saunkhri	Behdarya and Kothi	Talwara	Hoshairpur	Punjab	19
Bengaluru	Baichenahalli and Iraksandra	Tumkur	Tumkur	Karnataka	228
Chianki	Gonda	Meral	Garhwa	Jharkhand	197
Hisar	Chappar Jogian	Tosham	Bhiwani	Haryana	245
Indore	Piploda Dwarakdheesh	Ujjain	Ujjain	Madhya Pradesh	514
Solapur	Hingani	Man	Satara	Maharashtra	342

During 2017-18, 65 technologies were assessed under Participatory Technology Development (PTD) and 39 technologies were upscaled in different ORP villages (Table 4.2).

Table 4.2 : ORP centre-wise and theme-wise technologies assessed/upscaled during 2017-18

ORP village/ ORP centre	Technologies for participatory research development/refinement (PTD)						Technologies upscaled						Total
	RWM	CS	NM	EM	EIV	IFS/ ALU	RWM	CS	NM	EM	EIV	IFS/ ALU	
Yerraguntlapalli (Ananthapuramu)	3	1	1	1	-	1	-	-	1	2	1	-	11
Nevariaya (Arjia)	2	2	2	1	4	1	1	-	-	1	1	-	15
Behdarya-Kothi (Ballowal Saunkhri)	2	2	2	1	-	1	1	1	-	-	1	-	11
Baichenahalli (Bengaluru)	-	1	1	-	4	1	1	4	-	4	-	-	16
Gonda (Chianki)	2	1	-	1	2	-	-	3	1	-	6	-	16
Chhaparjogiyan (Hiasr)	1	2	2	-	2	1	2	-	-	-	1	-	11
Piplodadwarka-deesh (Indore)	2	1	-	1	1	1	1	-	1	-	-	-	08
Hingani (Solapur)	3	3	2	1	2	-	1	2	1	1	-	-	16
Total	**15**	**13**	**10**	**06**	**15**	**06**	**07**	**10**	**04**	**08**	**10**	**-**	**104**

*** RWM: Rainwater Management; CS: Cropping Systems; NM: Nutrient Management; EM: Energy Management; EIV: Evaluation of Improved Varieties; IFS/ALU: Integrated Farming System/Alternate Land Use System

4.1 Ananthapuramu

(Village Yerraguntlapalli, Kurnool district, Andhra Pradesh)

In 2017, Yerraguntlapalli village received a total annual rainfall of 717.1 mm against the normal rainfall of 670.5 mm which was excess by 6.9%. During south-west monsoon (June-Sept), 415.9 mm was received against the normal rainfall of 455.10 mm, which was 8.6% less than the normal. During north-east monsoon (Oct-Dec), 202.2 mm rainfall was received against the normal rainfall of 149.6 mm (Fig.4.1).

Normal onset of monsoon	:	7-8 June
Onset of monsoon during 2017-18	:	4 June
Normal annual rainfall	:	670.5 mm
Annual rainfall during 2017-18	:	717.1 mm
Mean crop seasonal rainfall	:	*Kharif*-455.1 mm; *Rabi* -149.6 mm
Crop seasonal rainfall during 2017-18	:	*Kharif*-415.9 mm; *Rabi* -202.2 mm

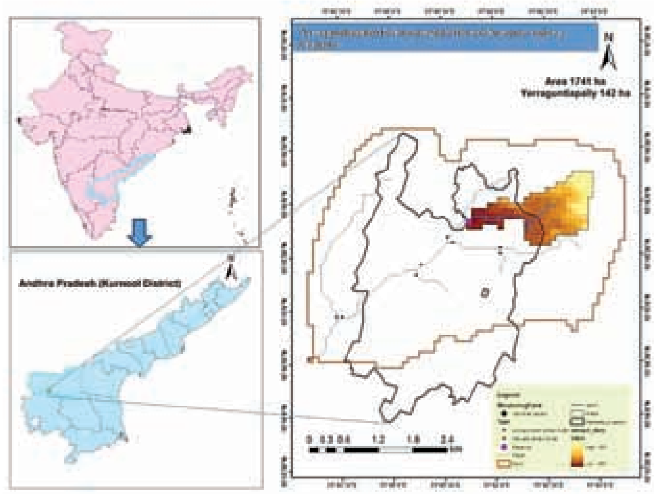


Fig. 4.1: Location map of Yerraguntlapalli village, Kurnool district

4.1.1 Participatory Technology Development

In an assessment of deep tillage with chisel plough for *in-situ* moisture conservation, deep tillage with chisel plough in pigeonpea under rainfed conditions improved seed yield by 12.5% (917 kg/ha) and recorded higher net returns (Rs.30974/ha), B:C ratio (2.87) and RWUE (2.37 kg/ha-mm) compared to farmers' practice (783 kg/ha) (Table 4.3).

Table 4.3 : Yield and economics of pigeonpea as influenced by deep tillage – Ananthapuramu

Treatment	Seed yield (kg/ha)	Mean seed yield (kg/ha) (3 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Deep tillage with chisel plough	917	743	16770	30974	2.87	2.37
T_2: No chisel ploughing (farmers' practice)	783	660	15370	24307	2.58	2.16

Deep tillage with chisel plough

Pigeonpea with deep tillage

Farmers' practice

Similarly, in an assessment of deep tillage with chisel plough for *in-situ* moisture conservation, deep tillage with chisel plough in groundnut under rainfed conditions improved pod yield by 15.2% (1283 kg/ha) and recorded higher net returns (Rs.29557/ha), B:C ratio (1.99) and RWUE (2.36 kg/ha-mm) compared to farmers' practice of no chisel ploughing (1113 kg/ha) (Table 4.4).

Table 4.4 : Yield and economics of groundnut as influenced by deep tillage – Ananthapuramu

Treatment	Pod yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Deep tillage with chisel plough	1283	29850	29557	1.99	2.36
T_2: No chisel ploughing (farmers' practice)	1113	28750	22830	1.79	2.05

Groundnut with improved practice (deep tillage with chisel plough)

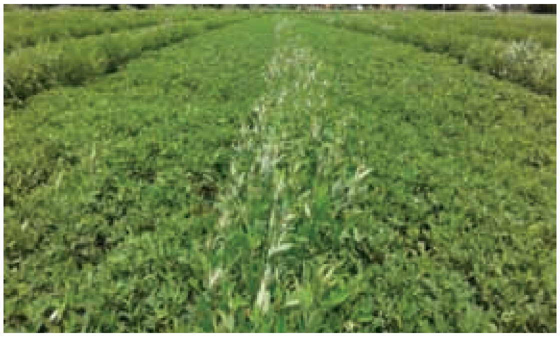
Farmers' practice

In an on-farm evaluation of intercropping systems, pigeonpea equivalent yield was higher with improved practice of groundnut + pigeonpea (15:1) (1109 kg/ha), with higher net returns (Rs.33645/ha) and RWUE (1.56 kg/ha-mm) compared to farmers' practice of pearlmillet + pigeonpea (1:1) (858 kg/ha). However, B:C ratio was higher with pearlmillet + pigeonpea (1:1) intercropping system (2.93) (Table 4.5).

Table 4.5 : Yield and economics of intercropping systems - Ananthapuramu

Treatment	Yield (kg/ha)		Pigeonpea equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter-crop					
T_1: Improved practice (Groundnut + pigeonpea: 15:1)	1250	125	1109	31500	33645	2.07	1.9
T_2: Farmers' practice (Pearlmillet + pigeonpea: 1:1)	650	450	858	16500	31916	2.93	1.47

Pearlmillet + pigeonpea intercropping (1:1)



Groundnut + pigeonpea intercropping (15:1)

In an assessment of integrated nutrient management in groundnut, pod yield was higher with improved practice (50% RDF + 5 t FYM/ha) (1470 kg/ha) with higher net returns (Rs.33460/ha), B:C ratio (1.65) and RWUE (2.47 kg/ha-mm) compared to farmers' practice of application of 125 kg DAP/ha (1356 kg/ha) (Table 4.6).

Table 4.6 : Yield and economics of groundnut under integrated nutrient management - Ananthapuramu

Treatment	Pod yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (3 years)				
T_1: 50% RDF + 5 t FYM/ha	1470	1073	30282	33460	1.65	2.47
T_2: Farmers' practice (125 kg DAP/ha)	1356	992	27730	30068	1.64	2.28

RDF: 20:40:40 kg N, P_2O_5 and K_2O/ha

INM in groundnut

Farmers' practice

In an assessment of sowing of groundnut with bullock drawn Anantha planter, 6% higher pod yield (1260 kg/ha), net returns (Rs.30631/ha), B:C ratio (2.09) and RWUE (2.16 kg/ha-mm) were recorded with improved practice compared to farmers' practice of sowing with local *Gorru* (1179 kg/ha) (Table 4.7).

Table 4.7 : Yield and economics of groundnut as influenced by sowing implements - Ananthapuramu

Treatment	Pod yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Bullock drawn anantha planter (improved practice)	1260	28005	30631	2.09	2.16
T_2: Sowing with local *Gorru* (farmers' practice)	1179	28925	25996	1.94	2.02

Sowing of groundnut with bullock drawn Anantha planter

Farmers' practice (Local Gorru)

4.1.2 Technology Upscaling

In demonstrations on improved varieties of groundnut, Dharani (1377 kg/ha) exhibited its superiority in out yielding K-6 (1265 kg/ha), with higher net returns (Rs.16559/ha), B:C ratio (1.54) and RWUE (2.06 kg/ha-mm) (Table 4.8).

Table 4.8 : Performance of improved variety of groundnut - Ananthapuramu

Variety	Pod yield (kg/ha)	Mean pod yield (kg/ha) (2 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Dharani	1377	975	28848	16559	1.54	2.06
T_1: Farmers' variety (K-6)	1265	892	28346	13188	1.44	1.88

Groundnut cv. Dharani

Groundnut cv. K-6

The results of on farm assessment of soil test based fertilizer application (STBF) in groundnut revealed that the pod yield was higher with soil test based fertilizer application (1243 kg/ha), with higher net returns (Rs. 19016/ha), B:C ratio (1.71) and RWUE (2.22 kg/ha-mm) compared to farmers' practice (897 kg/ha). This was due to reduced cost on fertilizer (Rs 1950/ha) through STBF application and improved pod yield of groundnut (Table 4.9).

Table 4.9 : Yield and economics of groundnut as influenced by soil test based fertilizer (STBF) application - Ananthapuramu

Treatment	Pod yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (2 years)				
T_1: STBF (improved practice)	1243	954	26644	19016	1.71	2.22
T_2: 125 kg DAP/ha (farmers' practice)	1161	897	27730	15167	1.52	2.09

Farmers' practice

Groundnut under improved practice (STBF)

In an assessment of sowing of groundnut with tractor drawn Anantha planter, 9.8% higher pod yield (1377 kg/ha), net returns (Rs.16559/ha), B:C ratio (1.54) and RWUE (2.06 kg/ha-mm) were recorded with improved practice compared to farmers' practice (1265 kg/ha) (Table 4.10).

Table 4.10 : Yield and economics of groundnut as influenced by sowing with tractor drawn Ananta planter - Ananthapuramu

Variety	Pod yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2017	Mean (2 years)				
T_1: Improved practice (Tractor drawn Anantha planter)	1377	975	28848	16559	1.54	2.06
T_2: Farmers' practice (Sowing with local bullock drawn seed drill)	1265	892	28346	13188	1.44	1.88

Sowing of groundnut with tractor drawn Ananta planter

Farmers' practice (Local seed drill)

4.2 Arjia

(Village Newariya, Chittorgarh district, Rajasthan)

During 2017, at Newariya, an annual rainfall of 662.8 mm was received against normal rainfall of 802.9 mm. Onset of monsoon was normal during the season (24th June). The monsoon ceased by 18th September with 39 rainy days. During *kharif,* a rainfall of 651.8 mm was received against normal rainfall of 748.2 mm (Fig. 4.2).

Normal onset of monsoon	:	25th SMW
Onset of monsoon during 2017-18	:	24th June
Normal annual rainfall	:	802.9 mm
Annual rainfall during 2017-18	:	662.8 mm
Mean crop seasonal rainfall	:	*Kharif* : 748.2; *rabi*: 33.7 mm
Crop seasonal rainfall during 2017-18	:	*Kharif*: 651.8 mm; *rabi*: Nil

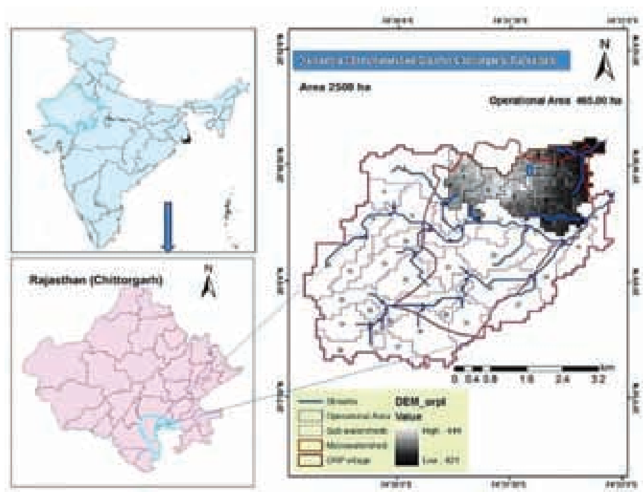


Fig. 4.2: Location map of Newariya village, Chittorgarh district

4.2.1 Participatory Technology Development

The improved moisture conservation practices (peripheral bunding, deep ploughing, tillage and sowing across the slope, soil mulching, ridging at 30DAS) in maize (PEHM-2) gave higher grain yield (2407 kg/ha), net returns (Rs. 23552/ha) and B:C ratio (2.56) compared to farmers' practice (1880 kg/ha, Rs. 16452/ha and 2.14, respectively). Mean data of 3 years indicated that improved moisture conservation practice gave 28.7% higher maize grain yield (1712 kg/ha) over farmers' practice of one deep ploughing + shallow tillage twice with cultivator (Table 4.11).

Table 4.11 : Maize yield and economics under improved *in-situ* moisture conservation - Arjia

Treatment	Grain yield (kg/ha)		Stover yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	2017	Mean (3 yrs)	2017	Mean (3 yrs)			
T_1: Improved practice*	2407	1712	3917	3189	15120	23552	2.56
T_2: Farmers practice	1880	1330	3317	2603	14400	16452	2.14

* Peripheral bunding, deep ploughing, tillage & sowing across slope, soil mulching and ridging at 30 DAS

In an on-farm assessment of foliar spray of potassium nitrate @ 1% in maize, two sprays (25 DAS and 40 DAS) along with application RDF (50:30 kg NP/ha) gave higher grain yield (2287 kg/ha), net returns (Rs. 22165/ha) and B:C ratio (2.54) followed by RDF + water spray (1933 kg/ha, Rs.17648/ha and 2.24) as compared to control (1833 kg/ha, Rs. 15992/ha and 2.16). Mean data of three years indicated that foliar spray of potassium nitrate @ 1% along with application of RDF gave 19.5% higher grain yield (2995 kg/ha) over farmers practice (2506 kg/ha) (Table 4.12).

Table 4.12 : Effect of foliar spray on yield and economics of maize - Arjia

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Grain (2017)	Mean (3 yrs)	Stover (2017)	Mean (3 yrs)			
T_1: RDF + no spray	1833	1332	3117	2506	13800	15992	2.16
T_2: RDF + water spray	1970	1423	3283	2672	14200	17648	2.24
T_3: RDF + KNO_3 (2 sprays @ 1%)	2287	1650	3650	2995	14400	22165	2.54

RDF: 50:30 kg NP/ha

In an on-farm assessment of maize (PEHM-2) + blackgram (PU-31) (2:2) intercropping system, maximum maize grain equivalent yield of 2568 kg/ha, net returns of Rs. 25505/ha and B:C ratio of 2.72 were recorded with maize + blackgram (2:2) intercropping system compared to mixed cropping of maize and blackgram (1546 kg/ha) and sole cropping of maize (1536 kg/ha). Mixed and sole cropping were also found less profitable (net returns of Rs.21137 and 21245/ha) as compared to intercropping system (Table 4.13).

Maize + blackgram (2:2) intercropping system

Table 4.13 : Maize yield and economics under different intercropping systems - Arjia

Treatment	Yield (kg/ha)		Maize equivalent yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Grain	Fodder	Grain (2017)	Mean (3 yrs)	Fodder (2017)	Mean (3 yrs)			
T_1: Maize + blackgram intercropping (2:2)	2347 (48)	3650 (123)	2568	3174	3823	2798	14870	25505	2.72
T_2: Maize + blackgram mixed cropping	2077 (32)	3383 (73)	2222	1546	3486	2398	14240	21137	2.48
T_3: Sole maize	2177	3550	2177	1536	3550	3642	13750	21245	2.55

Figures in parenthesis show yield of intercrop

In an on-farm assessment for suitability of groundnut (TG 37 A) + sesame (RT-351) (6:2) inter-cropping system (6:2), maximum groundnut pod equivalent yield of 764 kg/ha, net returns of Rs.19174/ha and B:C ratio of 2.07 were recorded with groundnut + sesame (6:2) intercropping system. Mixed cropping of groundnut and sesame gave very less groundnut pod equivalent yield of 542 kg/ha, with net returns of Rs. 9303/ha compared to intercropping as well as sole cropping of groundnut (Table). The mean data of three years indicated that intercropping systems viz., maize + blackgram (2:2) and groundnut + sesame (6:2) gave 17 and 39% higher main crop equivalent yield over mixed cropping, respectively (Table 4.14).

Groundnut + sesame (6:2) intercropping system

Table 4.14 : Groundnut equivalent yield and economics under different intercropping systems - Arjia

Treatment	**Yield (kg/ha)**		**Groundnut equivalent yield (kg/ha)**				**Cost of cultivation (Rs/ha)**	**NMR (Rs/ ha)**	**B:C ratio**
	Pod	**Fodder**	**Pod (2017)**	**Mean (3 yrs)**	**Fodder (2017)**	**Mean (3 yrs)**			
T_1: Groundnut + sesame (6:2) intercropping system	697 (32)	1047 (98)	764	603	1066	845	17850	19174	2.07
T_2: Mixed cropping of ground-nut and sesame	500 (20)	850 (55)	542	445	861	679	17250	9303	1.54
T_3: Sole groundnut	-	-	553	436	950	718	16850	10425	1.62

Figures in parenthesis are yield of intercrops

In an on-farm trial on performance of different *kharif* crops, maize performed better at all five locations and gave highest maize grain equivalent yield (2116 kg/ha) followed by sorghum (2033 kg/ha) compared to other crops. However, the highest net returns (Rs. 20873/ha) and B:C ratio (2.60) was recorded with sorghum due to less cost of cultivation followed by maize (Rs.20367/ha and 2.48, respectively) compared to rest of the crops. Mean data of 3 years indicated that maize followed by sorghum and groundnut performed better at farmers' field during normal as well as drought years (Table 4.15).

Table 4.15 : Maize equivalent yield and economics of different kharif crops - Arjia

Treatment	**MGEY (kg/ha)**		**MSEY (kg/ha)**		**Cost of cultivation (Rs/ha)**	**NMR (Rs/ha)**	**B:C ratio**
	2017	**Mean (3yrs)**	**2017**	**Mean (3yrs)**			
T_1:Maize	2116	1456	3490	2670	13750	20367	2.48
T_2:Sorghum	2033	1469	3810	3060	13050	20873	2.60
T_3:Groundnut	2063	1339	960	731	17025	10125	1.59
T_4:Blackgram	926	930	454	438	9950	2295	1.23
T_5:Greengram	939	801	442	395	9700	2669	1.28
T_6:Sesame	808	483	56	53	7550	2280	1.30

MGEY: Maize grain equivalent yield; MSEY: Maize stover equivalent yield

In an on-farm assessment of the effect of zinc application (soil/foliar) on yield and economics of maize (PEHM-2), improved practice (IP), RDF (50 kg N + 30 kg P_2O_5/ha) + 25 kg $ZnSO_4$/ha gave the highest maize yield of 2417 kg/ha, net returns of Rs. 23892/ha and B:C ratio of 2.63 closely followed by improved practice, RDF + spray of $ZnSO_4$ @ 0.5% with grain yield of 2107 kg/ha, net returns of Rs. 19547/ha and B:C ratio of 2.36 compared to farmers' practices (1777 kg/ha). Mean data of three years indicated that improved practice (50 kg N + 30 kg P_2O_5/ha) + soil application of 25 kg $ZnSO_4$/ha performed better and gave 30% higher yield (1698 kg/ha) over farmers' practice (1306 kg/ha) (Table 4.16).

Table 4.16 : Yield and economics of maize with zinc application - Arjia

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Grain (2017)	Mean (3 yrs)	Stover (2017)	Mean (3 yrs)			
T_1: Farmers' practice	1777	1306	2933	2456	13450	15203	2.13
T_2: IP(RDF) + 25 kg $ZnSO_4$/ha	2417	1698	3817	2928	14650	23892	2.63
T_3: IP (RDF) + spray of $ZnSO_4$ @ 0.5%	2107	1573	3467	2800	14400	19547	2.36

RDF: 50:30 kg NP/ha

In an on-farm assessment, sulphur application @ 120 kg/ha (gypsum) in groundnut (TG 37A) + sesame (RT-351) (6:2) intercropping system gave higher net returns of Rs. 18351/ha and B:C ratio of 2.03 from groundnut pod equivalent yield of 744 kg/ha as compared to farmers' practices (521 kg/ha,. Mean data of 3 years also indicated that sulphur application @ 120 kg/ha (gypsum) gave 44.7% higher groundnut pod equivalent yield (605 kg/ha) over farmers' practice of no sulphur application (418 kg/ha) (Table 4.17).

Table 4.17 : Groundnut equivalent yield and economics of groundnut + sesame (6:2) intercropping with sulphur application - Arjia

Treatment	Yield (kg/ha)		Groundnut equivalent yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Pod/ seed	Haulm	Pod (2017)	Mean (3 yrs)	Haulm (2017)	Mean (3yrs)			
T_1- Sulphur @ 120 kg /ha (gypsum)	650 (47)	1060 (113)	744	605	1083	892	17850	18351	2.03
T_2- Control	467 (27)	783 (78)	521	418	799	683	17050	8373	1.49

Figures in parenthesis are yield of intercrop

In an on-farm evaluation of maize cultivars, improved variety PEHM-2 gave higher grain yield of 2338 kg/ha, net returns of Rs. 23193/ha and B:C ratio of 2.66 while local variety gave grain yield of 1595 kg/ha with net returns of Rs. 12841/ha. Further, mean data of two years indicated that variety PEHM-2 performed better and gave 32% higher yield over local variety (Table). Among horsegram varieties, improved cultivar AK-42 gave higher seed yield of 390 kg/ha, net returns of Rs. 4717/ha and B:C ratio of 1.51 while local variety gave lowest seed yield of 183 kg/ha with negative net returns of Rs. 1986/ha . Mean data of three years indicated that variety AK-42 gave124% higher yield (354 kg/ha) over local variety (158 kg/ha).

In an on-farm evaluation of sorghum cultivars, CSV 15 gave higher grain yield of 2343 kg/ha, net returns of Rs. 23485/ha and B:C ratio of 2.75 while local variety gave grain yield of 1867 kg/ha with net returns of Rs. 16708/ha. Mean data of two years indicated that variety CSV 15 gave 37.3% higher grain yield (1742 kg/ha) over local variety (1269 kg/ha) (Table). Among groundnut cultivars, TG 37 A gave higher pod yield of 680 kg/ha, net returns of Rs. 15837/ha and B:C ratio of 1.92 while local variety gave pod yield of 412 kg/ha, net returns of Rs. 3667/ha and B:C ratio of 1.22. Mean data of three years indicated that variety TG 37A gave 72.8% higher pod yield over the local variety (331 kg/ha). Among sesame cultivars, RT

Improved variety of sorghum (CSV-15)

Performance of horsegram variety (AK-42)

Performance of sesame variety (RT-351)

351 gave higher seed yield of 118 kg/ha, net returns of Rs. 2068/ha and B:C ratio of 1.22 while local variety gave a yield of 75 kg/ha with negative net returns of Rs. 1705/ha. Mean data of two years study also indicated that RT 351 gave 55% higher seed yield over local variety (69 kg/ha) (Table 4.18).

Table 4.18 : Yield and economics of varieties of different crops - Arjia

Crop	Variety	Yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
		Grain/seed	Mean	Stalk/ fodder	Mean			
Maize	PHM-3	2040	2040	3280	3280	13970	18710	2.34
	PHEM-2	2338	2192	3645	3610	13970	23193	2.66
	Local	1595	1660	2793	2671	13280	12841	1.97
Horsegram	AK-21	320	259	575	451	9270	2728	1.29
	AK-42	390	354	447	321	9270	4717	1.51
	Local	183	158	217	212	8550	-1986	0.77
Sorghum	CSV-15	2343	1742	4463	3982	13450	23485	2.75
	Local	1867	1269	3400	2875	12325	16708	2.36
Groundnut	TG 37 A	680	572	1007	1027	17280	15837	1.92
	PM-1	560	560	900	900	17280	10170	1.59
	Local	412	331	677	670	16550	3667	1.22
Sesame	RT-351	118	107	353	288	9350	2068	1.22
	Local	75	69	240	217	8950	-1705	0.81

In an on-farm assessment of improved implements at 5 locations, the field capacity of the Arjia wheel hoe was found to be 7.0 man-day/ha as compared to *kudali*, the farmers' practice (22.8 man-days/ha). The increase in efficiency due to wheel hoe was 125% more as compared to *Kudali* (farmers' practice). Mean data of two years also showed similar trend.

4.2.2 Technology Upscaling

In 5 demonstrations at 3 locations, *in-situ* moisture conservation practices (peripheral bunding, deep ploughing, tillage and sowing operation against the slope and ridging 30 days after sowing in maize (PHEM-2) gave the higher maize grain yield (2487 kg/ha) with higher net returns (Rs. 23765/ha) and B:C ratio (2.59) as compared to farmers' practice of one deep ploughing + shallow tillage twice with cultivator (1830 kg/ha) (Table). In a demonstration of improved sesame variety RT 351, average yield of sesame was 165 kg/ha compared to local variety (farmers' practice) (96 kg/ha). Mean yield of 3 years indicated that sesame seed yield with RT351 was 110 kg/ha compared to local varieties (71 kg/ha). Improved sorghum variety (CSV-15) gave higher mean grain yield of 2270 kg/ha, net returns of Rs.22040/ha with B:C ratio of 2.66 compared to farmers' practice (local variety) (1808 kg/ha and net returns of Rs. 15488/ha). Mean yield of 3 years indicated that sorghum grain yield increased by 25% (1588 kg/ha) with var. CSV-15 over farmers' method (1269 kg/ha).

In an on-farm demonstration at 4 locations, improved blackgram variety (PU-31) gave higher seed yield of 170 kg/ha, net returns of Rs.540/ha with B:C ratio of 1.05 compared to farmers' practice (local variety) with less seed yield (76 kg/ha) and negative net returns of Rs. 4758/ha. Mean data of 3 years revealed that average yield of blackgram (513 kg/ha) improved by 62.5% with improved var. PU-31 over farmers' method (333 kg/ha). The yield levels were very low during 2015 due to late onset of monsoon and early withdrawal and in year 2017 due to yellow vein mosaic virus. Improved greengram variety (SML-668) gave higher seed yield (273 kg/ha), net returns of Rs.5047/ha and B:C ratio of 1.49 compared to farmers' practice of local variety (120 kg/ha with negative net returns of Rs. 2840/ha). Mean seed yield of greengram over 3 years (247 kg/ha) was increased by 47.9% over farmers' method. The yield levels were very low during 2015 due to late onset of monsoon and early withdrawal and in year 2017 due to continuous rainfall (Table 4.19).

Table 4.19 : Yield and economics of different crops under improved technologies - Arjia

Crop	Yield (kg/ha)						Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio	
	Improved practice (IP)			Farmers' practice (FP)								
	Seed	Mean	Straw	Seed	Mean	Straw	IP	FP	IP	FP	IP	FP
Maize	2487	2339	3550	1830	1794	2900	14950	13810	23765	15400	2.59	2.12
	2246	1572	3410	1796	1251	2950	14280	13840	21197	15087	2.48	2.09
Sesame	165	110	440	96	71	300	9275	8945	6620	349	1.71	1.04
Sorghum	2270	1588	4140	1808	1269	3100	13280	12150	22040	15488	2.66	2.27
Blackgram	170	247	360	76	152	193	10070	9625	540	-4758	1.05	0.51
Greengram	273	247	567	120	167	277	10320	9670	5047	-2840	1.49	0.71

Improved variety of sorghum (CSV-15)

Performance of maize variety (PEHM-2)

4.3 Ballowal Saunkhri

(Village Behdarya-Kothi, Hoshairpur district, Punjab)

In ORP village Behdarya-Kothi, the onset of monsoon was normal (28th June). The annual rainfall was 1048.7 mm, which was 2.99% deficit over the mean normal rainfall (1081 mm). During *kharif* and *rabi*, the rainfall was deficit by 17.5% and 37.5%, respectively to that of normal rainfall. A dry spell of 12 days (10th–21st September, 2017) was experienced at dough stage in maize. Further, a long dry spell of 78 days during *rabi* from 24th September to 10th December occurred which affected wheat emergence and all the crop growth stages of *rabi* crops (Fig. 4.3).

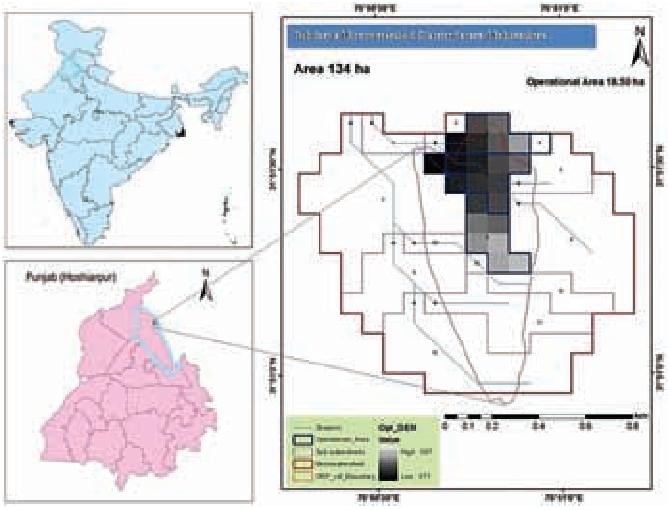


Fig. 4.3: Location map of Behdarya-Kothi village, Hoshiarpur district

Normal onset of monsoon	:	1st July
Onset of monsoon during 2017-18	:	28th June
Actual annual rainfall during 2017-18	:	1048.7 mm
Normal crop seasonal rainfall	:	*kharif*: 895.9 mm; *rabi* 184.8 mm
Actual crop seasonal rainfall during 2017-18	:	*kharif*: 738.7 mm; *rabi*: 115.5 mm

4.3.1 Participatory Technology Development

In an assessment of vegetative barriers in maize (PMH1), Napier bajra hybrid planted on the field bunds to conserve the soil moisture during the rainy season gave 11.7% higher grain yield (2940 kg/ha) over no vegetative barriers (2630 kg/ha) (Table). The net returns (Rs. 20067/ha), B:C ratio (1.60) and RWUE (5.8 kg/ha-mm) was also higher with planting of napier bajra hybrid cuttings on bunds over farmers' practice of no vegetative barrier (Rs. 14640/ha, 1.44 and 5.2 kg/ha-mm, respectively) (Table 4.20).

Table 4.20 : Effect of vegetative barriers on yield and economics of maize (PMH1) - Ballowal Saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: Vegetative barrier	2940	6439	33691	20067	1.60	5.80
T_2: No vegetative barrier	2630	5760	33450	14640	1.44	5.20

In an assessment of contingency measures to mitigate the effect of dry spell in maize, foliar spray of potassium nitrate (KNO_3) @ 2% during dry spell significantly increased the maize grain yield (3370 kg/ha) compared to reduction in plant population by 10% (3120 kg/ha) and control (2920 kg/ha). Foliar spray also gave higher net returns (Rs. 30653/ha) and B:C ratio (1.98) than control (Table 4.21).

Table 4.21 : Effect of different drought management practices on yield and economics of maize (PMH1) - Ballowal Saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Grain	Stover				
T_1: Control	2920	6570	28835	22677	1.79	5.76
T_2: KNO_3 spray @ 2%	3370	7583	31271	30653	1.98	6.65
T_3: Reduction in plant population by 10%	3120	7020	28990	28340	1.98	6.16

In wheat, foliar spray of thiourea (1000 ppm) during the dry spell at flowering stage recorded 20% increase in yield (2960 kg/ha) with higher net returns (Rs. 31815/ha) and B:C ratio (2.15) compared to no spray (2475 kg/ha, net returns of Rs. 26885/ha and B:C ratio of 2.02 (Table 4.22).

Table 4.22 : Effect of foliar spray on yield and economics of wheat (PBW-660) - Ballowal Saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw				
T_1: Control	2475	5560	26404	26885	2.02	18.61
T_2: Thiourea spray (1000 ppm)	2960	6420	27737	31815	2.15	22.26

In an assessment of raya (RLC-3) intercropping at row distance of 3 m in wheat (PBW 660) and sowing of raya on boundary of wheat field, the maximum wheat equivalent yield (WEY) of 3363 kg/ha was recorded with sowing of raya on the boundary of wheat field followed by wheat + raya intercropping (12:1) (3358 kg/ha) which resulted in 37% higher yield compared to sole wheat. The net returns of wheat + raya on boundary was Rs. 39388/ha with B:C ratio 2.42 (Table 4.23).

Table 4.23 : Yield and economics of wheat and raya intercropping - Ballowal Saunkhri

Crop	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain /seed	WEY				
T_1: Sole wheat	2850	2450	26898	34890	2.30	18.3
T_2: Wheat + raya (12:1)	2450+350	3358	27449	37931	2.38	25.1
T_3: Wheat + raya (boundary)	2650+275	3363	27689	39388	2.42	25.2

WEY: Wheat equivalent yield

In an evaluation of integrated nutrient management in maize, maximum grain yield of 3685 kg/ha was recorded with application of N through 75% inorganic + 25% organic source, which was 4, 8 and 13% higher over 100% inorganic N, 50% inorganic + 50% organic N and 100% organic N, respectively. The net returns (Rs. 37866/ha), B:C ratio (2.28) and RWUE (7.27 kg/ha-mm) was higher with application of 75% inorganic + 25% organic N source while the B:C ratio was considerably lower in organic source of N due to more application cost of FYM (Table 4.24).

Table 4.24 : Effect of different integrated nutrient management on yield and economics of maize (PMH2) - Ballowal Saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: 100% inorganic	3553	7784	27600	37371	2.35	7.01
T_2: 50% organic + 50% inorganic N	3420	7499	31149	31399	2.01	6.75
T_3: 75% inorganic + 25% organic N	3685	8080	29529	37866	2.28	7.27
T_4: 100 % organic	3252	7130	34672	24803	1.72	6.42

100% N: 80 kg/ha

In an assessment of seed soaking with molybdenum along with *Rhizobium* treatment, the maximum yield of chickpea (950 kg/ha) with higher net returns (26313 kg/ha), B:C ratio (2.24) and RWUE (7.11 kg/ha-mm) was recorded with seed soaking in molybdenum (500 ppm) + *Rhizobium* inoculation followed by seed soaking with molybdenum (500 ppm) (900 kg/ha, Rs.23813/ha, 2.12 and 6.73 kg/ha-mm, respectively) and compared to control (830 kg/ha) (Table 4.25).

Table 4.25 : Effect of seed soaking on yield and economics of chickpea - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg /ha- mm)
T_1: Control	830	20783	20717	2.00	6.21
T_2: Seed soaking with molybdenum (500 ppm)	900	21187	23813	2.12	6.73
T_3: Seed soaking with molybdenum (500 ppm) + *Rhizobium* inoculation	950	21187	26313	2.24	7.11

4.3.2 Technology Upscaling

In a demonstration of different maize hybrids, PMH1 gave maximum grain yield of 3744 kg/ha with net returns of Rs. 38185/ha and B:C ratio of 2.22 followed by PMH 2 with grain yield of 3458 kg/ha, net returns of Rs. 33109 and B:C ratio of 2.07 compared to local variety (3056 kg/ha) (Table 4.26).

Table 4.26 : Performance of maize hybrids under rainfed condition - Ballowal Saunkhri

Cultivar	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: PMH2	3458	30950	33109	2.07	6.83
T_2: PMH1	3744	31173	38185	2.22	7.39
T_3: Local	3056	29081	26798	1.92	6.03

In a demonstration of sesame cultivars, Pb Til No 2 recorded highest seed yield of 420 kg/ha with net returns of Rs 23137/ha and B:C ratio of 2.23 which was 16% higher over the RT 346 (390 kg/ha) with net returns of Rs.20137/ha and B:C ratio of 2.07 (Table 4.27).

Table 4.27 : Performance of sesame cultivars under rainfed condition - Ballowal Saunkhri

Variety	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Pb Til No.2	420	18863	23137	2.23	8.48
T_2: RT 346	390	18863	20137	2.07	7.88

In a demonstration of pearlmillet cultivar for fodder, FBC-16 recorded higher green fodder yield of 29667 kg/ha which was 46% higher over the local cultivar (20333 kg/ha). Further, FBC-16 cultivar proved superior with higher net returns and B:C ratio of Rs 18513/ha and 2.66, respectively (Table 4.28).

Table 4.28 : Performance of pearlmillet cultivar under rainfed condition - Ballowal Saunkhri

Cultivar	Fodder yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: FBC 16	29667	11154	18513	2.66	58.56
T_2: Local cultivar	20333	10524	9809	1.93	40.14

Among different wheat cultivars demonstrated, PBW U 550 gave maximum net returns of Rs.41729/ha and B:C ratio of 2.41 from a grain yield of 3529 kg/ha followed by PBW 725 with net returns of Rs.39316/ha and B:C ratio of 2.38 from grain yield of 3460 kg/ha compared to local variety (2475 kg/ha) (Table 4.29).

Table 4.29 : Varietal performance of wheat under rainfed condition - Ballowal Saunkhri

Variety	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: PBW 725	3460	28561	39316	2.38	25.9
T_2: HD 3086	3316	28387	38476	2.36	24.8
T_3: PBW 677	3090	28115	36161	2.29	23.1
T_4: PBW U 550	3529	29681	41729	2.41	26.4
T_5: PBW -Zn	3185	29267	36553	2.25	23.8
T_6: Local	2475	26337	24535	1.93	18.5

Among raya genotypes demonstrated under rainfed conditions, RLC 3 gave maximum seed yield of 880 kg/ha with net returns of Rs. 10706/ha, RWUE of 6.58 kg/ha-mm and B:C ratio of 1.54 followed by PBR 357 with seed yield 820, net returns of Rs.9426/ha and B:C ratio 1.48, which was 29 and 21% higher than the local raya cultivar (Table 4.30).

Table 4.30 : Yield and economics of raya cultivars - Ballowal Saunkhri

Variety	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Local	680	17675	7575	1.43	5.09
T_2: RLC3	880	19674	10706	1.54	6.58
T_3: PBR 357	820	19674	9426	1.48	6.13

Among gobhi sarson varieties under rainfed conditions, variety, GSC 7 gave higher seed yield of 1050 kg/ha with net returns of Rs. 21477/ha and B:C ratio of 2.05 compared to GSC 6 with seed yield of 980 kg/ha, net returns of Rs. 18677/ha and B:C ratio of 1.91 (Table 4.31).

Table 4.31 : Yield and economics of gobhi sarson cultivars - Ballowal Saunkhri

Variety	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: GSC 7	1050	20523	21477	2.05	7.86
T_2: GSC 6	980	20523	18677	1.91	7.34

In a demonstration of wheat cultivars (HD 3086, PBW 677) under supplemental irrigation at two critical growth stages (crown root initiation and flowering stage), supplemental irrigations (CRI and flowering stage) recorded highest grain yield of 3485 kg/ha which was 25 and 9% higher over the rainfed wheat (2820kg/ha) and irrigation at CRI stage (3260 kg/ha), respectively with higher net returns (Rs.34610/ha) and B:C ratio (2.63) (Table 4.32).

Table 4.32 : Yield and economics of wheat with supplemental irrigation at different crop stages - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
T_1: Two irrigations (CRI & flowering)	3485	21260	34610	2.63	12.3
T_2: One irrigation (CRI)	3260	20808	27208	2.31	15.6
T_3: No irrigation	2820	20264	17826	1.88	21.1

Depth of irrigation water: 75 mm per irrigation

During *kharif*, in maize demonstration, the improved practices gave higher net returns of Rs. 39388/ha and B:C ratio of 2.25 from grain yield of 3880 kg/ha compared to farmers' practice (3025 kg/ha). In blackgram, improved practice gave higher seed yield of 820 kg/ha, net returns of Rs. 14945/ha and B:C ratio of 1.62 compared to the farmers' practice (525 kg/ha). In sesame, improved practice gave higher seed yield of 436 kg/ha, net income of Rs. 20377/ha and B:C ratio of 2.84 compared to farmers' practice (260 kg/ha). In pearlmillet, improved practice gave higher green fodder yield of 22583 kg/ha, net returns of Rs. 19070/ha and B:C ratio of 2.29 compared to farmers' practices with lowest green fodder yield of 18729 kg/ha. During *Kharif* season, adoption of improved practices gave 16, 53, and 32% higher grain/fodder yield over the farmer practice in maize, sesame and pearlmillet fodder, respectively (Table 4.33).

Table 4.33 : Performance of improved practices of different crops under rainfed conditions - Ballowal Saunkhri

Crop	Treatment	Grain/Seed/fodder yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Maize (PMH1)	IP	3880	31558	39388	2.25	7.66
	FP	3025	28326	26986	1.95	5.97
Blackgram	IP	820	23989	14945	1.62	1.62
	FP	525	23151	1776	1.08	1.04
Sesame (Pb Til no.2)	IP	436	18863	20377	2.08	0.86
	FP	260	16774	6626	1.40	0.51
Pearlmillet (fodder) (FBC16)	IP	22583	14804	19070	2.29	44.58
	FP	18729	14612	13482	1.92	36.97

IP: Improved practice; FP: Farmers' practice

During *rabi* season, in wheat demonstration, improved practice gave higher net returns of Rs. 41607/ha and B:C ratio (2.65) from grain yield of 3080 kg/ha compared to farmers' practice (2085 kg/ha). In raya, improved practice gave higher net returns of Rs. 22160/ha and B:C ratio (2.12) from seed yield of 1050 kg/ha compared to farmers' practice (680 kg/ha). In gobhi-sarson, improved practice gave higher net returns of Rs. 12277/ha and B:C ratio (1.60) from seed yield of 865 kg/ha while farmers' practice gave net returns of Rs. 4031/ha from seed yield of 550 kg/ha . In case of taramira, improved practice gave higher seed yield of 560 kg/ha, net returns of Rs. 7222/ha and B:C ratio of 1.57 while the farmers' practice gave less yield (370 kg/ha). In *rabi* crops, improved practices in wheat, raya, gobhi sarson, taramira and linseed resulted in 47, 54, 49 and 21% higher grain/seed yield than farmers' practice (Table 4.34).

Table 4.34 : Performance of improved practices of different crops – Ballowal Saunkhri

Crop	Treatment	Grain/seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
Wheat (HD 3086)	IP	3080	25167	41607	2.65	23.0
	FP	2085	20974	24229	2.16	15.6
Raya (RLC 3)	IP	1050	19840	22160	2.12	7.9
	FP	680	17079	10121	1.59	5.1
Gobhi Sarson (GSC 6)	IP	820	20523	12277	1.60	6.1
	FP	550	17969	4031	1.22	4.1
Taramira (TMLC 2)	IP	568	12658	7222	1.57	4.2
	FP	370	12295	655	1.05	2.8

IP: Improved practice; FP: Farmers practice

In wild animal damage prone area, damage by wild and stray animals was more in maize crop than the sesame crop. Maize (PMH1) gave grain yield of 1150 kg/ha with negative net returns of Rs.6345/ha and B:C ratio of 0.77 while sesame (PBTil no.2) gave seed yield of 285 kg/ha with net return of Rs. 4878/ha and B:C ratio of 1.21 (Table 4.35).

Table 4.35 : Performance of sesame and maize in wild animal damage prone area - Ballowal Saunkhri

Crop	Grain/seed yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Sesame	285	0.56	23622	4,878	1.21
Maize	1150	2.27	27476	-6,345	0.77

Similarly, during *rabi,* wild and stray animals damage to wheat crop was much higher than the taramira crop. In these areas, taramira crop gave higher net returns (Rs.4836/ha) and B:C ratio of 1.38 while the net returns in wheat were only Rs 2151/ha. Moreover, the cost of cultivation in wheat was about two times higher than taramira which led to higher level of risk (Table 4.36).

Table 4.36 : Performance of wheat and taramira in wild animal damage prone area - Ballowal Saunkhri

Crop	Grain/ seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)
Wheat (PBW 660)	1020	24639	2151	1.09	7.6
Taramira (TMLC 2)	425	10804	4071	1.38	3.2

4.4 Bengaluru

(Villages Baichenahalli and Iraksandra, Tumkur district, Karnataka)

During 2017, in Baichenahalli and Iraksandra villages, onset of monsoon was delayed by 14 days (16th June) and total rainfall received was 824.8 mm which was excess by 13% (95 mm) as against normal rainfall of 729.8 mm. The rainfall received in *kharif* (June–September) was 571.9 mm and 280.8 mm for *rabi* crops. There were five dry spells: 10 days during 22-30 June, 31 days during 1-31 July, 10 days during 1-10 August, 16 days during 16-31 October and 54 days from 8 November to 31 December. Critical stages of plant growth such as the grand growth stage, flowering stage and grain filling to maturity stages of most of the crops coincided with dry spells with lower moisture content while maturity phase i.e. from November to December was totally dry resulting in poor yield (Fig. 4.4) .

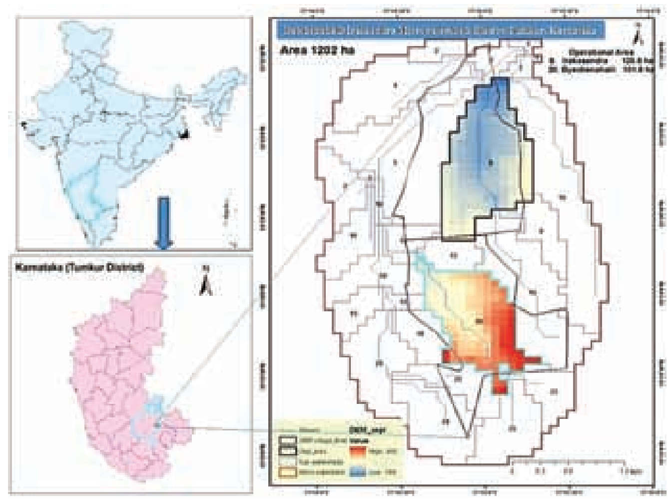


Fig. 4.4: Location map of Baichenahalli and Irakasandra villages, Tumkur district

Normal onset of monsoon	:	2nd June
Onset of monsoon during 2017-18	:	16th June
Normal annual rainfall	:	729.8 mm
Annual rainfall during 2017-18	:	824.8 mm
Mean crop seasonal rainfall	:	*kharif*: 332.35 mm; *rabi*: 311.35 mm
Crop seasonal rainfall during 2017-18	:	*kharif*: 571.9 mm; *rabi*: 280.80 mm

4.4.1 Participatory Technology Development

In an assessment of integrated nutrient management (INM) in fingermillet + pigeonpea (8:2) intercropping system, application of 50% N through organic source + 50% N and 100% PK through inorganic + 12.5 kg zinc sulphate/ha + 10 kg borax/ha recorded higher fingermillet grain equivalent yield (2253 kg/ha), net returns (Rs. 10441/ha), B:C ratio (1.30) and RWUE of 3.02 kg/ha-mm followed by RDF alone (2057 kg/ha, Rs.8837/ha, 1.27 and 2.76 kg/ha-mm, respectively) compared to farmers' practice of fingermillet + *akkadi* (1808 kg/ha) (Table 4.37).

Table 4.37 : Yield and economics of fingermillet + pigeonpea intercropping system (8:2) under integrated nutrient management - Bengaluru

Treatment	Yield (kg/ha)				COC (Rs/ ha)	NMR (Rs/ ha)	B:C ratio	RWUE (kg/ha-mm)
	FM grain	Stover	Pigeonpea	FME				
T_1: RDF (50: 40: 37.5 kg N, P_2O_5 and K_2O/ ha)	1256	4826	356	2057	32303	8837	1.27	2.76
T_2: 50% N through FYM +50% N and 100% PK through inorganic source + $ZnSO_4$ (12.5 kg/ha) + borax 10 kg/ha + bio-fertilizer	1322	4958	414	2253	34629	10441	1.30	3.02
T_3: Farmers' practice (DAP and urea with fingermillet + *akkadi* crops)	1120	3956	306	1808	33394	2776	1.08	2.42

Note: FM: fingermillet; FME: fingermillet equivalent yield

50% N through FYM + 50% N and 100% PK through inorganic source + micronutrients based on soil test + biofertilizer

Farmers' practice

In an evaluation of improved fingermillet varieties, medium duration variety GPU-28 recorded higher grain yield (2225 kg/ha), net returns (Rs.3656/ha), B:C ratio (1.14) and RWUE (1.65 kg/ha-mm) compared to all other improved varieties while local variety recorded lowest yield (1522 kg/ha), negative net returns (Rs. 2854/ha), B:C ratio (0.88) and RWUE (1.24 kg/ha-mm) (Table 4.38).

Table 4.38 : Yield and economics of different fingermillet varieties - Bengaluru

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw				
T_1: MR-1	2113	4232	25856	1639	1.06	1.49
T_2: GPU-28	2225	4158		3656	1.14	1.65
T_3: GPU-48	2125	3867		1319	1.05	1.51
Local Variety	1522	3656		-2854	0.88	1.24

In an assessment of pigeonpea + fieldbean intercropping system (1:1), among the four varieties of pigeonpea, BRG-2 + fieldbean (1:1) recorded higher pigeonpea equivalent yield (1054 kg/ha), net returns (Rs. 22992/ha), B:C ratio (1.72) and RWUE of 1.35 kg/ha-mm followed by BRG-1 + fieldbean (999 kg/ha, Rs.20120/ha, 1.28 and 1.28 kg/ha-mm, respectively) and BRG-4 + fieldbean recorded the lowest PEY (675 kg/ha) (Table 4.39).

Table 4.39 : Yield and economics of pulse based intercropping systems - Bengaluru

Treatment	Seed yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pigeonpea	Field bean	PEY				
T_1: BRG-1 + field bean	856	186	999	31832	20120	1.63	1.28
T_2: BRG-2 + field bean	902	198	1054		22992	1.72	1.35
T_3: BRG-4 + field bean	675	169	805		10028	1.32	1.03
T_4: BRG-5 + field bean	844	170	975		18856	1.59	1.25

PEY: Pigeonpea grain equivalent yield

In an assessment of different varieties of groundnut, GKVK-5 recorded higher pod yield (1324 kg/ha), net returns (Rs. 19709/ha) and B:C ratio (1.56) followed by ICGV-91114 (1156 kg/ha) and KCG-6 (1027 kg/ha) and the lowest pod yield (864 kg/ha) and B:C ratio (1.02) was recorded with farmers variety, TMV-2 (Table 4.40).

Table 4.40 : Yield and economics of different groundnut varieties - Bengaluru

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Haulm				
T_1: GKVK-5	1324	1682	34933	19709	1.56	1.75
T_2: KCG-6	1027	1007		7154	1.20	1.35
T_3: ICGV 91114	1156	1412		12719	1.36	1.52
T_4: TMV-2	864	1029		656	1.02	1.14

4.4.2 Technology Upscaling

Opening of *in-situ* moisture conservation furrow between paired rows of pigeonpea in fingermillet + pigeonpea intercropping system (8:2) recorded higher fingermillet grain equivalent yield (2150 kg/ha), net returns (Rs.15169/ha) and B:C ratio (1.54) compared to farmers' practice (Table 4.41).

Table 4.41 : Yield and economics of fingermillet + pigeonpea (8:2) intercropping system as influenced by in-situ moisture conservation – Bengaluru

Treatment	Fingermillet yield (kg/ha)		Intercrop yield (kg/ha)	FMEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw						
T_1: Fingermillet (MR-1) + pigeonpea (BRG-2) (8:2) with moisture conservation furrow	1117	4469	459	2150	27831	15169	1.54	3.16
T_2: Farmers' practice (Fingermillet + *Akkadi* crop)	1066	3861	PP: 35 Castor: 22 Sorghum: 24 FB: 17 Sesame: 19 Cowpea: 24	1342	29026	2268	1.07	1.97

FMEY: Fingermillet equivalent yield

Fingermillet + pigeonpea (8:2) with conversation furrow

Akkadi (Farmers' practice)

Similarly, Groundnut (GKVK-5) + pigeonpea (BRG-2) intercropping system (8:2) with moisture conservation furrow between paired rows of pigeonpea recorded higher groundnut equivalent yield of 1501 kg/ha with B:C ratio of 1.58 compared to farmers' practice with lowest GNEY (933 kg/ha) and B:C ratio (0.96), (Table 4.42).

Table 4.42 : Effect of *in-situ* moisture conservation on yield and economics of groundnut based production systems -Bengaluru

Treatment	Yield (kg/ha)		GNEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop					
T_1: Groundnut + pigeonpea (8:2) with conservation furrow	1013	434	1501	37883	22167	1.58	1.97
T_2: Groundnut + *Akkadi* (mixed cropping)	792	Pigeonpea-38 Castor-23 Sorghum-22 Fieldbean-19 Sesame-21	933	39777	-1441	0.96	1.23

GNEY: Groundnut pod equivalent yield

Groundnut + pigeonpea (8:2) with conservation furrow

Groundnut + Akkadi (Farmers' practice)

Pigeonpea + fieldbean intercropping system (1 :1) resulted in higher pigeonpea equivalent yield (882 kg/ha), net returns (Rs.7848/ha) and B:C ratio (1.24) compared to sole crop of pigeonpea with lower MCEY (705 kg/ha), net returns (Rs.5933/ha) and B:C ratio (1.20) and field bean (216 kg/ ha, Rs.-18703/ha and 0.34, respectively) (Table 4.43).

Table 4.43 : Yield and economics of pigeonpea + fieldbean (1:1) intercropping system - Bengaluru

Treatment	Yield (kg/ha)		MCEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop					
T_1: Pigeonpea (BRG-1) + field bean (HA-4) (1:1)	727	199	882	31832	7848	1.24	1.12
T_2: Pigeonpea sole (BRG-1)	705	-	705	28942	5933	1.20	0.99
T_3: Field bean sole (HA-4)	-	278	216	28433	-18703	0.34	0.27

MCEY: Main crop equivalent yield (pigeonpea)

Pigeonpea + field bean (1:1)

Sole pigeonpea (Farmers' practice)

In an assessment of weed management in groundnut (GKVK-5) + pigeonpea (BRG-2) intercropping system (8:2), application of alachlor (2.5 l/ha) along with one hand weeding resulted in effective suppression of weeds and gave higher groundnut pod equivalent yield of 1350 kg/ha, net returns (Rs. 21147/ha) and B:C ratio (1.64) compared to farmers' practice of manual weeding with lowest yield (1028 kg/ha), net returns (Rs. 6182/ha) and B:C ratio (1.17) (Table 4.44).

Table 4.44 : Effect of weed management on yield and economics of groundnut + pigeonpea intercropping system - Bengaluru

Treatment	Yield (kg/ha)		GEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	GN	PP					
T_1: Herbicide application (Alachlor) +1 hand weeding	895	404	1350	32833	21147	1.64	1.78
T_2: Farmers' practice (manual weeding)	696	295	1028	34933	6182	1.17	1.36

GN: Groundnut PP: Pigeonpea

Herbicide application (Alachlor) + 1 hand weeding

Farmers' practice

In an assessment of intercropping system, pigeonpea + maize (1:1) recorded higher maize equivalent yield (1893 kg/ha), net returns (Rs. 1330/ha) and B:C ratio (1.04) compared to sole maize alone with negative returns (Rs. -8306/ha). However there was a decrease in yield of maize and pigeonpea due to aberrant weather condition during crop growth period (Table 4.45).

Table 4.45 : Yield and economics of maize + pigeonpea (1:1) cropping system - Bengaluru

Treatment	Yield (kg/ha)		MCEY (kg/ha)	Cost of cultivation (Rs ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop					
T_1: Maize + pigeonpea (BRG-2) (1:1)	825	427	1893	32735	1330	1.04	2.49
T_2: Sole maize (Hema)	1131	-	1131	28664	-8306	0.71	1.49

Maize + pigeonpea (1:1)

Sole maize

In an evaluation of tamarind and mango based agri-horti system, intercropping of tamarind + fingermillet and mango + fingermillet recorded higher tamarind and mango equivalent yield of 1223 and 1312 kg/ha, respectively as compared to tamarind (667 kg/ha) and mango (125 kg/ha) as sole crops. Similar was the trend with respect to net returns and B:C ratio (Table 4.46).

Tamarind + fingermillet agri-horti system

Table 4.46 : Performance of agri-horti systems - Bengaluru

Treatment	Yield (kg/ha)	Finger millet yield (kg/ha)	TEY (kg/ha)	MEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Tamarind/mango						
T_1:Tamarind + fingermillet	612	1928	1223	-	18810	54542	3.90
T_2:Tamarind sole (local)	667	-	667	-	13167	26853	3.04
T_3: Mango + fingermillet	105	2012	-	1312	20898	18468	1.88
T_4:Mango (Badami and Rasapuri)	125	-	-	125	14628	-10878	0.26

4.5 Hisar (ORP)

(Village Chappar Jogian, Bhiwani district, Haryana)

In Chappar Jogiyan village, during 2017, the onset of monsoon was normal (28th June). A total rainfall of 406.8 mm was received which was excess by 16.2% (56.8 mm) compared to normal rainfall of 350 mm. During *kharif*, 368.3 mm rainfall was received which was excess by 31.4% (88 mm) compared to normal rainfall of 280 mm; during *rabi* the rainfall was 38.5 mm which was deficit by 45% (31.5 mm) compare to normal rainfall of 70 mm. One long dry spell of 21 days occurred during 1-21 August 2017 during the crop *kharif* season. A total amount of 142.5 mm rainfall was received as effective rainfall during the crop season of *kharif* while 38.5 mm rainfall was received as effective rainfall during the crop season of *rabi* crops (Fig. 4.5).

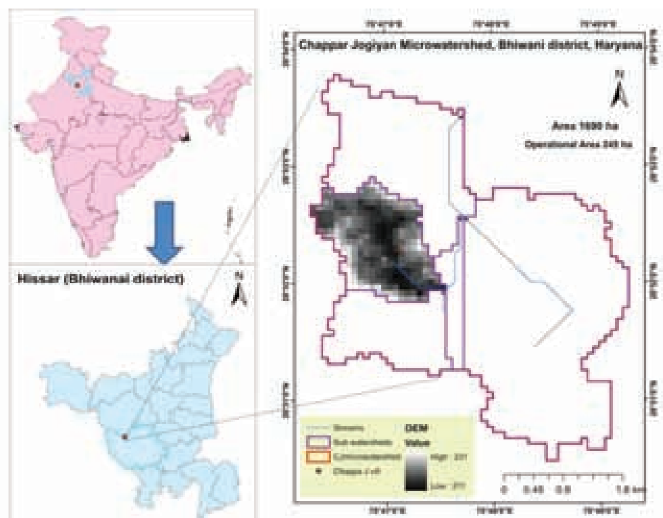


Fig. 4.5: Location map of Chappar Jogiyan village, Bhiwani district

Normal onset of monsoon	:	1st July
Onset of monsoon during 2017-18	:	28th June
Normal annual rainfall	:	350 mm
Annual rainfall during 2017-18	:	406.8 mm
Mean crop seasonal rainfall	:	*Kharif*: 290.0 mm *Rabi*: 60.0 mm
Crop seasonal rainfall during 2017-18	:	*Kharif*: 368.3 mm *Rabi:* 38.5 mm

4.5.1 Participatory Technology Development

In an assessment of on-farm demonstrations on foliar spray in mustard at 3 locations, higher seed and stalk yield (1690 and 3710 kg/ha), net returns (Rs. 48820/ha), B:C ratio (3.35) and RWUE of 19.10 kg/ha-mm was recorded with two sprays of 1% KNO_3 at 20 and 40 DAS followed by two sprays of 1% KCl (1610 kg/ha) as compared to no spray (1510 kg/ha). The yield improvement due to foliar spray of KNO_3 @ 1% was to 11.9% over no spray (Table 4.47).

Table 4.47 : Yield and economics of mustard as influenced by foliar spray - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stalk				
T_1: RDF with no spray	1510	3320	20200	42010	3.08	17.06
T_2: RDF+1% KNO_3 spray (twice)	1690	3710	20800	48820	3.35	19.10
T_3: RDF+1% KCl spray (twice)	1610	3530	21200	45120	3.13	18.19

One protective irrigation was given at 50 DAS in all treatments; RDF: 40:20 kg NP/ha

In an assessment of on-farm demonstrations on improved practices in pearlmillet (HHB 67 improved), adoption of package of practices such as improved hybrid + RDF (40:20 kg NP/ha) + interculture with wheel hand hoe recorded higher grain and stover yield (2010 and 4430 kg/ha) over farmers' practices (1580 and 3620 kg/ha). Further, the net returns (Rs.16130/ha), B:C ratio (1.82) and RWUE (14.10 kg/ha-mm) was also higher with improved package of practices as compared to farmers' practices (Table 4.48).

Table 4.48 : Yield and economics of pearlmillet as influenced by improved practices - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: Improved package of practices	2010	4430	19600	16130	1.82	14.10
T_2: Farmers' practice	1580	3620	18800	9507	1.50	11.09

Prealmillet under farmers' practice

Improved package of practices

Similarly, in an assessment of improved package of practices at five sites in clusterbean (HG 563), adoption of package of practices improved variety (HG 563) + RDF (20:40 kg NP/ha) + interculture with wheel hand hoe recorded higher seed and stalk yield (1230 and 2210 kg/ha), net returns (Rs.28116/ha), B:C ratio (2.43) and RWUE (8.63 kg/ha-mm) over farmers' practices (920 and 1680 kg/ha) (Table 4.49).

Table 4.49 : Yield and economics of clusterbean as influenced by improved practices - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stalk				
T_1: Improved package of practices	1230	2210	19700	28116	2.43	8.63
T_2: Farmers' practice	920	1680	18700	17108	1.91	6.46

Improved package of practice

Clusterbean under farmers' practice

In an assessment of improved package of practices in mungbean (MH-421), adoption of improved practices like improved variety + RDF (20:40 kg NP/ha) + interculture with wheel hand hoe improved the seed yield (840 kg/ha) by 230 kg/ha (38%) over farmers' practices (610 kg/ha). Further, the higher net returns (Rs. 27914/ha), B:C ratio (2.41) and RWUE (5.89 kg/ha-mm) were obtained by adopting package of practices in mungbean as compared to farmers' practices (Rs.16349/ha, 1.89 and 4.28 kg/ha-mm, respectively) (Table 4.50).

Table 4.50 : Yield and economics of mungbean as influenced by improved practices - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stalk				
T_1: Improved package of practices	840	1390	19750	27914	2.41	5.89
T_2: Farmers' practice	610	1070	18300	16349	1.89	4.28

Improved package of practices

Mungbean under farmers' practices

In an assessment of improved package of practices at four sites in mustard adoption of improved practices like improved variety (RH30) + RDF (40:20 kg NP/ha) + interculture with wheel hand hoe increased the seed yield (1675 kg/ha) by 17.1% over farmers' practice (1430 kg/ha). Similarly, higher net returns (Rs. 48805/ha), B:C ratio (3.42) and RWUE (18.93 kg/ha-mm) was obtained with improved practices as compared to farmers' practices (Table 4.51).

Table 4.51 : Yield and economics of mustard as influenced by improved practices - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stalk				
T_1: Improved package of practices	1675	3680	20200	48805	3.42	18.93
T_2: Farmers' practice	1430	3145	19250	39665	3.06	16.16


Mustard under improved package of practices

In an assessment of improved package of practices in chickpea, adoption of improved package of practices, improved variety (C 235) + RDF (20:40 kg NP/ha) + interculture with wheel hand hoe increased seed yield of chickpea (712 kg/ha) by 22.7% over farmers' practices (580 kg/ha). Similarly, higher net returns (Rs.13256/ha) and B:C ratio (1.71) was obtained with improved practices as compared to farmers' practice (Table 4.52).

Chickpea under improved package of practices

Table 4.52 : Yield and economics of chickpea as influenced by improved practices - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
T_1: Improved package of practices	712	798	18600	13256	1.71	18.49
T_2: Farmers' practice	580	650	17700	8250	1.46	15.06

Strip intercropping of pearlmillet (HHB 67 improved) + mungbean (MH421) (8:4) recorded 38.3% higher pearlmillet equivalent yield (2268 kg/ha), net returns (Rs.17559/ha), B:C ratio (1.89) and RWUE (15.91 kg/ha-mm) as compared to pearlmillet sole (1640 kg/ha, Rs. 10044/ha, 1.53 and 11.51 kg/ha-mm, respectively) (Table 4.53).

Table 4.53 : Yield and economics of strip intercropping of pearlmillet + mungbean (8:4) - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pearlmillet equivalent yield	Stover + stalk				
T_1: Pearlmillet + mungbean (8:4)	2268	2920 + 280	19600	17559	1.89	15.91
T_2: Farmers' practice (pearlmillet sole)	1640	3390	18750	10044	1.53	11.51

In an assessment of fertilizer use in pearlmillet, application of 60 kg N + 30 kg P2O5 + 20 kg K2O/ha gave higher grain yield (2210 kg/ha), net returns (Rs. 19184/ha), B:C ratio (1.97) and RWUE (15.51 kg/ha-mm) followed by application of 40 kg N + 20 kg P2O5/ha with grain yield of 1960 kg/ha, net returns (Rs.15886/ha) and B:C ratio of 1.85 compared to control (1590 kg ha) (Table 4.54).

Table 4.54 : Yield and economics of pearlmillet as influenced by fertilizer application - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: Control	1590	3340	17300	10701	1.62	11.16
T_2: 40 kg N + 20 kg P_2O_5/ha	1960	4160	18700	15886	1.85	13.75
T_3: 60 kg N + 30 kg P_2O_5 + 20 kg K_2O/ha	2210	4620	19700	19184	1.97	15.51

T_1: Control

T_2: 40 kg N + 20 kg P_2O_5/ha

T_3: 60 kg N + 30 kg P_2O_5 + 20 kg K_2O/ha

Performance of pearlmillet under different treatments

In an assessment of fertilizer requirement of mustard, application of 60 kg N + 30 kg P_2O_5 + 20 kg K_2O/ha gave higher seed yield (1775 kg/ha), net returns (Rs. 52220/ha), B:C ratio (3.53) and RWUE of 20.06 kg/ha-mm followed by application of 40 kg N + 20 kg P_2O_5/ha (1615 kg/ha), compared to control (1380 kg/ha) (Table 4.55).

Table 4.55 : Yield and economics of mustard as influenced by fertilizer application - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stalk				
T_1: Control	1380	2960	19580	37200	2.90	15.59*
T_2: 40 kg N + 20 kg P_2O_5/ha	1615	3485	20200	46270	3.29	18.25*
T_3: 60 kg N + 30 kg P_2O_5 + 20 kg K_2O/ha	1775	3790	20600	52220	3.53	20.06*

*One protective irrigation was given at 50 DAS in all treatments

T_1: Control

T_2: 40 kg N + 20 kg P_2O_5/ha

Performance of mustard under different treatments

In an assessment of newly released pearlmillet hybrids at six sites, pearlmillet hybrid HHB 272 recorded highest grain and stover yield (2110 and 4640 kg/ha), net returns (Rs. 18391/ha), B:C ratio (1.96) and RWUE (14.81 kg/ha-mm) followed by hybrid HHB 197 (1940 kg/ha, Rs.15457/ha, 1.81 and 13.61 kg/ha-mm, respectively) whereas farmers' hybrid Nandi 67 recorded the lowest grain yield (1570 kg/ha) (Table 4.56).

Table 4.56 : Performance of newly released pearlmillet hybrids during *kharif* - Hisar

Hybrid	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Grain	Stover				
T_1: Farmers' hybrid (Nandi 67)	1570	3510	19100	8888	1.46	11.02
T_2: HHB 67 Improved	1750	3890	19100	12061	1.63	12.28
T_3: HHB 197	1940	4320	19100	15457	1.81	13.61
T_4: HHB 223	1790	3960	19100	12743	1.67	12.56
T_5: HHB 272	2110	4640	19100	18391	1.96	14.81

In an assessment of newly released clusterbean varieties at five sites, clusterbean variety HG 2-20 recorded highest seed yield (1260 kg/ha), net returns (Rs. 29460/ha), B:C ratio (2.51) and RWUE of 8.84 kg/ha-mm followed by variety HG 870 (1120 kg/ha, Rs. 24036/ha, 2.23 and 7.86 kg/ha-mm, respectively) while, farmers' variety (HG 365) recorded the lowest seed yield (960 kg/ha) (Table 4.57).

Table 4.57 : Performance of newly released clusterbean varieties - Hisar

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stalk				
T_1: Farmers' variety (HG 365)	960	1720	19500	17812	1.91	6.74
T_2: HG 563	1050	1880	19500	21308	2.09	7.37
T_3: HG 870	1120	2010	19500	24036	2.23	7.86
T_4: HG 2-20	1260	2250	19500	29460	2.51	8.84

Clusterbean cv. HG 365

Clusterbean cv. HG 563

Clusterbean cv. 2-20

In an assessment of newly released mungbean varieties at eight locations in village Chhapar Jogiyan, mungbean variety MH 421 recorded highest seed yield (880 kg/ha), net returns (Rs. 30606/ha), B:C ratio (2.58) and RWUE (6.17 kg/ha-mm) followed by variety Basanti (790 kg/ha) and Sattya (740 kg/ha) whereas Asha recorded the lowest seed yield (590 kg/ha) (Table 4.58).

Table 4.58 : Performance of newly released mungbean varieties - Hisar

Variety	Yield (kg/ha)		Cost of cultivation	NMR	B:C ratio	RWUE
	Seed	Stalk	(Rs/ha)	(Rs/ha)		(kg/ha-mm)
T_1: Farmers' ariety (Asha)	590	940	19300	14156	1.73	4.14
T_2: Sattya	740	1170	19300	22657	2.17	5.19
T_3: Basanti	790	1250	19300	25492	2.32	5.54
T_4: MH 421	880	1410	19300	30606	2.58	6.17

Mungbean under T_1: Control

Mungbean under T_2: 40 kg N + 20 kg P_2O_5/ha

In an assessment of newly released mustard varieties variety RH 119 recorded highest seed yield (1732 kg/ha) and B:C ratio (3.50) followed by variety RH 406 (1720 kg/ha) and RB 50 (1695 kg/ha), whereas RH 30 recorded the lowest seed yield (1616 kg/ha) and B:C ratio (3.26) (Table 4.59).

Table 4.59 : Performance of newly released mustard varieties - Hisar

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
T_1: RH 30	1616	3490	20380	46130	3.26	18.26*
T_2: RB 50	1695	3640	20380	49360	3.42	19.15*
T_3: RH 406	1720	3730	20380	50430	3.47	19.43*
T_4: RH 119	1732	3745	20380	50910	3.50	19.57*

*Includes one protective irrigation

Mustard var. RB 50

Mustard var. RH 406

Two varieties of chickpea *viz.* C 235 and HC 1 were assessed at three different sites in village Chhapar Jogiyan. Variety HC 1 is normally sown under irrigated as well as under rainfed conditions. Chickpea variety C 235 recorded higher seed yield (676 kg/ha) net returns (Rs. 11650/ha) and B:C ratio (1.63) as compared to variety HC 1 (seed yield of 624 kg/ha and B:C ratio of 1.50) (Table 4.60).

Table 4.60 : Performance of chickpea varieties - Hisar

Variety	Yield (kg/ha) (2017)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	Seed	Stover				
T_1: C 235	676	762	18600	11650	1.63	17.56
T_2: HC 1	624	702	18600	9320	1.50	16.21

Chickpea var. C 235

Chickpea var. HC 1

4.5.2 Technology Upscaling

In an on-farm demonstrations on weed management in pearlmillet, weed management with wheel hand hoe at 30 DAS gave higher grain yield (1940 kg/ha), net returns (Rs. 16090/ha) and B:C ratio of 1.88 as compared to weeding kasola at 30 DAS with B:C ratio of 1.70. Similarly, weed management in mustard with wheel hand hoe at 30 DAS gave higher seed yield (1648 kg/ha), net returns (Rs. 47082/ha) and B:C ratio of 3.28 as compared to weeding with kasola at 30 DAS (1572 kg/ha). The improved varieties of pearlmillet, mungbean, cluster bean and mustard demonstrated at farmers' field gave higher yields with B:C ratio of 1.74, 2.55, 2.37 and 3.67 with variety HHB67 improved, MH-421, HG2-20 and RB 50, respectively compared to farmers' variety (Table 4.61).

Table 4.61 : Yield and economics of crops as influenced by improved management practices - Hisar

Technology	Grain/seed yield (kg/ha)	NMR (Rs/ha)	B:C ratio
Weed management in pearlmillet			
T_1: Wheel hand hoe at 30 DAS	1940	16090	1.88
T_2: Farmers' practice (kasola at 30 DAS)	1890	13850	1.70
Weed management in mustard			
T_1:Wheel hand hoe at 30 DAS	1648	47082	3.28
T_2:Farmers' practice (kasola 30 DAS)	1572	43158	3.04
Improved varieties of *kharif* crops			
Pearlmillet			
T_1:Farmers' Hybrid (Nandi)	1610	9490	1.50
T_2:HHB 67 Improved	1870	14107	1.74
Mungbean			
T_1:Farmers' variety (Asha)	570	13023	1.67
T_2:MH 421	870	30030	2.55
Clusterbean			
T_1:Farmers' variety (HG 365)	930	16636	1.85
T_2:HG 2-20	1190	26748	2.37
Improved variety of mustard			
T_1:RH 30	1680	48200	3.32
T_2:RB 50	1860	55480	3.67

Weeding with wheel hand hoe in pearlmillet

Weeding with kasola in pearlmillet

Mustard var. RB 50

4.6 Indore

(Village Piploda Dwarakdeesh, Ujjain district, Madhya Pradesh)

At Piploda Dwarakdeesh, the onset of monsoon was normal (3rd June). The annual rainfall was 942.4 mm, which was 11.7% (124.6 mm) deficit over the mean normal rainfall (1067 mm). During *kharif,* 909.4 mm rainfall was received which was deficit by 9.3% (93.1 mm) compared to normal *kharif* season rainfall of 1002.5 mm and during *rabi* 33.1 mm rainfall was received against normal of 64.5 mm. There was a long dry spell of 19 days (31st July to 18th August) coinciding with flowering stage of the crops (Fig. 4.6).

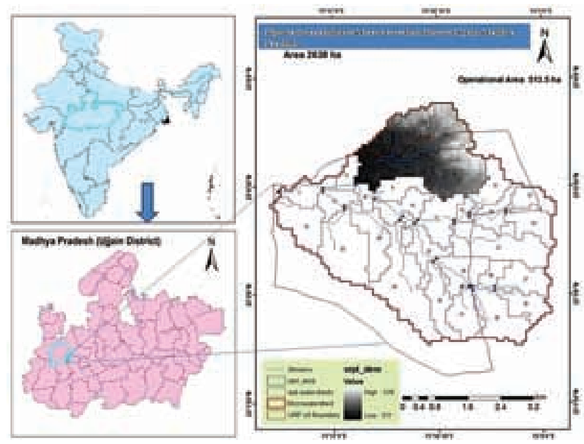


Fig. 4.6: Location map of Piploda Dwarakdheesh village, Ujjain district

Normal onset of monsoon	:	12-18th June
Onset of monsoon during 2017-18	:	4th June
Normal annual rainfall	:	1067 mm
Annual rainfall during 2017-18	:	942.4 mm
Mean crop seasonal rainfall	:	*kharif*:1002.5 mm; *rabi*:64.5 mm
Crop seasonal rainfall during 2017-18	:	*kharif:* 909.4 mm; *rabi*: 33.1 mm

4.6.1 Participatory Technology Development

In an assessment of use of harvested rain water available in gullies for enhancing productivity of chickpea, supplemental irrigation enhanced the yields of various chickpea varieties to the extent of 21.7% in JAKI 9218, 16.4% each in Vishal and Dollar and 6.0% in Local variety, respectively (Table 4.62).

Table 4.62 : Effect of supplemental irrigation from sunken pond in chickpea cultivars - Indore

Variety	Yield without supplemental irrigation (kg/ha)	Yield with supplemental irrigation (kg/ha)	% increase in yield	NMR (Rs/ha)	B:C ratio
T_1:Vishal	1504	1800	16.4	43300	2.01
T_2: Dollar	1504	1800	16.4	43300	2.01
T_3: JAKI 9218	1504	1920	21.7	47620	2.21
T_4: Local	1504	1600	6.0	36100	1.68

In an on-farm evaluation of suitable alternative crops to soybean, new variety of sorghum var. CSH-18 recorded higher grain yield (4470 kg/ha) followed by JJ1041 (3610 kg/ha) with yield advantage of 62.5 and 31.3%, respectively over local variety. Further, sorghum varieties, CSH18 and JJ1041 recorded higher net returns (Rs. 89648 and 68364/ha) and B:C ratio (3.56 and 2.95) compared to local variety (Rs.56265/ha and 2.88) (Table). Similarly, maize variety MHM1242 produced higher grain yield (5620 kg/ha) followed by Chandan (4540 kg/ha) with yield advantage of 62 and 30.8%, respectively over local variety. Maize varieties MHM1242 and Chandan also gave higher net returns (Rs. 89648 and 64889/ha, respectively) and B:C ratio (2.24 and 1.81, respectively) compared to local variety (Rs.56265/ha and 1.86) (Table 4.63).

Table 4.63 : Performance of sorghum and maize varieties - Indore

Crop	Grain yield (kg/ha)	Yield advantage (%)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Sorghum					
T_1: JJ1041	3610	31.3	35000	68364	2.95
T_2: CSH18	4470	62.5	35000	89648	3.56
T_3: Local	2750	-	3000	56265	2.88
Maize					
T_1: Chandan	4540	30.8	40000	64889	1.81
T_2: MHM1242	5620	62.0	40000	89648	2.24
T_3: Local	-	3470	3000	56265	1.86

The farmers of the region have adopted ridge and furrow system of sowing soybean. For this purpose, the traditional seed drills have been provided and fitted with sweeps in between the furrow openers. The provision of sweeps not only makes a shallow furrow in between seed rows to provide a drainage channel but also put extra soil on the seed lines to make it into a shape of ridge. The use of sweeps also remove the weeds if any in the fields. The same can be used for the intercultural operation during dry spell.

Sowing with raised bed planter

Sowing with raised bed planter

The newly purchased RB/BBF planter was found not properly working in the higher moisture (at field capacity) level at which normal seed drill works quite satisfactorily. Thus the raised bed planter delays the sowing by 1-2 days. The raised bed planting also resulted in lower yield may be due to wider spacing (45 cm), lesser plant population/m row length (15) and reduced number of rows/ha (4) compared to the traditional modified seed drill (Table 4.64).

Table 4.64 : Performance of local seed drill and raised bed planter - Indore

Particulars	Local seed drill	Raised bed planter
Area coverage (ha/hr)	0.35-0.45	0.3
No of rows	7-9	4.0
Row spacing	30 -35	45.0
Sowing depth (cm)	5-7	5.0
Labour requirement(man-h-ha)	5.0	5.0
Plant population /m row length	23	15.0
Seeding mechanism	(Non consistent) Fluted roller	(Consistent) Slotted roller
Sowing system	Ridge-furrow	BBF
Seed /ferti box	Single	Double

In an on-farm evaluation of performance of different promising varieties of soybean at 10 locations, the local variety JS 93-05 gave the lowest mean seed yield (1350 kg/ha). The farmers liked new varieties RVS 2001-4 and JS 20-34 due to their four seeded pods (more than 50% pods having four seed) and higher productivity. The variety, JS 95-60 gave higher seed yield (1707 kg/ha), net returns (Rs. 32053/ha) and B:C ratio (1.60) and also matured 7 to 8 days earlier than local varieties (Table 4.65).

Table 4.65 : Performance of new soybean variety - Indore

Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	NMR (Rs/ha)	B:C ratio
RVS2001-4	1558	2.12	27512	1.38
JS-20-34	1707	2.32	32053	1.60
JS93-05	1350	1.91	22700	1.14

4.7 Solapur

(Village Hingani, Satara district, Maharashtra)

In Hingani village, in the year 2017, the onset of monsoon was on 10th June (normal 9th June) and total rainfall received was 432.0 mm in 14 rainy days against the normal annual rainfall of 456.2 mm. The total rainfall received in *kharif* from June to 15 September was 272.0 mm in 10 rainy days and 160 mm in 4 rainy days in *rabi* season. Only one rainfall event was recorded in July with 6 mm rainfall whereas there was no rainfall during 13th July to 25th August. During *rabi,* no rainfall was received during November to December (Fig. 4.7).

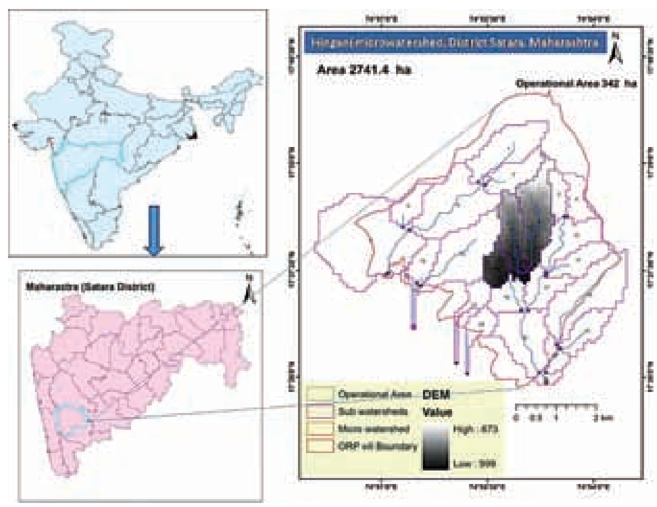


Fig. 4.7: Location map of Hingani village, Satara district

Normal onset of monsoon	:	7-9th June
Onset of monsoon during 2017	:	10th June
Normal annual rainfall	:	456.2 mm
Annual rainfall during 2017	:	432 mm
Crop seasonal rainfall during 2017	:	*kharif :* 272 mm; *rabi:* 160 mm

4.7.1 Participatory Technology Development

In an assessment of *in-situ* moisture conservation measures on yield and economics of *rabi* sorghum, higher mean grain yield of 1150 kg/ha and fodder yield 2895 kg/ha were recorded with compartmental bunding compared to farmers' practices (582 kg/ha), with higher net returns (Rs.18470/ha), B:C ratio (2.34) and RWUE (6.15 kg/ha-mm) (Table 4.66).

Table 4.66: Effect of in-situ moisture conservation on yield and economics of *rabi* sorghum - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: Compartment bunding in *kharif* season	1150	2895	13810	18470	2.34	6.15
T_2: Farmers' practice (two harrowings)	582	1640	11150	5886	1.53	3.18

Compartment bunds in kharif

Rabi sorghum with compartmental bunding

In an assessment of application of tank silt on yield and economics of *rabi* sorghum, tank silt application (20 t/ha) with ridges and furrows treatment recorded higher grain yield of 1115 kg/ha, stover yield of 3234 kg/ha, net returns of Rs.19204/ha, B:C ratio of 2.2 and RWUE of 5.96 kg/ha-mm compared to tank silt application without ridges and furrows (780 kg/ha) and farmers' practice (520 kg/ha) (Table 4.67).

Table 4.67 : Effect of tank silt application on yield and economics of rabi sorghum - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: Application of tank silt	780	2223	12500	10432	1.83	4.17
T_2: Application of tank silt + ridges and furrows	1115	3234	13800	19204	2.39	5.96
T_3: Farmers' practice (no tank silt and ridges & furrows)	520	1404	10020	4956	1.49	2.78

Rabi sorghum with tank silt application

Rabi sorghum without tank silt

In an assessment of rainwater harvesting in farm pond and efficient recycling for protective irrigation in *rabi* sorghum, a higher grain yield of 1190 kg/ha, stover yield of 3332 kg/ha, net returns of Rs.20878/ha, B:C ratio of 2.51 and RWUE of 6.36 kg/ha-mm were recorded with two protective irrigations at 30 & 65 DAS and followed by one protective irrigation (30 DAS) (875 kg/ha) compared to farmers practice of no protective irrigation (525 kg/ha) (Table 4.68).

Table 4.68 : Performance of *rabi* sorghum under protective irrigation - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-m)
	Grain	Stover				
T_1: One protective irrigation (30 DAS)	875	2406	12500	12875	2.03	4.68
T_2: Two protective irrigations (30 & 65 DAS)	1190	3332	13870	20878	2.51	6.36
T_3: Farmers' practice (no irrigation)	525	1365	11900	3010	1.25	2.85

Rainwater harvesting in farm pond and efficient recycling in rabi sorghum

In an assessment of intercropping systems, sunflower + pigeonpea intercropping system (2:1) recorded higher net returns (Rs.39080/ha) and B:C ratio (4.52) compared to pearlmillet + pigeonpea (2:1) intercropping system and sole crops (Table 4.69).

Table 4.69 : Performance of intercropping systems – Solapur

Cropping system	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain/seed	Stover				
T_1: Sole sunflower (Phule Bhaskar)	520	1100	7500	13300	2.77	1.78
T_2: Sole pearlmillet (Adishakti)	590	1425	6400	7070	2.10	2.02
T_3: Sole pigeonpea (Vipula)	610	1640	11800	29720	3.52	2.09
T_4: Sunflower (Phule Bhaskar) + pigeonpea (Vipula) (2:1)	410 495	1040 1360	11100	39080	4.52	1.40 1.70
T_5: Pearlmillet (Adishakti) + pigeonpea (Vipula) (2:1)	425 395	1230 995	10600	26195	3.47	1.46 1.35

In an assessment of doubled cropping systems, blackgram followed by *rabi* sorghum recorded highest net returns (Rs.39056/ha) and B:C ratio (2.65) followed by cowpea-*rabi* sorghum system with net returns of Rs. 23050/ha comparted to sole *rabi* sorghum (Rs 101000/ha) (Table 4.70).

Table 4.70 : Performance of double cropping systems - Solapur

Cropping system	Yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	
	Kharif crop		*Rabi* crop						
	Seed	Stover	Grain	Stover				*Kharif*	*Rabi*
T_1: Blackgram – *rabi* sorghum	460	920	980	2744	23600	39056	2.65	1.58	5.24
T_2: Cowpea – *rabi* sorghum	380	817	920	2714	21200	23050	2.09	1.30	4.92
T_3: *Kharif* fallow – *rabi* sorghum	-	-	725	1812.5	10200	10100	1.99	-	3.88

***Kharif* blackgram**

***Rabi* sorghum**

In an assessment of response of *rabi* sorghum to fertilizer application as per soil test, higher grain yield of 1140 kg/ha, stover yield 3306 kg/ha, net returns of Rs.20844/ha, B:C ratio (2.62) and RWUE (6.10 kg/ha-mm) was recorded with fertilizer application as per soil test (75:31 NP kg/ha) compared to farmers' practice of no fertilizers application (710 kg/ha) (Table 4.71).

Table 4.71 : Response of *rabi* sorghum to fertilizer application as per soil test - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: Fertilizer application as per soil test (NP 75:31 kg/ha)	1140	3306	12900	20844	2.62	6.10
T_2: Farmers' practice (no fertilizer)	710	1988	10020	10712	2.07	3.80

Sorghum with fertilizer as per soil test

Sorghum without fertilizer application

In an assessment of integrated nutrient management in *rabi* sorghum, application of 50% N through FYM and 50% N through inorganics recorded maximum grain yield (1030 kg/ha), stover yield (2781 kg/ha), net returns (Rs.14184/ha) and RWUE (5.51 kg/ha-mm). However, 100% N through inorganic fertilizer recorded higher B:C ratio (1.95) (Table 4.72).

Table 4.72 : Response of *rabi* sorghum to integrated nutrient management – Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: 50% N through FYM + 50% N through inorganic fertilizer	1030	2781	15480	14184	1.92	5.51
T_2: 100% N through inorganic fertilizer	910	2275	13100	12380	1.95	4.87
T_3: Farmers' practice (no fertilizer)	590	1416	10190	6094	1.60	3.16

RDF: 50:25 kg NP/ha

4.7.2 Technology Upscaling

In a demonstration of production potential of improved sorghum cultivars for medium and medium deep soils on medium deep soils variety Phule Revati recorded higher grain yield (1250 kg/ha), net returns (Rs.20900/ha), B:C ratio (2.48) and RWUE (6.68 kg/ha-mm) compared to the farmers' variety (720 kg/ha). On medium soils, cultivar Phule Suchitra recorded higher grain yield (910 kg/ha), net returns (Rs.10752/ha), B:C ratio (1.77) and RWUE (4.87 kg/ha-mm) compared to farmers' variety (630 kg/ha) (Table 4.73).

Table 4.73 : Performance of improved sorghum cultivars -Solapur

Soil type	Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Stover				
Medium	T_1: Phule Suchitra	910	2093	14000	10752	1.77	4.87
	T_2: Farmers' variety (M 35-1)	630	1420	13200	3820	1.29	3.37
Medium deep	T_1: Phule Revati	1250	3125	14100	20900	2.48	6.68
	T_2: Farmers' variety (M 35-1)	720	1656	13200	6384	1.48	3.85

Phule Suchitra on medium soil

Phule Revati on medium deep soil

In a demonstration on performance of improved cultivars of *kharif* crops, pearlmillet (Adishakti), sunflower (Phule Bhaskar) and horsegram (Phule Sakas) recorded higher grain/ seed yield (1040, 630 and 470 kg/ha, respectively) and stover yield (2600, 1386 and 880 kg/ha, respectively) as compared to local cultivars (Table 4.74). Improved varieties also gave higher net returns and B:C ratio compared to local cultivars.

Table 4.74 : Performance of improved varieties of pearlmillet, mothbean and horsegram - Solapur

Crop	Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain/ seed	Stover/ stalk				
Pearlmillet	T_1: Adishakti	1040	2600	11711	8569	1.73	3.56
	T_2: Local	720	1800	9066	4974	1.54	2.47
Sunflower	T_1: Phule Bhaskar	630	1386	10200	6810	1.67	2.16
	T_2: Local	420	924	9400	1940	1.2	1.44
Horsegram	T_1: Phule Sakas	470	880	10100	6350	1.62	1.61
	T_2: Local	350	660	9320	3722	1.4	1.20

In a demonstration of two-bowl ferti seed drill for sowing of *rabi* sorghum, sowing with two bowl ferti seed drill recorded highest grain yield (860 kg/ha), stover yield (2480 kg/ha), net returns (Rs.15100/ha), B:C ratio (2.47) and RWUE (4.60 kg/ha-mm) compared to farmers' practice of sowing with single bowl ferti-seed drill (735 kg/ha) (Table 4.75).

***Rabi* sorghum sown with two-bowl seed drill**

Table 4.75 : Effect of sowing with improved seed drill on rabi sorghum yield and economics - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
T_1: Sowing with two-bowl ferti seed drill	860	2480	10300	15100	2.47	4.60
T_2: Farmers' practice (sowing with single-bowl seed drill)	735	1990	9600	11590	2.21	3.93

In pearlmillet (cv. Shanti), application of K @ 25 kg/ha with recommended dose of N and P (50 and 25 kg/ha) recorded higher grain yield (1270 kg/ha), net returns (Rs.11347/ha) and B:C ratio (1.92) as compared to farmers' practice of no K application (890 kg/ha) (Table 4.76).

Table 4.76 : Response of pearlmillet to fertilizer application -Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Grain	Stover			
T_1: RDF (N 50 + P 25 + K 25 kg/ha)	1270	2410	12236	11347	1.92
T_2: Farmers' practice (N50 + P25 kg/ha)	890	1930	9066	7534	1.83

5. NICRA

During the first phase of the Technology Demonstration component of National Initiative on Climate Resilient Agriculture (NICRA), the AICRPDA-NICRA programme was undertaken at 23 centres. During the year, the on-farm programme was extended to 22 more adjoining villages to the existing 32 villages (total 54 villages) in 24 districts across 15 states (Fig 5.1). The real-time contingency plan (RTCP) was implemented with two pronged approach i.e. preparedness and real-time contingency measures to cope with delayed onset of monsoon and seasonal drought (early, mid and terminal) in more than 1000 farmers' fields in these villages during 2017-18.

Fig. 5.1: Location map of AICRPDA-NICRA villages

Experienced weather at AICRPDA- NICRA villages during 2017-18

During 2017-18, the onset of monsoon was delayed by 25, 13 and 11 days respectively in NICRA villages located in Jamnagar (Gujarat), Garhwa (Jharkhand) and Banaskantha (Gujarat) districts (Table 5.1). Further, there were 3-6 dry spells at different stages of crops in NICRA villages in Akola, Ananthapuramu, Bengaluru, Jagdalpur, Lakhimpur, Garhwa, Kandhamal, Parbhani and Kovilpatti districts.

Table 5.1 : Details of onset of monsoon in AICRPDA-NICRA villages (2017)

Villages & District	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Nagla Dulhe Khan and Kherra (Agra)	South–western semiarid zone in Uttar Pradesh	2-July	3-July	1
Warkhed and Kajleswar (Akola)	Western Vidarbha Zone in Maharashtra	10-June	14-June	4
Vannedoddipally and Bachepalli (Ananthapuramu)	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh	7-June	7-June	-
Kochariya, Lapsiya, Bagatpura and Tara ka Kheda (Bhilwara)	Southern zone in Rajasthan	1-July	24-June	-
Naiwan, Achalpur and Bhanivpur (Hoshiarpur)	Kandi region in Punjab	1-July	26-June	-

Villages & District	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Kavalagi and Honnutagi (Vijayapura)	Northern dry zone in Karnataka	7-June	7-June	-
Chamua and Ganakdoloni (Lakhimpur)	North Bank plain zone in Assam	5-June	1-June	-
Kumbhi, Bankheta and Chiraunjiya (Gar-hwa)	Western plateau zone of Jharkhand	10-June	23-June	13
Hardoiya and Pero Saraiya (Faizabad)	Eastern plain zone in Uttar Pradesh	21-June	21-June	-
Balawas & Budhshelly (Bhiwani)	South-western dry zone in Haryana	1-July	29-June	-
Ningnoti and Bishakhedi (Indore)	Malwa plateau in Madhya Pradesh	12-June	4-June	-
Tahakapal, Tandapal, Gumiyapal and Jhar-tarai (Bastar)	Basthar Plateau zone in Chattisgarh	15-June	3-June	-
Kadesara Kala and Hanauta (Lalitpur)	Bundhelkhand zone in Uttar Pradesh	25-June	23-June	-
Toppureddiapatti and Dharmathanpatti (Toothukkudi)	Southern zone of Tamil Nadu	1-June	6-June	5
Babhulgaon and Ujalamba (Parbhani)	Central Maharashtra Plateau Zone in Maha-rashtra	20-June	7-June	-
Budhadani and Gunjidraga (Kandhamal)	Eastern Ghat Zone in Orissa	10-June	10-June	-
Pata meghapar and Dangarvala (Jamnagar)	North Saurashtra zones in Gujarat	16-June	11-July	25
Khaner and Madana (Samba)	Low altitude subtropical zone in J&K	27-June	30-June	3
Patauna, Raura and Khira (Rewa)	Keymore plateau and Satpura Hill zone in Madhya Pradesh	23-June	30-June	7
Kalimati, Dholia and Gagu (Banaskantha)	Northern Gujarat in Gujarat	15-June	10-June	11
Narotewadi and Banegoan (Solapur)	Scarcity zone in Maharashtra	20-June	6-June	-
Tedha and Patharaha (Mirzapur)	Eastern Plain and Vindhyan Zone in Uttar Pradesh	1-July	21-June	-

In general, the total rainfall during *kharif* season (June-September), 2017 was below normal in all NICRA villages except in Chikamanahalli (Bengaluru), Kavalagi (Vijayapura), Chamuha (Lakhimpur), Balawas (Bhiwani), Tahakapal (Bastar), Kadesara Kalan (Lalithpur), Muttukrishnapuram (Toothukkudi), Babhulgaon (Parbhani), Petameghapar (Jamnagar) and Kalimati (Banastantha) (Fig. 5.2). Similarly, during *rabi* season (October-December) 2017, the rainfall was less than normal seasonal rainfall in NICRA villages of Varkhed (Akola), Achalpur (Hoshiarpur), Chikamanahalli (Bengaluru), Kavalagi (Vijayapur), Kumbhi & Bankheta (Garhwa), Nignoti (Indore), Kadesara Kala (Lalitpur), Khaner (Samba), Kalimati (Banaskanta) and Nerotewadi (Solapur). No rainfall was received in 6 NICRA vilages in *rabi* season at Nagala Dulhe Khan (Agra), Kochariya (Bhilwara), Hardoya (Faizabad), Babhulgaon (Parbhani), Patameghpar (Jamnagar) and Tedha (Mirzapur) (Fig. 5.3).

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

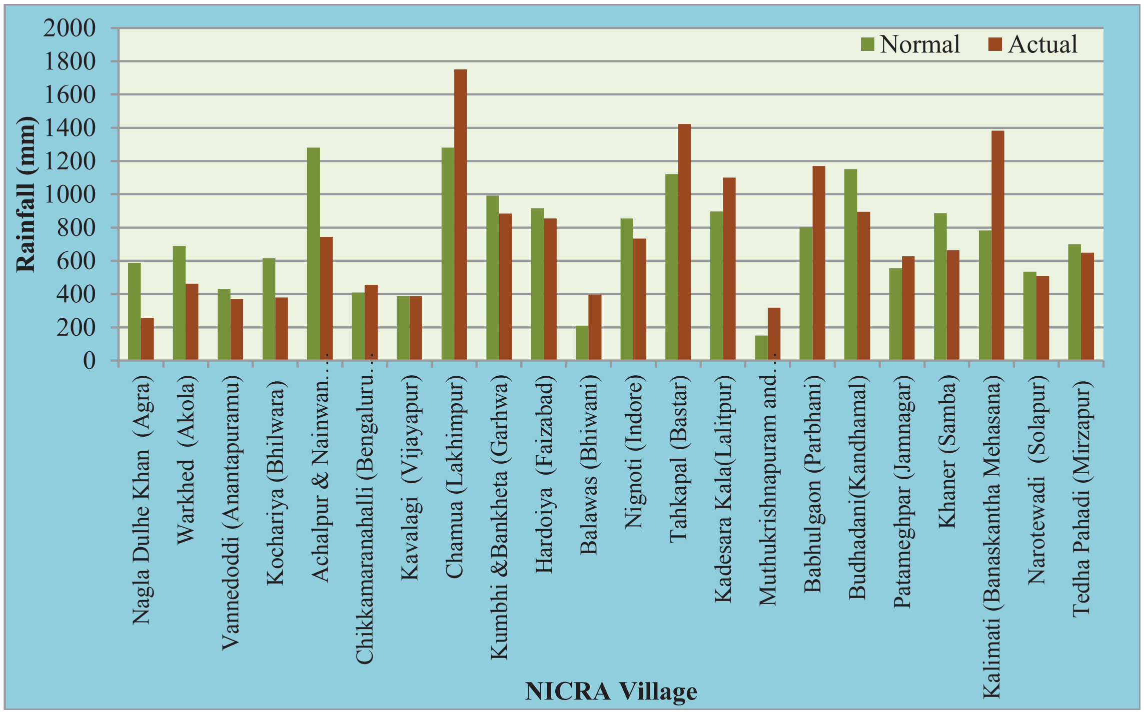


Fig. 5.2: Normal and actual (2017) rainfall in AICRPDA-NICRA villages (June - September)

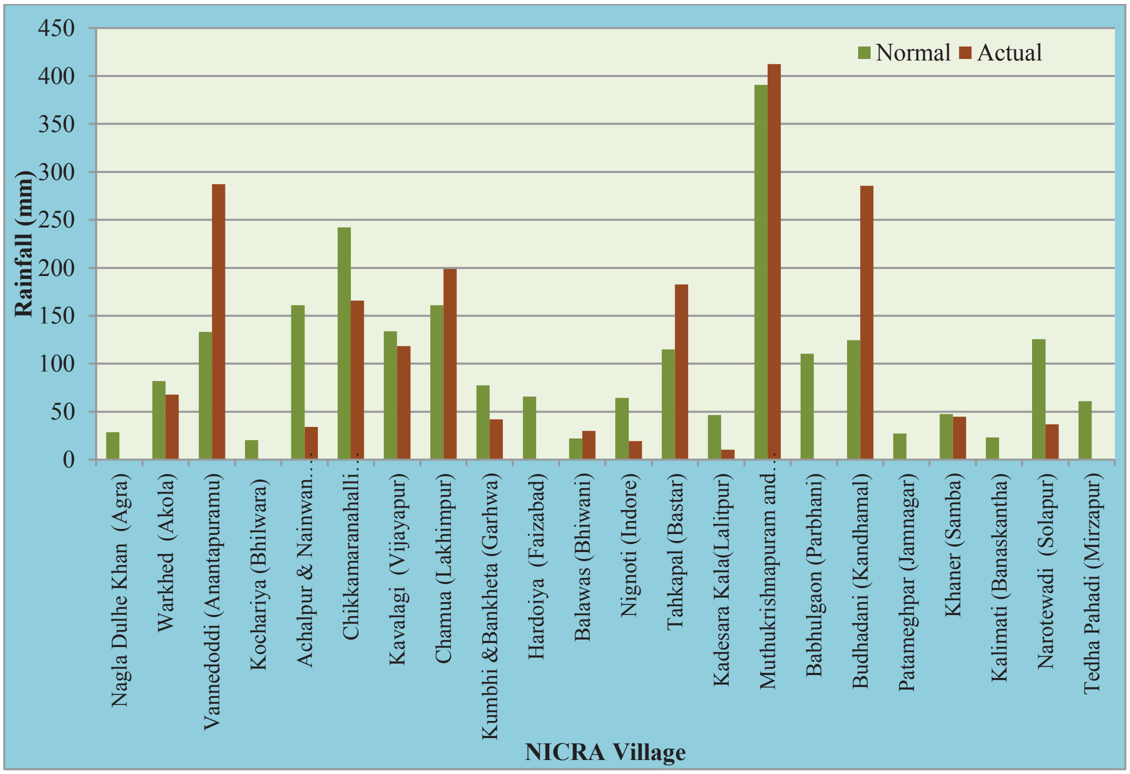


Fig. 5.3: Normal and actual (2017) rainfall in AICRPDA-NICRA villages (October - December)

Salient achievements during 2017-18 under AICRPDA-NICRA are briefly presented below.

I. Real-time contingency measures

a. On-station

Delayed onset of monsoon

At Anantapuramu, in Semiarid Alfisols, among different contingent crops sown in August, foxtail millet recorded higher grain yield (1468 kg/ha), net returns (Rs.20413/ha), B:C ratio (3.91) and RWUE (3.22 kg/ha-mm) closely followed by horsegram with seed yield of 768 kg/ha, net returns of Rs.20078/ha and B:C ratio of 3.68.

At Rajkot, the onset of monsoon was delayed by 18 days (4th July). Among different semi-spreading varieties of groundnut evaluated in Semiarid Vertisols, GG-20 recorded higher pod yield (1883 kg/ha), net returns (Rs 68657/ha) and B:C ratio (3.67) as compared to Kaushal (1597 kg/ha). Among semi-bunch groundnut varieties, GJG-9, JL-501 and TGA-37A recorded 19.1, 12.8 and 25.4% higher pod yield as compared to GG-7 (2187 kg/ha), respectively. In case of spreading varieties, GJG-17 performed better with pod yield of 1778 kg/ha and net returns of Rs 93550/ha compared to var. GG11 (1447 kg/ha). 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).

Foxtail millet

Horsegram

Mid-season and terminal drought

At Bengaluru, in Semiarid Alfisols, foliar spray in fingermillet during dry spell (18 days coinciding with panicle initiation) recorded higher grain and straw (4478 and 7421 kg/ha) yield compared to foliar spray after relieving of stress/dry spell (3864 and 6242 kg/ha), respectively. Among different sources of nutrients, foliar spray with recommended dose of micronutrient (borax at 75 g/ha and $ZnSO_4$ at 75 g/ha) recorded higher grain yield (4897 kg/ha) compared to control (4407 kg/ ha). At Arjia, in Semiarid Vertisols, foliar application of macro- and micronutrients during dry spell (>10 days dry spell) during grain filling of maize significantly enhanced the grain yield (2730 kg/ha) by 13.6% compared to foliar application at sufficient moisture just after dry spell (2403 kg/ha). Further, foliar application of water soluble NPKS complex fertilizer (18:18:18:6) @ 0.5% + $ZnSO_4$ @ 0.5% increased grain yield (2961 kg/ha) by 36.4% compared to control (2171 kg/ha), with higher net returns (Rs 41179/ha), B:C ratio (3.24) and RWUE (5.0 kg/ha-mm).

b. On-farm

Delayed onset of monsoon

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

Direct sown fingermillet

Transplanted fingermillet

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

Early season drought

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

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

Fingermillet + pigeonpea (8:2) with conservation furrow

Fingermillet + Akkadi system

At Patameghpar village (Jamnagar district, Gujarat), in medium black soils, the pod yield of groundnut was increased by 25.4% (2149 kg/ha) with net returns of Rs 70666/ha and B:C ratio of 4.1 due to weeding and interculture as compared to no weeding/interculture (1718 kg/ha).

Interculture in groundnut

Mid season drought

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

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

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

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

Terminal drought

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

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

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

Sorghum cv. Revati with supplemental irrigation

Castor with supplemental irrigation

Castor without supplemental irrigation

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

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

II. Preparedness

Rainwater management

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

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

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

Maize without supplemental irrigation

Pearlmillet under ridge sowing

Maize with supplemental irrigation

Pearlmillet under farmers' practice (broadcasting)

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

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

Cropping systems

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

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

Pigeonpea + cowpea (1:1)

Pigeonpea + field bean (1:1)

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

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

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

Nutrient management

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

Efficient energy management

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

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

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

Sowing with maize planter

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

III. Village Level Institutions

Village Climate Risk Management Committee (VCRMC)

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

Alternate land use/integrated farming system

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

Aonla + mixed fodder (maize + sorghum + pearlmillet)

Custom Hiring Centre (CHC)

During 2017-18, the CHC facilities were also extended to farmers of new villages adopted by the centres. CHCs helped in hiring the need based implements/machinery by resource poor farmers at affordable cost and carrying out land preparation, timely and precision sowing covering large area in short time and other agricultural operations with high energy efficiency. Since 2011, Custom Hiring Management Committee (CHMC) in each NICRA village facilitated CHC activities and maintenance of implements from the income generated through hiring. CHCs significantly contributed to alleviate labour shortage during peak demand period.

Power tiller

Paddy thresher

Power sprayer

Implements available in CHC at Budhadani, Kandhamal district, Odisha

Village Seed Bank

During the year, about 330 tons seed of different rainfed crops was produced/maintained in different NICRA villages.

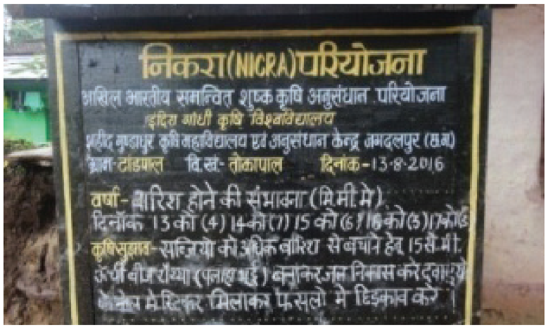
Fodder Bank

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

Fodder maize in Chikkamaranahalli village, Bengaluru Rural district

Making silage in Kadesara Kala village, Lalitpur district

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



Agromet advisory in Tandpal village, Bastar district, Chhattisgarh

Trainings/Field Visits/Field Days: During the year, 61 trainings and 22 field days/exposure visits were organized by the centres which benefitted 11611 stakeholders including farmers.

Balawas village, Bhiwani district, Hisar

Kalimati/Dholia village, Banaskantha district, Gujarat

Vannedoddipally village, Anantapuramu district, Andhra Pradesh

Linkages for Operationalizing District Agriculture Contingency Plans

During 2017-18, the scientists of the centres were actively involved in updating the district level crop contingency plans, involving scientists and officials from KVKs and line departments in respective states. Further, the scientists from centres also participated in state level meetings organized in 5 states (Karnataka, Andhra Pradesh, Telangana, Maharashtra and Rajasthan) for operationalization of district agriculture contingency plans and contributed in developing action plans.

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

PUBLICATIONS

6. Publications

6.1 Research Papers Published in Journals

PC Unit, AICRPDA

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6.4 Popular Articles

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Pardeep Kumar and Parminder Singh Sandhu. 2018. *Jhone Di Fasal Nu Paani, Khaddan Atte Dawaiean Paun De Tareeke*, Punjabi Tribune, Chandigarh July 28, 2018.

Manpreet Jaidka and Parminder Singh Sandhu. 2018. *Zameen di changi sehat lai vardaan hari khaad***.** *Kheti Dunia* Patiala, March 24, 2018.

6.5 Papers Presented in Seminars, Symposia, Conferences, Workshops/Meetings etc

Centre/Author/Title of the paper	Symposium/Seminar Conference	Date and Venue
Akola		
Ashwini Chandel, Gabhane VV, Jadhao VH and Rajesh Naik K. 2017. Long-term effect of INM on soil health and productivity of cotton + greengram intercropping system in *Vertisols*	International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development	10-11 February 2017, Hyderabad
Gabhane VV, Nagdeve MB, Ganvir MM, Patode RS and Ashwini Chandel. 2017. Nutrient balance and crop productivity as influenced by integrated nutrient management in cotton-soybean rotation under *Vertisols* in semiarid agro-ecosystem of Maharashtra.	International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development	10-11 February 2017, Hyderabad
Jadhao VH, Gabhane VV, Ashwini Chandel, Usha Satpute and Turkhede AB. 2017. Effect of potash application through gliricidia green leaf manuring on yield and nutrient uptake by soybean.	International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development	10-11 February 2017, Hyderabad
Rajesh Naik K, Gabhane VV, Ashwini Chandel and Nagdeve MB. 2017. Soil fertility and cotton productivity as influenced by potash management through gliricidia green leaf manuring in *Vertisols*	International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development	10-11 February 2017, Hyderabad
Patode RS, Nagdeve MB, Palaspagar NR and Ravindra Chary G. 2017. Relationship of catchment, storage capacity and command area for rainwater harvesting in the farm pond.	International Conference on Sustainable technologies for intelligent water management (STIWM-2018)	16-19 February 2017, IIT, Roorkee
Nagdeve MB, Patode RS and Gabhane VV. 2017. Yield maximization through sustainable water conservation in dryland agriculture.	International Conference on Sustainable technologies for intelligent water management (STIWM-2018)	16-19 February 2017, IIT, Roorkee
Nayana R. Palaspagar, Nagdeve MB and Patode RS. 2017. Livelihoods of small farmers.	Convention on Agripreneurship for Sustainable Development and Prosperity of Agriculture	8-9 July, 2017, Dr. PDKV, Akola
Wankhade RM, Patode RS and Nagdeve MB. 2017. Effect of CCTs on groundwater recharge of micro-catchment	Convention on Agripreneurship for Sustainable Development and Prosperity of Agriculture	8-9 July 2017, Dr. PDKV, Akola
Gabhane VV, Rajesh Naik K, Nagdeve MB, Patode RS and Ashwini Chandel. 2017. Effect of potash management through gliricidia green leaf manuring on cotton productivity and nutrient balance in *Vertisols* of Maharashtra	3rd International Conference on Bioresource & Stress Management	8-11 November 2017, Jaipur
Ganvir MM, Karunakar AP, Bhale VM, Nagdeve MB, Gabhane VV and Wanjari SS. 2017. Influence of weather variability, plant density and fertilizer regimes on yield of cotton under rainfed conditions in Maharashtra.	3rd International Conference on Bioresource & Stress Management	8-11 November 2017, Jaipur

Sonune BA, Kharche VK, Gabhane VV, Konde NM, Katkar RN, Paslawar AN, Jadhao SD and Mali DV. 2017. *In- situ* green manuring with dhaincha in cotton: A low cost technology for sustainable soil health and crop productivity in salt affected soils of Purna Valley in Vidarbha region of Maharashtra	3rd International Conference on Bioresource & Stress Management	8-11 November 2017, Jaipur
Megha A Khambalkar, Shilpa V Khambalkar, Gabhane VV, Thawari SB, Bhuyar AR. 2017. Integrated nutrient management in cotton as affected by nutrient availability of soil under rainfed condition	3rd International Conference on Bioresource & Stress Management	8-11 November 2017, Jaipur
Turkhede AB, Nagdeve MB, Anil Karunakar, Gabhane VV, Thakare SK, Mohod VD and Mali RS. 2017. Climate resilient cotton based sequence intercropping with tractor drawn seed drill under rainfed condition in Vidarbha region of Maharashtra.	3rd International Conference on Bioresource & Stress Management	8-11 November 2017, Jaipur
Turkhede AB, Nagdeve MB, Karunakar AP, Gabhane VV, Mohod VD and Mali RS. 2017. Intercropping with vegetables for upgrading the income of rainfed cotton.	3rd International Conference on Bioresource & Stress Management	8-11 November 2017, Jaipur
Patode RS, Ramamohan Reddy K and Nagdeve MB. 2017. Water resources management for sustainable agriculture	3rd International Conference on Environmental Management	27-30 November 2017, JNTUH, Hyderabad
Nagdeve MB, Patode RS and Pande CB. 2017. Assessment of rainwater harvesting structure on groundwater regime by using GIS based approach	International Seminar on Global Climate Change: Implications for Agriculture and Water Sectors (CCAW-2017)	14-16 December 2017, Aurangabad
Patode RS, Pande CB and Nagdeve MB. 2017. Watershed management and development plan of Patur watershed in Maharashtra by using geospatial technology	International Seminar on Global Climate Change: Implications for Agriculture and Water Sectors (CCAW-2017)	14-16 December 2017, Aurangabad
Turkhede AB, Karunakar AP, Nagdeve MB, Gabhane VV and Mali RS. 2017. Climate resilient cotton based sequence intercropping with tractor drawn seed drill under rainfed condition in Vidarbha region of Maharashtra	International Seminar on Global Climate Change: Implications for Agriculture and Water Sectors	14-16 December 2017, Aurangabad
Nagdeve MB, Patode RS, Gabhane VV and Ganvir MM. 2017. Sustainable conservation practices for dryland farming in Vidarbha region of Maharashtra	National Conference on Sustainable Water and Environmental Management (SWEM-17)	21-23 December 2017, JNTUH, Hyderabad
Patode RS, Nagdeve MB, Palaspagar NR and Ravindra Chary G. 2017. Rainwater management through *in-situ* soil and water conservation techniques and utilization of harvested water through farm pond.	National Conference on Sustainable Water and Environmental Management (SWEM-17)	21-23 December 2017, JNTUH, Hyderabad
Patode RS, Nagdeve MB, Ravindra Chary G and Ramamohan Reddy K. 2017. Water resources development for sustainable production in dryland agriculture through catchment management	National Conference on Sustainable Water and Environmental Management (SWEM-17)	21-23 December 2017, JNTUH, Hyderabad

Nagdeve MB, Patode RS, Pande CB, Gabhane VV and Karunakar AP. 2018. Impact assessment through GIS based approach of rainwater harvesting structure on drainage line for developing groundwater regime	National Seminar on Recent Trends in Plant Sciences and Agricultural Research	11-12 January 2018, Solapur
Agra		
Chauhan SK and Arvind Singh. 2018. Efficient utilization of harvested water for growing high value crops under dry land condition of western Uttar Pradesh.	Industrial Conference on Innovative Technologies Towards Energy, Environment, Food & Sustainable Agriculture	26-28 February 2018, Bichpuri, Agra
Ballowal Saunkhri		
Abrar Yousuf and Singh MJ. 2017. Scientific interventions in rainwater management in lower shivaliks under changing climate scenario	26th National Conference on Natural Resource Management for Climate Smart Sustainable Agriculture	11-13 September 2017, Barapani
Vijay Kumar, Vivek Sharma, Sharma SC and Sukhvinder Singh. 2017. Impact of improved production technologies on productivity enhancement of chickpea in sub-mountane Punjab.	The National Conference on Alternate Farming Systems to Enhance Farmers' Income	19-21 September 2017, Nauni, Solan
Khokhar Anil, Singh MJ, Vijay Kumar, Vivek Sharma, Abrar Yousuf and Sandhu PS. 2017. Real time contingency planning: An adaptation strategy for crop management under changing climatic scenario.	2nd Himachal Pradesh Sciences Congress on Science & Technology for Sustainable Livelihood in Indian Himalayan Region	20-21 November 2017, Shimla
Singh MJ and Anil Khokhar. 2017. Technological interventions for improving the productivity of rainfed crops in kandi region of Punjab.	2nd Himachal Pradesh Sciences Congress on Science & Technology for Sustainable Livelihood in Indian Himalayan Region	20-21 November 2017, Shimla
Sharma, Vivek, Singh MJ and Anil Khokhar. 2017. Integrated nutrient management in maize (*Zea mays* L)-wheat (*TriticumaestivumL*) cropping system for sustainable production under rainfed conditions in sub-tropical North India.	82nd Annual Convention of the Indian Society of Soil Science	11-14 December 2017, Kolkata
Chianki		
Singh DN, Ahmad Ekhlaque, Munish Kumar Singh and Paul A. 2017. Genetic variability and character association for yield and related attributes in rainfed chickpea.	International Conference on Agriculture and Applied Science for Food Security (AAPS-2017)	13-15 May 2017, Battishputli, Kathmandu
Sah Akhilesh, Ali Naiyar, Singh DN and Yadava MS. 2018. Growth yield and economics of rice-wheat system as influenced by integration of organic sources and inorganic fertilizer.	2nd International Conference on Agriculture (ICFA-2018)	29-31 March 2018, Dhanbad
Kovilpatti		
Elamathi S, Sanjivkumar V, Anandraj N and Baskar K. 2017. Impact of *in-situ* green manuring on cotton under dryland *Vertisol* conditions.	Third National conference on Agricultural Scientific Tamil.	12-13 August 2017, Coimbatore
Elamathi S, Anandhi P and Anandaraj N. 2017. Response of maize based intercropping system on maize yield and weed control.	Third National conference on Agricultural Scientific Tamil	12-13 August 2017, Coimbatore

Rangaraj T, Elamathi S and Solaiappan U. 2017. Agroforestry system under dryland conditions - An over view.	Third National conference on Agricultural Scientific Tamil	12-13 August 2017, Coimbatore
Sanjivkumar V, Baskar K, Jawahar D, Renukadevi A, Elamathi S and Anandraj N. 2017. Effect of fertilizer and moisture conservation practices on yield of sorghum under dryland conditions.	Third National conference on Agricultural Scientific Tamil	12-13 August 2017, Coimbatore
Parbhani		
Asewar BV, Gore AK, Pendke MS, Gaikwad GK. 2017. Agronomic interventions for increasing resilience in agriculture under changing climate.	National Seminar on Agronomic Approaches for Climate Resilience in Agriculture	1-2 May 2017, ANGRAU, Nandyal
Phulbani		
Bastia DK, Behera SK and Panda MR. 2018. Productivity and economics of maize + vegetables intercropping system under organic management in North Eastern Ghat Zone of Odisha.	International Conference on Organic Farming for Sustainable Agriculture	2-3 June 2018, OUAT, Bhubaneswar
Rakh Dhiansar		
Vikas Abrol, Singh AP, Brinder Singh, Anil Kumar, Peeyush Sharma, Hemant Dadhich, Jai Kumar. Effect of foliar application of nutrients on wheat crop productivity and profitability under rainfed conditions	National Conference on Innovative Technological Interventions for Doubling Farmers Income (NaCITI - 2018)	8-10 February 2018, SKUAST-J, Jammu
Brinder Singh, Anil Kumar, Vikas Abrol, Singh AP, Ashu Sharma and Jai Kumar. Influence of integrated nutrients on yield and economics of pearlmillet	National Conference on Innovative Technological Interventions for Doubling Farmers Income (NaCITI - 2018)	8-10 February, 2018 SKUAST-J, Jammu
Jai Kumar, Singh AP, Anil Kumar, Brinder Singh, Vikas Abrol, Hemant Dadhich and Sunny Raina. Evaluation of different *in-situ* soil moisture conservation techniques in Sub-tropical rainfed maize under Shiwalik foot hills of Jammu region	National Conference on Innovative Technological Interventions for Doubling Farmers Income (NaCITI - 2018)	8-10 February, 2018 SKUAST-J, Jammu
Arvind P. Singh, Anil Kumar, Jai Kumar, Vikas Abrol, Hemant Dhadich, Brinder Singh and Sunny Raina. Development and Testing of Agri-Horti-Silvi-Pastoral System Models for Rainfed Shiwalik Foothills of Jammu and Kashmir	National Conference on Innovative Technological Interventions for Doubling Farmers Income (NaCITI – 2018)	8-10 February 2018, SKUAST-J, Jammu
Solapur		
Amrutsagar VM, More NB, Kadam BS, Gaikwad BT, Ranshur NJ and Pawar AB. 2017. Integrated nutrient management for *rabi* sorghum under dryland Agriculture.	National Seminar on Soil and Plant Health Sustainability Scenario Towards Changing Needs	7 -8 October 2017, Parbhani chapter ISSS, VNMKV, Parbhani

More NB, Archana Pawar, Kadam BS, Tamboli BD and Amrutsagar VM. 2017. Studies on the effect of tillage and nutrient management on yield of *rabi* sorghum and soil fertility under dryland condition.	National Seminar on Soil and Plant Health Sustainability Scenario Towards Changing Needs	7 -8 October, 2017, VNMKV, Parbhani
More NB, Archana Pawar, Kadam BS, Tamboli BD and Amrutsagar VM. 2007. Foliar application of water soluble fertilizer 19:19:19 at different growth stages on yield, nutrient uptake of safflower under dryland conditions.	National Seminar on Soil and plant health sustainability scenario towards changing needs	7-8 October 2017, VNMKV, Parbhani
Archana Pawar, More NB, Amrutsagar VM and Kadam BS. 2017. Nutrient management module for minimizing drought impact and yield maximization of *rabi* sorghum on *Vertisol* under dryland conditions.	National Seminar on Soil and Plant Health Sustainability Scenario Towards Changing Needs	7-8 October 2017, VNMKV, Parbhani
Takte AS, More NB, Kadam BS, Rajguru AB and Amrutsagar VM. 2017. Foliar application of DAP at different growth stages on yield of chickpea under dryland conditions.	National Seminar on Soil and Plant Health Sustainability Scenario Towards Changing Needs	7-8 October 2017, VNMKV, Parbhani
Takte AS. More NB, Kadam BS, Rajguru AB and Amrutsagar VM. 2017. Integrated phosphorus management on pigeon pea yield, moisture use efficiency and soil fertility status on *Inceptisols* under dryland conditions	National Seminar on "Soil and Plant Health Sustainability Scenario Towards Changing Needs"	7-8 October 2017, VNMKV, Parbhani
Archana Pawar, More N.B., Tamboli B.D. and Amrutsagar V.M. 2017. Integrated nutrient management for *rabi* sorghum under dryland conditions.	International Seminar on Global Climate Change: Implications for Agriculture and Water Sectors	14-16 December 2017, Aurangabad
More NB, Pawar AB, Amrutsagar VM and Tamboli BD. 2018. Improvement in soil fertility and productivity of black gram –*Rabi* sorghum crop sequences with tillage and residue retention for resource conservation in *Inceptisol.*	National seminar on Recent Trends in Plant Sciences and Agriculture Research	11-12 January 2018, Solapur.
Amrutsagar VM, More NB, Pawar AB and Ravindra Chary G. 2018. Foliar nutrient management module for minimizing drought impact and moisture stress management in *rabi* sorghum	National Seminar on Recent Trends in Plant Sciences and Agriculture Research	11-12 January 2018, ZARS, Solapur
Vijayapura		
Shirahatti MS and Surakod VS. 2018. Drought management strategies for Northern Karnataka.	National Conference on Drought Management Strategies	8-9 March 2018, Bangaluru

Anantapuramu (ORP)		
Radha Kumari C, Sahadeva Reddy B and Ravindranatha Reddy B. 2017. Performance evaluation of groundnut varieties in rainfed *Alfisols* of scarce rainfall zone.	National Seminar on Agronomic Approaches for Climate Resilience in Agriculture	02 May 2017, RARS, Nandyal
Radha Kumari C, Sahadeva Reddy B and Ravindranatha Reddy B. 2017. Evaluation of profitable intercropping system with pigeonpea under paired row planting	National Seminar on Agronomic Approaches for Climate Resilience in Agriculture	02 May 2017, RARS, Nandyal
Radha Kumari C, Sahadeva Reddy B and Ravindranatha Reddy B. 2017. Weed management in clusterbean in rainfed *Alfisols*	Third International Conference on Bioresource Management and Stress Management	8 - 11 November 2017, Jaipur
Radha Kumari C, Ravindranatha Reddy B and Sahadeva Reddy B. 2017. Studies on redgram based intercropping system with groundnut, cowpea, greengram and foxtailmillet in rainfed alfisols.	Third International Conference on Bioresource Management and Stress Management	8 - 11 November 2017, Jaipur
Ballowal Saunkhri (ORP)		
Vivek Sharma. 2017. Rhizospheric effect of arbuscular mycorrhizal fungi on growth and nutrient uptake of *Picrorrhiza kurroa* Royle an important medicinal herb	2nd Himachal Pradesh Science Congress	20-21 November 2017, Shimla
Vivek Sharma. 2017. Integrated nutrient management in maize (*Zea mays* L)-wheat (*Triticum aestivum* L) cropping system for sustainable production under rainfed conditions in sub- tropical north	82nd Annual Convention of the Indian Society of Soil Science	11-14 December 2017, Kolkata
Bengaluru (ORP)		
Ramachandrappa BK, Thimmegowda MN, SrikanthBabu PN and Savitha MS. 2017. Climate resilient intercropping system in fingermillet and groundnut for rainfed condition.	XIII Agricultural Science Congress, Climate Smart agriculture	21-24 February 2017, UAS, Bengaluru
Sathish A, Bhavitha NC, Manjunatha BN and Thimmegowda MN. 2017. Improvement of soil quality as influenced by biofertilization in sustainable mixed cropping of finger millet and pigeonpea under rainfed condition of eastern dry zone of Karnataka.	XIII Agricultural Science Congress, Climate Smart agriculture	21-24 February 2017, UAS, Bengaluru
Thimmegowda MN, Sathish A, Manjunatha BN and Bhavitha NC. 2016. Bio-fertilization on sustainable mixed cropping of finger millet and pigeonpea yield under rainfed condition.	XIII Agricultural Science Congress, Climate Smart agriculture	21-24 February 2017, UAS, Bengaluru

7. Technologies for Assessment/Upscaling

Ananthapuramu (Scarce Rainfall Zone of Andhra Pradesh)

- Phosphatic biofertilizer consortia (*Bacillus megatherium var. phosphoticum* @ 5 kg/ha + *Aspergillus awamori* @ 5 kg/ha and *Arbuscular mycorrhiza* @ 12.5 kg/ha) with FYM @ 500 kg/ha as starter dose for higher productivity of groundnut

Arjia (Southern Zone of Rajasthan)

- Rainwater harvesting and recycling by *nadi* system for higher crop productivity
- Foliar spray of $ZnSO_4$ @ 0.5% + soluble NPK (18:18:18) @ 2% during dry spell for higher productivity of maize
- New horsegram variety Pratap Kulthi-2 (AK-53)

Ballowal Saunkhri (Kandi Region of Punjab)

- Strip cropping of maize + cowpea (8:4)

Bengaluru (Southern Dry Zone of Karnataka)

- Custard apple based agri-horti system
- Amla based agri-horti system

Faizabad (Eastern Plain Zone of Uttar Pradesh)

- Pigeonpea + maize (1:1) intercropping system

Jagdalpur (Bastar Plateau Zone of Chhattisgarh)

- Multi-storey method of nursery raising in rice

Parbhani (Marathwada Region of Maharashtra)

- Application of cetyl alcohol @ 20 mg/m^2 after every 10 days for minimization of evaporation from farm ponds

Rewa (Baghelkhand Region of Madhya Pradesh)

- Chickpea + linseed (4:2) intercropping system

Vijayapura (Northern Dry Zone of Karnataka)

- Optimum crop geometry (120 cm x 45 cm) and nutrient management (60:30:30 kg NPK/ha) for higher productivity of Bt cotton

8. Scientists as Resource Persons

a) Developing and dissemination of contingency crop plans

Centre	Participation in SAU level weather watch group meeting	Participation in State/ Dist level contingency plan meetings with line department	On station demonstration of contingency plan on real time basis	On farm demonstration of contingency plans in ORP and other villages though line departments and KVK adopted villages	Dissemination of contingency plans through radio, television and press/video conference	Contribution of weekly crop advisories/articles on cropping with drought in the local language news papers	Production and distribution of late planting varieties through seed project
Agra	-	√	√	√	√	-	-
Akola	√	√	√	-	-	-	-
Anantapuramu	√	√	√	√	√	√	--
Arjia	√	√	√	√	√	√	√
Bengaluru	√	√	√	√	√	√	√
Vijayapura	√	√	√	√	√	√	-
B Saunkhri	√	√	√	√	√	√	-
Chianki	√	√	√	√	√	√	√
Faizabad	-	-	√	-	√	-	-
Hisar	√	√	√	√	√	√	√
Indore	√	√	√	√	√	√	√
Jagdalpur	√	√	√	√	√	√	√
B. Chariali	-	-	-	-	-	-	-
Kovilpatti	√	√	√	√	√	√	√
Parbhani	√	√	√	√	√	√	√
Phulbani	-	√	√	√	-	√	-
Rajkot	√	√	√	√	√	√	√
Rakh Dhiansar	-	√	√	-	-	-	-
Rewa	√	√	√	√	√	√	√
SK Nagar	-	-	-	-	-	-	-
Solapur	√	√	√	√	√	√	√
Varanasi	-	-	-	-	-	-	-
Anantapuramu (ORP)	-	-	-	-	-	-	-
Arjia (ORP)	-	-	-	-	-	-	-
Bengaluru (ORP)	-	-	-	-	-	-	-
Hisar (ORP)	-	-	-	-	-	-	-
B. Saunkhri (ORP)	-	-	-	-	-	-	-
Indore (ORP)	√	√		√	√	√	√
Chianki (ORP)	-	-	-	-	-	-	-
Solapur (ORP)	-	-	-	-	-	-	-

b) Radio talks

Centre	Resource person	No. of radio talks
Anantapuramu	B. Ravindranath Reddy	1
	M. Vijaya Sankar Babu	2
	A. Malliswara Reddy	2
	P. Srivalli	1
Bengaluru	B.K. Ramachandrappa	1
	Mudalagiriyappa	1
	R. Krishna Murthy	3
Chianki	D.N. Singh	2
Faizabad	Neeraj Kumar	2
Indore	M.P. Jain	2
	D.H. Ranade	2
	O.P. Girothia	1
	A. Upadhyay	1
Jagdalpur	Adikant Pradhan	2
Kovilpatti	V. Sanjivkumar	1
Parbhani	G.K. Gaikwad	2
Rakh Dhiansar	A.P. Singh	1
	Jai Kumar	1
	Vikas Abrol	1
Rewa	D.P. Dubey	1
	S. Pandey	1
Anantapuramu (ORP)	C. Radha Kumari	2
Bengaluru (ORP)	M.N. Thimmegowda	3

c) TV talks

Centre	Resource person	No. of TV talks
Arjia	J. K. Balyan	1
	A.K. Kothari	3
Bengaluru	B.K. Ramachandrappa	2
	Mudalagiriyappa	1
Chianki	D.N. Singh	1
Faizabad	Neeraj Kumar	1
Jagdalpur	Adikant Pradhan	1
Parbhani	B.V. Asewar	3
	A.K. Gore	1
	M.S. Pendke	1
	G.K. Gaikwad	1
Bengaluru (ORP)	M.N. Thimmegowda	3
	K. Devaraja	1
Indore (ORP)	D.H. Ranade	1

9. Workshops and Trainings

9.1 Workshops/Group meetings/Brainstorming etc. organized

PC Unit

9.1.1 Technical Workshop of AICRPDA-NICRA

A Two day Technical Workshop of AICRPDA-NICRA was held at ICAR-CRIDA during 26-27 May, 2017, with the objective to review the overall progress of the centres and to develop technical programme for next phase of NICRA (2017-20). Dr. S. Bhaskar, ADG (AAF&CC), NRM Division, ICAR, Dr. K. Sammi Reddy, Director (Acting), ICAR-CRIDA, Dr. G. Ravindra Chary, Project Coordinator (Dryland Research), Dr. M. Prabhakar, PI (NICRA), Dr. P. Vijaya Kumar, PC, AICRPAM, Dr. M. Maheswari, Head, DCS, and Heads of KVK and sections & scientists from CRIDA and Chief scientists/ scientists from 23 AICRPDA Centres participated.

Dr. Bhaskar appreciated the contributions of AICRPDA centres in location-specific real time contingency technologies to cope with weather aberrations, their validation and implementation in farmers' fields. Dr. Bhaskar suggested that the main challenge in rainfed farming is management of midseason drought, and suggested to develop/refine technologies for a) efficient utilization of farm pond water, b) foliar sprays, and c) soil management to cope with midseason drought. Dr. K. Sammi Reddy, Director, ICAR-CRIDA emphasized the need for focused work under AICRPDA-NICRA programme and also suggested to bring out experiences from real-time contingency plan implementation during 2011-17, and also publish the results in reputed journals. Dr M Prabhakar PI (NICRA) suggested to bring out flyers/short video films of successful technologies. Dr. G. Ravindra Chary, Project Coordinator (Dryland Research), while welcoming the participants, briefed about the aim of the workshop and presented the overall progress of AICRPDA-NICRA. The major recommendations of the workshop were to take up two common

Dr. S. Bhaskar, ADG (A, AF & CC) addressing the participants on-station experiments across 23 AICRPDA centres: a) Studies on foliar sprays to cope with midseason drought, and b) Evaluation of crops/varieties under delayed onset of monsoon; the main focus of on-farm program 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; In addition to existing NICRA villages, the program would be expanded to adjoining villages with focus on demonstration of low cost rainfed technologies; 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 RCPs from AICRPDA-NICRA villages will be up-scaled in AICRPAM-NICRA villages by the AICRPAM; 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.

9.1.2 XVI Working Group Meeting of AICRPDA

The XVI Working Group Meeting of All India Coordinated Research Project for Dryland Agriculture (AICRPDA), ICAR-CRIDA was organized at AICRPDA centre, Jagdalpur, IGKV, Chhattisgarh during 1st to 5th February 2018 with the main objective to critically review the progress at 19 main, 3 sub, 5 voluntary and 8 ORP centres and finalize technical programme for 2018-19. During the inaugural session, Shri Kedar Kashyap ji, Hon'ble Education Minister, Govt. of Chhattisgarh was the chief guest, Dr. S.K. Patil, Hon'ble Vice Chancellor, IGKV presided and other dignitaries present were Shri Anoop Shrivastava, IAS, Secretary, Agriculture, Govt. of Chhattisgarh, Dr. J.C. Katyal , Hon'ble Chairman, and members (Dr. V.M. Mayande, Dr. A.M. Shekh, Dr.V.S. Korikanthimath, Dr. Gorantiwar) of VII QRT (CRIDA-AICRPDA-AICRPAM), Dr. S. Bhaskar, ADG (Agronomy, Agroforestry & Climate Change), NRM Division, ICAR, Dr. M.B. Chetti, ADG (HRD), Education Division, ICAR & Governing Body Member, IGKV, other GB members of IGKV, Dr. K. Sammi Reddy, Acting Director, CRIDA, Dr. G. Ravindra Chary, Project Coordinator, AICRPDA, Dr. P. Vijaya Kumar, Project Coordinator, AICRPAM, Dr. M. Maheswari, Head, Division of Crop Sciences, Dr. M. Osman, Head, PME Cell, CRIDA, public representatives from Bastar region and district officials. The participants included scientists from PC Unit, AICRPDA, CRIDA, 19 main, 3 sub, 8 ORP and 5 voluntary centres of AICRPDA centres, 4 centres of AICRPAM, IGKV, AICRPs at Jagdalpur and KVKs in Bastar region and importantly, the farmers including women farmers from Bastar region.

Felicitation of Best Dryland Formers

On the occasion, Shri Kashyap ji, Hon'ble minister and dignitaries felicitated 13 best dryland farmers from various states for their efforts in adoption and popularizing the improved rainfed technologies, released 19 publications brought out by PC unit, AICRPDA and AICRPDA centre. Shri Kedar Kashyap ji inaugurated an exhibition highlighting the doable technologies/practices from AICRPDA centre, Jagdalpur, other AICRPs in IGKV, and KVKs in Bastar region for the benefit of rainfed farmers from various states and other stakeholders involved in rainfed agriculture research and development.

This was followed by technical sessions on progress review and technical programme development. A focused discussion was also held on CRIDA-AICRPDA collaborative project on 'Development of microbial consortia for drought tolerance in rainfed crops'; collaborative research and strengthening rainwater management and farm mechanization research, and collaborative program of AICRPDA-AICRP on Cotton on evaluation of high density planting system of cotton in diverse rainfed agro-ecologies.

The participants visited on-farm interventions in Tahkapal village, Bastar district adopted by AICRPDA centre, Jagdalpur and interacted with the farmers. The major outcome of the deliberations during the meeting include finalization of technical programme 2018-19 at centres, and initiated new collaborative research with CRIDA, AICRPAM, AICRP on Cotton, ICAR-CICR and AICRP on Agroforestry.

9.2 Workshop/Conferences/Seminars participated

Workshop/Conference/Seminar	Date	Venue	Participants
Ballowal Saunkhri			
Tools on Monitoring Evaluation & Impact Assessment of Rainfed Technologies and Agricultural Development Programmes	1 October, 2017	CRIDA, Hyderabad	Parminder Singh Sandhu
Bengaluru			
ZREP workshop zone-6	6-7 April, 2017	V.C. Farm, Mandya	B.K. Ramachandrappa
Bi-monthly review meeting of FOR-2432 Indo-German project	12 April, 2017	Ajit premji University	B.K. Ramachandrappa
ZREP workshop zone-5	18-20 April, 2017	UAS, GKVK, Bengaluru	B.K. Ramachandrappa
47th Annual Group Meeting of AICRP on Sorghum	22 April, 2017	UAS, GKVK, Bengaluru	B.K. Ramachandrappa
Climate Smart Agriculture Meeting	18 May, 2017	UAS, GKVK, Bengaluru	B.K. Ramachandrappa
Workshop on doubling farmers income	16 June, 2017	UAS, GKVK, Bengaluru	M.N. Thimmegowda
Workshop on doubling farmers income	20 June, 2017	KSDA, Bengaluru	M.N. Thimmegowda
International conference on silicon	24-28 December, 2017	UAS, GKVK, Bengaluru	R. Krishna Murthy
Impact of fertilizer policy on soil heath governance	23 February, 2018	FAI KSDA, Bengaluru	M.N. Thimmegowda B.G. Vasanthi
District drought proofing actions plan workshop	27-28 February, 2018	Vikas Soudha, Bengaluru	Mudalagiriyappa M.N. Thimmegowda
National conference on drought proofing strategies	8-9 March, 2018	Le meridian Hotel, Bengaluru	Mudalagiriyappa M.N. Thimmegowda
Biswanath Chariali			
National Semiar on climate change and sustainable development with special focus on North East India	17-18 May, 2017	Nagaland University	P.K. Sarma
Mid-term evaluation of contingency plan	01 December, 2017	BNCA, Biswanath Chariali	P.K. Sarma, D. Sarma
Mid-term evaluation of contingency plan	13 December, 2017	AAU, Jorhat	P.K. Sarma

Workshop/Conference/Seminar	Date	Venue	Participants
Kovilpatti			
National Conference on Agricultural Scientific Tamil	12-13 August, 2017	TNAU, Coimbatore	V. Sanjivkumar S. Elamathi
Rajkot			
National Conference on Developing Climate Services: along with weather forecasting for building climate smart farmers	20 June, 2017	AAU, Anand	V.D. Vora
Third International Conference on Bioresource and Stress Management	8-11 November, 2017	Jaipur	V.D. Vora, G.R. Sharma, G.S. Sutaria and P.D. Vekaria
International seminar on Global Climate Change: Implications for Agriculture and Water Sectors	8-11 November, 2017	State Institute of Agriculture Management, Jaipur, Rajasthan	G.B. Vekaria, G.S. Sutaria, V.D. Vora, M.M. Talpada and P.D. Vekaria
Solapur			
4th National Conference on Water, Environment & Society (NCWES - 2017)	16 - 18 March, 2017	JNTU, Hyderabad	S. K. Upadhye
State Level Seminar of Indian Society of Soil Science	7-8 October, 2017	VNMKV, Parbhani	N. B. More, R. M. Gethe
National Seminar on Recent Trends in Plant Sciences and Agriculture Research	9-11 January, 2018	ZARS, Solapur	V. M. Amrutsagar, N. B. More, R. M. Gethe, B. R. Najan, A. B. Pawar, M. S. Patil, A. D. Devkar
International conference on Doubling farmers income through innovative approach	9-11 April, 2018	KVK, Baramati	V. M. Amrutsagar, N. B. More, B. R. Najan
Vijayapura			
National Water convention on Drought free India	16-18 August, 2017	Office of District Collector & Jalbiradari	M.S. Shirahatti V. S. Surakod
National workshop on RS & GIS application in Agroforestry	15-16 September, 2017	UAS, Dharwad	M.S. Shirahatti
Workshop on drought mitigation action plan for northern Karnataka districts	1 November, 2017	Bagalkot	M.S. Shirahatti
Workshop on drought mitigation action plan for 16 districts of Karnataka	27-28 February, 2018	Vikassoudha, Bangalore	M.S. Shirahatti V.S. Surakod
National conference on drought management strategies	8-9 March, 2018	KSDMC, Bangalore	M.S. Shirahatti V.S. Surakod

9.3 Trainings attended

Title	Date	Venue	Participants
Arjia			
Production of Bio-CNG and Organic Manure through Anaerobic Agro-waste Decomposition Techniques.	10-30 August, 2017	DFRS, Arjia, Bhilwara	J. K. Balyan
Organic Farming	05-29 December, 2017	Directorate of Research, MPUAT, Udaipur	R.K. Sharma
Ballowal Saunkhri			
Modeling and Advances in micro-irrigation for enhancing the crop water use efficiency	05-25 July, 2017	SKUAST-Kashmir	Abrar Yousuf
Effective Teaching, Research and Extension	07-17 November, 2017	PAU, Ludhiana	Abrar Yousuf

Title	Date	Venue	Participants
Bengaluru			
Water productivity assessment for improved irrigation performance and water security using remote sensing and GIS in Karnataka	9-13 October, 2017	Bengaluru	M.N. Thimmegowda
Biswanath Chariali			
Arsenic & Fluoride removal from groundwater	24-25 February, 2018	Tezpur University, Tezpur	Palakshi Borah
Wheat Blast Screening and Surveillance Training (International)	24 February to 5 March, 2018	CIMMYT, Mexico	M.K. Sarma
Awareness cum Training programme on Quality Seed Production of Wheat and Barley for enhancing adoption of new varieties	12 March, 2018	BNCA, Biswanath Chariali	D. Sarma
Faizabad			
Crop Management Strategies for Augmenting Farmers Income	13 September to 5 October, 2017	GBPUA&T, Pantnagar	Neeraj Kumar
Indore			
Tools and monitoring, Evaluation and Impact assessment of Rainfed technology and Agriculture Development	01-10 November, 2017	CRIDA, Hyderabad	O.P. Girothia, and A. Upadhyay
Climate Smart Agriculture Machinery for Conservation Agriculture	06-26 November, 2017	ICAR-CIAE, Bhopal	D.V. Bhagat
Environmental Education and Disaster Management	03-23 January, 2018	DAVV, Indore	D.V. Bhagat
Environmental Education and Disaster Management	03-23 January, 2018	DAVV, Indore	Swati Barche
Rajkot			
Proper handling of mini soil testing machine	18-22 May, 2017	ATARI, Jodhpur	D.S. Hirpara
Rakh Dhiansar			
Capacity development program on behavioral adaptation with climate change in Himalayan region	19-23 June, 2017	HIPA, Shimla	A. P. Singh
Production of bio-CNG and organic manure through anaerobic agro waste decomposition techniques	10-30 August, 2017	DFRS, MPUAT, Bhilwara	Brinder Singh
Training program on mustard	10-17 January, 2018	AICRP on Mustard, Bharatpur	Jai Kumar
Vijayapura			
Induction Training Course for Newly Recruited Assistant Professor Cadre Post of UAS Dharwad	24 April to 06 May, 2017	UAS, Dharwad	U.M. Momin
Protected Cultivation with Special Reference to Soilless Cultivation, Hydroponics and Aeroponics	09-29 January, 2018	UAS, Dharwad	U.M. Momin
Arjia (ORP)			
Organic Agriculture Intensification	22 November, 2017 to 12 December, 2017	CAFT Centre, DOR, MPUAT, Udaipur	R.K. Sharma
Ballowal Saunkhri (ORP)			
Organic Production Management: Approaches and Practices	11 September, 2017 to 01 October, 2017	MPUAT, Udaipur	Parminder Singh Sandhu

Title	Date	Venue	Participants
Toolson Monitoring Evaluation & Impact Assessment of Rainfed Technologies and Agricultural Development Programmes	1-10 November, 2017	ICAR-CRIDA, Hyderabad	Parminder Singh Sandhu
Hisar (ORP)			
Waste to Wealth: Biocompost Production and Utilization Innovations in Organic Agriculture	10-30 August, 2017	ICAR-IARI, New Delhi	S.K. Sharma
Enhancing the Productivity of Rainfed Agro-Ecosystem through Suitable Interventions	14 December 2017 to 3 January, 2018	Dryland Farming Research Station, Arjia, Bhilwara	S.K. Sharma

9.4 Trainings/Field days organized

Title	Date	Venue	Participants
Akola			
One day farmer's training programme	29 March, 2018	AICPRDA centre, Akola	40 farmers
Anantapuramu			
Pigeonpea plant protection and cultivation aspects	20 November, 2017	AICRPDA centre, Anantapuramu	30 farmers
Kisan Diwas	15 February, 2018	AICRPDA centre, Anantapuramu	95 farmers
Farmers awareness programme on climate change	23 May, 2018	AICRPDA centre, Anantapuramu	45 farmers
Arjia			
Improved practices to enhance *kharif* crops production	25-26 July, 2017	AICRPDA centre, Arjia	25 farmers
Improved practices to enhance oilseed crops production	8-9 August, 2017	AICRPDA centre, Arjia	30 farmers
Farmers-Scientist *Sangosthi* on Climate Resilient Contingent crop planning	14 August, 2017	Bhilwara	208 farmers
Improved practices to enhance Pulses crops production	14-15 September, 2017	AICRPDA centre, Arjia	28 farmers
Improved practices to enhance *kharif* crops production	25-26 September, 2017	AICRPDA centre, Arjia	26 farmers
Pre-seasonal training on post-harvest technology of *rabi* crops.	5 October, 2017	Bhilwara	26 farmers
Improved crop production technologies to enhance *rabi* crops production	5-6 October, 2017	AICRPDA centre, Arjia	30 farmers
Farmers' Scientist interaction on *rabi* crop production technology	14 October, 2017	AICRPDA centre, Arjia	26 farmers
Field day on improved growing practice of Horsegram	15 October, 2017	Bhilwara	65 farmers
Improved crop production technologies to enhance *rabi* pulses production	2-3 November, 2017	AICRPDA centre, Arjia	30 farmers
Improved crop production technologies to enhance *rabi* oilseeds production	16-17 November, 2017	AICRPDA centre, Arjia	35 farmers
Improved management practices for alternative land use in dryland areas	20-21 November, 2017	AICRPDA centre, Arjia	25 farmers

Title	Date	Venue	Participants
Improved crop production technologies to enhance *rabi* crops production	4-5 December, 2017	AICRPDA centre, Arjia	30 farmers
Improved crop production technologies to enhance *rabi* pulses production	7-8 December, 2017	AICRPDA centre, Arjia	30 farmers
Improved crop production technologies to enhance *rabi* oilseeds production	9-10 January, 2018	AICRPDA centre, Arjia	28 farmers
Improved seed production technologies of cereals to enhance *rabi* crops production	23-24 January, 2018	AICRPDA centre, Arjia	28 farmers
Improved seed production technologies of pulsed to enhance *rabi* crops production	23-24 February, 2018	AICRPDA centre, Arjia	30 farmers
Improved seed production technologies of pulsed to enhance oilseed crops production	12-13 March, 2018	AICRPDA centre, Arjia	25 farmers
Improved crop production technologies to enhance *rabi* crops production.	14-15 March, 2018	AICRPDA centre, Arjia	28 farmers
Ballowal Saunkhri			
Five day training on propagation and production of horticultural crops	22-26 May 2017	AICRPDA centre, Bal-lowal Saunkhri	20 Farm women from Bharmour, Himachal Pradesh
Hisar			
Agro-techniques for higher yield of *kharif* crops	4 July, 2017	AICPRDA centre, Hisar	48 farmers
Agro-techniques for higher yield of *rabi* crops	13 October, 2017	AICPRDA centre, Hisar	61 farmers
Importance of water harvesting in dryland areas	21April, 2018	AICPRDA centre, Hisar	100 farmers
Indore			
Importance of IFS	24 March, 2018	Barwani	35 farmers
Jagdalpur			
Nursery technique for vegetables	12 November, 2015	Tahkapal village, Bastar district	11 farmers
PHT at village	23 December, 2015	Tahkapal village, Bastar district	23 farmers
Kovilpatti			
Improved management practices on dryland crops	23 March, 2018	AICRPDA centre, Kov-ilpatti	40 farmers
Parbhani			
Improved agronomic practices for rainfed crops	March 30, 2018	Village Ujalamba, Tq. & Dist. Parbhani	25 farmers
Rakh Dhiansar			
Improved agro practice in rainfed agriculture	28 March, 2017	AICRPDA centre, Rakh Dhiansar	45 farmers
Vijayapura			
Preparedness for the *rabi* crops	13 September, 2017	AICPRDA centre, Vi-jayapura	100 farmers
Skill training for the rural youth soil conservation	5-10 March, 2018	AICPRDA centre, Vi-jayapura	25 farmers
Dryland practices for the sustainable agriculture	23 March, 2018	AICPRDA centre, Vi-jayapura	100 farmers

Title	Date	Venue	Participants
Anantapuramu (ORP)			
Improved dryland technologies	15 February, 2018	Yerraguntlapalli village, Kurnool district	58 farmers
Improved dryland technologies to combat climate change	23 May, 2018	Yerraguntlapalli village, Kurnool district	73 farmers
Arjia (ORP)			
Improved dryland technologies	23 June, 2017	Newariya, Rashmi, District	67 farmers
Farmer's scientist interaction cum training on rainwater management	05 October, 2017	Newariya, Rashmi, District	36 farmers
Bengaluru (ORP)			
One day *kharif* planning meeting cum Training and launching of new ORP site	29 May, 2017	Baichenahall and Iraksandra Village, Tumkur district	58 farmers
Chianki (ORP)			
Krishak Gosthi	09 February, 2017	Gonda village, Garhwa district	85 farmers
Krishak Gosthi on *rabi* crops management	09 February, 2017	Gonda village, Garhwa district	83 farmers
Management of *rabi* crops	28 February, 2017	Gonda village, Garhwa district	82 farmers
Krishak Gosthi on *rabi* crops management	28 February, 2017	Gonda village, Garhwa district	85 farmers
Training cum *kharif* seed distribution	07 July, 2017	Gonda village, Garhwa district	370 farmers
Training cum *rabi* seed distribution	15 November, 2017	Gonda village, Garhwa district	265 farmers
Krishak Gosthi on *rabi* crops management and animal protection	29 November, 2017	Gonda village, Garhwa district	44 farmers
Training on protected cultivation	21 January, 2018	Gonda village, Garhwa district	35 farmers
Production of vegetables under protected cultivation	23 February, 2018	Gonda village, Garhwa district	50 farmers

Field day at AICRPDA centre, Hisar

One day farmers' training at AICPRDA centre, Akola

SUCCESS STORIES

10. Success Stories

Ananthapuramu

Sowing of groundnut + pigeonpea intercropping (8:2) with tractor drawn planter

1.	Name of the farmer	:	**Sri. G. Prabhakar Reddy**	
2.	Address	:	Village- Y. Kothapalli; Post- Y. Kothapalli; Tehsil-Atmakur; District- Ananthapuramu; State- Andhra Pradesh	
3.	Contact details	:	9951473669	
4.	Details of the farm	:	5 acres (dryland)	
5.	Membership in Self-Help Group, Producers Cooperative/ Company, Cooperative Society, *etc*.,	:	SHG	
6.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	Utilized services of custom hiring center of AICRPDA *Kharif*, 2017	
7.	Technologies / Good Agricultural Practices / facilities / benefits obtained	:	Sowing of groundnut and pigeonpea (8:2) with intercropping planter	
8.	Details of results obtained due to the adoption of technologies	:	**Improved production technologies**	**Traditional production practices**
	Productivity (q/ha)	:	Groundnut-18.35 Pigeonpea-5.24	Groundnut-15.0 Pigeonpea-2.5
	Cost of production (Rs/ha)	:	15235	18000
	Net income (Rs/ha)	:	70888	17584
	Price realized (Rs/q)	:	Groundnut-4200 Pigeonpea-4500	Groundnut-4200 Pigeonpea-4500
	Natural resources saved /conserved like soil, water *etc*.	:	Soil moisture	-
9	Marketing strategy	:	Private	
10.	Factors contributing to success	:	Used recommended seed rate (95 kg groundnut and 5 kg pigeonpea/ha) through intercropping planter which enabled to maintain optimum plant population /m^2	

Arjia

b. Yellow seeded improved maize variety PEHM-2

1.	Name of the farmer	:	**Sri. Ramjas Sharma** s/o Sh. Sohan Lal Sharma	
2.	Address	:	Village Newariya; Post- Newariya; Tehsil-Rashmi; District- Chittorgarh; State: Rajasthan	
3.	Details of the farm	:	0.4 ha, Rainfed	
4.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	ACRIPDA, 2016-18	
5.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained	:	Adoption of yellow seed variety PEHM-2 of maize along with ridging after sowing (30 DAS) increased the net returns by 38.3% over traditional practice.	
6.	Details of results obtained due to the adoption of technologies		**Improved production technologies**	**Traditional production practices**
	Maize variety PEHM-2			
	Productivity (kg/ha)	:	3050	2115
	Cost of production (Rs.) for 0.4 ha	:	6744	5988
	Net income (Rs/ha) for 0.40 ha	:	11556	6702
	Price realized (Rs./kg)	:	15.0	15.0
7.	Marketing Strategy – Access to market	:	Local market	
8.	Factors contributing to success	:	Improved variety with package of practices	

Chianki

Pigeonpea + okra intercropping system (1:1)

1.	Name of the farmer	:	**Sri. Parsuram Kushwaha**	
2.	Address	:	Village- Gonda, Post-Bana, Tehsil-Meral District-Garhwa, State- Jharkhand	
3.	Contact details	:	09955173943	
4.	Details of the farm	:	8 acres of arable land	
5.	Membership in Self-Help Group, Producers Cooperative/ Company, Cooperative Society etc.,	:		
6.	Name of the control sector/sheets schemes utilized by the farmer and the period:	:	AICRPDA, 2017 – 18	
7.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained	:	Piogeonpea based intercropping systems (Pigeonpea + okra, Pigeonpea + maize)	
8.	Details of results obtained due to the adoption of the technologies			
	Name of the technology / technologies adopted: Cultivation of hybrid okra with improved package of practices		**Improved production technologies**	**Traditional production practices**
	Productivity (kg/ha)	:	14000	7000
	Cost of production (Rs/ha)	:	22600	18000
	Net income (Rs/ha)	:	190200	85200
	Price realized (Rs/ton)	:	13058	12017
	Natural resources saved /conserved like soil, water etc.	:	Rainwater	-
	Impact of the adopted technology to other farmers in the village		Farmers know about important of conservation of rainwater and quality	
9.	Factors contributing to success	:	Quality seed of high yielding variety and adoption of improved package and practices	

Bengaluru

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

1.	Name of the farmer	:	**Sri Veeranna** S/o Ramaiah			
2.	Address	:	Village- Baichenahalli; Post- Elerampura; Tehsil- Kortagere taluk; District- Tumakuru; State- Karnataka			
3.	Details of the farm	:	4.00 ha; Rainfed			
4.	Membership in Self-Help Group, Producers Co-operative/ Company, Cooperative Society etc.	:	Member of milk producers co-operative society, Baichenahalli			
5.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	ORP, AICRPDA			
6.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained	:	Fingermillet + pigeonpea (8:2) cropping system			
7.	Details of results obtained due to the adoption of technologies	:	**Improved production technologies**		**Traditional production practices**	
	Productivity (kg/ha)	:	Finger millet	Pigeonpea	Finger millet -1915 Pigeonpea- 83, Castor-75, Sorghum-47, Field bean-35, Cowpea-43, Sesamum-12	
			2677	967		
	Cost of production (Rs/ha)	:	27391		28106	
	Net income (Rs/ha)	:	128203		31709	
	B:C ratio		5.68		2.13	
	Price realized (Rs/ton)	:	Finger millet	Pigeonpea	Finger millet	Pigeonpea
			22000	40000	22000	40000
	Natural resources saved /conserved like soil, water etc.	:	Soil and water		-	
8.	Marketing Strategy – Access to market	:	Private and co-operative marketing			
9.	Factors contributing to success	:v	Opening moisture conservation furrow between paired rows of pigeonpea, acts as *in-situ* water harvesting structure, better utilization of natural resources, improved soil health and fertility and serve as insurance for weather aberrations.			

b. Improved fingermillet varieties

1.	Name of the farmer	:	**Sri.Nagarajaiah,** S/o Late Bheemaiah
2.	Address	:	Village- Baichenahalli; Post- Elerampura; Tehsil- Kortagere; District- Tumakuru; State- Karnataka
3.	Details of the farm	:	4.0 ha, Rainfed Baichanahalli
4.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	ORP, AICRDPA, 2015-17
5.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained	:	Improved fingermillet varieties
6.	Table. Details of results obtained due to the adoption of technologies		

Variety	Yield (kg/ha)		Returns (Rs/ha)		B:C ratio
	Grain	Straw	Gross	Net	
Long duration varieties					
MR-1	2295	5987	54980	29774	2.12
Medium duration varieties					
GPU-28	2458	6115	58662	33456	2.33
Short duration variety					
GPU-48	2369	5162	55990	30784	2.22
Local	1975	4023	46467	21261	1.84
Price realized (Rs/ton)		Grain	Straw	Grain	Straw
		22000	750	22000	750

7. Marketing strategy – Access to market : Private and co-operative marketing
8. Factors contributing to success : Selection of variety according to the sowing window

c. Pigeonpea + field bean (1:1) intercropping system

1. Name of the farmer : **Sri. Venkatesh**, s/o Bandappa
2. Address : Village- Baichenahalli; Post- Elerampura; Tehsil- Kortagere; District- Tumakuru; State - Karnataka
3. Details of the farm : 0.4 ha, rainfed
4. Technologies / Good Agricultural Practices / Facilities / Benefits obtained : Pigeonpea + fieldbean (1:1) intercropping system
5. Details of results obtained due to the adoption of technologies :

	Improved production technologies	Traditional production practices
Productivity (kg/ha)	778 - Pigeonpea 198 – Field bean	746 – Pigeonpea
Cost of production (Rs/ha)	30264	27574
Net income (Rs/ha)	58426	47026
B:C ratio	2.93	2.70
Price realized (Rs/ton)	Pigeonpea- 100000 Field bean– 55000	Pigeonpea sole- 100000

6. Marketing strategy – Access to market : Private and co-operative marketing
7. Factors contributing to success : Efficient use of available natural resources

Indore

a: Sowing of soybean in BBF with modified seed drill (attached with ditcher)

1.	Name of the farmer	:	**Raju Upmanyu**	
2.	Address	:	Village- Bisakhedi; Post – Kadwali; Tehsil- Sanwer; District-Indore; State- Madhya Pradesh	
3.	Contact details	:	7089157782	
4.	Details of the farm	:	3.75 ha	
5.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	AICRPDA-NICRA (2016-18)	
6.	Details of results obtained due to adoption rainfed technology			
	Name of the technology/technologies adopted	:	Sowing of soybean in BBF with modified seed drill (attached with ditcher)	
			Improved technology	**Traditional practice**
	Productivity (kg/ha)	:	1250	110000
	Cost of production (Rs/ha)	:	20000	18000
	Net income (Rs/ha)	:	17500	15000
	Price realized (Rs./ton)	:	30000	30000
	Natural resources saved /conserved like soil, water etc.	:	Soil and water	-

b. Water harvesting tank for storing runoff water and efficient use in *rabi* crops

1.	Name of the farmer	:	**Sri. Vasudeo**
2.	Address	:	Village- Gaddukhedi; Post- Gaddukhedi; Tehsil- Dewas; District- Dewas; State- Madhya Pradesh
4.	Details of the farm	:	10 ha, Open and tube well
6.	Names of central sector/state schemes utilized by the farmers and the period		ORP, AICRPDA (2010-18)
7.	Technologies / good agricultural practices / facilities / benefits obtained	:	Water harvesting tank constructed for storing runoff water. The runoff water would help the farmer to utilize it during the moisture stress period.
8.	Details of results obtained due to the adoption of technologies: The activity made possible to bring additional 7 ha in wheat, 2 ha in chickpea and 1 ha under other crops and allowed farmer to diversify his cropping pattern and could grow potato, summer maize, vegetables and sweet potato. Similarly, the area under wheat increased than chickpea because of increased water availability for sufficient irrigation.		
9.	Natural resources saved/conserved like Soil, water.	:	Soil loss reduced drastically, water storage increased and recharged groundwater
10.	Factors contributing to success	:	Additional water availability and more area under irrigation

Jagdalpur

a. Year round vegetable cultivation with pace of market demand

1.	Name of the farmer	:	**Shri. Bhola** S/O Shri Ganpat	
2.	Address	:	Village- Tahkapal; Post- Karanji; Tehsil- Tokapal; District- Bastar; State- Chhattisgarh	
3.	Details of the farm	:	4.50 acres	
4.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	AICRPDA (2015 -17)	
5.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained with details	:	Improved production technologies	
6.	Details of results obtained due to the adoption of technologies	:	**Improved production technologies**	**Traditional production practices**
	Cost of production (Rs/ha)	:	300000	195000
	Net income (Rs/ha)	:	350000	215000
	Price realized (Rs/ton)	:	7000	3000
	Natural resources saved/conserved like soil, water etc.	:	Rainwater	-
	Product quality improvement	:	-	-
7.	Marketing strategy – Access to market	:	Local market	
8.	Factors contributing to success	:	He understood the system of cultivation and timeliness by using this intervention he is earning more than 3.00 lakh rupees per annum.	

Cabbage crop

Parbhani

Intercropping of soybean + pigeonpea (4:2) and stress management during mid-season drought in soybean

1.	Name of the farmer	:	**Vitthal Manikrao Dalve**
2.	Address	:	Village- Bhabhulgaon; Taluk- Parbhani; District- Parbhani; State- Maharashtra
3.	Contact details	:	09921071183
4.	Details of the farm	:	7.25 ha, Open bore well, farm pond
5.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	Farm pond under ***Jalyukt Shiwar Abhiyan***, sericulture, Shadenet technology for production of tomato, Gobar gas plant
6.	Other rainfed technologies / Good Agricultural Practices / Facilities / Benefits obtained	:	Adopted artificial well recharge model and used modern tools and implements from custom hiring centre (seed cum ferti drill, stubble collector, ridger).

7.	Details of results obtained due to adoption rainfed technology			
	Technology –I- Intercropping system		**Improved production technologies**	**Traditional production practice**
	Productivity (kg/ha)	:	2438	1456
	Cost of production (Rs/ha)	:	24500	18272
	Net income (Rs/ha)	:	42545	21855
	Price realized (Rs/ton)	:	27500	27500
	Natural Resources saved /conserved like soil, water etc.	:	conserved soil and water by opening of conservation furrow	-
	Impact of the adopted technology to other farmers in the village	:	Many farmers visited the demonstration plot of intercropping and adopted in subsequent year	
	Technology –II : Stress management during mid-season drought		**Technology – II (KNO_3) spray in soybean**	**Traditional practice (- No spray**
	Productivity (kg/ha)	:	1574	1415
	Cost of production (Rs/ha)	:	20000	18487
	Net income (Rs/ha)	:	23285	20425
	Price realized (Rs/ton)	:	27500	27500
	Impact of the adopted technology to other farmers in the village		Other farmers adopted the spraying of KNO_3 for drought mitigation on their respective farms	
8.	Factors contributing to success	:	**Soybean + pigeonpea intercropping (4:2)** with *insitu* moisture conservation of opening of furrow after every 4 rows at 30 days after sowing with recommend fertilizer application as per soil analysis **Application of KNO_3:** The Foliar application of KNO_3 @ 1.0% at 35 DAS and @ 2.0% at 65-70 DAS to mitigate the mid-season drought increased the yield by 13% in soybean. **Dust mulching:** Three frequent hoeings in the month of July and August as dust mulching in soybean increased the yield by upto 15%.	

Rajkot

Preparation of compost from cotton stalk and its use in cotton cultivation

1.	Name of the farmer	:	**Sri. Jitendra Dhirubhai Vora**
2.	Address	:	Village- Shivrajgadh; Tehsil- Gondal; District-Rajkot; State - Gujarat
3.	Contact details	:	9924015503
4.	Details of the farm	:	2 ha, 1 ha irrigated, 1 ha partially irrigated
5.	Membership in Self-Help Group, Producers Co-operative/ Company, Cooperative Society etc.,	:	Member of Farmer's Cooperative Society of Shivrajgadh village
6.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	AICRPDA-NICRA
7.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained	:	Preparation of compost from cotton stalk and its use in cotton cultivation

8.	Details of results obtained due to the adoption of technologies	:	**Improved production technologies**	**Traditional practice**
	Productivity (kg/ha)	:	4000	2700
	Cost of production (Rs/ha)	:	35000	29977
	Net income (Rs/ha)	:	175000	105023
	Price realized (Rs./ton)	:	52500	50000
	Natural Resources saved /conserved like soil, water etc.	:	Improved soil fertility and productivity	-
	Product quality improvement	:	Improve whiteness of lint and its length	-
9.	Factors contributing to success	:	Availability of cotton stalks	

Solapur

a. Intercropping system of sunflower + pigeonpea (2:1)

1.	Name of the farmer	:	**Shri. Chandrakant Shantvirappa Patil**	
2.	Address	:	Village- Hanjagi; Post Hanjagi; Tehasil- Akkalkot; District- Solapur; State- Maharashtra	
3.	Contact Details	:	9921850328	
4.	Details of the farm	:	Size: 0.60 ha, Source of irrigation : Well	
5.	Membership in Self Help Group, producers co-operative/company, co-operative society, etc.	:	Member of co-operative society Hanjagi, Member of Sugar factory and Farmers-Scientist Club of ZARS, Solapur.	
6.	Names of the central sector / state scheme utilized by the farmer and the period	:	State Department of Agriculture; Operational Research Project (2006 onwards)	
7.	Technologies / good agricultural practices / facilities / benefits obtained with details	:	Intercropping of sunflower + pigeonpea (2:1) with improved package of practices, Seed treatment : Sunflower – *Azotobacter*, PSB, trichoderma Pigeonpea - *Rhizobium*, PSB, trichoderma Fertilizer (N:P2O5:K_2O kg/ha) – 50:25:0 IPM – Seed treatment, pheramone traps, Neem seed extract spray Cultivars: Sunflower – Bhanu, Pigeonpea – Vipula	
8.	Details of results obtained due to adoption of technologies	:	**Improved production technologies**	**Traditional production technologies**
	Productivity (q/ha) Sunflower	:	6.15	--
	Pigeonpea	:	8.20	10.50 (sole)
	Cost of production (Rs/ha)	:	10028	9106
	Net income (Rs/ha)	:	23471	17194
	Natural resources saved / conserved like soil, water, etc.	:	Soil	--
9.	Marketing strategy – Access to market	:	Private market	
10.	Factors contributing to success	:	Sound technology, motivation of the farmer, minimize risk under aberrant weather condition.	

b. In-situ moisture conservation with ridges and furrows for *rabi* sorghum

1.	Name of the farmer	:	**Shri. Mujgonda Shivanand Mudollappa**	
2.	Address	:	Village- Hanjagi; Post Hanjagi; Tehasil- Akkalkot; District- Solapur; State- Maharashtra	
3.	Details of the farm	:	Size: 0.40 ha, Source of irrigation : Well	
4.	Membership in Self Help Group, producers co-operative/company, co-operative society, etc.	:	Member of co-operative society, Hanjagi, Member of farmers-scientists club of MPKV, Rahuri, President of Krishi Vigyan Mandal, Hanjagi	
5.	Names of the central sector / state scheme utilized by the farmer and period	:	State Department of Agriculture, Operational Research Project (2006-2010)	
6.	Technologies / good agricultural practices / facilities / benefits obtained with details	:	*In-situ* moisture conservation through opening of ridges and furrows in *kharif* season. Use of improved cultivar of sorghum – M35-1 Fertilizer: 50:25:0 N:P_2O_5:K_2O kg/ha Seed treatment:Azotobacter, PSB, *Trichoderma*	
7.	Details of results obtained due to adoption of technologies	:	**Improved production technologies**	**Traditional production technologies**
	Productivity: Grain (q/ha)	:	8.36	6.00
	Fodder (q/ha)		23.06	16.00
	Cost of production (Rs/ha)	:	5560	4560
	Net income (Rs/ha)	:	7296	4540
	Price realized (Rs/q) Grain	:	850	850
	Fodder		250	250
	Natural resources saved / conserved like soil, water, etc.	:	35% more moisture conserved due to ridges and furrows	--
8.	Marketing strategy – Access to market	:	Private market	
9.	Factors contributing to success	:	*In-situ* moisture conservation (ridges and furrows) during *kharif* season, use of improved cultivar and fertilizer, and timely interculturing (three hoeings at 3, 5 and 8th weeks after sowing)	

c. Potassuum management in pearlmillet

1. Name of the farmer	:	**Shri. Shivanad Mudolappa Mujgonda**	
2. Address	:	Village- Hanjagi; Post Hanjagi; Tehasil- Akkalkot; District- Solapur; State- Maharashtra	
3. Contact details	:	9421025064	
4. Details of the farm (size, location, water availability, etc.)	:	Size : 0.8 ha, Source of irrigation : Well	
5. Membership in Self Help Group, producers co-operative/ company, co-operative society, etc.	:	Member of co-operative society,irrigation society President of Krishi Vigyan Mandal, Hanjagi, Member of farmers-scientists club of MPKV, Rahuri	
6. Names of the central sector / state scheme utilized by the farmer and the period	:	Operational Research Project (2006-2010)	
7. Technologies / good agricultural practices / facilities / benefits obtained with details	:	Application of 25 kg potash with recommended dose of NP (50:25 kg/ha) to pearlmillet with improved cultivar, Shradha.	
8. Details of results obtained due to adoption of technologies	:	**Improved production technologies**	**Traditional production technologies**
Productivity (q/ha)	:	7.80	6.40
Cost of production (Rs/ha)	:	5010	4500
Net income (Rs/ha)	:	1750	1000
Price realized (Rs/q)	:	750	750
Natural resources saved / conserved like soil, water, etc.	:	Increased moisture use efficiency	--
Product quality improvement	:	Higher number of grains and grain size	--
9. Marketing strategy – Access to market	:	Local market	

d. *In-situ* moisture conservation with compartment bund for higher yield of *rabi* sorghum

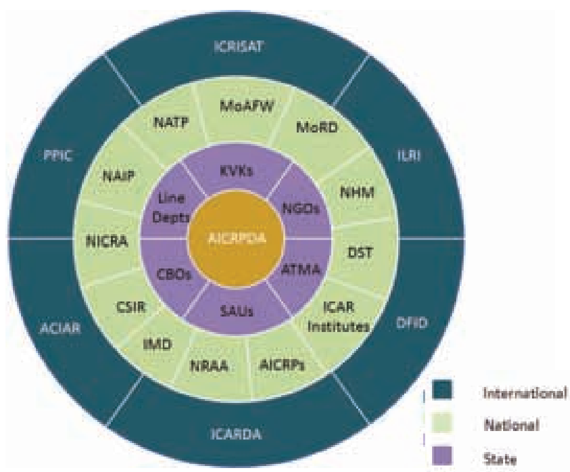
1.	Name of the farmer	:	**Shri. Vishwas Laxman Jadhav**	
2.	Address	:	Village- Hanjagi; Post Hanjagi; Tehasil- Akkalkot; District- Solapur; State- Maharashtra	
3.	Contact details	:	9960636537	
4.	Details of the farm	:	Size : 2.0 ha, Source of irrigation : Well	
5.	Membership in Self Help Group, producers co-operative/company, co-operative society, etc.	:	Member of co-operative society, Hanjagi	
6.	Names of the central sector / state scheme utilized by the farmer and the period	:	Operational Research Project (2006-2010)	
7.	Technologies / good agricultural practices / facilities / benefits obtained	:	Compartment bunding during *kharif* season having plot size 6 m x 6 m by Baliram plough on medium deep soil. Use of improved cultivar – M35-1 Fertilizer (NPK kg/ha) – 50:25:0 Seed treatment : *Azotobacter*, PSB, *Trichoderma*	
8.	Details of results obtained due to adoption of technologies	:	**Improved production technologies**	**Traditional production technologies**
	i) Productivity (q/ha) Grain	:	10.75	8.50
	Fodder		25.00	21.00
	ii) Cost of production (Rs/ha)	:	8000	5500
	iii) Net income (Rs/ha)	:	8200	6500
	iv) Price realized (Rs/q) Grain	:	1000	1000
	Fodder	:	300	300
	v) Natural resources saved / conserved like soil, water, etc.	:	Rainwater Reduced the soil erosion.	--
9.	Marketing strategy – Access to market	:	Private market	
10.	Factors contributing to success	:	*In-situ* moisture conservation during *kharif* season Use of improved cultivar and fertilizer Timely interculturing (three hoeings at 3, 5 and 8th weeks after sowing)	
11.	Any other relevant information	:	Useful on the medium deep soil	

COLLABORATION/ LINKAGES

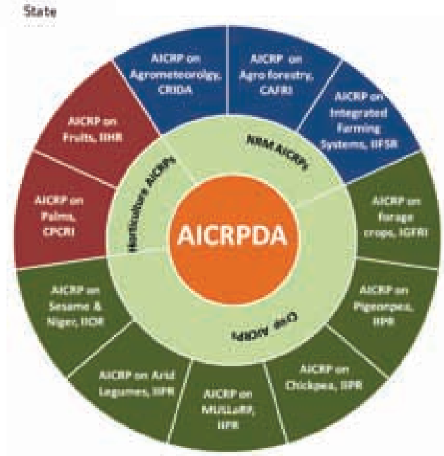
11. Collaboration/ Linkages

The centres were involved in various state level interface meetings in Andhra Pradesh, Karnataka, Rajasthan, Maharashtra, and Tamil Nadu, and contributed for operationalization of district level agricultural contingency plans in linkage with state line departments. The doable rained technologies developed at various centres are integrated into various national/state level programs such as PMKSY, RKVY, MGNREGA, *Krishi bhagya* (Karnataka), *Panta Sanjeevani* (Andhra Pradesh). The centres were also involved in capacity buillding of vatrious stakeholders and technology upscaling/dissemination activities in strong linkage with KVKs, ATMA, stateline departments etc.

The research collaboration was strengthened with AICRP on Agrometeorology, ICAR-CRIDA, Hyderabad; AICRP on Integrated Farming Systems, ICAR-IIFSR, Modipuram and AICRP on Agroforestry, ICAR-CAFRI, Jhansi and crop AICRPs at identified common centres.



Linkages with Institutions



Linkages with ICAR Institutes and AICRPs

HONORS / AWARDS

12. Honors / Awards

Akola

- **Executive Council Member** of Indian Society of Dryland Agriculture, ICAR-CRIDA, Hyderabad to V.V. Gabhane for the period 2016 to 2018.
- **First Best Poster Presentation Award** to S.B. Gupta, A.Y. Talokar, M.B. Nagdeve and B.N. Patil in International Seminar on Global Climate Change: Implications for Agriculture and Water Sectors (CCAW-2017) at Aurangabad during 14-16 December, 2017.
- **Second Best Poster Presentation Award** to S.B. Sakhare, M.B. Nagdeve and M.M. Ganvir in International Seminar on Global Climate Change: Implications for Agriculture and Water Sectors (CCAW-2017) at Aurangabad during 14-16 December, 2017.
- **Best Paper Presentation Award** to M.B. Nagdeve, R.S. Patode, C.B. Pande, V.V. Gabhane and A.P. Karunakar in National Seminar on Recent Trends in Plant Sciences and Agricultural Research at Solapur during 11-12 January, 2018.
- **Best Paper Presentation Award** to V.V. Gabhane, M.B. Nagdeve, M.M. Ganvir, R.S. Patode and Ashwini Chandel in International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development at Hyderabad during 10-11 February, 2018.

Anantapuramu

- **Best Performing Officer Award** to M. Vijaya Sankar Babu by district administration, Anantapuramu on the eve of Republic Day Celebrations on 26 January, 2018.

Ballowal Saunkhri

- **Certificate of Appreciation** to Manmohanjit Singh by Vice-Chancellor, PAU, Ludhiana
- **Best Poster Presentation Award** to Manmohanjit Singh, Er. Abrar Yousuf and D.S. Rana in 26th National Conference on Natural Resource Management for Climate Smart Sustainable Agriculture, at Barapani, Meghalaya during 11-13 September, 2017.

Biswanath Chariali

- **Reviewers' Excellence award** to M.K. Sarma by ARCC, Haryana

Kovilpatti

- **Gold Medal for the year 2017** to S. Elamathi in Third National Conference on Agricultural Scientific Tamil at TNAU, Coimbatore during 12-13 August, 2017.
- **Best Editor Award** to S. Elamathi in Third National Conference on Agricultural Scientific Tamil at TNAU, Coimbatore during 12-13 August, 2017.

Phulbani

- **Outstanding Reviewer Award** to S. K. Behera by Field Crops Research (Elsevier Publication) during 2017.
- **Outstanding Reviewer Award** to S. K. Behera by Agricultural Water Management (Elsevier Publication) during 2017.

Solapur

Best Paper Presentation Award to V.M. Amrutsagar in National Seminar on Recent Trends in Plant Sciences and Agricultural Research, at Solapur during 11-12 January, 2018.

Best Paper Presentation Award to N.B. More, A.B. Pawar V.M. Amrutsagar and B.D. Tamboli in National Seminar on Recent Trends in Plant Sciences and Agricultural Research, at Solapur during 11-12 January, 2018.

Best Research article Award to R.M. Gethe, D.D. Pawar, B.R. Najan in National Seminar on Recent Trends in Plant Sciences and Agricultural Research, at Solapur during 11-12 January, 2018.

Life Time Achievement Award to V.M. Amrutsagar in National Seminar on Recent Trends in Plant Sciences and Agricultural Research, at Solapur during 11-12 January, 2018.

Outstanding Scientist Award to S. K. Upadhye in National Seminar on Recent Trends in Plant Sciences and Agricultural Research, at Solapur during 11-12 January, 2018.

Appreciation Award to B.S. Kadam in National Seminar on Recent Trends in Plant Sciences and Agricultural Research, at Solapur during 11-12 January, 2018.

Vijayapura

- **Vasantrao Naik Award** for the outstanding research and application in dryland farming systems to AICRPDA centre, Vijayapura for 2017.

Best Dryland Farmer Awards

Seventeen farmers from AICRPDA/NICRA villages were honored and awarded with the **Best Dryland Farmer Award** for their efforts in adoption and popularizing the improved rainfed technologies during the XVI Working Group Meeting of AICRPDA at AICRPDA centre, Jagdalpur, IGKV, Chhattisgarh during 1-5 February, 2018.

Name of the farmer	For adoption and popularization of dryland technology
Shri Patel Shantibhai Kantibhai, Kalimati village, Banaskantha district, Gujarat	Open well recharging and adoption of micro-irrigation system in maize and *rabi* rajma for quality seed production
Shri Deepak Ramchandra Saratape from Hingani village, Satara district, Maharashtra	Application of tank silt for higher yield of *rabi* sorghum under rainfed conditions
Shri Man Singh from Chhapar Jogiyan village, Bhiwani district, Haryana	*In-situ* moisture conservation for higher productivity of rainfed crops
Shri Amar Nath Pandey, Patauna village, Rewa district, Madhya Pradesh	Soybean + pigeonpea (4:2) intercropping system for higher productivity
Shri Vitthal Manikrao Dalve, Babulgaon village, Parbhani district, Maharashtra	Foliar spray of KNO_3 to cope with mid-season drought in soybean-chickpea cropping system
Shri Dayaram Balya Patel from Limbai village, Barwani district, Madhya Pradesh	Guava based Agri-horti system for higher productivity
Shri Kamal Saikia, Chamua village, Lakhimpur district, Assam	Crop diversification with toria, potato and vegetables for higher productivity and profitability
Shri Paramjit Singh, Achalpur village, Hoshiarpur district, Punjab	*In-situ* moisture conservation and drill sowing of maize and wheat for higher productivity
Sri B. Rajasekhar Reddy from Yerraguntlapalli village, Kurnool district, Andhra Pradesh	Soil test based fertilizer application in groundnut for higher productivity
Shri Mahadeo Gulabrao Dange, Warkhed village, Akola district, Maharashtra	*In-situ* moisture conservation through furrow opening in soybean + pigeonpea (4:2) intercropping system
Shri Veeranna from Baichenahalli village, Tumkur district, Karnataka	Soil test based fertilizer application and *in-situ* moisture conservation in fingermillet + pigeonpea (8:2) intercropping system
Smt Sonadayi from Tahkapal village, Bastar district, Chattisgarh	Rainwater harvesting in farm pond and efficient use for cultivation of *rabi* vegetables
Shri Jitendra Dhirubhai Vora from Shivrajgadh village, Rajkot district, Gujarat	Preparation of compost from cotton stalk and its efficient use for higher productivity of cotton
Shri Balanagouda Ninganagouda Mannapur from Hungund village, Bagalakote district, Karnataka	Rainwater harvesting in farm pond and efficient utilization for relay cropping of onion with *rabi* sorghum
Shri Desraj from Raya village, Samba district, Jammu & Kashmir	Aonla + gobhi sarson based agri-horti pastoral system
Shri Bhola from Tandpal village, Bastar district, Chhattisgarh	Year round vegetable cultivation from the harvested rainwater in farm pond
Shri Manaa Ram from Tahkapal village, Bastar district, Chhattisgarh	Crop diversification using harvested rainwater in farm pond

Shri Patel Shantibhai Kantibhai, Kalimati village, Banaskantha district, Gujarat

Shri Amar Nath Pandey, Patauna village, Rewa district, Madhya Pradesh

Shri Mahadeo Gulabrao Dange, Warkhed village, Akola district, Maharashtra

Shri Dayaram Balya Patel from Limbai village, Barwani district, Madhya Pradesh

Shri Deepak Ramchandra Saratape, Hingani village, Satara district, Maharashtra

Shri Balanagouda Ninganagouda Man-napur, Hungund village, Bagalakote district, Karnataka

Smt Sonadayi, Tahkapal village, Bastar district, Chhattisgarh

Shri Bhola, Tandpal village, Bastar district, Chhattisgarh

Shri Manaa Ram, Tahkapal village, Bastar district, Chhattisgarh

13. Visitors

Visitors to AICRPDA centres

Centre	Name	Designation	Date
Bengaluru	S. Bhaskar	ADG (A, AF & CC), NRM Division, ICAR	29 August, 2017
	-	Delegates from Indonesia	21 November, 2017
Solapur `	K. P. Viswanatha	Vice-Chancellor, MPKV, Rahuri	09 January, 2018
	Kum. Praniteetai Shinde	MLA, Solapur	09 January, 2018
	S. R. Gadhak	Director of Research, MPKV, Rahuri	09 January, 2018
	K.D. Kokate	Director of Extn. Education, MPKV, Rahuri	09 January, 2018
	A. L. Pharandhe	Dean (F/A), MPKV, Rahuri	09 January, 2018
	S. K. Bansal	Project Director, Potash for Life, New Delhi	09 January, 2018
	S. K. Chaudhari	ADG (SWM), NRM Division, ICAR	29 March, 2018

Visit of Dr. S. Bhaskar, ADG (A,AF&CC) to AICRPDA centre, Bengaluru

Visit of delegates from Indonesia to AICRPDA centre, Bengaluru

14. Project Team

PROJECT TEAM

Name	Designation	Tel/Fax/Mobile/E-mail
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Supporting Staff		
N. Manikya Rao	SSS	-
S. Sankar Reddy	SSS	-

Name/Designation/Address	Name/Designation/Address	Name/Designation/Address
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D. Sub-Centres		
Agra **S.P. Singh,** Chief Scientist AICRP for Dryland Agriculture RBS College, Bichpuri, **Agra** 283 105 Uttar Pradesh Fax: 0562-2636449 ; (O): 0562-2636449 (R): 0562-6540634; Mobile: 09997820202 E-mail: aicrpagra@gmail.com	**Faizabad** **O.P. Rai,** Chief Scientist (up to 30.09.2017) H.C. Singh, SWC Engineer Neeraj Kumar, Soil Scientist A.K. Singh, Agronomist AICRP for Dryland Agriculture Department of Agronomy N.D. University of Agri. & Tech., Kumarganj **Faizabad** 224 229 (Uttar Pradesh) Fax: 05270-262480/262917/262393 (O): 05270-262071 ; Mobile : 09450763850 Email: nksoilchem@gmail.com	**Rakh Dhiansar** **A.P. Singh,** Chief Scientist Vikas Abrol, Soil Scientist Hamant Dadhich, SWC Engineer AICRP for Dryland Agriculture Dryland Agri. Res. Sub Station **Rakh Dhiansar**, Bari Brahmana, Jammu 181 133 (O): 01923-220821; (R): 0191-2459193 Mobile: 09419119434 E-mail: apsinghagron@gmail.com aicrpda.rakhdhiansar@gmail.com

Name/Designation/Address	Name/Designation/Address	Name/Designation/Address
E. ORP Centres		
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Name/Designation/Address	Name/Designation/Address	Name/Designation/Address
F. Voluntary Centres		
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15. Budget

BUDGET

Statement showing the remittance, expenditure and closing balances for AICRPDA centres for the year 2017-18

(In. Rupees)

	Centre	OB as on 1.04.2017		Revised Estimates	Revenue Receipts	Expenditure as per AUCs for the year 2017-18						Closing balance as on 31.03.2018		
		Salaries	Other than salaries			P&A	RC	TA	NRC	HRD	Total	Salaries	Other than salaries	Total
1	Akola	-6838152	0	14031100		9845450	409909	42184	47035	10000	10354578	-3712502	550872	-3161630
2	Anata-puramu	-6271233	0	12773800		9329116	899918	86396	39323	9667	10364420	-3886549	24696	-3861853
3	Arjia	-2380600	0	11882500		10607615	900000	68273	0	0	11575889	-2125715	51727	-2073989
4	Biswa-nanth Chariali	2337511	0	5576000		7275626	1014076	122411	30000	9980	8452093	-587115	48533	-538582
5	Ballowal Saunkhri	-3965653	0	13400500		11103200	795780	52628	49476	9990	12011074	-2588353	12126	-2576227
6	Bangalore	-3606483	0	11999500		8098819	586337	24338	32162	9932	8751588	-665802	307231	-358571
7	Chianki	2486014	0	1305000		1192437	139790	29483	0	0	1361710	1693577	735727	2429304
8	Hisar	-480915	0	6945000		5396137	546519	14838	0	0	5957494	422948	83643	506591
9	Indore	-8383912	0	17410100		11727234	896567	95978	62200	10000	12791979	-3896046	130255	-3765791
10	Jagdalpur	402057	0	4130000		4981575	1000000	130000	90000	0	6201575	-1679518	10000	-1669518
11	Kovilpatti	-4025671	0	12697366		9495011	485570	91497	35301	6291	10113671	-1783316	341341	-1441976
12	Parbhani	1333730	0	6924508		6308418	819323	60000	42173	4988	7234902	-403910	93516	-310394
13	Phulbani	2129698	0	4295000		3228723	151524	33669	0	0	3413916	271277	609807	881084
14	Rewa	-3623326	0	12310000		8793336	297281	49823	0	0	9140440	-816662	362896	-453766
15	S.K.Nagar	350666	0	8030000		5971706	818131	56381	39765	9900	6895883	1378960	105823	1484783
16	Solapur	-6211152	0	15554609		11478377	988627	124880	30000	0	12621884	-3309920	31493	-3278427
17	Targhadia	362664	0	7577500		6556398	481881	59645	0	0	7097924	523766	318474	842240
18	Varanasi	-3335557	0	11341083		10956323	209536	29930	0	0	11195789	-3820797	630534	-3190263
19	Vijayapura	-7162317	0	14815000		8302508	796211	94240	47888	9653	9250500	-1864825	267008	-1597817
20	Agra	-1489428	0	9261300	28398	6757352	243254	45354	0	6457	7052417	682918	64935	747853

	Centre	OB as on 1.04.2017		Revised Estimates	Revenue Receipts	Expenditure as per AUCs for the year 2017-18						Closing balance as on 31.03.2018		
		Salaries	Other than salaries			P&A	RC	TA	NRC	HRD	Total	Salaries	Other than salaries	Total
21	Faizabad	296659	0	5990500		4924275	715027	44136	0	0	5683438	242725	64337	307062
22	R.Dhiansar	-128000	0	8345000		7505000	400000	78000	80000	7000	8070000	122000	25000	147000
23	Anantapur ORP	-1013810	0	4642810		3128274	398790	79830	0	0	3606894	20726	1380	22106
24	Arjia ORP	-4087975	0	7970559		3367571	400000	39882	0	0	3807453	75013	118	75131
25	Ballowal Saunkhri ORP	-754703	0	4694703		3416710	398984	39406	0	0	3855100	83290	1610	84900
26	Bangalore ORP	1521291	0	1820500		1460730	364276	29136	0	0	1854142	-80230	46588	-33642
27	Chianki ORP	2615735	0	2778200		2156919	292174	26652	0	0	2475745	2827016	91174	2918190
28	Hisar ORP	-4155693	0	7184482		4035464	329219	40000	0	0	4404683	-1446675	70781	-1375894
29	Indore ORP	-4377365	0	8619565		4035464	329219	54929	0	0	4419612	-298264	120852	-177412
30	Solapur ORP	-1890339	0	7076315		4160176	447669	69960	0	0	4677805	505800	2371	508171
31	Aklera, AU (Kota)	0	23146	220000		0	149998	23575	30000	0	203573	0	39573	39573
32	Darsi, ANGRAU	0	57360	200000		0	149924	4040	29750	0	183714	0	73646	73646
33	Imphal, CAU	0	1515065	240000		0	88712	54221	16000	0	158933	0	81067	81067
34	Munger, BAU	0	109631	190000		0	123003	5888	19275	0	148166	0	151465	151465
35	Raichur, UAS	0	45166	219000		0	162558	18530	29855	0	210943	0	8057	8057
36	PC Unit	0	13259	627500		0	624416	0	0	0	624416	0	3084	3084
	Total	-60346259	1763627	263079000	28398	195595944	17854203	1920133	750203	103858	216224343	-24116184	5561740	-18554444

ANNEXURE-I

Annexure-I

Proceedings of XVI Working Group Meeting of AICRPDA at AICRPDA Centre, Jagdalpur, IGKV, Chhattisgarh during 1-5 February, 2018

The XVI Working Group Meeting of All India Coordinated Research Project for Dryland Agriculture (AICRPDA), ICAR-CRIDA was organized at AICRPDA centre, Jagdalpur, IGKV, Chhattisgarh during 1st to 5th February 2018 with the main objective to critically review the progress at 19 main, 3 sub, 5 voluntary and 8 ORP centres and finalize technical programme for 2018-19. Shri Kedar Kashyap ji, Hon'ble Education Minister, Govt. of Chhattisgarh, Dr. S.K. Patil, Hon'ble Vice Chancellor, IGKV, Shri Anoop Shrivastava, IAS, Secretary, Agriculture, Govt. of Chhattisgarh, Dr. J.C. Katyal , Hon'ble Chairman, and members (Dr. V.M. Mayande, Dr. A.M. Shekh, Dr.V.S. Korikanthimath, Dr. Gorantiwar) of VII QRT (CRIDA-AICRPDA-AICRPAM), Dr. S. Bhaskar, ADG (A, AF & CC), NRM Division, ICAR, Dr. M.B. Chetti, ADG (HRD), Education Division, ICAR & Governing Body Member, IGKV, Dr. K. Sammi Reddy, Acting Director, CRIDA, Dr. G. Ravindra Chary, Project Coordinator, AICRPDA, Dr. P. Vijaya Kumar, Project Coordinator, AICRPAM, Dr. M. Maheswari, Head, Division of Crop Sciences, Dr. M. Osman, Head, PME Cell, CRIDA, scientists from PC Unit, AICRPDA, CRIDA, 19 main, 3 sub, 8 ORP and 5 voluntary centres of AICRPDA centes, 4 centres of AICRPAM, IGKV, AICRPs at Jagdalpur and KVKs in Bastar region and importantly, the farmers including women farmers from Bastar region participated.

Recommendations:

The following recommendations related to research, administrative and financial aspects were made keeping in view of the emerging researchable issues in rainfed agriculture, SFC 2017-20 of AICRPDA recommendations vide F.No. NRM-24-3/2017-IA-II dated 7th December, 2017 and further the aspects on technology development, on-farm technology assessment/ refinement, rationalizing the utilization of available funds and staff position at the centres.

1. New Initiatives

1.1. Rationalization of Manpower

As per SFC 2017-20 of AICRPDA, the staff has been rationalized at 22 centres w.e.f 1.4.2018. The revised staff strength at main centres is 17 and sub-centres is 12 and accordingly the staff strength may be regulated w.e.f. 1.4.2018, as communicated earlier to the centres

- The 8 ORP centres at Ananthapuramu, Arjia, Bengaluru, Ballowal Saunkhri, Chianki, Hisar, Indore and Solapur will be closed w.e.f. 1.4.2018.
- In view of the reduced manpower (157) at centres, for both on-station and on-farm participatory research at centres, the need based contractual staff (Young professional-I and/or Young professional-II) to be engaged against the vacant sanctioned positions at the centre and their salaries may be booked under the budget allocated under the head research/operational expenses in that financial year.
- At 19 main centres, the plant breeder position is converted to Senior scientist (Agronomy) w. e. f 1.4.2018, who is exclusively allocated for on-farm research at these centres.
- At 3 sub centres viz. Agra, Rakh Dhiansar and Faizabad, one Scientist (Agronomy) is allocated exclusively for on-farm participatory research

1.2. A new Functional mechanism in AICRPDA for On-Farm Participatory Research for Participatory Technology Development and Technology Upscaling

With rationalization of manpower as approved in SFC 2017-20 of AICRPDA, a new functional mechanism is initiated for on-farm participatory research which is **MANDATORY** at all 22 centres w.e.f. 1.4.2018.

- At 19 main centres, a Senior scientist (Agronomy), a senior technical assistant and a field man are exclusively allocated for on-farm participatory research.
- At 3 subcentres viz. Agra, Rakh Dhiansar and Faizabad, a Scientist (Agronomy), a senior technical assistant and a filed man are exclusively allocated for on-farm participatory research.

1.3. Staffing Pattern for On-Station and On-Farm Participatory Research at Centres

1.3.1. At 19 Main Centres: The staffing pattern for On-station and On-farm research at 19 centres viz. Akola, Anantapuramu, Arjia, Ballowal Saunkhri, Bengaluru, Vijayapura, Biswanath Chariali, Chianki, Hisar, Indore, Jagdalpur, Kovilpatti, Parbhani, Phulbani, Rajkot, Rewa, Sardar Krishinagar, Solapur and Varanasi is as below w.e.f. 1.4.2018

Sl. No.	Approved designation	VI CPC Pay Scale (ICAR)	No. of Posts
a. Overall Coordination of both on-station and on-farm participatory research in addition to research in the specific discipline of Chief scientist			
1.	Chief Scientist/Professor (Agronomy/Soil Science/ Soil & Water Conservation Engineering)	37400-67000+10000 GP	1
b. On -Station Research			
2.	Senior Scientist/Associate Professor (Agronomy)	37400-67000+9000 GP	1
3	Senior Scientist/Associate Professor (Soil Science)	37400-67000+9000 GP	1
4.	Senior Scientist/Associate Professor (Soil & Water Conservation Engineering)	37400-67000+9000 GP	1
5.	Senior Technical Assistant	9300-34800 +4200 GP	1
6.	Senior Technical Assistant	9300-34800 +4200 GP	1
7.	Senior Technical Assistant	9300-34800 +4200 GP	1
8.	Field man	5200-20200 +1900 GP	1
9.	Field man	5200-20200 +1900 GP	1
10.	Lab Attendant	5200-20200 +1800 GP	1
c. On-Farm Participatory Research			
11.	Senior Scientist/Associate Professor (Agronomy)	37400-67000+9000 GP	1
12.	Senior Technical Assistant	9300-34800 +4200 GP	1
13.	Field man	5200-20200 +1900 GP	1
d. Common for On-Station and On- Farm Participatory Research			
14.	Head Clerk with Computer Skills	9300-34800 +4200 GP	1
15.	Tractor Driver	5200-20200 +1900 GP	1
16.	Jeep Driver	5200-20200 +1900 GP	1
17.	Peon	5200-20200 +1800 GP	1
	Total		**17**

1.3.2. At 3 Sub-centres: The staffing pattern for On-station and On-farm research at 3 centres viz.. Agra, Faizabad and Rakh Dhiansar is as below w.e.f. 1.4.2018

Sl.No.	Approved designation	VI CPC Pay Scale (ICAR)	No. of Posts
a. Overall Coordination of both on-station and on-farm participatory research including research in the specific discipline of chief scientist			
1.	Senior Scientist/Associate Professor (Agronomy/Soil Science/ Soil & Water Conservation Engineering)	37400-67000+10000 GP	1
b. On - Station Research			
2.	Scientist/Assistant Professor (Soil & Water Conservation Engineering / Soil Science)	15600-31900+ 6000/7000 GP	1
3.	Senior Technical Assistant	9300-34800 +4200 GP	1
4.	Senior Technical Assistant	9300-34800 +4200 GP	1
5.	Field man	5200-20200 +1900 GP	1
c. On-Farm Participatory Research			
6.	Scientist/Assistant Professor (Agronomy)	15600-31900+6000/7000 GP	1
7.	Senior Technical Assistant	9300-34800 +4200 GP	1
8.	Field man	5200-20200 +1900 GP	1
d. Staff Common for On-Station and On- Farm Participatory Research			
9.	Tractor Driver	5200-20200 +1900 GP	1
10.	Jeep Driver	5200-20200 +1900 GP	1
11.	Head Clerk with Computer Skills	9300-34800+4200 GP	1
12.	Peon	5200-20200 +1800 GP	1
		Total	**12**

1.3.3. Responsibilities of the Staff

- The Chief scientists at all the 22 centres will, besides research in his area of specialization, will coordinate and is responsible for both on-station and on-farm participatory research in a very interactive multidisciplinary mode.
- The three staff designated exclusively for on-farm participatory research viz. Senior scientist (Agronomy), Senior Technical Assistant and Field man at 19 Main centres and Scientist/Assistant Professor (Agronomy), Senior Technical Assistant and Field man at 3 Sub-centres, will be responsible for on-farm participatory research in technology assessment/ refinement and upscaling of the research findings/ doable rainfed technologies
- In case the Senior Scientist (Agronomy), meant exclusively for on-farm participatory research is vacant at Main centre , the Chief scientist/filled in Senior scientist (Agronomy) will look after the on-farm participatory research till the position of Senior scientist (Agronomy) is filled up
- In case the Scientist (Agronomy), meant exclusively for on-farm participatory research is vacant at Sub centre , the Chief scientist/filled in Scientist (SWC Engineering / Soil science) will look after the on-farm participatory research till the position of Scientist (Agronomy) is filled up
- In case, the Senior Technical Assistant and Field man positions for on-farm participatory research are vacant at main/subcentres, the filled in positions for these categories at main and sub centres have to be utilized for on-farm participatory research, till these positions are filled up
- At 19 Main centres, **it is mandatory** that the three scientists meant for on-station research viz. Senior Scientist/Associate Professor (Agronomy), Senior Scientist/Associate and Professor (Soil Science) and Senior Scientist/Associate Professor (SWC Engineering) will also be involved intensively and support on-farm participatory research in technology assessment/refinement and upscaling of the research findings/ doable rainfed technologies of their respective disciplines

- At 3 Sub-centres, **it is mandatory that** the Scientist/ Assistant Professor (Soil & Water Conservation Engineering / Soil Science) will also be involved intensively and support on-farm participatory research in technology assessment/refinement and upscaling of the research findings/ doable rainfed technologies of his discipline
- All the scientific, technical, administrative and supporting staff at the centre should support the scientist and technical staff exclusively allocated for on-farm participatory research
- The vehicle and driver available at the centre to be allocated/utilized for on-farm participatory research on **PRIORITY basis**.

1.4. Rainwater management Research

- All the centres to develop Intensity-Frequency-Duration (IFD) relationship in runoff and to develop seepage equations for unlined farm ponds
- Selected centres to conduct experiments on minimization of evaporation losses from farm ponds and to explore various methods including use of solar panels, neem oil, shade net, growing of climbers etc and to conduct experiments on minimizing seepage losses from farm ponds. Water budgeting at village level may also be worked out by the centres.
- The centres to assess whether existing farm ponds at different AICRPDA centres are optimum/over sized/ under sized under present circumstances of rainfall pattern

1.5. Rainfed Integrated Farming Systems Research

- The sample size for survey of traditional rainfed farming systems to be 240 at each centre. All the centres to ensure randomized sampling of farmers for the survey of traditional rainfed farming systems and complete the survey by the end of March, 2018.
- The Microsoft excel format would be mailed to the centres for entry of survey information on traditional rainfed farming systems. The data entry in the given formats and analysis to be completed by the end of April, 2018.

1.6. Initiate satellite experiments at all the centres having permanent manurial trials (PMTs).

1.7. Collaborative research

1.7.1. AICRPDA-CRIDA collaborative project on 'Development of microbial consortia for drought tolerance in rainfed crops' to be initiated at identified AICRPDA centres viz. Ballowal Saunkhri, Ananthapuramu, Vijayapura and Parbhani.

1.7.2. AICRPDA-ICAR-CICR/AICRP on Cotton collaborative program on 'Evaluation of high density planting system (HDPS) of cotton in diverse rainfed agro-ecologies', best treatments of HDPS of cotton along with suitable *in-situ* moisture conservation practices would be demonstrated in AICRPDA-NICRA villages of Kovilpatti, Parbhani, Akola and Rajkot centres.

1.7.3. AICRPDA-AICRPAM: A common experiment on "Real time monitoring and management of agricultural drought in major rainfed crops" will be conducted at AICRPDA centres in collaboration with AICRPAM centres at 7 common centres of AICRPDA-AICRPAM viz. Ananthapuramu, Bengaluru, Akola, Parbhani, Solapur, Kovilpatti and Vijayapura

The AICRPDA centres at Faizabad and Hisar and other than above mentioned 7 centres, will send daily weather information to PC unit, AICRPDA for updating to AICPAM weather data network

1.7.4. AICRPDA-AICRP-Integrated Farming Systems

AICRPDA centre	AICRP-IFS Centre	Nature of collaboration
1. Biswanath Chariali	1. Jorhat	Technical guidance
2. Jagdalpur	2. Raipur	Technical guidance
3. Indore	3. Indore	Observations
4. SK Nagar	4. S.K. Nagar	Observations
5. Varanasi	5. Varanasi	Observations

1.7.5. AICRPDA-AICRP - Agroforestry

AICRPDA centre	AICRP-AF centre	Nature of collaboration
1. Hisar	1. Hisar	Common experiment
2. SK Nagar	2. SK Nagar	Observations
3. Rakh Dhiansar	3. Jammu	Technical guidance
4. Ballowal Saunkhri	4. Ludhiana	Technical guidance
5. Indore	5. Jabalpur	Technical guidance
6. Bengaluru	6. Bengaluru	Observations
7. Biswanath Chariali	7. Kahi Kuchi (Guwahati)	Technical guidance
8. Phulbani	8. Bhubaneswar	Technical guidance
9. Arjia	9. Fatehpur Shekhawati	Technical guidance
10. Akola	10. Nagpur	Technical guidance
11. Bijapur	11. Dharwad	Technical guidance
12. Solapur	12. Rahuri	Technical guidance

1.7.6. AICRPDA-AICRP-Forage crops

AICRPDA centre	AICRP-Forage centre	Nature of collaboration
1. Chianki	1. Ranchi	Technical guidance
2. Phulbani	2. Bhubaneswar	Technical guidance
3. Imphal	3. Imphal	Observations
4. Biswanath Chariali	4. Jorhat	Technical guidance
5. Hisar	5. Hisar	Observations
6. Jagdalpur	6. Raipur	Observations

1.7.7. AICRPDA- AICRP - Fruits

AICRPDA centre	AICRP-Fruit centre	Nature of collaboration
1. Akola	1. Akola	Observations
2. Phulbani	2. Bhubaneswar	Technical guidance
3. Biswanath Chariali	3. Jorhat	Technical guidance
4. Chianki	4. Ranchi	Technical guidance
5.Imphal	5. Imphal	Observations

2. Other technical aspects

- Every 3 years, the centres should conduct SWOT analysis of rainfed agriculture in the domain districts
- All centres to develop strong linkage with line departments and converge with on-going central/ state programmes/schemes for strengthening rainfed agriculture &d development and capacity building including skill development

3. Reporting

- The final report on Impact of ORP Programme in the recent village to be submitted by all ORP centres by the end of April, 2018.The Chief scientists of Ananthapuramu, Ballowal Saunkhri, Bengaluru, Arjia, Chianki, Hisar, Indore, and Solapur are responsible for submission of the same.
- Submission of data sheets of all the experiments as per schedules to PC Unit is mandatory
- Data of all experiments to be statistically analyzed and reported. Time-series analysis of long-term data to be carried out for drawing valid conclusions.
- It is mandatory to submit to PC Unit : RPF-I for new experiments, RPF-II for progress of research for on-going experiments and RPF-III for completed experiments with all the relevant data, scope for upscaling, on-farm evaluation, scope for recommendation by SAU as package of practices

- o Timely submission of weekly weather bulletin, monthly staff position and expenditure, and monthly technical progress report to PC Unit

4. Administrative aspects

- o There is no provision for REEMPLOYMENT any AICRPDA staff i.e. scientific, technical and other staff at the AICRPDA centre after their retirement either from the AICRPDA centre or from their respective SAUs/ Institutes
- o There is no provision to engage any contractual staff (RAs/SRFs/JRFs etc) at AICRPDA centres against any vacant sanctioned positions for the centre
- o In view of the negative balances under the head pay & allowances and budgetary allocation to AICRPDA, it is suggested not to fill any vacant positions of the sanctioned staff till further communication and or prior approval of competent authority.
- o Presently, one vehicle is available with 4 ORP centres viz. Ananathapuramu, Bengaluru, Arjia, Chianki and Solapur (13 years old). A decision to be taken regarding these vehicles as per suggestion from ICAR.

5. Budget aspects

- o At each centre, the budget allocation in a financial year under research/operational expenses, NRC, HRD and T.A. should be judiciously utilized **as per priority/ need for on-station and on-farm participatory research**
- o There is no provision for REEMPLOYMENT of any staff (scientific/technical and other staff) at AICRPDA centres after their retirement from the AICRPDA centre/respective institute/SAU.

Acronyms

AAU	Assam Agricultural University
AICRPAM	All India Coordinated Research Project on Agrometeorology
AICRPDA	All India Coordinated Research Project for Dryland Agriculture
ALU	Alternate Land Use
AM	*Arbuscular Mycorrhiza*
ANGRAU	Acharya NG Ranga Agricultural University
ARS	Agriculture Research Station
AU	Agriculture University
AVT	Advanced Varietal Trial
AWC	Available Water Capacity
BAU	Bihar Agricultural University
BBF	Broad Bed Furrow
BC ratio	Benefit:Cost ratio
BD	Bulk Density
BHU	Banaras Hindu University
BMT	Bamboo Mat
CAL	Cetyl Alcohol
CAU	Central Agricultural University
CAZRI	Central Arid Zone Research Institute
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CCT	Continuous Contour Trenches
CD	Critical Difference
CAEY	Custard Apple Equivalent Yield
CEY	Chickpea Equivalent Yield
CHC	Custom Hiring Center
CHMC	Custom Hiring Management Committee
CR	Crop Residue
CRIDA	Central Research Institute for Dryland Agriculture
CS	Cropping Systems
CT	Conventional Tillage
DAS	Days After Sowing
DFRS	Dryland Farming Research Station
Dr. PDKV	Dr Panjabrao Deshmukh Krishi Vidyapeeth

EC	Electrical Conductivity
EM	Energy Management
EIV	Evaluation of Improved Varieties
FP	Farmers' Practice
FYM	Farmyard Manure
FYT	Final Yield Trial
GRD	General Recommended Dose
Ha	Hectare
Hb	Herbicide
HC	Hydraulic Conductivity
HDPS	High Density Planting System
HRFD	Half Recommended Fertilizer Dose
HW	Hand Weeding
ICAR	Indian Council of Agricultural Research
IF	Inorganic Fertilizer
IFS	Integrated Farming System
IGKV	Indira Gandhi Krishi Vishwavidyalaya
IGFRI	Indian Grassland and Fodder Research Institute
IISWC	Indian Institute of Soil and Water Conservation
IMD	Indian Meteorological Department
INM	Integrated Nutrient Management
IP	Improved Practice
IVT	Initial Varietal Trial
JAU	Junagadh Agricultural University
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya
kg	Kilogram
LAI	Leaf Area Index
LER	Land Equivalent Ratio
LSVT	Large Scale Varietal Trial
LT	Low Tillage
MCEY	Main Crop Equivalent Yield
MEY	Maize Equivalent Yield
MEY	Mustard Equivalent Yield

MGEY	Maize Grain Equivalent Yield
MJ	Mega Joule
MLT	Multi Location Trial
mm	Millimeter
MPKV	Mahatma Phule Krishi Vidyapeeth
MPUAT	Maharana Pratap University of Agriculture and Technology
MR	Maize Residue
MSEY	Maize Stover Equivalent Yield
MUE	Moisture Use Efficiency
MWD	Mean Weight Diameter
NCPC	Nano Clay Polymer Composite
NDUAT	Narendra Dev University of Agriculture and Technology
NICRA	National Innovations in Climate Resilient Agriculture
NM	Nutrient Management
NMR	Net Monetary Returns
NOL	Neem Oil
NRM	Natural Resource Management
OC	Organic Carbon
ORP	Operational Research Project
OT	Off-Season Tillage
OUAT	Orissa University of Agriculture & Technology
PAN	Pan Evaporation
PAU	Punjab Agricultural University
PET	Potential Evapotranspiration
PEY	Pearlmillet Equivalent Yield
PEY	Pigeonpea Equivalent Yield
PMT	Permanent Manurial Trail
PSB	Phosphate Solubilizing Bacteria
PSF	Phosphate Solubilizing Fungi
PST	Paddy Straw
PVA	Polyvinyl alcohol
RBSC	Raja Balwant Singh College
RC	Resource Characterization
RDF	Recommended Dose of Fertilizer
RDN	Recommended Dose of Nitrogen

REY	Rice Equivalent Yield
RFS	Ridge Furrow System
Rs.	Rupees
RT	Reduced Tillage
RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
RWC	Relative Water Content
RWUE	Rainwater Water Use Efficiency
SAL	Steryl Alcohol
SDAU	Sardarkrushinagar Dantiwada Agricultural University
SDT	Saw Dust
SI	Supplemental Irrigation
SK Nagar	Sardarkrushi Nagar
SKUAS&T	Sher-e-Kashmir University of Agricultural Science & Technology
SMW	Standard Meteorological Week
Sol	Silicon Oil
SSP	Single Super Phosphate
STBF	Soil Test Based Fertilizer
SW	South-West
SWC	Soil & Water Conservation
SYI	Sustainable Yield Index
TEY	Tomato Equivalent Yield
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
VNMKV	Vasantrao Naik Marathwada Krishi Vidyapeeth
WEY	Wheat Equivalent Yield
WUE	Water Use Efficiency
WSI	With supplemental irrigation
WOSI	Without supplemental irrigation
ZT	Zero Tillage

Print Media

PRINT MEDIA

Ananthapuramu


ఏక పంటగా కంది వేసుకోండి


వేరుశనగ సాగుకు అనుకూలం


వేరుశనగ వేయకపోవడమే మేలు


జాతీయ పురస్కారం


శరణ్యం

Ballowal Saunkhri


ਬਲੋਵਾਲ ਸੌਂਖੜੀ ਵਿਖੇ ਕਿਸਾਨ ਮੇਲਾ 6 ਨੂੰ

ਅਜੀਤ


गांव कोठी में किसान गोष्ठी का आयोजन


ਪਿੰਡ ਟਕਾਰਲਾ ਵਿਖੇ ਕਿਸਾਨ ਸਿਖਲਾਈ ਕੈਂਪ ਲਗਾਇਆ

Chianki


किसान वैज्ञानिक विधि से करें खेत


हिन्दुस्तान
आयुक्त ने अधिक मुनाफा कमाने के दिये टिप

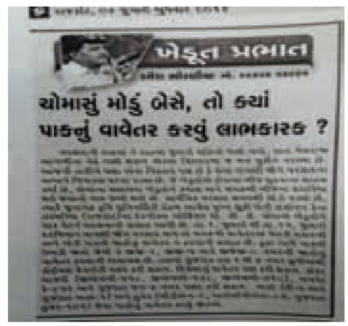

पलामू जागरण
किसान श्रीविधि से करें धान की खेती : प्रमोद
गढ़वा के किसान परशुराम को देश का सर्वश्रेष्ठ कृषक पुरस्कार मिला


पलामू भास्कर
दैनिक भास्कर
भाभा अनुसंधान केंद्र के कृषि वैज्ञानिक ने चियांकी में लगी सरसों का फसल देखी

Jagdalpur


धान की फसल में लीफ फोल्डर बीमारी का खतरा

Rajkot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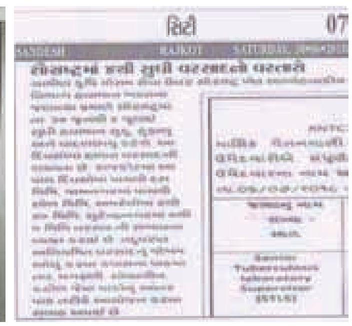
ચોમાસું મોડું બેસે, તો ક્યાં પાકનું વાવેતર કરવું લાભકારક ?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Kovilpatti


கருகும் மிளகாய் செடி: விவசாயிகள் கவலை


3 ஆண்டுகளாக ஒருபோக நெல் விவசாயம் இல்லை
தவிக்கும் விவசாயிகள்


புல்லமடையில் மிளகாய் செடிகள் கருகின

Solapur (ORP)


सोलापूर कृषी विशेष


अॅग्रो


लोकमत
संशोधनाच्या प्रक्रियेत शेतकऱ्यांचा सहभाग हवा

Notes

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Dr. J.C. Katyal, Hon'ble Chairman & Members, VII QRT, Dr. S. Bhaskar, ADG (A, AF&CC) and AICRPDA Scientists visit AICRPDA-NICRA Village Tahkapal, Bastar district

Scientist-farmer Interaction Meeting, Tahkapal Village, Bastar District

Farmers and Students visit Exhibition/Kisan mela - AICRPDA Centre, Akola

Farmers training at Nagla Dulhe Khan Village, Agra district

Field day at AICRPDA Centre, Hisar

Delegates of 7th International Symposium on "Silicon in Agriculture" visit AICRPDA centre, Bengaluru

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

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