AICRPDA

वार्षिक प्रतिवेदन
Annual Report
2015 - 16

भाकृअनुप
ICAR

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

XV Working Group Meeting of AICRPDA

AICRPDA Centre, Biswanath Chariali, 24-27 December, 2015

Release of publications

Dr. Ch. Srinivasa Rao, Director, CRIDA addressing the participants

III Annual Review Workshop of AICRPDA-NICRA

AICRPDA Centre, Anantapuramu, 01-03 September, 2015

Release of publications

Award to Best Dryland Woman Farmer

Two-day AICRPDA-TSP National Review Workshop

AICRPDA Centre, Arjia, 1-2 March, 2016

Dr. G. Ravindra Chary, Project Coordinator, AICRPDA, briefing the purpose of the workshop

Address by Dr. Ch. Srivasa Rao, Director, CRIDA

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Preface

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) since its inception in 1972 has the mandate to develop location specific technologies to address emerging issues in rainfed agriculture. The 22 centres located in diverse rainfed agro-ecologies have been conducting research in thematic areas of rainwater management, cropping systems, contingency crop planning, identifying drought tolerant varieties, nutrient management, energy management along with system based research on alternate land use and integrated farming systems. Further, the unique feature of the project is on-farm assessment/refinement and upscaling of rainfed technologies through Operational Research Project (ORP) centres and other projects.

This annual report of AICRPDA 2015-16 contains the salient findings of on-station experiments, technologies assessed and upscaled under on-farm situations at 22 centres and 8 ORPs, National Innovations in Climate Resilient Agriculture (NICRA) and Tribal sub-plan programmes. I hope the information in this report is useful to the researchers, students, and other stakeholders engaged in rainfed agriculture research and development.

My sincere thanks to Dr. T. Mohapatra, Secretary, DARE & Director General, ICAR, Dr. S. Ayyappan, former Secretary, DARE & DG, ICAR, Dr. K. Alugusundaram, DDG(NRM) I/c, Dr. A.K. Sikka, former DDG (NRM), Dr. S. Bhaskar, ADG (A,AF &CC) for their kind guidance and constant encouragement and support in implementing this project successfully. I also thank the scientists and officials from NRM Division, ICAR for their time to time support.

The contributions of the chief scientists and scientists from the 22 centers and 8 ORPs are highly appreciated. I also acknowledge the support of officials/scientists of SAUs/ICAR Institutes/ other AICRPs, KVKs, ATMA, state line departments, particularly the farmers from ORP, NICRA and TSP villages.

I wish to compliment Dr. G. Ravindra Chary, Project Coordinator (Dryland Research), for coordination, monitoring and evaluation of the technical program and Dr. K.A. Gopinath, Principal Scientist (Agronomy) and Er. Boini Narsimlu, Senior Scientist (SWC Engg.) for compilation and synthesis of data and bringing out report in the present form. I acknowledge Dr. A. Girija, Dr. D. Anantha Rao for technical help and Smt. N. Lakshmi Narasu for secretarial help.

(Ch. Srinivasa Rao)
Director
ICAR-CRIDA, Hyderabad

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कार्यकारी सारांश

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना देश के शुष्क, अर्ध-शुष्क, उप-आर्द्र, आर्द्र एवं अति-आर्द्र जलवायुओं में स्थित 22 केंद्रों के नेटवर्क से वर्षा आधारित उत्पादन प्रणालियों (चावल, मक्का, ज्वार, बाजरा, रागी, कपास, मूंगफली एवं सोयाबीन) के विविध जैव-भौतिक एवं सामाजिक-आर्थिक परिस्थितियों का प्रतिनिधित्व करता है। इस परियोजना का अधिदेश वर्षाजल प्रबंधन, सस्यन प्रणाली, पोषक प्रबंधन, ऊर्जा प्रबंधन, वर्षा आधारित फसलों के उन्नत किस्मों का मूल्यांकन, वैकल्पिक भूमि उपयोग/समेकित कृषि प्रणाली के विषय क्षेत्रों में केंद्र पर अनुसंधान द्वारा स्थान विशेष की प्रौद्योगिकियों को निर्माण करना है। इन प्रौद्योगिकियों का मूल्यांकन 8 प्रचालन अनुसंधान परियोजनाओं द्वारा किसानों के खेतों पर किया जाता है। 2015-16 के दौरान, कुल 284 जैसे वर्षाजल प्रबंधन-59; सस्यन प्रणाली-47; पोषक प्रबंधन-55; ऊर्जा प्रबंधन-29; उन्नत किस्मों का मूल्यांक-60; वैकल्पिक भूमि उपयोग-19; समेकित कृषि प्रणाली- 12 एवं संसाधन लक्षण-2 खेतों पर परीक्षणों का आयोजन किया गया। प्रचालन अनुसंधन परियोजनाओं में, 100 कृषि जांचों/प्रदर्शनों जैसेकि वर्षाजल प्रबंधन-27; सस्यन प्रणाली-22; पोषक प्रबंधन-16; ऊर्जा प्रबंधन-15; उन्नत किस्मों का मूल्यांक-14; वैकल्पिक भूमि उपयोग/समेकित कृषि प्रणाली-6 का आयोजन किया गया।

वर्ष 2015-16 के दौरान, **चियान्की** (20 दिनों की देरी), अरजिया (17 दिनों की देरी) एवं रीवा (10 दिनों की देरी) को छोड़ सभी एक्रीपडा के केंद्रों पर मानसून का आरंभ साधारण था। इसके अलावा, बिस्वनाथ चरिअलि, **चियान्की** जगदलपुर, फुलबानी, अरजिया, **बल्लोवाल सौंक्रि** आग्रा, विजयपुर, सोलापुर, इंदौर, अनंतपुरम, राजकोट एवं अकोला में फसलों के विभिन्न स्तरों पर हर 10 दिनों से अधिक के अंतराल पर 3-5 शुष्क दौर हुए। जून के महिने में, चयनकी, **बल्लोवाल सौंक्रि,** एस.के. नगर, सोलापुर एवं रीवा में वर्षा की कमी 40 प्रतिशत से अधीक थी। जुलाई के महिने में, जगदलपुर, आग्रा, विजयपुर, अनंतपुरम, अकोला, सोलापुर, कोविलपट्टी एवं परभनी जैसे 8 केंद्रों में वर्षा की कमी 50 प्रतिशत से अधिक थी। जबकि, अगस्त में, 11 केंद्रों (फैज़ाबाद, पुलबानी, **बल्लोवाल सौंक्रि, रख धियान्सर**, बेंगलुरू, आग्रा, हिसार, एस.के. नगर, सोलापुर, राजकोट एवं परभनी) में एवं सितंबर में,10 केद्रों (**चियान्की**, फैजाबाद, वारणासी, अरजिया, आग्रा, हिसार, एस.के. नगर, सोलापुर, इंदौर एवं रीवा) में वर्षा की कमी 45 प्रतिशत से अधिक थी।

प्रमुख उपलब्धियां नीचे दी जा रही हैं।

वर्षाजल प्रबंधन

स्व-स्थाने नमी संरक्षण

स्व-स्थाने नमी संरक्षण प्रयोगों में मेढ़ एवं कूंड प्रणाली, उत्थित क्यारी, जलमग्न क्यारी, फसल अवशेष/प्लास्टिक से पलवार, वनस्पति रोध, चौड़ी क्यारी कूंड प्रणाली, संरक्षण कूंड, कर्षण, खरपतवार प्रबंधन आदि जैसे उपचार शामिल हैं।

परभनी में, फसल उगाऊ एवं मानसून अवधि के दौरान तूफान के जैसे मृदा अपवाह एवं प्रतिशत नमी हानि देखी गई। सपाट क्यारी के उपचार से 94 एमएम का अधिकतम अपवाह एवं चौड़ी क्यारी कूंड के उपचार से 49 एमएम का न्यूनतम अपवाह हुआ जोकि सपाट क्यारी उपचार की तुलना में 52 प्रतिशत कम था। सपाट क्यारी उपचार की 31 से 48 प्रतिशत की तुलना में सभी नमी संरक्षण उपचारों ने कम अपवाह दर्ज किया। सपाट क्यारी उपचार से 2.41 टन प्रति हेक्टेयर का अधिकतम मृदा अपवाह हुआ एवं चौडी क्यारी तथा कूंड प्रणालीसे 1.05 टन प्रति हेक्टेयर का न्यूनतम हानि देखा गया जोकि सपाट क्यारी उपचार की तुलना में 66 प्रतिशत कम था।

फुलबानी में, चौडी क्यारी कूंड की तुलना में फसल अवशेषों की पलवार एवं मेंढ कूंड प्रणाली से तीन सब्जी फसलों जैसेकि पत्तागोभी, टमाटर एवं भिंडी (क्रमश: 6450,12650 एवं 6520 किलोग्राम प्रति हेक्टेयर) से बेहतर बी:सी अनुपात (2.60, 3.24 एवं 2.51) एवं वर्षाजल उपयोग क्षमता (12.31,24.14 एवं 12.44 किलोग्राम प्रति हेक्टेयर-एमएम) सहित अधिकतम उत्पादन प्राप्त हुआ। राख धैनसर में, चौड़ी क्यारी कूंड + ल्यूकेना पत्तों के पलवार से क्रमश: 27564/- रुपए प्रति हेक्टेयर, 2.23 एवं 10.51 किलोग्राम प्रति हेक्टेयर-एमएम का अधिक कुल प्रतिफल, बी:सी अनुपात एवं वर्षाजल उपयोग क्षमता सहित अधिक मक्का अनाज उत्पादन (2777 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ। परभनी में, सोयाबीन में, चौड़ी क्यारी कूंड प्रणाली से महत्वपूर्ण रूप से उन्नत बीज उत्पादन (848 किलोग्राम प्रति हेक्टेयर), वर्षाजल उपयोग क्षमता (2.97 किलोग्राम प्रति हेक्टेयर-एमएम), निवल आय (13972/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.78) दर्ज किया गया, इसके बाद हर चार पंक्तियों के बाद कूंड के निर्माण ने (722 किलोग्राम प्रति हेक्टेयर) दर्ज किया। इंदौर में, सपाट भूमि पर बोवाई (418 किलोग्राम प्रति हेक्टेयर) एवं हर क्यारी में दो पंक्तियों सहित 60 सेंटीमीटर उत्थित क्यारी (315 किलोग्राम प्रति हेक्टेयर) की तुलना में क्यारी में 3 पंक्तियों सहित 90 सेंटीमीटर उत्थित क्यारी से महत्वपूर्ण रूप से उन्नत सोयाबीन उत्पादन (542 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

राजकोट में, मेढ़ एवं कूंड प्रणाली ने महत्वपूर्ण रूप से उन्नत कपास बीज एवं डंठल उत्पादन (क्रमश: 2573 एवं 4196 किलोग्राम प्रति हेक्टेयर), बी:सी अनुपात (3.34) दर्ज किया एवं चौड़ी क्यारी कूंड (2388 किलोग्राम प्रति हेक्टेयर) के समान मृदा नमी मात्रा (24.3 प्रतिशत) एवं उत्पादन दर्ज किया। प्लासटिक पलवार(25 माइक्रन शीट) ने उन्नत कपास बीज एवं डंठल उत्पादन (क्रमश: 2474 एवं 4209 किलोग्राम प्रति हेक्टेयर) एवं मृदा नमी मात्रा (22.6 प्रतिशत)

दर्ज किया तथा उत्पादन 5 टन प्रति हेक्टेयर (2369 किलोग्राम प्रति हेक्टेयर) की दर से किए गए भूसी पलवार के समान था।

कोविलपट्टी में, रोटावेटर जुताई + चिसिल जुताई ने कपास का अधिकतम उत्पादन (974 किलोग्राम प्रति हेक्टेयर), 11330/-रुपए प्रति हेक्टेयर का निवल आय एवं 1.35 का बी:सी अनुपात सहित 2.05 किलोग्राम प्रति हेक्टेयर-एमएम का वर्षाजल उपयोग क्षमता दर्ज किया, जो कि पारंपरिक कृषि की तुलना में 11 प्रतिशत अधिक था।

बेंगलुरू में, आमला रोपण (3200 वर्ग मीटर) में, कम अपवाह (4.09 घन मीटर), मृदा हानि (6.1 किलोग्राम) एवं नाइट्रोजन हानि (94 किलोग्राम) सहित माइक्रो-साइट सुधार (3273 किलोग्राम प्रति हेक्टेयर एवं 123320/- रुपए प्रति हेक्टेयर) के रूप में खाई व अर्धचंद्राकार मेढ़ से उन्नत उत्पादन एवं निवल आय दर्ज किया।

बहि-स्थाने वर्षाजल प्रबंधन

बहि-स्थाने वर्षाजल प्रबंधन मुख्यतया कृषि तालाबों में वर्षाजल का संचयन एवं संरक्षी/अतिरिक्त सिंचाई के रूप में कुशल उपयोग, कुछ मामलों में सूक्ष्म सिंचाई प्रणालियों के द्वारा किया जाता है।

जगदलपुर में, सब्जियों की फसलों(गोभी एवं टमाटर) में स्प्रिंकलर से दो अतिरिक्त सिंचाई देने से उन्नत उत्पादन (2645 किलोग्राम प्रति हेक्टेयर), निवल आय (48070/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.66) एवं वर्षाजल उपयोग क्षमता (19.74 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया। वाराणासी में, वनस्पति एवं पुष्पण स्तरों पर 5 सेंटीमीटर की अतिरिक्त सिंचाई से लौकी, भिंडी, बैंगन एवं मिर्च जैसी सब्जी फसलों के मूल्यांकन में, लौकी ने अधिकतम उत्पादन (12500 किलोग्राम प्रति हेक्टेयर), बी:सी अनुपात (3.3) दिया। मटर की किस्मों को बोवाई से पहले सिंचाई देने से, मलविया-15 (1152 किलोग्राम प्रति हेक्टेयर) की तुलना में एपी-3 ने उन्नत बीज उत्पादन (1486 किलोग्राम प्रति हेक्टेयर), निवल आय (17720/-रुपए प्रति हेक्टेयर), बी:सी अनुपात(2.1) एवं जल उपयोग क्षमता (14.65 किलोग्राम प्रति हेक्टेयर-एमएम) दिया।

अरजिया में, पानी को ऊपर चढ़ाने में विद्युत मोटर कुशल सिद्ध हुआ, इसके बाद गेसिफर पंप सेट का स्थान था। अतिरिक्त सिंचाई से, तोरई ने 2.04 किलोग्राम प्रति घन मीटर की जल उत्पादकता, 67440/-रुपए प्रति हेक्टेयर का निवल आय एवं 3.21 का बी:सी अनुपात सहित 5541 किलोग्राम प्रति हेक्टेयर का अधिकतम मक्का समतुल्य उत्पादन दर्ज किया। सतही सिंचाई की तुलना में ड्रिप सिंचाई से 58.5 प्रतिशत जल की बचत हुई एवं 12 प्रतिशत तक मक्का समतुल्य उत्पादन में वृद्धि हुई। बल्लोवाल सांकुरी में, शुष्क दौर के दौरान एक अतिरिक्त सिंचाई ने वर्षा आधारित मक्का की तुलना में 52 प्रतिशत का उन्नत मक्का उत्पादन दिया। रबि मौसम के दौरान, गेहूं में मुकुट जड़ आरंभ (CRI) स्तर पर एक अतिरिक्त सिंचाई ने वर्षा आधारित फसल की तुलना में 56 प्रतिशत उन्न्त उत्पादन दिया। इंदौर में, रबि के दौरान मीठी मकई एवं टमाटर में 3 लीटर प्रति घंटा की दर से ड्रिप की अतिरिक्त सिंचाई दी गई एवं टमाटर फसल द्वारा 30 लीटर प्रति पौधा या 83 सेंटीमीटर प्रति हेक्टेयर तथा मीठी मकई द्वारा 24 लीटर प्रति पौधा या 88 सेंटीमीटर प्रति हेक्टेयर डिसचार्ज जल का उपयोग किया गया।

राजकोट में, खेती की प्रवाह के अंतर्गत अधिकतम मृदा हानि(536.49 किलोग्राम प्रति हेक्टेयर) एवं अधिकतम अपवाह(15.41 प्रतिशत) दर्ज किया गया। अकोला में, कृषि तालाब-2 के 4 हेक्टेयर जलग्रहण क्षेत्र में वर्षा के कारण अपवाह 357.5 एमएम था जिससे कृषि तालाब में 2579 घन मीटर अपवाह के संग्रहण में सहायता मिली। कुल अपवाह 64.48 एमएम दर्ज किया गया, जोकि वर्षा के कारण हुई अपवाह का 18.04 प्रतिशत था। संचित तालाब जल(2579.2 घन मीटर) से यदि 5 सेंटी मीटर संरक्षण सिंचाई दी गई तो करीब 4.0 हेक्टेयर क्षेत्र को सिंचा जा सकता है।

परभनी में, हर 5 दिनों के बाद 10 एमजी प्रति वर्ग मीटर की दर से एसटिल एल्कोहल (acetyl alcohol) के बजाय 5 दिनों के अंतराल पर 15 एमजी प्रति वर्ग मीटर की दर से एसटिल एल्कोहल (acetyl alcohol) से वाष्पण हानि को कम करने में महत्वपूर्ण पाया गया। विभिन्न मात्राओं एवं अवधियों से एसटिल एल्कोहल (acetyl alcohol) के प्रयोग से वाष्पण दर को 54 से 66 प्रतिशत तक कम करने में प्रभावी पाया गया। अनंतपुर में, वाष्पण हानि को कम करने के उद्देश्य से किए गए एक अध्ययन में छोटी सीमेंट संरचनाएं, बांस के मेट वाष्पण हानि (6.7 सेंटीमीटर प्रति दिन) को देर करने में प्रभावी पाए गए। रसायनिक पदार्थों में, स्टेरिल एल्कोहल (steryl alcohol) वाष्पण हानि (10.85 सेंटीमीटर प्रति दिन) को कम करने में प्रभावी पाया गया इसके बाद सिलिकॉन तेल एवं सेटिल एल्कोहल का स्थान था। ये रसायन एक सप्ताह की अवधि के लिए प्रभावी पाए गए, इसके बाद इनकी क्षमता घटती गई।

सस्यन प्रणालियां

अंतर सस्यन प्रणालियां

मोटे अनाज की फसल पर आधारित अंतर सस्यन प्रणालियों में, बिस्वनाथ चरिअलि में, तिल + उडद (1:1) प्रणाली में 30:20:20 किलोग्राम नाइट्रोजन फासफोरस एवं पोटाश के प्रयोग से अधिकतम तिल समतुल्य उत्पादन (1347 किलोग्राम प्रति हेक्टेयर), एलईआर (2.03), निवल आय (91049/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (6.49 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया गया। वाराणासी में, चासल (एनडीआर-97) + भिंडी (एचआरबी-55) (1:1) अंतर सस्यन प्रणाली ने अधिकतम भिंडी समतुल्य उत्पादन (13411 किलोग्राम प्रति हेक्टेयर) एवं 4.93 का बी:सी अनुपात एवं 15.6 किलोग्राम प्रति हेक्टेयर-एमएम का वर्षाजल उपयोग क्षमता सहित 106912/-रुपए प्रति हेक्टेयर का निवल आय दर्ज किया। राख धैनसर में, लोबिया के 2 पंक्तियों में मक्का की जोड़ी पंक्तियों से 1.63 का अधिकतम बी:सी अनुपात सहित क्रमश: 2423 किलोग्राम प्रति हेक्टेयर एवं 1.32 का अधिकतम मक्का समतुल्य उत्पादन एवं एलईआर प्राप्त हुआ। हिसार में, 45:120 पर सेसबनिआ की जोड़ी पंक्तियों + बाजरा की 2 पंक्तियों से अधिकतम बाजरा समतुल्य उत्पाद

(1930 किलोग्राम प्रति हेक्टेयर), निवल आय(6832/-रुपए प्रति हेक्टेयर), बी:सी अनुपात(1.38) एवं वर्षाजल उपयोग क्षमता (9.11 किलोग्राम प्रति हेक्टेयर-एमएम) प्राप्त हुआ।

तिलहन आधारित अंतर सस्यपन प्रणालियों में, अनंतपुरम में, मूंगफली + अरहर अंतर सस्यपन प्रणाली (15:1) ने उन्नत मूंगफली समतुल्य उत्पादन (1041 किलोग्राम प्रति हेक्टेयर), भूमि समतुल्य दर (1.14), निवल आय (31280/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.48) दर्ज किया गया।

कपास आधारित अंतर सस्यपन प्रणालियों में, राजकोट में, कपास + लोबिया(1:1) से कपास समतुल्य उन्नत बीज उत्पादन (3360 किलोग्राम प्रति हेक्टेयर), निवल आय (124229/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.36) एवं वर्षाजल उपयोग क्षमता (5.72 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया गया।

दोहरी सस्यन प्रणालियां

बिस्वनाथ चरिअलि में, मक्का + आलू से 9074 किलोग्राम प्रति हेक्टेयर का अधिकतम मक्का समतुल्य उत्पादन हुआ, इसके बाद मक्का-राज़मा प्रणाली (7819 किलोग्राम प्रति हेक्टेयर) था, जबकि मक्का-राज़मा प्रणाली से 61162/-रुपए प्रति हेक्टेयर का अधिकतम निवल आय एवं बी:सी अनुपात (2.87) दर्ज किया गया। 150 प्रतिशत सिफारिश किए गए बीज दर से मटर की बोवाई की गई एवं चावल की कटाई के 15 दिन पहले मटर का अधिकतम बीज उत्पादन (474 किलोग्राम प्रति हेक्टेयर) हुआ। अकोला में, एकल कपास एवं सोयाबीन की तुलना में कपास + सोयाबीन (4:10) – कुसुंभ अनुक्रम में महत्वपूर्ण रूप से अधिक निवल आय (41752/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (2.93 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया गया। अधिक घनत्व रोपण प्रणाली से कपास की मानसून पूर्व बोवाई के अंतर्गत, देशी कपास (एकेए-7) + सोयाबीन (6:6) –सरसों अनुक्रम ने महत्वपूर्ण रूप से उन्नत कपास समतुल्य उत्पादन (2148 किलोग्राम प्रति हेक्टेयर), निवल आय (63080/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.54) एवं वर्षाजल उपयोग क्षमता (3.75 किलोग्राम प्रति हेक्टेयर/एमएम) दर्ज किया गया।

पर्ण छिड़काव

वाराणासी में, सितंबर महिने में 20 दिनों के शुष्क दौर के दौरान 2 प्रतिशत KCl + Zn + Bo से पर्ण छिड़काव ने निवल आय (16705/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.04) एवं वर्षाजल उपयोग क्षमता (2.2 किलोग्राम प्रति हेक्टेयर-एमएम) सहित चावल का अधिकतम अनाज उत्पादन दिया इसके बाद 2 प्रतिशत थियोरिआ (2027 किलोग्राम प्रति हेक्टेयर) के पर्ण छिड़काव का था। बिस्वनाथ चरिअलि में, पुष्पण से पहले सिफारिश की गई उर्वरक मात्रा + 2 प्रतिशत KNO_3 पर्ण छिड़काव ने 1146 किलोग्राम प्रति हेक्टेयर का अधिकतम तोरिआ उत्पादन दिया एवं यह पुष्पण से पहले तथा सिलिक्वा (siliqua) निर्माण (1109 किलोग्राम प्रति हेक्टेयर) पर सिफारिश किया गया उर्वरक + 2 प्रतिशत KNO_3 के पर्ण छिड़काव के समान था। अरजिया में, घुटनों की ऊंचाई एवं टेस्सलिंग स्तरों पर 5 प्रतिशत की दर से जिंक सल्फेट + 2 प्रतिशत नाइट्रोजन फासफोरस पोटाश (NPK) (घुलनशील) के पर्ण छिड़काव ने महत्वपूर्ण रूप से उन्नत मक्का अनाज एवं कड़बी का उत्पादन (1775 एवं 6992 किलोग्राम प्रति हेक्टेयर) दिया। बल्लोवाल सांकुरी में, दो बार(टेस्सलिंग एवं डाऊ स्तर) पर 1 प्रतिशत KNO_3 के पर्ण छिड़काव ने अधिकतम अनाज उत्पादन(2438किलोग्राम प्रति हेक्टेयर), वर्षाजल उपयोग क्षमता (7.91 किलोग्राम प्रति हेक्टेयर-एमएम), निवल आय (10285/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.33) दिया। बेंगलुरू में, बाली निकलने की अवस्था में 2 प्रतिशत KNO_3 के पर्ण छिड़काव से 2.35 को बी:सी अनुपात एवं वर्षाजल उपयोग क्षमता (5.08 किलोग्राम प्रति हेक्टेयर-एमएम) सहित रागी का उन्नत अनाज एवं कड़बी का उत्पादन (क्रमश: 2637 एवं 5139 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। हिसार में, 250 ग्राम प्रति हेक्टेयर की दर से (2 बार) थियोरिआ के छिड़काव के परिणामस्वरूप बाजरा (1189 किलोग्राम प्रति हेक्टेयर), सरसों (1450 किलोग्राम प्रति हेक्टेयर), बी:सी अनुपात (1.07 एवं 2.4) एवं वर्षाजल उपयोग क्षमता (5.61 और 39.2 किलोग्राम प्रति हेक्टेयर-एमएम) दोनों फसलों में दर्ज किया गया। विजयपुर में, बोवाई के 45 एवं 75 दिनों के बाद सिफारिश किया गया उर्वरक + KNO_3 (0.5 प्रतिशत) के छिड़काव ज्वार का अनाज उत्पादन(1996 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया जबकि सिफारिश किया गया उर्वरक + एकल पोटाशियम फासफेट (1 प्रतिशत) के पर्ण छिड़काव ने 1626 किलोग्राम प्रति हेक्टेयर का न्यूनतम उत्पादन दिया।

इंदौर में, नियंत्रण की तुलना में 250 ग्राम प्रति हेक्टेयर की दर से थियोरिआ + 600 मिली लीटर प्रति हेक्टेयर की दर से ट्राइजोफॉस का पर्ण छिड़काव एवं इसके बाद 1 प्रतिशत KNO_3 + 600 मिली लीटर प्रति हेक्टेयर की दर से ट्राइजोफॉस के पर्ण छिड़काव से महत्वपूर्ण रूप से उन्नत सोयाबीन बीज उत्पादन(365 किलोग्राम प्रति हेक्टेयर), बी:सी अनुपात (0.64) एवं वर्षाजल उपयोग क्षमता (0.39) दर्ज किया गया। राजकोट में, बोवाई के 30 से 35 दिनों के बाद 2 प्रतिशत यूरिआ + बोवाई के 60 दिनों के बाद 2 प्रतिशत KNO_3 के पर्ण छिड़काव से मूंगफली का अधिकतम उत्पादन (1667 किलोग्राम प्रति हेक्टेयर) ,पलाल उत्पादन (4506 किलोग्राम प्रति हेक्टेयर), निवल आय (64902/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.34) एवं वर्षाजल उपयोग क्षमता (2.93 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया गया। अनंतपुर में, मृदा जांच आधारित उर्वरक का प्रयोग + 1 प्रतिशत KCl का छिड़काव (2 बार) से मूंगफली का उन्नत उत्पादन (2042 किलोग्राम प्रति हेक्टेयर) ,पलाल उत्पादन (2163 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। परभनी में, सिफारिश किया गया उर्वरक + 1 एवं 2 प्रतिशत(बोवाई के 35 एवं 65 दिनों के बाद) का KNO_3 का पर्ण छिड़काव ने अधिकतम कपास बीज उत्पादन (898 किलोग्राम प्रति हेक्टेयर), बी:सी अनुपात (1.21) एवं वर्षाजल उपयोग क्षमता (3.15 किलोग्राम प्रति हेक्टेयर-एमएम) दिया।

पोषक प्रबंधन

स्थाई खाद जांच

बिस्वनाथ चरिअलि में, स्थाई खाद जांच के अंतर्गत, चौथे वर्ष के चावल-मूंग-तोरिआ प्रणाली में, 75 प्रतिशत सिफारिश किया गया उर्वरक(अजैविक) + 3 टन प्रति हेक्टेयर की दर से वर्मीकंपोस्ट के प्रयोग से अधिकतम अहु चावल का उत्पादन एवं रबि के दौरान, तोरिआ का उन्नत बीज उत्पादन (1122 किलोग्राम प्रति हेक्टेयर) दिया, जबकि मूंग के मामले में, 50 प्रतिशत सिफारिश किया गया उर्वरक + 3 टन प्रति हेक्टेयर की दर से वर्मीकंपोस्ट ने अधिकतम बीज उत्पादन (1071 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया जोकि 75 प्रतिशत सिफारिश किया गया उर्वरक (अजैविक) + 3 टन प्रति हेक्टेयर की दर से वर्मीकंपोस्ट के समान था। अन्य उपचारों की तुलना में 76 प्रतिशत सिफारिश किया गया उर्वरक (अजैविक) + 3 टन प्रति हेक्टेयर की दर से वर्मीकंपोस्ट ने निम्न मृदा स्थूल घनत्व (1.01 Mg प्रति घन मीटर) अधिक उपलब्ध जलग्रहण क्षमा (17.56 प्रतिशत) जैविक कार्बन (0.91 प्रतिशत) एवं उपलब्ध नाइट्रोजन (453 किलोग्राम प्रति हेक्टेयर), फासफोरस (51 किलोग्राम प्रति हेक्टेयर) एवं पोटाश (233 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

बोल्लोवाल सांकुरी में, मक्का-गेहूं प्रणाली में स्थाई खाद जांच के अंतर्गत, 100 प्रतिशत नाइट्रोजन फासफोरस पोटाश + 10 टन अहाता खाद से अधिकतम मक्का उत्पादन (3049 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया जोकि नियंत्रण को छोड़ सभी उपचारों एवं उर्वरक द्वारा 100 प्रतिशत नाइट्रोजन के समान था। 100 प्रतिशत नाइट्रोजन फासफोरस पोटाश + 10 टन अहाता खाद एवं इसके बाद 50 प्रतिशत नाइट्रोजन फासफोरस पोटाश + 10 टन अहाता खाद के प्रयोग से उन्नत जैविक कार्बन मात्रा (0.5 प्रतिशत) दर्ज किया गया। 50 प्रतिशत नाइट्रोजन फासफोरस पोटाश + 10 टन अहाता खाद के प्रयोग से उन्नत फासफोरस (38.7 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। 100 प्रतिशत नाइट्रोजन फासफोरस पोटाश + 10 टन अहाता खाद के प्रयोग से उन्नत पोटाश (279.6 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

बेंगलुरू में, 38वें वर्ष के रागी के एकल सस्यन से स्थाई खाद जांच के अंतर्गत, सिफारिश किए गए नाइट्रोजन फासफोरस पोटाश (क्रमश: 1502 एवं 2779 किलोग्राम प्रति हेक्टेयर) की तुलना में 10 टन अहाता खाद + 100 प्रतिशत सिफारिश किया गया नाइट्रोजन फासफोरस पोटाश के प्रयोग से 2.43 का बी:सी अनुपात एवं वर्षाजल उपयोग क्षमता (5.02 किलोग्राम प्रति हेक्टेयर-एमएम) सहित रागी अनाज एवं भूसी का उत्पादन (क्रमश: 2588 एवं 4788 किलोग्राम प्रति हेक्टेयर) महत्वपूर्ण रूप से अधिक पाया गया। अन्य उपचारों की तुलना में 10 टन अहाता खाद + 100 प्रतिशत नाइट्रोजन फासफोरस पोटाश के प्रयोग से महत्वपूर्ण रूप से उन्नत जैविक कार्बन (0.58 प्रतिशत) एवं उपलब्ध पोषक (213,64 एवं 70 किलोग्राम नाइट्रोजन फासफोरस पोटाश) दर्ज किए गए।

इंदौर में, 24वें वर्ष के स्थाई खाद जांच के अंतर्गत, 6 टन अहाता खाद + नाइट्रोजन 20 फासफोरस 13 ने अधिकतम उत्पादन (1988 किलोग्राम प्रति हेक्टेयर) दिया। इसी प्रकार वर्ष 2015 में, 6 टन अहाता खाद + नाइट्रोजन 20 फासफोरस 13 से शामिल समेकित पोषक प्रबंधन ने उन्न्त बीज एवं कड़बी उत्पादन (1367 एवं 3774 किलोग्राम प्रति हेक्टेयर), निवल आय (32246/-रुपए प्रति हेक्टेयर) एवं 2.64 का बी:सी अनुपात दिया। अहाता खाद + नाइट्रोजन 20 फासफोरस 13 के अंतर्गत खेतों में अधिकतम औसम भार व्यास एवं नियंत्रण में न्यूनतम (0.44 एमएम) प्राप्त किया गया। विभिन्न उपचारों में पोरोसिटी का स्तर 43.77 से 56.98 प्रतिशत तक था और यह खाद + नाइट्रोजन 20 फासफोरस 13 के अंतर्गत अधिकतम था। 6 टन अहाता खाद + नाइट्रोजन 20 फासफोरस 13 वाले खेतों में मृदा जैविक कार्बन अधिक (0.87 प्रतिशत) था।

अनंतपुर में, मूंगफली में स्थाई खाद जांच के अंतर्गत, 50 प्रतिशत सिफारिश किया गया 50 प्रतिशत उर्वरक + 4 टन प्रति हेक्टेयर की दर से मूंगफली का छिलके के प्रयोग से महत्वपूर्ण रूप से उन्नत फली उत्पादन (1449 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया इसके बाद 50 प्रतिशत उर्वरक + 50 किलोग्राम प्रति हेक्टेयर की दर से $ZnSO_4$ (3 वर्षों में एक बार) (1445 किलोग्राम प्रति हेक्टेयर) का स्थान था। केवल जैविकों के प्रयोग से किए गए उपचारों में थोडा अधिक मृदा pH से तटस्थता या जैविकों एवं अजैविकों का संयोग देखा गया। 4 टन प्रति हेक्टेयर (1.31 Mg/m3) की दर से मूंगफली छिलका के प्रयोग से निम्न स्थूल घनत्व दर्ज किया गया।

समेकित पोषक प्रबंधन

बिस्वनाथ चरिअलि में, सिफारिश की गई उर्वरक मात्रा के प्रयोग से चावल-तोरिआ सस्यन प्रणाली ने महत्वपूर्ण रूप से उन्नत तोरिआ बीज उत्पादन (646 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (6.83 किलोग्राम प्रति हेक्टेयर-एमएम) दिया। फैजाबाद में, मृदा प्रयोग के रूप में 75 प्रतिशत नाइट्रोजन फासफोरस पोटाश + 25 किलोग्राम प्रति हेक्टेयर की दर से $ZnSO_4$ + 10 किलोग्राम प्रति हेक्टेयर की दर से $FeSO_4$ ने अधिकतम अनाज उत्पादन (3828 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (8.09 किलोग्राम प्रति हेक्टेयर-एमएम) दिया। राख धैनसर में, उर्वरकों द्वारा 100 प्रतिशत नाइट्रोजन फासफोरस पोटाश के प्रयोग से 2798 किलोग्राम प्रति हेक्टेयर का महत्वपूर्ण रूप से उन्नत मक्का अनाज उत्पादन हुआ जोकि वर्मीकंपोस्ट (2648 किलोग्राम प्रति हेक्टेयर) द्वारा अजैविक+25 प्रतिशत नाइट्रोजन से 75 प्रतिशत नाइट्रोजन के प्रयोग के समान था। जैविक कार्बन में भिन्नता 0.28 से 0.41 प्रतिशत थी। वर्मीकंपोस्ट द्वारा 100 प्रतिशत नाइट्रोजन के प्रयोग से अधिकतम जैविक कार्बन दर्ज किया गया इसके बाद अहाता खाद द्वारा 100 प्रतिशत नाइट्रोजन का स्थान था। 75 प्रतिशत अजैविक नाइट्रोजन + वर्मीकंपोस्ट द्वारा 25 प्रतिशत नाइट्रोजन के प्रयोग से नाइट्रोजन एवं फासफोरस (क्रमश: 197.0 एवं 16.96 किलोग्राम प्रति हेक्टेयर) के उन्न्त मूल्य दर्ज किए गए। बेंगलुरू में, 150 प्रतिशत सिफारिश किया गया पोटाश प्रति हेक्टेयर + 30 किलोग्राम प्रति हेक्टेयर की दर से मेंगनीशियम के प्रयोग से रागी का

उन्नत अनाज एवं भूसी उत्पादन (क्रमश: 566 एवं 2071 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

आग्रा में, सरसों में निर्माण की अवस्था पर सिफारिश किया गया उर्वरक मात्रा + आधार मात्रा के रूप में 50 किलोग्राम प्रति हेक्टेयर पोटाश + 2 प्रतिशत नाइट्रोजन फासफोरस पोटाश (19:19:19) का छिड़काव से महत्वपूर्ण रूप से उन्नत बीज उत्पादन (658 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ। विजयपुर में, 10 किलोग्राम $FeSO_4.7H_2O$ +15 किलोग्राम $ZnSO_4.7H_2O$ प्रति हेक्टेयर + सिफारिश किया गया उर्वरक ने चना बीज उत्पादन (777 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (7.22 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया। इंदौर में, 50 प्रतिशत नाइट्रोजन फासफोरस पोटाश, 20 किलोग्राम Zn, 10 किलाग्राम S + 10 टन प्रति हेक्टेयर का अहाता खाद + राइजोबियम सहित 5 टन फसल अवशेष + पीसीबी से महत्वपूर्ण रूप से उन्नत सोयाबीन बीज उत्पादन(753 किलोग्राम प्रति हेक्टेयर) प्राप्त हुआ। अनंतपुरम में, पीएसबी+पीएसएफ+एएम फफुंदी सहित 50 प्रतिशत सिफारिश किया गया उर्वरक ने अधिकतम मूंगफली उत्पादन (2314 किलोग्राम प्रति हेक्टेयर) दर्ज किया। इसके बाद मृदा आधारित उर्वरक + पीएसबी + पीएसएफ + एएम फफुंदी से 2314 किलोग्राम प्रति हेक्टेयर का फली उत्पादन हुआ।

कर्षण एवं पोषक प्रबंधन

बिस्वनाथ चरिअलि में, न्यूनतम कर्षण से उन्नत मूंगफली उत्पादन (736 किलोग्राम प्रति हेक्टेयर), पलाल उत्पादन (1835 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (0.83 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया गया इसके बाद रोटावेटर से कर्षण का स्थान रहा। पोषक प्रबंधन प्रक्रियाओं में, 50 प्रतिशत सिफारिश किया गया उर्वरक + 50 प्रतिशत जैविक (वर्मीकंपोस्ट) ने उन्नत फली उत्पादन (673 किलोग्राम प्रति हेक्टेयर), पलाल उत्पादन (1672 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (0.75 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया। पारंपरिक कर्षण (कर्षण(लेडरिंग द्वारा तीन से चार बार हल चलाना) द्वारा अधिकतम क्षेत्र क्षमता (28.50 घंटा प्रति हेक्टेयर) दर्ज किया गया एवं न्यूनतम कर्षण (एक बार हैरो चलाना) द्वारा अधिक ऊर्जा उपयोग क्षमता (0.85) दर्ज किया गया।

बल्लोवाल सांकुरी में, अन्य उपचारों की तुलना में पारंपरिक कर्षण + निराई-गुड़ाई अधिकतम मक्का उत्पादन (2053 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (6.6 किलोग्राम प्रति हेक्टेयर-एमएम) सहित बेहतर सिद्ध हुआ। नाइट्रोजन प्रयोग के मामले में, 100 प्रतिशत अजैविक स्रोत ने अधिकतम उत्पादन (2206 किलोग्राम प्रति हेक्टेयर), निवल आय (10313/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (7.1 किलोग्राम प्रति हेक्टेयर-एमएम) दिया। अजैविक माध्यमों द्वारा 100 प्रतिशत नाइट्रोजन की तुलना में 100 प्रतिशत नाइट्रोजन (जैविक), 50 प्रतिशत नाइट्रोजन (जैविक) + 50 प्रतिशत नाइट्रोजन (अजैविक) से क्रमश: 24.9 प्रतिशत एवं 7.9 प्रतिशत निवेश ऊजा में बचज हुई। अजैविक स्रोत द्वारा 100 प्रतिशत नाइट्रोजन से उत्पाद ऊर्जा उत्पादन अधिकतम थी इसके बाद 50 प्रतिशत नाइट्रोजन (जैविक) + 50 प्रतिशत नाइट्रोजन (अजैविक) का स्थान था। 50 प्रतिशत सीटी +निराई-गुड़ाई + शाकनाशी के अंतर्गत मक्का का ऊर्जा उपयोग क्षमता अधिकतम (9.32) था इसके बाद 100 प्रतिशत सीटी एवं 50 प्रतिशत + निराई-गुड़ाई उपचारों(9.17) का था।

इंदौर में, कम कर्षण + 4 टन प्रति हेक्टेयर कंपोस्ट + शाकनाशी ने अधिक निवल आय (38187/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (1.75 किलोग्राम प्रति हेक्टेयर-एमएम) सहित महत्वपूर्ण रूप से उन्न्त 882 किलोग्राम प्रति हेक्टेयर का बीज उत्पादन दर्ज किया। अन्य उपचारों की तुलना में एलटी+2 टन प्रति हेक्टेयर ग्लेरिसिडिया के पत्ते+शाकनाशी से न्यूनतम निवेश ऊर्जा (2809 MJ प्रति हेक्टेयर) दर्ज किया गया। अन्य उपचारों की तुलना में एलटी+4 टन प्रति हेक्टेयर कंपोस्ट+शाकनाशी से अधिकतम ऊर्जा निवेश (2809 MJ प्रति हेक्टेयर) दर्ज किया गया।

परभनी में, सोयाबीन + अरहर(4:2) प्रणाली में, पारंपरिक कर्षण ने अधिकतम सोयाबीन बीज समतुल्य उत्पादन (2439 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (8.55 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया। पोषको के माध्यमों में, सिफारिश किए गए उर्वरकों ने अधिकतम सोयाबीन बीज समतुल्य उत्पादन (2574 किलोग्राम प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (9.03 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया। पारंपरिक कर्षण + वर्मीकंपोस्ट से 9.8 सेंटीमीटर प्रति घंटा का अधिकतम अंत:स्यंदन दर दर्ज किया गया जबकि कम कर्षण + निराई-गुड़ाई + सिफारिश की गई उर्वरक मात्रा में 5.0 सेंटीमीटर प्रति घंटा का न्यूनतम अंत:स्यंदन दर दर्ज किया गया। अन्य उपचारों की तुलना में अहाता खाद प्रयोग सहित कम कर्षण + निराई-गुड़ाई के अंतर्गत खेतों में न्यूनतम स्थूल घनत्व (1.20 ग्राम प्रति घन सेंटीमीटर) दर्ज किया गया।

कृषि यांत्रिकीकरण

विजयपुर में, बैलों द्वारा चालित बीज ड्रिल से क्षेत्र क्षमता की 0.25 से 0.27 घंटे प्रति हेक्टेयर थी जबकि ट्रेक्टर चालित बीज ड्रिल से क्षेत्र की क्षमता 0.84 से 0.85 घंटे प्रति हेक्टेयर थी। कोविलपट्टी में, हवा की सहायता से चलने वाली बीज ड्रिल से छोटे अनाजों की सीधी बोवाई से बीज दर समें 30 से 40 प्रतिशत बचत हुई एवं प्रति हेक्टेयर क्षेत्र में हवा की सहायता से चलने वाला बीज ड्रिल, ट्रेक्टर द्वारा चलने वाला गोरू एवं बीज बिखेरने के लिए से क्रमश: 124, 2.81 एवं 3.00 घंटे का समय लगा।

उन्नत किस्मों का मूल्यांकन

केंद्रों पर विभिन्न वर्षा आधारित फसलों के किस्मों का मूल्यांकन किया गया। स्थानीय किस्मों/लोकप्रिय किस्मों की तुलना में बेहतर निष्पादन देने वाली क्सिमें थी: बिस्वनाथ चरिअलि में टीटीबी-404 (4053 किलोग्राम प्रति हेक्टेयर) मध्यम अवधि की अधिक उत्पादन देने वाली चावल की किस्म थी; अरजिया में उड़ी किस्म केपीयू 11-39; बल्लोवाल सांकुरी

में तारामिरा किस्म टीएमएलसी 2 (824 किलोग्राम प्रति हेक्टेयर); बेंगलुरू में मूंगफली किस्म आईसीजीवी-0350 (2363 किलोग्राम प्रति हेक्टेयर); रीवा में सरसों की किस्म पूसा तारक (917 किलोग्राम प्रति हेक्टेयर); अनंतपुरम में मूंगफली प्रविष्टी एमएलटीजी-वीजी-15-9 (1550 किलोग्राम प्रति हेक्टेयर का फली उत्पादन); राजकोट में मूंगफली किस्म जेएसपी-60 (3028 किलोग्राम प्रति हेक्टेयर)।

वैकल्पिक भूमि उपयोग प्रणाली

अरजिया में, सीमांत भूमि पर स्थित नीम पेड़ की पंक्तियों में, मड बाल/पेल्लेट से सेंचुरस घास बीज की बोवाई ने 6927/-रुपए प्रति हेक्टेयर का अतिरिक्त आय, 1.70 का बी:सी अनुपात एवं 3.2 किलोग्राम प्रति हेक्टेयर-एमएम का वर्षाजल उपयोग क्षमता सहित महत्वपूर्ण रूप से उन्नत सूखा घास उत्पादन (2157 किलोग्राम प्रति हेक्टेयर) दिया। इसके अलावा, 20 किलाग्राम नाइट्रोजन + 30 किलोग्राम P_2O_5 प्रति हेक्टेयर से उन्न्त सूखा घास उत्पादन (2478 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। बल्लोवाल सांकुरी में, अमरूद एवं आमला आधारित कृषि-बागवानी प्रणाली में, अमरूद एवं आमला रोपण में उड़द का उत्पादन क्रमश: 224 एवं 346 किलोग्राम प्रति हेक्टेयर था। एकल फसल एवं फलों की खेती की तुलना में आमला (132802/-रुपए प्रति हेक्टेयर) साथ ही साथ अमरूद (512270/-रुपए प्रति हेक्टेयर) आधारित प्रणाली से अधिक निवल आय प्राप्त हुआ। विजयपुर में, 10 मीटर x 9 मीटर(168 किलोग्राम प्रति हेक्टेयर) की तुलना में 10 मीटर x 6 मीटर (205 किलोग्राम प्रति हेक्टेयर) के रोपण ज्यामिती में इमली का फल उत्पादन महत्वपूर्णरूप से उन्न्त था। सिगनल घास (2418किलोग्राम प्रति हेक्टेयर) की तुलना में जीनी घास से महत्वपूर्णरूप से उन्नत हरा घास (3602 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। अकोला में, हनुमानफल एवं सीताफल आधारित कृषि-बागवानी में, सीसीटी उपचारित जलग्रहण से अंतर फसलों ने बेहतर निष्पादन दिया एवं अनुपचारित जलग्रहण की तुलना में सीसीटी उपचारित जलग्रहण के भूमिजल रीचार्ज में अगस्त में (4.39 मीटर) इसके बाद सितंबर (4.29 मीटर) का स्थान था। औसतन, अनुपचारित जलग्रहण (2.09 मीटर) की तुलना में सीसीटी उपचारित जलग्रहण 21.2 प्रतिशत अधिक था। परभनी में, चौब + मूंग (1:6) से उन्नत उत्पादन प्रणाली (2246 किलोग्राम प्रति हेक्टेयर), निवल आय (10807/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग क्षमता (7.88 किलोग्राम प्रति हेक्टेयर-एमएम) था इसके बाद चौब + सोयाबीन (1:2) (2147 किलोग्राम प्रति हेक्टेयर) एवं चौब + उड़द (1:6) (2056 किलोग्राम प्रति हेक्टेयर) का स्थान था।

समेकित कृषि प्रणाली

वाराणासी में, पशु आधारित कृषि प्रणाली(तीन भैंस + दो भैंस के बछड़े) ने अधिकतम निवल आय (257800/-रुपए प्रति हेक्टेयर) एवं रोज़गार (200 कार्य दिवस प्रति हेक्टेयर प्रति वर्ष) सहित 2050 किलोग्राम प्रति हेक्टेयर का चावल उत्पादन दिया जबकि ओनला एवं तिल आधारित कृषि –बागवानी प्रणाली ने क्रमश: 100 एवं 110 किलोग्राम प्रति हेक्टेयर का उत्पादन सहित 42500/-रुपए प्रति हेक्टेयर का निवल आय एवं 75 कार्य दिवस प्रति हेक्टेयर प्रति वर्ष का रोज़गार प्रदान किया।

राजकोट में, किसानों की एकल कपास की कृषि (24973/-रुपए प्रति हेक्टेयर) की तुलना में दूध देने वाले पशु(गाय) सहित फसलों ने 32173/-रुपए का उन्नत निवल आय दर्ज किया। किसानों की कपास की कृषि के अंतर्गत 175 कार्य दिवस प्रति हेक्टेयर प्रति वर्ष की तुलना में समेकित कृषि प्रणाली के अंतर्गत 365 कार्य दिवस प्रति हेक्टेयर प्रति वर्ष का रोज़गार प्राप्त हुआ।

कोविलपट्टी में, फसल सहित समेकित कृषि प्रणाली, पशुधन(1 दुधारु पशु) एवं बकरी पालन (10+1) के समेकित कृषि प्रणाली से औसत प्रणाली उत्पादकता एवं औसत प्रणाली आय क्रमश: 10609 किलोग्राम प्रति हेक्टेयर एवं 133876/-रुपए प्रति हेक्टेयर थे जबकि परंपरागत प्रणाली में एकल सस्यन एवं फसल, पशुधन एवं बकरी पालन के कारण औसत रोज़गार क्रमश: 212 एवं 437 कार्य दिवस प्रति हेक्टेयर प्रति वर्ष हो गया।

चालू अनुसंधान परियोजना (ओआरपी)

आंध्र प्रदेश(अनंतपुर केंद्र)के कर्नूल जिले के येर्रगुंटला गांव में, वर्षा आधारित परिस्थितियों के अंतर्गत किसानों की प्रक्रिया (676 किलोग्राम प्रति हेक्टेयर एवं 35700/-रुपए प्रति हेक्टेयर) की तुलना में अरहर में चिसिल हल से भूमि की गहरी जुताई से उन्नत बीज उत्पादन(728 किलोग्राम प्रति हेक्टेयर) एवं निवल आय (49000/-रुपए प्रति हेक्टेयर) प्राप्त हुआ। अनंता आटोमेटिक बैल चालित बीज रोपण से सेटेरिया की बोवाई से उन्न्त अनाज उत्पादन (1125 किलोग्राम प्रति हेक्टेयर) एवं बी:सी अनुपात (3.3) प्राप्त हुआ।

पंजाब (बल्लोवाल सांकुरी केंद्र) होशियारपुर जिले के बेहदारया एवं कोठी गांव में, गेहूं की पारंपरिक कर्षण एवं निराई-गुड़ाई से अधिकतम अनाज उत्पादन (2149 किलोग्राम प्रति हेक्टेयर) एवं बी:सी अनुपात (1.82) दर्ज किया गया। मक्का में, अजैविक माध्यम से 100 प्रतिशत नाइट्रोजन के प्रयोग से 71.6 किलोग्राम प्रति हेक्टेयर-एमएम एवं 2.08 का बी:सी अनुपात सहित 3608 किलाग्राम प्रति हेक्टेयर अधिकतम अनाज उत्पादन दर्ज किया गया।

कर्नाटक (बेंगलुरू) के तुमकूर जिले के बैचनहल्ली एवं इरकसंद्रा गांव में, रागी + अरहर (8:2) अंतरा सस्यन प्रणाली में अरहर के जोड़ी पंक्तियों के बीच संरक्षण नालों के निर्माण ने उन्नत रागी समतुल्य उत्पादन (4076 किलोग्राम प्रति हेक्टेयर), वर्षाजल उपयोग क्षमता (5.89 किलोग्राम प्रति हेक्टेयर-एमएम) एवं बी:सी अनुपात (3.44) दर्ज किया गया। रागी + अरहर (8:2) प्रणाली में, जैविक माध्यम से 50 प्रतिशत नाइट्रोजन +अजैविक माध्यम से 50 प्रतिशत नाइट्रोजन एवं 100 प्रतिशत फासफोरस पोटाश + 12.5 किलोग्राम जिंक सल्फेट + 10 किलोग्राम बोराक्स प्रति हेक्टेयर के प्रयोग से अधिकतम रागी समतुल्य उत्पादन (4580 किलोग्राम प्रति हेक्टेयर) एवं बी:सी अनुपात (3.85) दर्ज किया गया।

झारखंड (चयनकी केंद्र) के घरवा जिले के गोंडा गांव में, देशी हल (1338 किलोग्राम प्रति हेक्टेयर) की तुलना में डिस्क हैरो से जब नमी का संरक्षण किया गया तो सरसों में डिस्क हैरों से (आर एच 30) एवं सरसों का उन्नत बीज उत्पादन (1522 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।

इंदौर में, सोयाबीन के आशाजनक किस्मों के मूल्यांकन में एक नई किस्म जेएस 2029 ने चार बीज वाली फलियों (50 प्रतिशत से अधिक फलियों में चार बीज थे) सहित उन्नत उत्पादन (535 किलोग्राम प्रति हेक्टेयर), निवल आय (3583/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.21) का उन्नत निष्पादन दिया। स्थानी किस्मों की तुलना में जेएस 9560 में भी चार बीज वाली फलियां, अधिक उत्पादन एवं 7 से 8 दिनों की परिपक्वता वाली थी, अत: यह आलू के बाद सोयाबीन उगाने की इच्छा रखने किसानों के लिए उपयुक्त था।

सोलापुर में, रबि ज्वार में स्व–स्थाने नमी संरक्षण के मूल्यांकन में, किसनों की प्रक्रिया (45 किलोग्राम प्रति हेक्टेयर) की तुलना में उपखंडीय मेंढ़ से 111 किलोग्राम प्रति हेक्टेयर का उन्नत औसत अनाज उत्पादन दर्ज किया गया। रबि ज्वार के ऊगाउ स्तर पर लंबी अवधि के शुष्क दौर से रबि ज्वार का उत्पादन प्रभावित हुआ।

अरजिया में, मक्का + उड़द (2:2) अंतर सस्यन प्रणाली के जारी मूल्यांकन में, प्रचालन क्षेत्र में सूखा के कारण मक्का एवं उड़द का कम उत्पादन प्राप्त हुआ। मिश्रित सस्यन (385 किलोग्राम प्रति हेक्टेयर) की तुलना में मक्का + उड़द (2:2) अंतर सस्यन प्रणाली से अधिकतम मक्का अनात समतुल्य उत्पादन (572 किलोग्राम प्रति हेक्टेयर) हुआ। बहुत कम उत्पादनों (385 एवं 305 किलोग्राम प्रति हेक्टेयर) के कारण मिश्रित एवं एकल मक्का दोनों से नकारात्मक आय दर्ज किया गया।

प्रौद्योगिकी उन्नयन

आंध्र प्रदेश (अनंतपुर केंद्र) के कर्नूल जिले के येरगुंटला गांव में, किसानों की प्रक्रिया (452 एवं 965 किलोग्राम प्रति हेक्टेयर) की तुलना में मूंगफली में मृदा जांच आधारित उर्वरकों के प्रयोग से उन्न्त फली एवं पलाल उत्पादन (530 एवं 1085 किलोग्राम प्रति हेक्टेयर) एवं निवल आय (4395/-रुपए प्रति हेक्टेयर) दर्ज किया। मूंगफली के6 (480 किलोग्राम प्रति हेक्टेयर) की उन्नत किस्म ने अधिक निवल आय (22915/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.0) सहित 452 किलोग्राम प्रति हेक्टेयर देने वाली ओएमवी-2 से आगे बढ़ गया।

राजस्थान (अरजिया केंद्र) के चितौढगढ जिले के नेवारिया गांव में, चना किस्म एके-42 के प्रदर्शन ने 267 किलोग्राम प्रति हेक्टेयर का अधिकतम बीज उत्पादन, 4124/- रुपए प्रति हेक्टेयर का निवल आय, 1.57 का बी:सी अनुपात दिया जबकि स्थानीय किस्म 95 किलोग्राम प्रति हेक्टेयर का उत्पादन सहित 2888/-रुपए का नकारात्मक निवल आय प्राप्त हुआ।

पंजाब (बल्लोवाल सांकुरी) के होशियारपुर जिलेके बेहदरिया एवं कोठी गांव के मक्का-गेहूं सस्यन के प्रदर्शन ने 5875 किलोग्राम प्रति हेक्टेयर के मक्का समतुल्य उत्पादन से 54524/-रुपए का अधिकतम निवल आय प्राप्त हुआ, इसके बाद मक्का-राया (45612/-रुपए प्रति हेक्टेयर) का था।

कर्नाटक (बेंगलुरू) के तुमकूर जिले के बैचनहल्ली एवं इरकसंद्रा गांव में, अरहर के जोड़ी पंक्तियों के बीच नमी संरक्षण नालों सहित मूंगफली + अरहर अंतरसस्यन 8:2 की पंक्ति अनुपात के प्रदर्शन ने किसानों की प्रक्रिया (869 किलोग्राम प्रति हेक्टेयर) की तुलना में 3.95 किलोग्राम प्रति हेक्टेयर-एमएम, निवल आय (86707/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (3.61) सहित उन्नत मूंगफली समतुल्य उत्पादन (2168 किलोग्राम प्रति हेक्टेयर) दिया।

झारखंड (चयनकी केंद्र) के घरवा जिले के छप्पर गोंड़ा गांव में, चावल की कटाई के बाद न्यूनतम कर्षण की परिस्थितियों के अंतर्गत अवशेष नमी पर चना का प्रदर्शन, उन्नत किस्म केपीजी-59 ने क्रमश: 34951/-रुपए प्रति हेक्टेयर, 3.69 एवं 28.30 किलोग्राम प्रति हेक्टेयर-एमएम का निवल आय, बी:सी अनुपात एवं वर्षाजल उपयोग क्षमता सहित उन्न्त बीज एवं कड़बी का उत्पादन (1138 एवं 815 किलोग्राम प्रति हेक्टेयर) दिया। किसानों की निवेश स्तर (110 नाइट्रोजन:45 P2O5) (2207 किलोग्राम प्रति हेक्टेयर) की तुलना में मध्यम भूमि परिस्थितियों में सिफारिश किए गए उर्वरकों (150:70:90) सहित संकर चावल किस्म अरजिया तेज ने अधिकतम अनाज (5047 किलोग्राम प्रति हेक्टेयर) एवं कड़बी उत्पादन (6020 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया एवं सिफारिश किए गए उर्वरकों से भी अधिक निवल आय (63157/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (4.38) एवं वर्षाजल उपयोग क्षमता (6.49 किलोग्राम प्रति हेक्टेयर-एमएम) दर्ज किया गया।

हरियाणा (हिसार केंद्र) भिवानी जिले के छप्पर जोगियन गांव में, सरसों की किस्म आरएच 119 के प्रदर्शन ने अधिकतम बीज उत्पादन (1523 किलोग्राम प्रति हेक्टेयर) एवं बी:सी अनुपात (2.84) दर्ज किया। चना किस्म एचसी 1 (400 किलोग्राम प्रति हेक्टेयर) की तुलना में किस्म सी-235 ने उन्नत बीज उत्पादन (432 किलोग्राम प्रति हेक्टेयर) एवं बी:सी अनुपात (0.85) दर्ज किया।

राष्ट्रीय जलवायु समुत्थान कृषि में नवप्रवर्तन (निक्रा)

अवधि के दौरान, सही समय की आकस्मिक फसल योजना कार्यान्वयन पर बल दिया गया एवं मौसम प्रतिकूलताओं से जूझने की तैयारी की गई तथा इन्हे 15 राज्यों के 24 जिलों में फैले 33 गांवों के करीब 400 हेक्टेयर क्षेत्र के 1050 किसानों के खेतों में कार्यान्वित किया गया। 2015-16 के दौरान, राजसमंद एवं सोलापुर जिलोंमें स्थित निक्रा के गांवों में मानसून के आने में दो सप्ताहों से अधिक की देरी हुई। इसके अलावा, निक्रा के लखिमपुर, घरवा,कंधमाल, विजयपुर एवं सोलापुर जिलों के गांवों में फसलों की विभिन्न स्तरों पर 4-6 शुष्क दौर चले। बलवास एवं बुधशेल्ली (भिवानी), कालिमति (बंसकांता), निगनोती (इंदौर), पाटा मेघपर (जामनगर), चिक्कमारनहल्ली (बेंगलुरू ग्रामीण) एवं तहकपल (बस्तर) को छोड़ सभी निक्रा गांवों में खरीफ के दौरान (जून-सिंतबर), 2015 के दौरान कुल वर्षा साधारण से कम थी। मानसून

के आगमन में देरी से जूझने के लिए लघु अविधि के विभिन्न फसलों को प्रस्तुत किया गया जिससे उत्पादन में 20 प्रतिशत की वृद्धि हुई। देश भर में फैले विभिन्न वर्षा आधारित प्रणालियों में आंरभिक/मध्य/अंतिम सूखा से जूझने के लिए सही समय की आकस्मिक उपायों के प्रभाव से उत्पादन में 25 प्रतिशत तक की वृद्धि हुई। गांव जलवायु जोखिम प्रबंधन समिति, कस्टम हायरिंग केंद्र आदि जैसे गांव के संस्थानों ने आकस्मिक उपायों को सही समय पर लागू करने में महत्वपूर्ण योगदान दिया।

जनजाति उप-योजना (टीएसपी)

जनजाति उप-योजना राजस्थान, झारखंड़, मध्य प्रदेश, ओडिशा, असम, छत्तीसगढ़ एवं गुजरात के 8 जिलों 22 गांवों के 7 केंद्रों द्वारा कार्यान्वित किया गया। जनजाति उप-योजना गांवों में किए गए प्रमुख हस्तक्षेपो में फसल/प्राकृतिक संसाधन प्रबंधन/पशुधन/जीविकोपार्जन आधारित हैं। गांवों को प्रदान किए गए भौतिक संपत्तियों में कृषि तालाब, उन्नत उपकरण, उन्नत पशु नस्ल आदि हैं। वर्षा आधारित फसलों की उत्पादकता को 45 प्रतिशत वृद्धि, 60 प्रतिशत तक लाभ एवं डेरी,सुअर पालन, मुर्गी पालन, मशरूम उगाना, वर्मीकंपोस्ट इकाई आदि जैसे जीविकोपार्जन हस्तक्षेपों पर जनजाति किसानों/युवा/महिलाओं के लाभ के लिए 31 प्रशिक्षण कार्यक्रमों का आयोजन कर वहां के लोगों को जीविकोपार्जन प्रदान किया गया।

मॉनीटरी एवं मूल्यांकन

अवधि के दौरान, देश भर में फैले एक्रीपडा नेटवर्क केंद्रों का तकनीकी, भौतिकी एवं आर्थिक लक्ष्यों का मॉनीटरी एवं मूल्यांकन किया गया। परियोजना समन्वयक (एक्रीपडा), परियोजना समन्वयन एकक के वैज्ञानिकों एवं एक्रीपडा के कर्मचारियों ने अनंतपुर, बेंगलुरू, इंदौर, हिसार, बिस्वनाथ चरिअलि, आग्रा, अरजिया, विजयपुर, सोलापुर, परभनी, चयनकी एवं बल्लोवाल सांकुरी केंद्रों का दौरा किया। दौरों के दौरान ही संबंधित अधिकारियों द्वारा सुधार/कोई आवश्यक कार्रवाई के लिए वहीं कार्यवाही तैयार की गई।

24-27 दिसंबर, 2015 के दौरान बिस्वनाथ चरिअलि केंद्र पर एक्रीपडा का पंद्रहवें कार्यदल की बैठक का आयोजन किया गया एवं बैठक के दौरान ही तकनीकी, भौतिकी एवं आर्थिक लक्ष्यों की भी समीक्षा की गई। दिनांक 1-3 सितंबर, 2015 के दौरान एएनजीआरएयु अनंतपुर केंद्र पर हुई तीसरी एक्रीपडा-निक्रा समीक्षा कार्यशाला के दौरान निक्रा के अंतर्गत हुई कार्य प्रगति की समीक्षा की गई। दिनांक 1-2 मार्च, 2016 के दौरान एक्रीपडा केंद्र अरजिया पर हुई दो दिवसीय समीक्षा कार्यशाला के दौरान एक्रीपडा-टीएसपी की गतिविधियों की समीक्षा की गई।

संपर्क एवं सहयोग

अवधि के दौरान, राज्य कृषि विश्वविद्यालयों, भाकृअनुप के संस्थानों, कृषि विज्ञान केंद्रों, राज्य सरकार के संबंधित विभागों, गैर सरकारी संगठनों एवं अपनानेयोग्य वर्षा आधारित प्रौद्योगिकियों तथा क्षमता निर्माण के उन्नयन के लिए बारानी अनुसंधान के लिए प्राथमिकता देने वाले किसानों से सहयोग/संपर्क को जारी रखे हुए है। इसके अलावा, राष्ट्रीय कृषि विकास योजना, राष्ट्रीय खाद्यान्न सुरक्षा मिशन, पीएमकेएसवाई, राज्य के बारानी कृषि मिशन आदि जैसे जारी राज्य एवं राष्ट्रीय कार्यक्रमों से समाभिरूपता में अपनानेयोग्य वर्षा आधारित प्रौद्योगिकियों के उन्नयन के लिए प्रयासरत विभिन्न संगठनों से संपर्क भी स्थापित किए हुए है। केंद्रों ने भी प्रिंट एवं इलेक्ट्रानिक मीडिया द्वारा बेहतर बारानी प्रक्रियाओं, कृषि सलाह, आकस्मिक योजनाओं आदि का प्रसार किया है।

प्रकाशन

वर्ष के दौरान एक्रीपडा दल के द्वारा कुल 199 प्रकाशनों का योगदान किया गया है जिसमें 66 अनुसंधान लेख, 4 पुस्तक अध्याय, सम्मेलनों में प्रस्तुत करने के लिए 62 लेख, 28 पुस्तक/बुलेटिन/रिपोर्ट एवं 39 लोक प्रिय लेख शामिल हैं।

मानव संसाधन विकास, वर्षा आधारित प्रौद्योगिकियों के प्रभाव एवं उन्न्यन

केंद्रों द्वारा प्रथम एवं द्वितियक पणधारियों के ज्ञान में वृद्धि/कौशल विकास के लिए केंद्र पर एवं केंद्र के बाहर(चालू अनुसंधान परियोजना/निक्रा/ जनजाति उप-योजना गांव) क्षमता निर्माण गतिविधियों का आयोजन किया गया। प्रौद्योगिकी उन्नयन गतिविधियों में पणधारी परामर्श कार्यशालाएं, खेतों का प्रदर्शन, क्षेत्रीय दिवस, प्रदर्शन दौरे आदि शामिल हैं। इन प्रौद्योगिकियों की शक्ति एवं सीमाओं के मूल्यांकन के लिए अनंतपुर, बेंगलुरू एवं इंदौर केंद्रों द्वारा चालू अनुसंधान परियोजना द्वारा अपनाए गए गांवों में वर्षा आधारित प्रौद्योगिकियों का प्रभाव विश्लेषण किया गया। दिनांक 19 नवंबर, 2015 को एक्रीपडा केंद्र, बल्लोवाल सांकुरी में आयोजित एक दिवसीय जिलास्तरीय पणधारी परामर्श कार्यशाला के दौरान केंद्रों द्वारा वर्षा आधारित प्रौद्योगिकियों को निष्पादन एवं सीमाओं का अध्ययन किया गया तथा इन प्रौद्योगिकियों के उन्नयन के अवसरों की समीक्षा की गई।

बजट

वर्ष 2015-16 की अवधि के लिए एक्रीपडा के 22 नेटवर्क केंद्रों के लिए कुल 2113.57 लाख रुपए एवं 8 चालू अनुसंधान परियोजनों के लिए 252.67 लाख रुपए का कुल बजट आबंटित किया गया।

Executive Summary

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) with network of 22 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, alternate land use(ALU)/integrated farming systems (IFS). The technologies are assessed on farmers' fields through 8 Operational Research Projects (ORPs). During 2015-16, a total of 284 on-station experiments were conducted viz. RWM-59; CS-47; NM-55; EM-29; EIV-60; ALU-19;IFS-12 and resource characterization-2. In ORPs, 100 on-farm trials/demonstrations were conducted viz. RWM-27; CS-22; NM -16; EM-15; EIV-14; ALU/IFS-6.

During 2015-16, the onset of monsoon normal across all AICRPDA centres expect Chianki (delay by 20 days), Arjia (17 days) and Rewa (10 days). Further, there were 3-5 dry spells of more than 10 days each at different stages of crops at Biswanath Chariali, Chianki, Jagdalpur, Phulbani, Arjia, Ballowal Saunkhri, Agra, Vijayapura, Solapur, Indore, Anantapuramu, Rajkot and Akola. In June, the rainfall was deficit by more than 40% at Chianki, Ballowal Saunkhri, SK Nagar, Solapur and Rewa. In July, 8 centres viz. Jagdalpur, Agra, Vijayapura, Anantapuramu, Akola, Solapur, Kovilpatti and Parbhani recorded more than 50% deficit rainfall. However, the rainfall was deficit by more than 45% at 11 centres (Faizabad, Phulbani, Ballowal Saunkhri, Rakh Dhiansar, Bengaluru, Agra, Hisar, SK Nagar, Solapur, Rajkot and Parbhani) in August, and 10 centres (Chinaki, Faizabad, Varanasi, Arjia, Agra, Hisar, SK Nagar, Solapur, Indore and Rewa) in Spetember, 2015.

The salient achievements are given below.

Rainwater management

In-situ moisture conservation

The experiments on *in-situ* moisture conservation include treatments such as ridge and furrow system, raised and sunken bed, mulching with crop residues/plastic mulches, vegetative barriers, broad bed furrow system, conservation furrow, tillage, weed management etc.

At Parbhani, the storm-wise runoff, soil loss and per cent moisture during the crop growth period and monsoon period was determined. The highest runoff of 94 mm was produced in the treatment of flat bed and minimum runoff of 49 mm was produced in the treatment of BBF which was 52% less than the flat bed treatment. All moisture conservation treatments recorded less runoff as compared to flatbed treatment to the tune of 31 to 48%. The highest soil loss of 2.41 t/ha was produced in the treatment of flat bed and minimum soil loss of 1.05 t/ha was produced in the broad bed and furrow (BBF) system which was 66% less than the flat bed treatment.

At Phulbani, ridge furrow system with mulching of crop residues resulted in highest yield of three vegetable crops viz., cauliflower, tomato and okra (6450, 12650 and 6520 kg/ha, respectively) with higher B:C ratio (2.60, 3.24 and 2.51) and RWUE (12.31, 24.14 and 12.44 kg/ha-mm) compared to BBF: at Rakh Dhiansar, higher maize grain yield was obtained (2777 kg/ha) in BBF + mulching with leucaena leaves with higher net returns, B:C and RWUE of Rs.27564/ha, 2.23 and 10.51 kg/ha-mm, respectively; at Parbhani, in soybean, BBF system recorded significantly higher seed yield (848 kg/ha), RWUE (2.97 kg/ha-mm), net returns (Rs.13972/ha) and B:C ratio (1.78), followed by opening of furrow after every 4 rows (722 kg/ha); at Indore, 90 cm raised bed width with 3-rows per bed recorded significantly higher soybean seed yield (542 kg/ha) compared to sowing on flat land (418 kg/ha) and 60 cm raised bed with 2-rows per bed (315 kg/ha).

At Rajkot, ridge and furrow system recorded significantly higher seed cotton and stalk yield (2573 and 4196 kg/ha respectively), B:C ratio (3.34) and soil moisture content (24.3%) and the yields were at par with BBF (2388 kg/ha). Plastic mulching (25 micron sheet) recorded significantly higher seed cotton and stalk yield (2474 and 4209 kg/ha) and soil moisture content (22.6%) and the yields were at par with straw mulch @ 5 t/ha (2369 kg/ha).

At Kovilpatti, rotovator ploughing + chisel ploughing recorded the highest yield of cotton (974 kg/ha), RWUE of 2.05 kg/ha-mm with net returns of Rs.11330/ha and B:C ratio of 1.35, which was 11% higher than the conventional tillage.

At Bengaluru, in amla plantation (3200 m^2), higher yield and net returns were recorded with trench–cum-crescent bund as micro -site improvement (3273 kg/ha and Rs.123320/ha) with less runoff (4.09 m^3), soil loss (6.1 kg) and nitrogen losses (94 kg).

Ex-situ rainwater management

The *ex-situ* rainwater management is mainly through harvesting of rainwater in farm ponds and efficient utilization as protective/supplemental irrigation, in some cases with microirrigation systems.

At Jagdalpur, two supplemental irrigations with sprinklers in vegetable crops (cauliflower/tomato) recorded higher yields (2645 kg/ha), net returns (Rs.48070/ha), B:C ratio (2.66) and RWUE (19.74 kg/ha-mm). At Varanasi, in an evaluation of vegetable crops viz. bottle gourd, okra, brinjal and chilli with supplemental irrigation of 5 cm at vegetative and flowering stages, bottle gourd gave the highest yield (12500 kg/ha), B:C ratio (3.3). A pre-sowing irrigation to pea varieties, AP-3 gave higher seed yield (1486 kg/ha), net returns (Rs.17720 /ha), B:C ratio (2.1) and WUE (14.65 kg/ha-mm) as compared to Malvia-15 (1152 kg/ha).

At Arjia, electric motor was found as better lifting device followed by the gassifier pump set. With supplemental irrigation, ridge gourd recorded the highest maize equivalent yield (MEY) of 5541 kg/ha with water productivity of 2.04 kg/m^3, net returns of Rs.67440/ha and B:C ratio of 3.21. Drip irrigation saved the water by 58.5% over surface irrigation and increased MEY by 12%. At Ballowal Saunkhri, one supplemental irrigation during dry spell gave 52% higher maize yield over rainfed maize. During rabi season, one supplemental irrigation at CRI stage in wheat gave 56% higher yield over rainfed crop; at Indore, with supplemental irrigation, drip irrigation at 3 liter/hour was applied to sweet corn and tomato during rabi and the discharge water used by tomato crop was 30 liter per plant or 83 cm/ha and sweet corn 24 liters per plant or 88 cm/ha.

At Rajkot, maximum soil loss (536.49 kg/ha) and maximum runoff (15.41%) was recorded under cultivated follow. At Akola, the runoff causing rainfall in the catchment area of 4 ha of farm pond-2 was 357.5 mm which helped in accumulation of 2579.2 m^3 runoff in the farm pond. The total runoff recorded was 64.48 mm, which was 18.04% of the runoff causing rainfall. From the stored pond water (2579.2 m^3), if protective irrigation of 5 cm is given, about 4.0 ha area could be irrigated.

At Parbhani, application of acetyl alcohol @ 15 mg/m^2 at an interval of 5 days was found to be significantly superior in minimizing the evaporation losses except acetyl alcohol @ 10 mg/m^2 after every 5 days. Application of acetyl alcohol with various rates and duration was found to be effective in reducing evaporation rate by 54 to 66%; at Anantapuramu, in a study on minimizing the evaporation losses with different materials in small cement structures, bamboo mat was found effective in preventing evaporation losses (6.7 cm/day). Among chemical materials, steryl alcohol was found effective in minimizing evaporation losses (10.85 cm/day) followed by silicon oil and cetyl alcohol. The chemicals were found effective for a period of one week, later on their efficiency decreased.

Cropping systems

Intercropping systems

In cereal crop based intercropping systems, at Biswanath Chariali, maximum sesame equivalent yield (SEY) (1347 kg/ha), LER (2.03), net returns (Rs.91049/ha) and RWUE (6.49 kg/ha-mm) were recorded with application of 30:20:20 kg NPK/ha in sesame + blackgram system (1:1); at Varanasi, rice (NDR-97) + okra (HRB-55) intercropping system (1:1), recorded highest okra equivalent yield (13411 kg/ha) and net returns of Rs.106912/ha with B:C ratio of 4.93 and RWUE of 15.6 kg/ha-mm; at Rakh Dhiansar, the highest maize equivalent yield (MEY) was obtained with paired rows of maize with 2 rows of cowpea with the MEY and LER of 2423 kg/ha and 1.32, respectively with the highest B:C ratio of 1.63; at Hisar, paired row of sesbania at 45 : 120 + 2 rows of pearl millet resulted in highest pearlmillet equivalent yield (PEY) (1930 kg/ha), net returns (Rs.6832/ha), B:C ratio (1.38) and RWUE (9.11 kg/ha-mm).

In oilseed crop based intercropping systems, at Anantapuramu, groundnut + pigeonpea intercropping system (15:1) recorded higher groundnut equivalent yield (1041 kg/ha), land equivalent rate (1.14), net returns (Rs.31280/ha) and B:C ratio (1.48).

In cotton based intercropping systems, at Rajkot, higher seed cotton equivalent yield (3360 kg/ha), net returns (Rs.124229/ha), B:C ratio (3.36) and RWUE (5.72 kg/ha-mm) was recorded with cotton + cowpea (1:1).

Double cropping systems

At Biswanath Chariali, maximum maize equivalent yield (MEY) of 9074 kg/ha was obtained with maize-potato system followed by maize-rajmah system (7819 kg/ha) while maximum net returns of Rs.61162/ha and B:C ratio (2.87) was recorded with maize-rajmah system. Pea relayed with 150% recommended seed rate and 15 days before harvesting of rice gave maximum seed yield (474 kg/ha); at Akola, significantly higher net returns (Rs.41752/ha)) and RWUE (2.93 kg/ha/mm) were recorded with cotton + soybean (4:10) - safflower sequence than sole cotton and soybean. Under pre-monsoon sowing of cotton with high density planting system, Deshi cotton (AKA-7) + soybean (6:6) – mustard sequence recorded significantly higher cotton equivalent yield (2148 kg/ha), net returns (Rs.63080/ha), B:C ratio (2.54) and RWUE (3.75 kg/ha/mm).

Foliar spray

At Varanasi, foliar spray with 2% KCl + Zn + Bo during dry spell of 20 days in September gave highest grain yield of rice (2110 kg/ha) with higher net returns (Rs 16705/ha), B:C ratio (2.04) and RWUE (2.2 kg/ha-mm) followed by foliar spray of 2% thiourea (2027 kg/ha); at Biswanath Chariali, RDF+ 2% KNO_3 foliar spray before flowering gave maximum toria yield of 1146 kg/ha and was at par with RDF + 2% KCl spray before flowering and at siliqua formation (1109 kg/ha); at Arjia, foliar spray of zinc sulphate @ 0.5% + NPK (soluble) @ 2% at knee high and tasseling stages gave significantly higher maize grain and stover yield (1775 and 6992 kg/ha); at Ballowal Saunkhri, foliar spray of 1% KNO_3 twice (tasseling and dough stages) gave highest grain yield (2438 kg/ha), RWUE (7.91 kg/ha-mm), net returns (Rs.10285/ha) and B:C ratio (1.33); at Bengaluru, higher grain and straw yield of fingermillet was recorded with foliar spray of 2% KNO_3 at panicle initiation stage (2637 and 5139 kg/ha, respectively) with B:C ratio of 2.35 and RWUE (5.08 kg/ha-mm); at Hisar, spray of thiourea at 250 g/ha (2 sprays) resulted in higher yield of pearl millet (1189 kg/ha) and mustard (1450 kg/ha), B:C ratio (1.07 and 2.4) and RWUE (5.61 and 39.2 kg/ha-mm) in both the crops; at Vijayapura, RDF + KNO_3 (0.5%) sprays at 45 and 75 DAS was superior with grain yield of sorghum (1996 kg/ha) while RDF + foliar spray of mono potassium phosphate (1%) gave lowest yield of 1626 kg/ha.

At Indore, significantly higher soybean seed yield (365 kg/ha), B:C ratio (0.64) and RWUE (0.39) was recorded with foliar spray of thiourea @ 250 g/ha + trizophos @ 600 ml/ha, followed by foliar spray of 1% KNO_3 + trizophos @ 600 ml/ha tank mix as compared to control; at Rajkot, maximum groundnut pod yield (1667 kg/ha), haulm yield (4506 kg/ha), net returns (Rs.64902/ha), B:C ratio (2.34) and RWUE (2.93 kg/ha-mm) was recorded with foliar spray of 2 % urea at 30 to 35 DAS + KNO_3 2% at 60 DAS; at Anantapuramu, higher groundnut pod yield (2042 kg/ha) and haulm yield (2163 kg/ha) were recorded with application of soil test based fertilizer (STBF) + 1% KCl spray (2 times). At Parbhani, application of RDF + foliar spray of KNO_3 @ 1 and 2% (35 and 65 DAS) gave maximum seed cotton yield (898 kg/ha), B:C ratio (1.21) and RWUE (3.15 kg/ha-mm).

Nutrient management

Permanent Manurial Trials (PMTs)

At Biswanath Chariali, under PMT, rice–greengram-toria system in the 4^{th} year, application of 75% RDF (inorganic) + vermicompost @ 3 t/ha gave maximum ahu rice grain yield (1321 kg/ ha) and during rabi, higher seed yield of toria (1122 kg/ha) whereas in case of greengram, the maximum seed yield (1071 kg/ha) was recorded with 50% RDF + vermicompost @ 3 t/ha which was at par with 75% RDF (inorganic) + vermicompost @ 3 t/ha. Application of 76% RDF + vermicompost 3 t/ha recorded lower soil bulk density (1.01 Mg/m^3) higher available water holding capacity (17.56%), organic C (0.91%), and available N (453 kg/ha), P 51 kg/ha) and K 233 kg/ha) compared to other treatments.

At Ballowal Saunkhri, under PMT with maize-wheat system, highest maize yield (3049 kg/ha) was recorded with 100% NPK + FYM 10 t/ha which was at par with all treatments except control and 100% N through fertilizer. The higher organic carbon content (0.5%) was recorded with 100% NPK + FYM 10 t/ha followed by 50% NPK + FYM 10 t/ha. Application of 50% NPK + FYM 10 t/ha recorded higher P (38.7 kg/ha) and 100% NPK + FYM 10 t/ha recorded higher K (279.6 kg/ha).

At Bengaluru, under PMT in the 38^{th} year with mono-cropping of finger millet, the finger millet grain and straw yield was found to be significantly higher (2588 and

4788 kg/ha respectively) with application of FYM @ 10 t/ha+ 100% rec. NPK compared to application of rec. NPK (1502 and 2779 kg/ha, respectively) with a higher B:C ratio of 2.43 and RWUE (5.02 kg/ha-mm). Significantly higher organic C (0.58%) and available nutrients (213, 64 and 70 kg NPK/ha) were recorded with application of FYM at 10 t/ha + 100% NPK compared to other treatments.

At Indore, under PMT in the 24th year, FYM 6 t/ha + N20 P13 gave highest yield (1988 kg/ha). Similarly in 2015, integrated nutrient management involving (FYM 6 t/ha+ N20 P13) gave higher seed and stalk yield (1367 and 3774 kg/ha), net returns (Rs. 32246/ha) and B:C ratio 2.64. The maximum mean weight diameter was obtained in the plots under FYM + N20 P13 (1.90 mm) and minimum in control (0.44 mm). The porosity ranged from 43.77 to 56.98% in different treatments and was highest with FYM + N20 P13. The soil organic C was higher (0.87%) in plots with FYM 6 t/ha + N_2O P_{13}.

At Anantapuramu, under PMT in groundnut, application of 50% RDF + groundnut shells @ 4 t/ha recorded significantly higher pod yield (1449 kg/ha) which was closely followed by application of 100% RDF + $ZnSO_4$ @ 50 kg/ha (once in 3 years) (1445 kg/ha). Slightly higher soil pH towards neutral was observed in treatments applied with organics alone or combination of organics and inorganics. Higher soil available P (99 kg/ha) was recorded with application of 100% RDF + $ZnSO_4$ @ 50 kg/ha (once in 3 years). The lower bulk density was recorded with application of groundnut shells @ 4 t/ha (1.31 Mg/m^3).

Integrated nutrient management

At Biswanath Chariali, rice-toria cropping sequence with RDF gave significantly higher seed yield of toria (646 kg/ha) and RWUE (6.83 kg/ha-mm); at Faizabad, 75% NPK + FYM @ 6 t/ha + $ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 10 kg/ha as soil application gave maximum grain yield (3828 kg/ha) and RWUE of 8.90 kg/ha-mm; at Rakh Dhiansar, significantly higher maize grain yield of 2798 kg/ha was obtained with application of 100% NPK through fertilizer which was at par with application of 75% N through inorganic + 25% N through vermicompost (2648 kg/ha). Organic carbon varied from 0.28 to 0.41% and highest organic carbon was recorded with application of 100% N through vermicompost followed by 100% N through FYM. The higher value of nitrogen and phosphorus (197.0 and 16.96 kg/ha), respectively was recorded with application of 75% N inorganic + 25% N through vermicompost; at Bengaluru, application of 150% recommended K/ha + magnesium @ 30 kg/ha recorded higher grain and straw yield of fingermillet (566 kg/ha and 2071 kg/ha respectively)

At Agra, RDF + 50 kg K/ha as basal dose + 2% NPK spray (19:19:19)in mustard at siliqae formation produced significantly higher seed yield (658 kg/ha) ; at Vijayapura, application of 10 kg $FeSO_4.7H_2O$ + 15 kg $ZnSO_4.\ 7H_2O$/ha + RDF recorded higher chickpea seed yield (777 kg/ha) and RWUE (7.22 kg/ha-mm); at Indore, significantly highest soybean seed yield (753 kg/ha) was obtained with 50% NPK, 20 kg Zn, 10 kg S + 10 t/ha FYM + 5 t residue with Rhizobium + PSB; at Anantapuramu, 50% RDF with PSB + PSF + AM fungi recorded highest groundnut pod yield (2314 kg/ha) followed by soil test based fertilizer (STBF) + PSB+PSF+AM fungi with pod yield of 2232 kg/ha.

Tillage and nutrient management

At Biswanath Chariali, higher groundnut pod yield (736 kg/ha), haulm yield (1835 kg/ha) and RWUE (0.83 kg/ha-mm) were recorded with minimum tillage followed by tillage with rotavator. Among nutrient management practices, 50% RDF + 50% organic (vermicompost) recorded higher pod yield (673 kg/ha), haulm yield (1672 kg/ha) and RWUE (0.75 kg/ha-mm). The maximum field efficiency (28.50 hr/ha) was recorded by conventional tillage (three to four ploughing followed by laddering) and higher energy use efficiency (0.85) was recorded by minimum tillage (one harrowing).

At Ballowal Saunkhri, conventional tillage + interculture was better than other treatments with highest maize yield (2053 kg/ha) and RWUE (6.6 kg/ha-mm). In case of N application, 100% (inorganic source) gave highest yield (2206 kg/ha), net returns (Rs.10313/ha) and RWUE (7.1 kg/ha-mm). Application of 100% N (organic), 50% N (organic) + 50% N (inorganic) saved 24.9% and 7.9% input energy over 100% N through inorganic source. The output energy production was highest with 100% N through inorganic source followed by 50% N (organic), + 50% N (inorganic). The energy use efficiency of maize was maximum (9.32) under 50% (CT) + interculture + herbicide followed by 100% CT and 50% + interculture treatments (9.17).

At Indore, low tillage + 4 t/ha compost + herbicide recorded significantly highest seed yield of 882 kg/ha with higher net returns (Rs. 38187/ha) and RWUE (1.75 kg/ha-mm). The lowest input energy (2809 MJ/ha) was recorded with LT + 2 t/ha glyricidia leaves + herbicide compared to other treatments. The highest energy outpur (24515 MJ/ha) was recorded with LT + 4 t/ha compost + herbicide compared to other treatments.

At Parbhani, in soybean + pigeonpea (4:2) system, conventional tillage recorded maximum soybean seed equivalent yield (2439 kg/ha) and RWUE (8.55 kg/ha-mm). Among nutrient sources, RDF gave highest soybean seed equivalent yield (2574 kg/ha) and RWUE (9.03 kg/ha-mm).Maximum infiltration rate of 9.8 cm/hr was recorded with conventional tillage + vermicompost whereas minimum of 5.0 cm/hr was observed in reduced tillage + interculture + RDF. The lowest bulk density (1.20 g/cm^3) was recorded in the plots under reduced tillage + interculture with FYM application compared to other treatments.

Farm mechanization

At Vijayapura, the field efficiency with bullock drawn seed drills was 0.25 to 0.27 hr/ha while it was 0.84-0.85 hr/ha for the tractor drawn seed drill.

At Kovilpatti, line sowing of minor millets with air assisted seed drill resulted in 30 to 40% saving in seed rate and time taken per hectare was 1.24, 2.81 and 3.00 hours with air assisted seed drill, tractor drawn gorru and broadcasting, respectively.

Evaluation of improved varieties

The cultivars of various rainfed crops were evaluated at the centres. The varieties that performed better compared to local checks/popular varities were:, medium duration high yielding rice variety TTB-404 (4053 kg/ha) at Biswanath Chariali; blackgram cv. KPU 11-39 at Arjia; taramira cv. TMLC 2(824 kg/ha at Ballowal Saunkhri;, groundnut cv. ICGV-0350 (2363 kg/ha at Bengaluru ; mustard cv. Pusa Tarak(917 kg/ha at Rewa ;, groundnut, entry MLTG –VG-15-9 (pod yield of 1550 kg/ha at Anantapuramu; groundnut cv. JSP-60 (3028 kg/ha at Rajkot.

Alternate land use system

At Arjia, in the existing neem tree rows on marginal land, Cenchrus grass seed sowing with mud ball/pellet gave significantly higher dry grass yield (2157 kg/ha) with additional returns of Rs.6927/ha, B:C ratio of 1.70 and RWUE of 3.2 kg/ha-mm. Further, application of 20 kg N+30 kg P_2O_5/ha recorded higher dry grass yield (2478 kg/ha); at Ballowal Saunkhri, in a study on guava and amla based agri-horti systems, the yield of blackgram was 224 & 346 kg/ha, respectively in guava and amla plantation. Guava and amla yielded 28845 19480 kg/ha fruit yield respectively. The net returns from amla (Rs.142802/ha) as well as guava (Rs.512270/ha) based system were higher than sole cultivation of crops and fruit plants; at Vijayapura, the fruit yield of tamarind was significantly higher in the planting geometry of 10 m x 6 m (205 kg/ha) than 10 m x 3 m (149 kg/ha) and 10 m x 9 m (168 kg/ha). The guinea grass recorded significantly higher green fodder (3602 kg/ha) than signal grass (2418 kg/ha); at Akola, in hanumanphal and custard apple based agri-horti systems, the intercrops performed better with CCT treated catchment and the increase in groundwater recharge of CCT treated catchment over untreated catchment was more in August (4.39 m) followed by September (4.29 m). On an average, the ground water recharge in the CCT treated catchment was 21.2% more compared to the non treated catchment (2.09 m); at Parbhani, drumstick + greengram (1:6) recorded higher system yield (2246 kg/ha), net returns (Rs.10807/ha) and RWUE (7.88 kg/ha-mm) followed by drumstick + soybean (1:2) (2147 kg/ha) and drumstick + blackgram (1:6) (2056 kg/ha).

Integrated farming system

At Varanasi, animal based farming system (three buffalo + two buffalo calf) gave highest net returns (Rs.257800/ha) and employment generation (200 man-days/ha/year) with a rice yield of 2050 kg/ha while agri-horti system recorded net returns of Rs.42500/ha and employment generation of 75 man-days/ha/year with aonla and sesame yield of 100 and 110 kg/ha, respectively.

At Rajkot, higher net returns of Rs.32173/ha was recorded for crops along with milch animal (cow) compared to farmer's practice of sole cotton cultivation (Rs.24973/ha). The employment generation under IFS module was 365 man-days/ha/yr compared to 175 man-days/ha/yr under farmer's practice of cotton cultivation.

At Kovilpatti, IFS with crops, livestock (1 milch animal) and goat rearing (10+1), the mean system productivity and mean system income in IFS were 10,609 kg/ha and Rs.133876 /ha whereas in conventional system the values were 2713 kg/ha and Rs.35,281/ha. The mean employment generation was 212 and 437 man days/year due to cropping alone and integration of crops, livestock and goat rearing.

Operational Research Project (ORP)

Participatory Technology Development

In Yerraguntlapalli village, Kurnool district, Andhra Pradesh (Anantapuramu centre) , sub soiling with chisel plough in pigeonpea under rainfed conditions improved seed yield (728 kg/ha) and net returns (Rs.49000/ha) compared to farmers' practice (676 kg/ha and Rs.35700/ha); sowing of setaria with Ananta automatic bullock drawn seed planter, higher grain yield (1125 kg/ha) and B:C ratio (3.3) with Ananta automatic bullock drawn.

In Behdarya and Kothi village, Hoshiarpur district, Punjab (Ballowal Saunkhri centre) in wheat, highest grain yield (2149 kg/ha) and B:C ratio (1.82) was recorded with conventional tillage (CT) + interculture; in maize, maximum grain yield of 3608 kg/ha with RWUE of 71.6 kg/ha-cm was recorded with application of 100% N through inorganic source and B:C ratio of 2.08.

In Baichenahalli and Iraksandra village, Tumkur district, Karnataka (Bengaluru centre), opening of conservation furrow between paired rows of pigeonpea in finger millet + pigeonpea (8:2) intercropping system recorded higher finger millet grain equivalent yield (4076 kg/ha), RWUE (5.89 kg/ha-mm) and B:C ratio (3.44); kg/ha); in fingermillet + pigeonpea (8:2) system, 50% N through organic source + 50% N & 100% PK through inorganic + 12.5 kg zinc sulphate +10 kg borax per ha recorded maximum finger millet grain equivalent yield (4580 kg/ha) and B:C ratio (3.85).

In Gonda village, Garhwa district, Jharkahnd (Chianki centre), bunded rice cultivation gave higher yield (2289 kg/ha) and B:C ratio compared to unbunded condition (1285 kg/ha).

In Chhapar Jogiyan village, Bhiwani district, Haryana (Hisar centre), disc harrowing in mustard (RH 30), higher seed yield of mustard (1522 kg/ha) was recorded when soil moisture was conserved with disc harrow as compared to country plough (1338 kg/ha).

At Indore, in an evaluation of promising varieties of soybean a new variety JS 2029 performed better with four seeded pods (more than 50% pods having four seeds), higher yield (535 kg/ha), net returns (Rs.3583/ha) and B:C ratio (1.21). JS 9560 also possess four seeded pods, high yielding and matures 7 to 8 days earlier than local varieties and thus suitable for the farmers willing to grow potato after soybean.

At Solapur, in an assessment of in-situ moisture conservation in rabi sorghum, higher mean grain yield of 111 kg/ha was attained with compartmental bund compared to farmers practice (45 kg/ha). Prolonged dry spell at grand growth stage of rabi sorghum affected the yield.

At Arjai, in an on-farm assessment of maize + blackgram (2:2) intercropping system, very low yield of maize and blackgram was obtained due to drought in the operational area. Maximum maize grain equivalent yield was obtained in maize + blackgram (2:2) inter-cropping system (572 kg/ha) as compared to mixed cropping (385 kg/ha). Both mixed cropping and sole maize recorded negative returns due to very low yields (385 and 308 kg/ha).

Technology upscaling

In Yerraguntlapalli village, Kurnool district, Andhra Pradesh (Anantapuramu centre) , demonstration of soil test based fertilizer application in groundnut recorded higher pod and haulm yields (530 and 1085 kg/ha) and net returns (Rs. 4395/ha) compared to farmer's practice (452 and 965 kg/ha) and improved varieties of groundnut K6 (480 kg/ha) exhibited its superiority in out yielding TMV-2 (452 kg/ha), with higher net returns (Rs.22915/ha) and B:C Ratio (1.0)

In Newariya village, Chittorgarh district, Rajasthan (Arjia centre), demonstration of horsegram cv. AK-42 gave maximum seed yield of 267 kg/ha, net returns of Rs. 4124/ha, B:C ratio of 1.57, while local variety gave a yield of 95 kg/ha with negative net returns of Rs.2888/ha.

In Behdarya and Kothi village, Hoshiarpur district, Punjab (Ballowal Saunkhri centre) demonstration of maize - wheat cropping system gave highest net returns of Rs 54524/ha from maize equivalent yield (MEY) of 5875 kg/ha followed by maize - raya system (Rs.45612/ha).

In Baichenahalli and Iraksandra village, Tumkur district, Karnataka (Bengaluru centre) , demonstration of groundnut + pigeonpea intercropping (8:2) row proportion with moisture conservation furrow between paired rows of pigeonpea recorded higher groundnut pod equivalent yield (2168 kg/ha) with RWUE of 3.95 kg/ha-mm, net returns (Rs. 86707/ha) and B:C ratio (3.61) compared to farmers' practice (869 kg/ha).

In Gonda village, Garhwa district, Jharkahnd (Chiankicentre), demonstration of chickpea on residual moisture under minimum tillage conditions after harvest of rice, the improved variety KPG-59 gave higher seed and stover yield (1138 and 815 kg/ha) with net returns, B:C ratio and RWUE of Rs.34951/ha, 3.69 and 28.30 kg/ha-mm, respectively and maximum grain (5047 kg/ha) and straw yield (6020 kg/ha) of hybrid rice variety Arize Tej was recorded with RDF (150:70:90) in medium land condition as compared to farmers' input level (110 N: 45 P_2O_5) (2207 kg/ha); and application of RDF also recorded higher net returns (Rs.63157 kg/ha), B:C ratio (4.38) and RWUE (6.49 kg/ha-mm).

In Chhapar Jogiyan village, Bhiwani district, Haryana (Hisar centre), demonstration of mustard variety RH 119 recorded highest seed yield (1523 kg/ha) and B:C ratio (2.84) and chickpea cv. C-235 recorded higher seed yield (432 kg /ha) and B:C ratio (0.85) as compared to variety HC 1 (400 kg/ha).

National Innovations on Climate Resilient Agriculture (NICRA)

During the period, the emphasis continued on real time contingency crop plan implementation and preparedness to cope with weather aberrations and implemented in 1050 farmers' fields covering about 400 ha in 33 villages in 24 districts across 15 states. During 2015-16, the onset of monsoon was delayed by more than two weeks in NICRA villages located in Rajasmand and Solapur districts. Further, there were 4-6 dry spells at different stages of crops in NICRA villages Lakhimpur, Garhwa, Kandhamal, Vijayapur and Solapur districts. The total rainfall during kharif season (June-September), 2015 was below normal in all NICRA villages except in Balawas & Budhshelly (Bhiwani), Kalimati (Banaskantha), Nignoti (Indore), Pata Meghpar (Jamnagar), Chikkamaranahalli (Bengaluru Rural) and Tahkapal (Bastar). Introduction of short duration varieties of various crops to cope with delayed onset of monsoon resulted in yield increase upto 20 per cent. Real-time contingency measures to cope with early/midseason/terminal drought impacted yield enhancement by up to 25% 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.

Tribal Sub-Plan (TSP)

The TSP program was implemented by 7 centers in 22 villages in Rajasthan, Jharkhand, Madhya Pradesh, Odisha, Assam, Chhattisgarh and Gujarat covering 8 districts. The major interventions in TSP villages included crop/NRM/livestock/livelihood based. The physical assets created in the villages included farm ponds, improved implements, improved animal breeds etc. The livelihood of the beneficiaries were improved through enhancing productivity of rainfed crops by up to 45%, profitability by up to 60% and livelihood interventions such as dairy, piggery, poultry, mushroom cultivation, vermicompost units etc. 31 trainings were organized for the benefit of tribal farmers/youth/women.

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 Ananatapuramu, Bengaluru, Indore, Hisar, Biswanath Chariali, Agra, Arjia, Vijayapura, Solapur, Parbhani, Chianki and Ballowal Saunkhri 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 the XV Working Group Meetting of AICRPDA held at Biswanath Chariali centre, AAU during 24-27 December, 2015. The progress under NICRA was reviwed during the Third AICRPDA-NICRA Review Workshop held at Ananatapuramu cente, ANGRAU during 1-3 September, 2015. The activities of AICRPDA - TSP at was reviewed during a Two-day Review Workshop held at AICRPDA Centre, Arjia during 1- 2 March, 2016.

Linkages and Collaboration

During the perod, the collaboration/linkages continued with SAUs, ICAR Institutes, KVKs, state line departments, NGOs and farmers to prioritized dryland research, for upscaling doable rainfed technologies and capacity building, further also established linkages with various organizations to upscale doable rainfed technologies in convergence with ongoing state and national programmes like RKVY, NFSM, PMKSY, Dryland Farming Missions of states etc. The centres also disseminated improved dryland practices, agro-advisories, contingency plans etc through print and electronic media.

Publications

Overall, 199 publications were contributed by AICRPDA team comprising of 66 research papers, 4 book chapters, 62 papers in conferences, 28 books/bulletins/reports and 39 popular articles during the year.

HRD, impacts and upscaling of rainfed technologies

The centers both at on-station and on-arm (ORP/NICRA/TSP villages) organized capacity building activities for enhancing the knowledge base/skill development of primary and secondary stakeholders. The technology upscaling activities included stakeholder consultation workshops, on-fram demonstrations, field days, exposure visits etc. The impact analysis of rainfed technologies is being done in ORP adopted villages by Anantapur, Bengaluru and Indore centres for assessing the strengths and limitations of these technologies. The performance and limitations of the rainfed technologies emanated from the centers and the scope for upscaling of these technologies were reviewed during one day District Level Stakeholder Consultation Workshops at AICRPDA Centre, Ballowal Saunkhri on 19th November, 2015.

Budget

The total budget allocated for 22 network centers of AICRPDA for the period 2015-16 was Rs.2113.57 lakhs and Rs. 252.67 lakhs was allocated for 8 Operational Research Project centers.

1. Introduction

Rainfed agriculture, which is totally rain dependent, accounts for 55.3% (about 78 m ha) of the net cultivated area in India and plays an important role in country's economy. It supports 82% of rural poor and contributes to 40 % of national food basket. Monsoon, management (native region) and market along with other abiotic and biotic stresses and socio economic status of the farmers are the key factors affecting rainfed agriculture and livelihood of small and marginal farmers. Further, climate change/ variability and unabated land degradation are the twin problems that are impacting productivity, profitability and sustainability of rainfed production systems. To meet the emerging challenges, continued and renewed research efforts are being made majorly through a network of 22 centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) to develop location-specific doable rainfed technologies focusing higher rainwater productivity, profitability and sustainability. The prioritized research programs are rainwater management, cropping systems, nutrient management, alternate land use and integrated farming systems, energy management and evaluation of improved varieties.

Mandate

Main/Sub-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 transferability of improved dryland
- Technology to farmers' fields

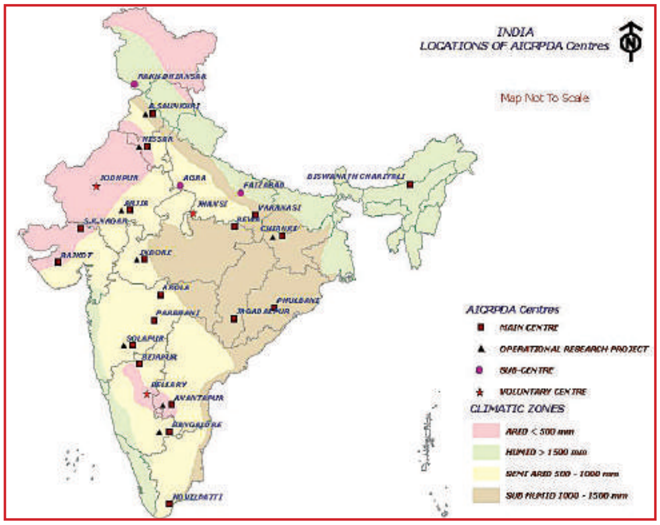


Fig.1.1. Location map of AICRPDA Network Centres

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

The agroecological setting of AICRPDA network centers are given in Table 1.1.

The assessment and refinement of location specific technologies are carried out at 8 Operational Research Projects (*viz.,* Anantapuramu, Arjia, Ballowal Saunkhri, Bangalore, Hisar, Indore, Ranchi and Solapur) by conducting on-farm participatory research in farmers' fields. Adopting the paradigm of agro-ecosystems based research, the 22 main centers are now undertaking research in 8 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) with Project Coordination unit at CRIDA, Hyderabad. The location of centers, ORPs and Organogram of AICRPDA are shown in Fig.1.1 and Fig.1.2.

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*	MRPS
Agra (SC)	RBSC, Agra	South–western semiarid zone in Uttar Pradesh (4.1)	Semiarid (Hot dry)	Pearlmillet
Akola (MC)	PDKV Akola	Western Vidarbha Zone in Maharashtra (6.3)	Semiarid (Hot moist)	Cotton
Anantapuramu (MC & ORP)	ANGRAU, Guntur	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	Groundnut
Arjia (MC & ORP)	MPUAT, Udaipur	Southern zone in Rajasthan (4.2)	Semiarid (Hot dry)	Maize
Ballowal Saunkhri (MC & ORP)	PAU, Ludhiana	Kandi region in Punjab (9.1)	Subhumid) (Hot dry)	Maize
Bellary (VC)	CSWCRTI, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	Rabi Sorghum
Bengaluru (MC & ORP)	UAS_B, Bengaluru	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	Fingermillet
Vijayapura (MC)	UAS_D, Dharwad	Northern dry zone in Karnataka (6.1)	Semiarid (Hot dry)	Rabi Sorghum
Biswanath Chariali (MC)	AAU, Jorhat	North Bank plain zone in Assam (15.2)	Humid (Hot)	Rice
Chianki (MC & ORP)	BAU, Ranchi	Western plateau zone of Jharkhand(11.0)	Subhumid (Hot moist)	Rice
Faizabad (SC)	NDUAT, Faizabad	Eastern plain zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	Rice
Hisar (MC & ORP)	CCSHAU, Hisar	South-western dry zone in Haryana(2.3)	Arid (Hyper)	Pearlmillet
Indore (MC & ORP)	RVSKVV, Gwalior	Malwa plateau in Madhya Pradesh (5.2)	Semiarid (Hot moist)	Soybean
Jagadalpur (MC)	IGAU, Raipur	Basthar Plateau zone in Chattisgarh (12.1)	Subhumid (Hot moist)	Rice
Jhansi (VC)	IGFRI, Jhansi	Bundhelkhand zone in Uttar Pradesh (4.4)	Semiarid (Hot moist)	kharif Sorghum
Jodhpur (VC)	CAZRI, Jodhpur	Arid Western zone of Rajasthan (2.1)	Arid (Hyper)	Pearlmillet
Kovilpatti (MC)	TNAU, Coimbatore	Southern zone of Tamil Nadu (8.1)	Semiarid (Hot dry)	Cotton
Parbhani (MC)	MAU, Parbhani	Central Maharastra Plateau Zone in Maharashtra (6.2)	Semiarid (Hot moist)	Cotton
Phulbani (MC)	OUAT, Bhubaneswar	Eastern Ghat Zone in Orissa (12.1)	Subhumid Hot moist)	Rice
Rajkot (MC)	JAU, Junagarh	North Saurashtra zones in Gujarat (5.1)	Semiarid (Hot dry)	Groundnut
Rakh Dhiansar (SC)	SKUAS_T, Jammu	Low altitude subtropical zone in Jammu and Kashmir (14.2)	Semiarid (Moist dry)	Maize
Rewa (MC)	JNKVV, Jabalpur	Keymore plateau and Satpura Hill zone in Madhya Pradesh (10.3)	Subhumid (Hot dry)	Soybean
S.K. Nagar (MC)	SDAU, Dantewada	Northern Gujarat in Gujarat (2.3)	Semiarid/Arid (Hot dry)	Pearlmillet
Solapur (MC & ORP)	MPKV, Rahuri	Scarcity zone in Maharashtra (6.1)	Semiarid (Hot dry)	Rabi Sorghum
Varanasi (MC)	BHU, Varanasi	Eastern Plain and Vindhyan Zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	Rice

MC- Main Centre; SC- Sub Centre; VC: Voluntary Centre; ORP: Operational Research Project **Climate details as per AESR details given by NBSSLUP (ICAR)

Research Centres and Operational Research Project Centres of All India Co-ordinated Research Project for Dryland Agriculture					
ICAR Institutes	State Agricultural Universities			Technical Universities	
Voluntary Centers	Main Centers	Sub-centers	Operational Research Projects	Main Centers	Sub- centers
1. Bellary (CS&WCRTI) 2. Jhansi (IGFRI) 3. Jodhpur (CAZRI)	1. Akola (PDKV) 2. Ananatapur (ANGRAU) 3. Arjia (MPUAT) 4. Ballowal-Saunkhri (PAU) 5. Bangalore (UAS_B) 6. Bijapur (UAS_D) 7. Hisar (CCSHAU) 8. Indore (JNKV) 9. Jagadalpur (IGAU) 10. Biswanath Chariali (AAU) 11. Kovilpatti (TNAU) 12. Parbhani (MAU) 13. Phulbani (OUAT) 14. Rajkot (JAU) 15. Chianki (BAU) 16. Rewa (JNKV) 17. SK Nagar (SKDAU) 18. Solapur (MPKV)	1. Faizabad (NDUAT) 2. Rakh Dhiansar (SKUAT_J)	1. Anantapur (ANGRAU) 2. Arjia (MPUAT) 3. Ballowal-Saunkhri (PAU) 4. Bengalure (UAS_B) 5. Hisar (CCSHAU) 6. Indore (JNKV) 7. Ranchi (BAU) 8. Solapur (MPKV)	1. Varanasi (BHU)	1. Agra(Bichpuri College)
Scientific 15, Technical 30, Administration 6 and Supporting 15	Scientific 90, Technical 180, Administration 54 and Supporting 90	Scientific 6, Technical 12, Administration 6 and Supporting 6	Scientific 24, Technical -- 0, Administration 16 and Supporting 16	Scientific 5, Techinical 10, Administration 2 and Supporting 5	Scientific 3, Techinical 6, Administration 2 and Supporting 3

Fig.1.2. Organogram of AICRPDA Network

During the XXIV Biennial Workshop of AICRPDA at AICRPDA Centre, Indore, RVSKVV, Madhya Pradesh, during 26-29 December, 2014, the progress of research achieved during 2012-14 across 22 AICRPDA centres and 8 ORP centres was reviewed and technical programme was finalized for 2015-16. During the workshop, 91 experiments were concluded and 61 new experiments were approved (Fig 1.3). During 2015-16, in total, 284 on-station experiments were conducted across the centres. Among these, Permanent Manurial Trials (PMTs), and long-term experiments on tillage and nutrient management were 10 each; foliar sprays- 12; experiments on control of evaporation from farm ponds-3, and small farm mechanization-17. The major action points from the workshop are given in Annexure-1.

The technical programme (on-station experiments) centre-wise and theme-wise, during 2015-16 is given in Table 1.2.

Table 1.2: Number of experiments conducted by AICRPDA Centers (on-station) during 2015-16

Production System/Center	RWM	CS	NM	EM	EIV	ALU	IFS	RC	Total
Rice based production system									
Biswanath Chariali	3	5	3	1	7	-	-	2	21
Chianki	2	2	1	2	2	2	-	-	11
Faizabad	2	2	3	1	1	1	-	-	10
Jagadalpur	2	1	3	4	2	3	-	-	15
Phulbani	3	1	1	-	2	1	-	-	8
Varanasi	3	1	1	1	1	1	1	-	9
Total	**15**	**12**	**12**	**9**	**15**	**8**	**1**	**2**	**74**
Maize based production system									
Arjia	4	2	3	-	4	1	-	-	14
Ballowal Saunkhri	3	2	2	2	3	1	2	-	15
Rakh Dhiansar	2	2	3	1	-	-	1	-	9
Total	**9**	**6**	**8**	**3**	**7**	**2**	**3**	**-**	**38**
Fingermillet based production system									
Bangalore	5	1	3	-	3	-	-	-	12
Total	**5**	**1**	**3**	**-**	**3**	**-**	**-**	**-**	**12**
Pearlmillet based production system									
Agra	2	4	2	1	-	-	-	-	9
Hisar	2	2	2	1	1	1	1	-	10
SK Nagar	3	1	4	1	2	1	1	-	13
Total	**7**	**7**	**8**	**3**	**3**	**2**	**2**	**--**	**32**
Sorghum based production system									
Bijapur	2	5	3	3	7	4	-	-	24
Solapur	2	2	2	1	3	-	2	1	13
Total	**4**	**7**	**5**	**4**	**10**	**4**	**2**	**1**	**37**

Soybean based production system									
Indore	3	2	2	2	3	2	-	-	14
Rewa	2	2	1	1	4		-	-	10
Total	**5**	**4**	**3**	**3**	**7**	**2**	**-**	**-**	**24**
Groundnut based production system									
Anantapur	4	2	5	3	4	-	1	-	19
Rajkot	4	2	2		4	-	1	-	13
Total	**8**	**4**	**7**	**3**	**8**	**-**	**2**	**-**	**32**
Cotton based production system									
Akola	1	4	3	1	4	1	-	-	14
Kovilpatti	2	1	3	1	2	-	1	-	10
Pharbani	3	1	3	2	1	-	1	-	11
Total	**6**	**6**	**9**	**4**	**7**	**1**	**2**	**-**	**35**
Grand Total	**59**	**47**	**55**	**29**	**60**	**19**	**12**	**3**	**284**
% Experiments	**20.77**	**16.55**	**19.37**	**10.21**	**21.13**	**6.69**	**4.23**	**1.06**	**100**

The technical programme of 8 ORPs (on-farm) centre-wise, during 2015-16 is given in Table 1.3.

Table 1.3: On-farm trials/demonstrations in ORP villages during 2015-16

ORP centre	Participatory Technologies Development (PTD)						Technologies for upscaling						Total
	RWM	CS	NM	EM	EIV	IFS/ ALU	RWM	CS	NM	EM	EIV	IFS/ ALU	
Anantapur	3	1	1	1	-	-	-	-	1	2	1	-	10
Arjia	3	2	2	1	3	1	-	1	-	-	-	-	13
Ballowal Saunkhri	3	-	1	1	-	1	2	2	-	-	2	1	13
Bangalore	2	1	1	1	2	1	1	2	-	5	1	-	17
Chianki	2	1	1	1	-	1	-	2	1	-	2	-	11
Hisar	2	2	-	-	1	-	2	1	3	-	1	-	12
Indore	2	-	1	1	1	1	1	-	-	-	-	-	7
Solapur	3	2	3	1	-	-	1	5	1	1	-	-	17
Grand Total	**20**	**9**	**10**	**7**	**7**	**5**	**7**	**13**	**6**	**8**	**7**	**1**	**100**
% of Total	**20**	**9**	**10**	**7**	**7**	**5**	**7**	**13**	**6**	**8**	**7**	**1**	**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

Besides the above, all the 22 centres and IGFRI, Jhansi implemented NICRA technical programme, and 7 centres *viz.,* Arjia, Chianki, Indore, Phulbani, Biswanath Chariali, Jagdalpur and SK Nagar implemented TSP programme. Brief details of these are presented in Chapter 5.

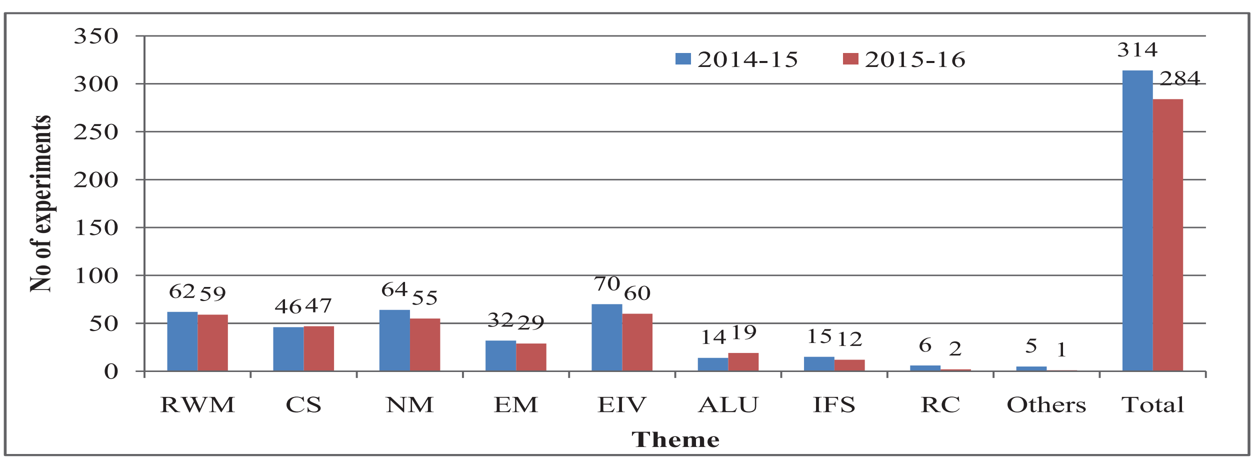


Fig.1.3: Number of experiments conducted by AICRPDA Centers (on-station) during 2014-15 & 2015-16

2. Resource Characterization

2.1 Climate and soils

The AICRPDA network centres are located in diverse agro-ecological settings i.e. arid, semiarid (dry and mosit), subhumid (dry and moist) and humid climates and dominant soil types viz. Inceptisols, Vertisols, Alfisols, Aridisols, Entisols 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^{0}C to 42.4^{0}C and mean annual minimum temperature from 26.7^{0}C to 16.4^{0}C (Table 2.1).

Table 2.1: Climate characteristics across AICRPDA network centres

AICRPDA Centre	Climate	Mean annual rainfall (mm)	PET (mm)	Water surplus (mm)	Water deficit (mm)	Air temperature (^{o}C)		Sun-shine (hr/day)	Wind speed (km/hr)
						Max	Min		
Agra	Semiarid (Hot dry)	665	598	0	152	35.3	26.7	-	-
Akola	Semiarid (Hot moist)	824	604	0	49	32.8	24.2	-	-
Anantapuramu	Arid (Hot)	544	641	0	312	34.0	21.5	8.2	10.8
Arjia	Semiarid (Hot dry)	656	1681	125	655	42.4	17.4	7.4	-
Ballowal Saunkhri	Subhumid (Hot dry)	1011	739	0	155	30.5	16.4	7.9	2.3
Bengalure	Semiarid (Hot moist)	926	503	0	60	27.8	19.3	4.5	10.7
Biswanath Chariali	Humid (Hot)	1990							
Chianki	Subhumid (Hot moist)	1179	455	597	0	30.4	22.7	4.3	4.3
Faizabad	Subhumid (Hot dry)	1051	1482	255	69	30.8	19.1	7.3	-
Hisar	Arid (Hyper)	412	769	0	459	37.5	26.3	9.7	5.9
Indore	Semiarid (Hot moist)	958	616	70	0	30.7	22.5	4.7	16.3
Jagdalpur	Subhumid (Hot moist)	1297							
Kovilpatti	Semiarid (Hot dry)	723	812	0	631	36.7	24.7	6.6	14.5
Parbhani	Semiarid (Hot moist)	901							
Phulbani	Subhumid (Hot moist)	1580	478	609	0	36.6	23.5	7.5	6.8
Rajkot	Semiarid (Hot dry)	590	738	0	157	33.7	24.5	5.7	17.7
Rakh Dhiansar	Semiarid (Moist dry)	860	700	-	0	29.0	17.3	5.0	-
Rewa	Subhumid (Hot dry)	1088	688	173	74	31.4	19.1	8.4	4.6
Sardar Krishi Nagar	Semiarid/ Arid (Hot dry)	670	572	161	88	30.2	18.7	8.3	5.2
Solapur	Semiarid (Hot dry)	732	589	0	67	32.3	22.3	4.6	8.6
Varanasi	Semi arid (Hot moist) Subhumid (Hot dry)	1049	577	190	0	34.4	26.6	5.8	5.2
Vijayapura	Semiarid (Hot dry)	595	622	0	228	31.0	21.6	6.7	9.4

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 2.2).

Table 2.2: Soil characteristics 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
Anantapuramu	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

2.2 Experienced rainfall during 2015-16 across AICRPDA network centres

At the network centres of AICRPDA, the daily weather data are recorded for eight parameters viz., air temperature (OC), wind speed (km/hr), PET (mm), rainfall (mm), sun-shine (hr/day) etc. The water surplus (mm) and water deficit (mm) from this information is also calculated for interpretation of the experimental results. The data on actual monthly rainfall received at different AICRPDA centres during 2015 are given in Table 2.3.

Rice based production system

At Biswanath Chariali, during the year 2015, the onset of monsoon was normal (1st June). A rainfall of 2467.6 mm was received which was deficit by 602.8 mm compared to normal (1864.8 mm). During south-west monsoon (*kharif*), a rainfall of 1680.4 mm was received against a normal rainfall of 1182.2 mm. The rainfall during *rabi* was excess by 81.5 mm compared to normal rainfall of 120 mm (Fig 2.1).

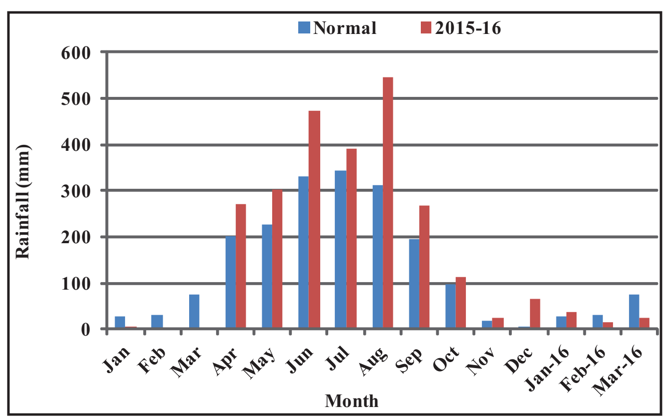


Fig.2.1: Normal and actual (2015-16) monthly rainfall at Biswanath Chariali

At Chianki, the onset of monsoon was delayed by 3 weeks (28th June). A rainfall of 917 mm was received which was deficit by 263 mm compared to normal (1180 mm) (Fig.2.2). During *kharif* (June–September), 904.2 mm of rainfall was received which was deficit by 133.8 mm compared to normal of 1038 mm. During *rabi* season, it was 33.8 mm which was deficit by 32.1 mm compared to normal of 65.9 mm and in summer, rainfall was 9.6 mm which was deficit by 33.1 mm as against normal of 42.7 mm.

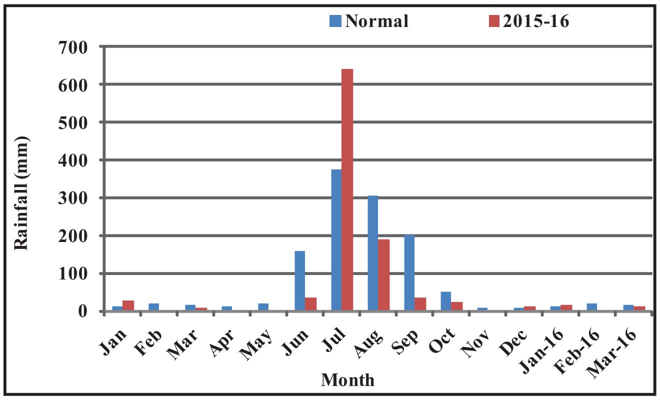


Fig. 2.2: Normal and actual (2015-16) monthly rainfall at Chianki

At Faizabad, the onset of monsoon was timely (25th June; normal onset 21st June). A rainfall of 635 mm was received which was deficit by 405.1 mm (38.9%) compared to normal rainfall (1040.1 mm). During south-west monsoon (*kharif*), 484.3 mm rainfall was received which was deficit by 430.8 mm (47.1%) compared to normal of 914.9 mm. During north-east monsoon (October - December), no rainfall was received which was deficit by 100% compared to normal (65.6 mm) and during summer, 111.7 mm of rainfall was received which was excess by 78.7 mm (238.5%) compared to normal rainfall of 33.2 mm (Fig.2.3).

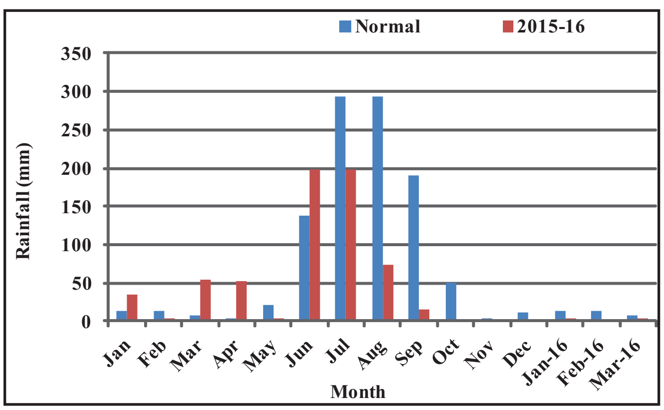


Fig.2.3: Normal and actual (2015-16) monthly rainfall at Faizabad

During 2015, At Jagdalpur, the onset of monsoon was normal (4th June). A total rainfall of 1560.5 mm was received which was excess by 156.5 mm compared to normal of 1404.4 mm (Fig.2.4). During south-west monsoon (*kharif*), there was 1306.6 mm rainfall which was excess of 185.1 mm (16.5%) as against normal rainfall of 1121.5 mm. During north-east monsoon (October - December), 17.6 mm of rainfall was received which was deficit 97.2 mm as that of normal (114.8 mm). During summer, 226.3 mm of rainfall was received which was excess by 80.02 mm (54.9%) compared to normal rainfall of 146.1 mm.

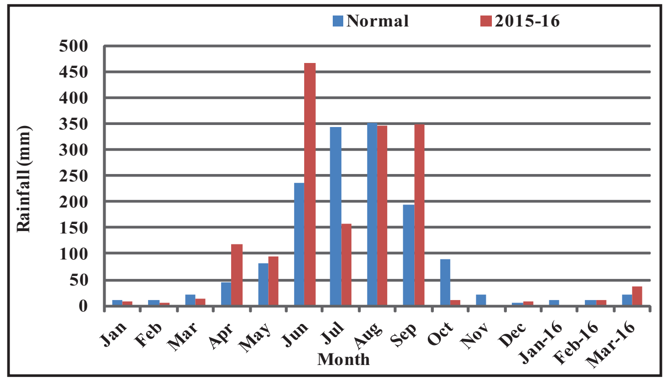


Fig 2.4: Normal and actual (2015-16) monthly rainfall at Jagdalpur

At Phulbani, the onset of monsoon was delayed by 2 days (12th June). A rainfall of 1060.6 mm was received during the year which was deficit by 346.6 mm than normal rainfall of 1407.3 mm. Out of total rainfall, 778.8 mm was received during *kharif* season (June- September) and was deficit by 371.7 mm (32.3%) than normal of 1246.2 mm. In *rabi* season, there was 69.6% deficit rainfall (108.73 mm) than normal of 52.7 mm and in summer, it was excess by 69.77 mm (64.3%) than normalof108.4mm (Fig.2.5).

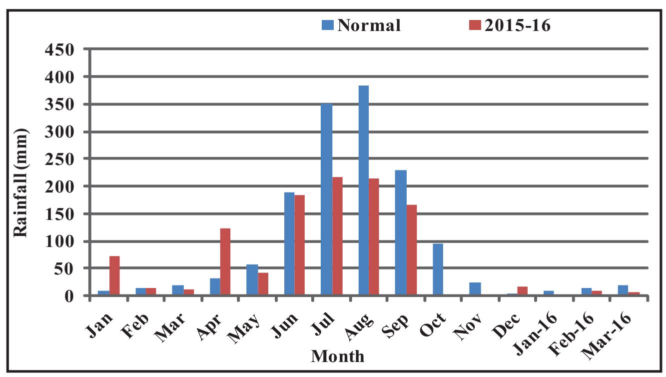


Fig.2.5: Normal and actual (2015-16) monthly rainfall at Phulbani

At Varanasi, the onset of monsoon was timely (16th June). A rainfall of 1008.6 mm was received which was deficit by 72.4 mm compared to normal (1081.7 mm) (Fig.2.6). During south-west monsoon (*kharif*), 857.3 mm of rainfall was received which was deficit by 87.2 mm compared to normal (944 mm). During north-east monsoon (October - December), 23 mm of rainfall was received which was deficit by 37.9 mm compared to normal (60.9 mm). During summer, 81.1 mm of rainfall was received which was excess by 48.8 mm compared to normal (32.3 mm).

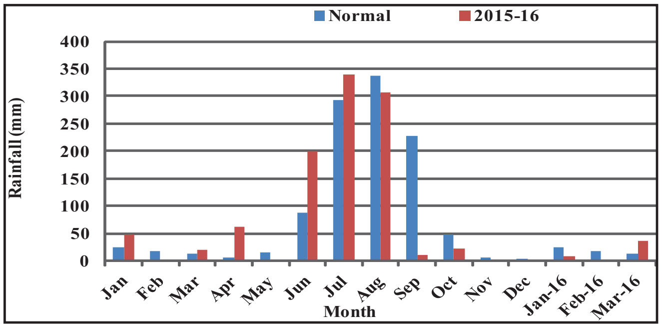


Fig.2.6: Normal and actual (2015-16) monthly rainfall at Varanasi

Maize based production system

At Arjia, the onset of monsoon was delayed by 17 days (19th July). A rainfall of 679.2 mm was received which was excess by 21.5 mm compared to normal rainfall of 657.7 mm. During south-west monsoon (June to September), 521.6 mm rainfall was received which was excess by 92.8 mm (15.7%); During October-December, there was no rain against normal of 20.2 mm. During summer (March-May), 83.8 mm of rainfall was received which was excess by 68.7 mm compared to normal (15.1 mm) (Fig.2.7).

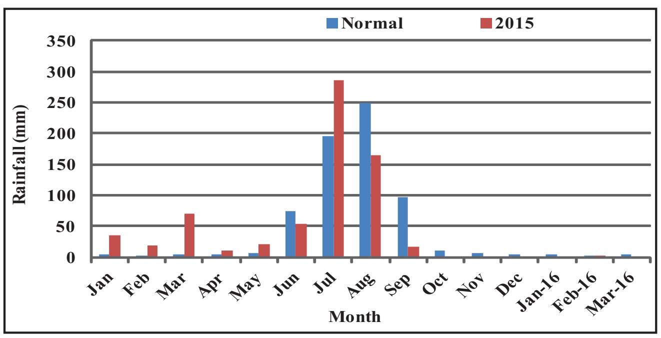


Fig.2.7: Normal and actual (2015-16) monthly rainfall at Arjia

The annual rainfall recorded at Ballowal Saunkhri was 917 mm, which was deficit by 177.3 mm than the normal annual rainfall of 1094.3 mm. Out of the total rainfall, 611 mm was received during the *kharif* season (June to September) as against normal of 862 mm. In *rabi*, 13 mm rainfall was received which was 177.5 mm deficit than normal of 190.5 mm. In summer season, 197 mm rainfall was received which was excess by 114.9 mm as against normal of 82.1 mm (Fig.2.8).

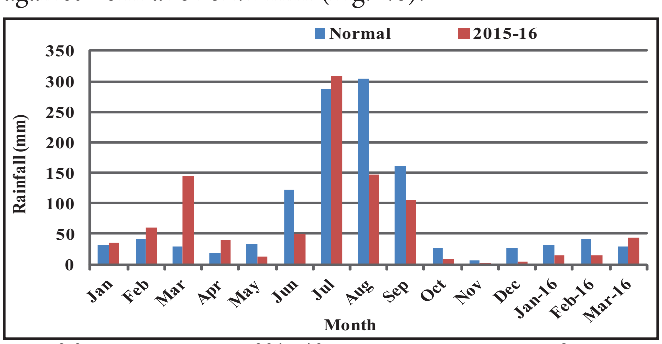


Fig.2.8: Normal and actual (2015-16) monthly rainfall at Ballowal Saunkhri

The annual rainfall recorded at Rakh Dhiansar during the year 2015 was 1119.3 mm, which was deficit by 28.7 mm than the normal annual rainfall of 1148 mm. Out of the total rainfall, 648.3 mm was received during the *kharif* season (June to September) as against normal of 885.8 mm. In *rabi,* 47.1 mm rainfall was received which was 0.5 mm deficit than normal of 47.6 mm. In summer season, 313.7 mm rainfall was received which was deficit by 119.6 mm as against normal of 114.1 mm (Fig.2.9).

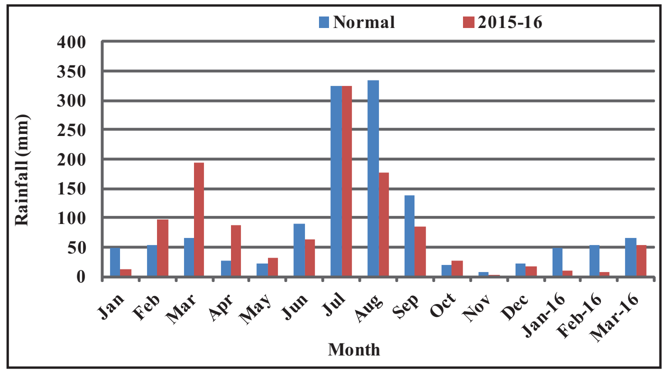


Fig.2.9: Normal and actual (2015-16) monthly rainfall at Rakh Dhiansar

Fingermillet based production system

At Bengalure, the onset of monsoon was normal (1st of June). A rainfall of 1061.2 mm was received which was excess by 138.1 mm (15.0%) compared to normal (923.1 mm). During *kharif* season (June–September), 569.4 mm rainfall was recorded which was excess by 52.5 mm (10.2%) against normal of 516.9 mm. In *rabi* season, it was 181 mm which was deficit by 60.1 mm (24.9%) than the normal of 241.1 mm and in summer 310.8 mm rain fall was recorded and was excess by 155mm (99.5%) than normal of 155.8 mm (Fig.2.10).

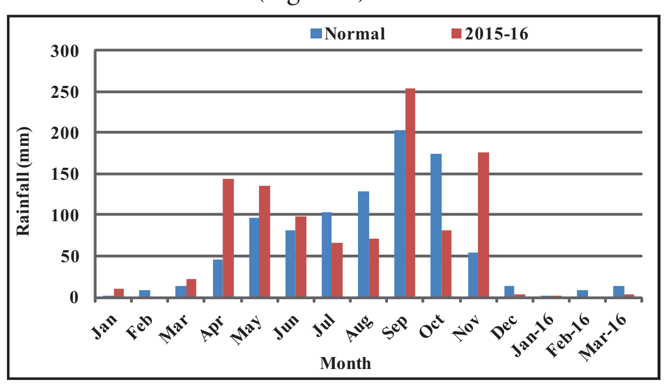


Fig.2.10: Normal and actual (2015-16) monthly rainfall at Bangalore

Pearlmillet based production system

During 2015, at Agra, the onset of monsoon was early by 7 days (25 June). A rainfall of 519 mm was received which was deficit by 143.5 mm compared to normal (662.5 mm). During south-west monsoon (*kharif*), 233.2

mm rainfall was received which was deficit by 354 mm (60%) as against normal of 587.1 mm. During north-east monsoon (October-December), 45.6 mm rainfall was received which was excess by 17.1 mm compared to normal (28.5 mm). During summer (January-March), 192.4 mm of rainfall was received which was excess by 169.1 mm compared to normal (23.4 mm) (Fig.2.11).

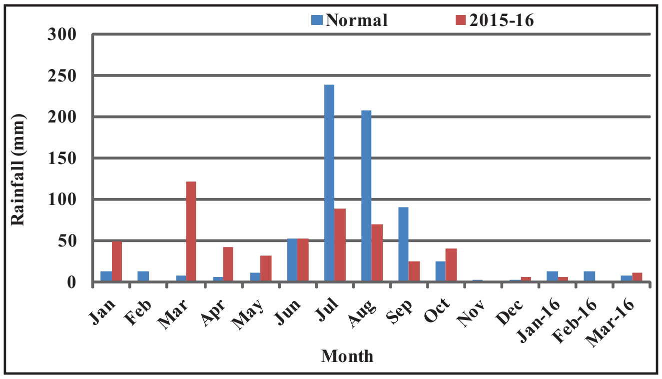


Fig. 2.11: Normal and actual (2015-16) monthly rainfall at Agra

During 2015, at Hisar, the onset of monsoon was normal (24th June) and a rainfall of 536.4 mm was received which was excess by 124.4 mm (30.2%) compared to normal (412 mm) (Fig.2.12). During *kharif* season, 326.4 mm rainfall was received which was deficit by 9.4 mm (2.8 %) than normal of 335.8 mm. In *rabi*, 11.5 mm rainfall was received which was 2.3 mm excess than normal of 9.2 mm and in summer, rainfall was excess by 167.1 mm than normal of 8.3 mm.

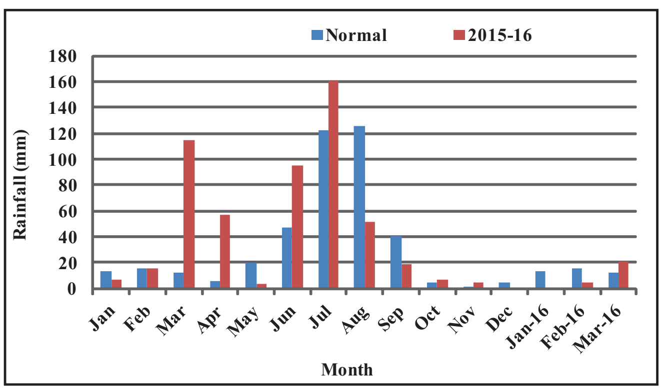


Fig.2.12: Normal and actual (2015-16) monthly rainfall at Hisar

At SK Nagar, the onset of monsoon was delayed by 31 days (26th July). A rainfall of 960.7 mm was received which was excess by 322.7 mm compared to normal (638 mm) (Fig.2.13). During south-west monsoon (*kharif*), 931.2 mm rainfall was received which was excess by 333.1 mm than normal rainfall of 598.1 mm; during north-east monsoon (October-December), no rains were received compared to normal rainfall of 27.1 and in summer (March-May), 27 mm rainfall was received which was excess by 18.2 mm compared to normal rainfall of 8.8 mm. Terminal drought in different crops occurred due to early withdrawal of monsoon.

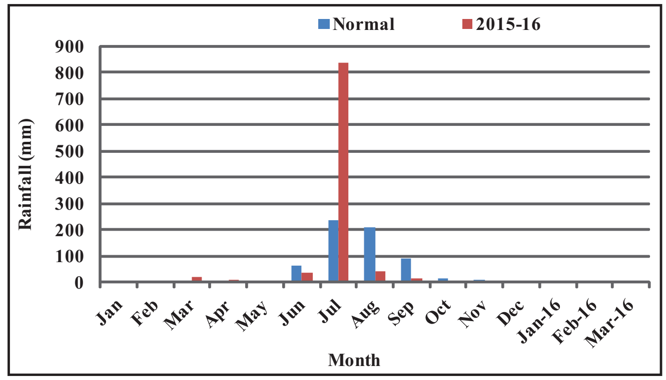


Fig.2.13: Normal and actual (2015-16) monthly rainfall at SK Nagar

Sorghum based production system

During 2015 at Vijayapura, a rainfall of 651.1 mm was received which was excess by 56.7 mm (9.5%) compared to normal (594.4 mm). Out of total rainfall in 2015 (651.1 mm), *kharif* season (June - September) recorded 432.6 mm which was excess by 44 mm (11.3%) than seasonal normal of 388.6 mm. During *rabi*, it was 106.9 mm which was deficit by 27.3 mm (20.3%) than normal of 134.2 mm and in summer 107 mm was recorded and was excess by 41.4 mm (63.1%) than normal of 65.6 mm (Fig.2.14).

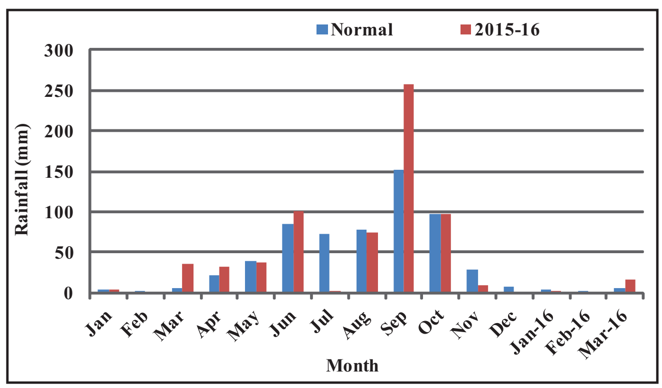


Fig.2.14: Normal and actual (2015-16) monthly rainfall at Vijayapura

At Solapur, a rainfall of 343.4 mm was received which was deficit by 377.9 mm compared to normal of 721.3 mm. During *kharif*, 143.8 mm rainfall was recorded, which was deficit by 387.3 mm than normal of 531.1 mm; *rabi* recorded 67.8 mm which was deficit by 57.7 mm than normal rainfall of 125.5 mm and in summer, 119.8 mm rainfall was received which was 67.2 mm excess rainfall as against normal of 52.6 mm (Fig.2.15).

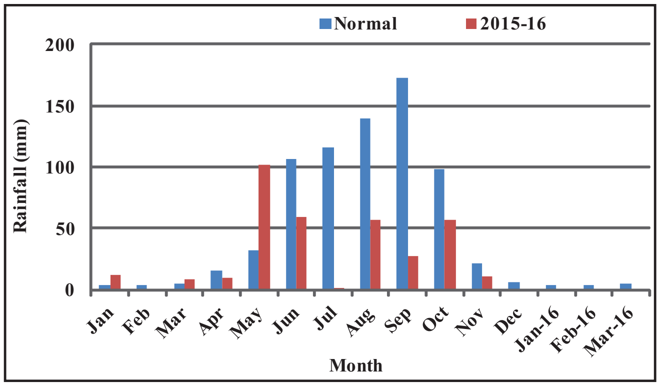


Fig.2.15: Normal and actual (2015-16) monthly rainfall at Solapur

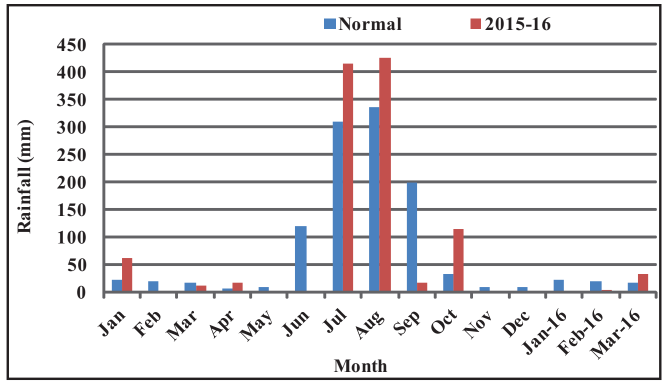


Fig.2.17: Normal and actual (2015-16) monthly rainfall at Rewa

Soybean based production system

At Indore, annual rainfall of 1252.4 mm was received which was excess by 294.4 mm compared to normal (958 mm). During south-west monsoon (*kharif*), the rainfall received was 1174.1 mm whereas the normal was 854.5 mm which was excess by 319.61 mm (37.4%). During north-east monsoon (October-December), 4.5 mm rainfall was received which was deficit by 60.0 mm (93 %) compared to normal (64.5 mm). During summer, 13.2 mm rainfall was received which was deficit by 17.45 mm (56.9 %) compared to normal (30.6 mm) (Fig.2.16).

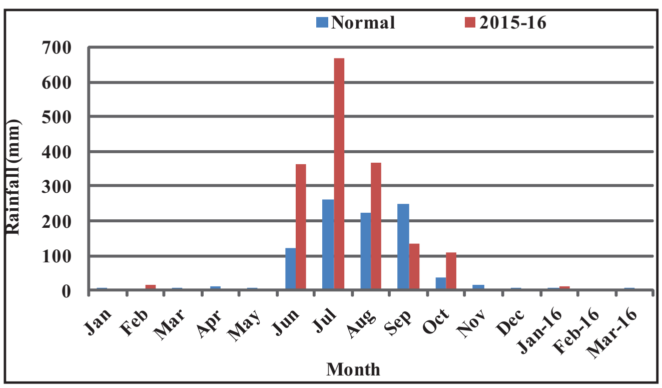


Fig.2.16: Normal and actual (2015-16) monthly rainfall at Indore

At Rewa, the onset of monsoon was delayed by 10 days (02nd July). A rainfall of 1064 mm was received which was deficit by 2.4% compared to normal rainfall of 1090 mm. The rainfall during *kharif* season was 857.6 mm as against normal rainfall of 965.1 mm. During *rabi* season, the rainfall was excess by 129.9 % (115.2 mm) compared to normal rainfall of 50.1 mm (Fig.2.17).

Groundnut based production system

At Anantapuramu, during 2015, the onset of monsoon was timely (6th June). A total rainfall of 641 mm was received which was excess by 71 mm (12.5%) compared to normal (570 mm). Out of total rainfall 311.4 mm was received in *kharif* season which was 40.6 mm deficit (11.6%) than normal of 352 mm. In *rabi,* it was 152.8 mm and was excess by 8.8 mm (6.1%) than normal of 144 mm and in summer season, 176.8 mm rainfall was received which was excess by 105.3 mm (147.3%) than normal of 71.5 mm (Fig.2.18).

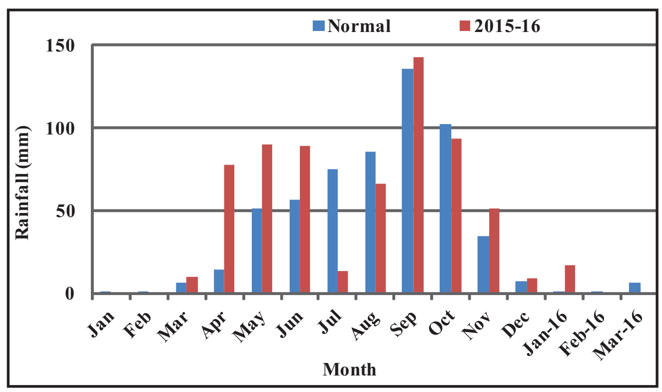


Fig.2.18: Normal and actual (2015-16) monthly rainfall at Anantapuramu

During 2015 at Rajkot, the onset of monsoon was early by 2 days (14th June). A rainfall of 587.2 mm was received which was deficit by 0.5 mm was compared to normal 590.4 mm. During south-west monsoon (*kharif*), 587.2 mm rainfall was received which was excess by 29.27 mm (5.2%) than normal of 557.9 mm. During *rabi* and summer, there was no rainfall occurred compared to normal 24.5 mm and 6 mm, respectively (Fig.2.19).

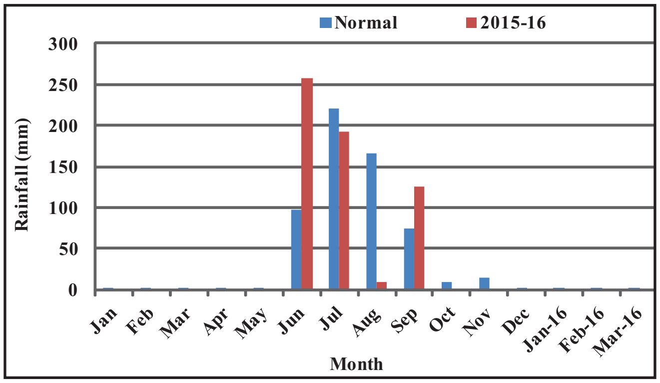


Fig.2.19: Normal and actual (2015-16) monthly rainfall at Rajkot

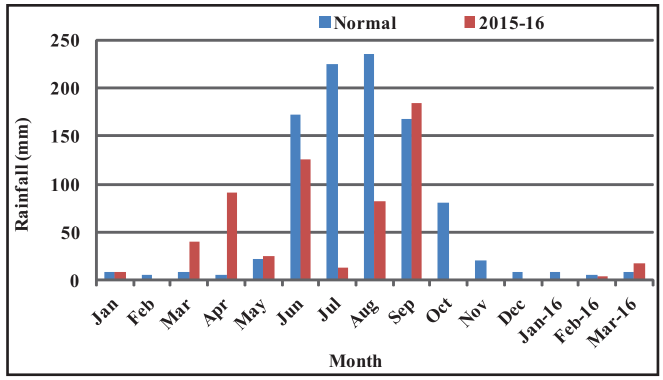


Fig.2.21: Normal and actual (2015-16) monthly rainfall at Kovilpatti

Cotton based production system

During 2015, at Akola, the onset of monsoon was on 11th June and a rainfall of 756.4 mm was received which was excess by 9.1 mm (1.2%) compared to normal (756.4 mm) (Fig.2.20). Out of total rainfall received, 613 mm was received during *kharif* season which was deficit by 53.3 mm compared to normal of 666.3 mm. During *rabi* (October-December), no rainfall was received compared to normal of 66.8 mm. During summer (March-May), 152.5 mm of rainfall was received which was excess by 129.2 mm compared to normal (23.3 mm).

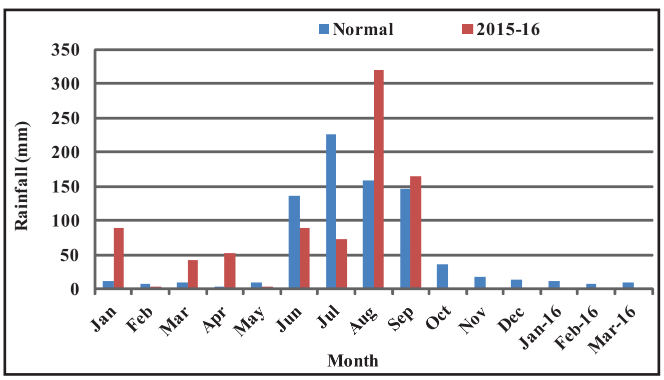


Fig.2.20: Normal and actual (2015-16) monthly rainfall at Akola

During 2015, at Kovilpatti, a rainfall of 988.9 mm was received which excess by 266.3 mm (36.8%) was compared to normal 722.6 mm. During *kharif* (June to September), 218.6 mm rainfall was received which was excess by 68.4 mm than normal of 150.2 mm; in *rabi* season (October – December), 475.8 mm rainfall was received which was excess by 84.9 mm than normal of 391 mm and during summer (March to May), 294.2 mm rainfall was received which was also excess by 153.3 mm than normal of 140.9 mm (Fig. 2.21).

At Parbhani during 2015, the onset of monsoon was early by 11 days (9th June). A rainfall of 574.8 mm was received which was deficit by 388.2 mm (40.3%) compared to normal of 963 mm (Fig.2.22). During *kharif* season, 406.3 mm rainfall was recorded which was deficit by 394.2 mm (49.2%) than normal rainfall of 800.5 mm; *rabi* season received 1.8 mm rainfall and was deficit by 108.7 mm (98.4%) than normal of 110.5 mm and summer season received 157.5 mm which was excess by 121 mm (331.5%) as against normal of 36.5 mm.

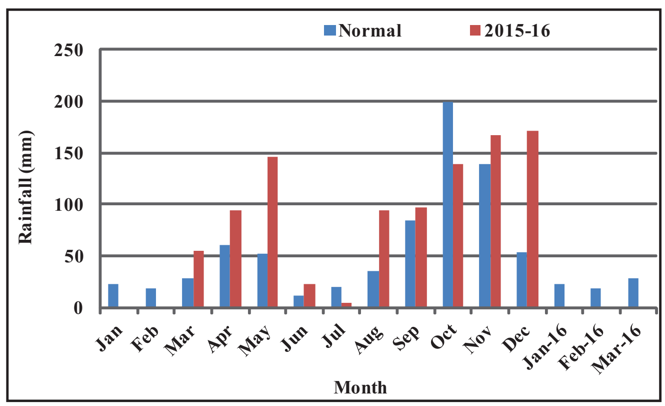


Fig.2.22: Normal and actual (2015-16) monthly rainfall at Parbhani

Table 2.3: Production system wise rainfall (mm) received at AICRPDA centres during 2015

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	473.2	42.7	341.9	391.8	14.6	313.4	546.3	74.3	195.3	269.1	37.8	96.3	111.2	15.5	17.8	23.6	32.6	5.9	66.7	1030.5
Chianki	157.3	36.8	-76.6	374.6	641.6	71.3	303.8	190.6	-37.3	202.3	35.2	-82.6	50.8	23.8	-53.1	7.2	0	-100.0	7.9	10.0	26.6
Faizabad	137.4	197.3	43.6	292.5	198.4	-32.2	294.1	73.4	-75.0	191.1	15.2	-92.0	50.5	0	-100.0	4.0	0	-100.0	11.1	0	-100.0
Jagdalpur	235.5	466.1	97.9	342.6	156.3	-54.4	350.5	347.0	-1.0	192.9	348.4	80.6	88.2	10.6	-88.0	20.2	0	-100.0	6.4	7.0	9.4
Phulbani	188.7	182.6	-3.2	350.4	216.7	-38.2	383.2	213.5	-44.3	228.2	166.0	-27.3	95.7	0.0	-100.0	24.0	0	-100.0	5.0	16.0	218.1
Varanasi	86.8	199.4	129.7	293.3	338.9	15.5	336.9	307.1	-8.8	227.5	11.9	-94.8	49.1	23.0	-53.2	7.2	0	-100.0	4.6	0.0	-100.0
Maize based production system																					
Arjia	74	53.4	-27.3	196.0	286.9	46.7	249.0	164.4	-33.9	97.0	17.0	-82.4	10.0	0.0	-100.0	7.0	0	-100.0	4.0	0	-100.0
Ballowal Saunkhri	122	50.9	-58.3	288.0	308.2	7.0	304.0	146.8	-51.8	161.0	105.2	-34.7	28.0	8.0	-71.6	7.0	0.5	-92.8	27.0	4.5	-83.2
Rakh Dhiansar	90.8	63.6	-30.0	323.8	324.4	0.2	333.9	175.7	-47.4	137.3	84.6	-38.4	19.3	26.7	38.3	6.4	2.4	-62.5	21.9	18.0	-17.8
Fingermillet based production system																					
Bangalore	81.7	97.4	19.2	103.0	66.0	-35.9	129.0	71.0	-45.0	203.2	254.2	25.1	173.9	80.8	-53.5	53.9	176.8	228.0	13.3	4.2	-68.4
Pearlmillet based production system																					
Agra	51.5	51.8	0.6	238.6	88.2	-63.0	207.2	69.2	-66.6	89.8	24.0	-73.3	24.6	40.0	62.6	2.0	0	-100.0	1.9	5.6	194.7
Hisar	47	95.4	101.3	122.0	160.8	31.4	126.0	51.2	-59.2	40.0	19.0	-53.0	5.0	7	42.9	0	4.5	440.0	4.0	0	-100.0
SK Nagar	61.2	34.7	-43.3	234.6	839.5	257.8	209.8	40.0	-80.9	92.5	17.0	-81.6	16.6	0	-100.0	9.4	0	-100.0	1.1	0	-100.0
Sorghum based production system																					
Vijayapura	85.4	100.7	17.9	72.5	0.8	-98.9	78.0	73.9	-5.3	151.6	257.2	69.7	97.3	97.0	-0.3	29.5	9.9	-66.4	7.2	0	-100.0
Solapur	107.1	59.3	-44.6	115.8	0.5	-99.6	139.6	56.4	-59.6	172.7	27.6	-84.0	97.9	57.5	-41.3	21.6	10.3	-52.3	6.0	0	-100.0
Soybean based production system																					
Indore	120.8	362.4	200.0	260.8	666.4	155.5	225.4	367.7	63.1	247.5	136.2	-45.0	39.7	107.6	171.0	18.3	0	-100.0	6.5	2.2	-66.2
Rewa	120	0	-100.0	309.0	415.7	34.6	337.0	424.9	25.9	199.0	17.0	-91.5	32.0	115.2	261.1	10.0	0	-100.0	9.0	0	-100.0
Groundnut based production system																					
Anantapuramu	56	89.4	58.8	75.0	13.2	-82.3	85.0	66.4	-22.1	136.0	142.4	4.8	102.0	93.4	-8.5	35.0	50.8	46.8	7.0	8.6	17.8
Rajkot	97.2	257.9	165.4	221.2	193.1	-12.7	165.6	10.3	-93.8	73.9	125.9	70.3	9.0	0	-100.0	15.0	0	-100.0	1.0	0	-100.0
Cotton based production system																					
Akola	136.5	88.1	-35.5	224.8	72.1	-67.9	158.5	320.1	102.0	146.5	164.3	12.2	35.4	0	-100.0	18.0	0	-100.0	13.4	0	-100.0
Kovilpatti	11.1	23.0	107.2	19.8	4.6	-76.8	35.1	93.6	166.7	84.2	97.4	15.7	198.6	139.1	-30.0	138.5	166.3	20.1	53.8	170.7	217.3
Pharbani	172.4	125.6	-27.1	225.0	13.6	-94.0	235.8	83.2	-64.7	167.3	183.9	9.9	80.4	1.8	-97.8	20.9	0	-100.0	9.2	0	-100.0

N: Normal; A: Actual; D: Deficit

3. Salient Achievements

3.1 Rice Based Production System

3.1.1 Rainwater management

At Biswanath Chariali, in an experiment on enhancing crop productivity through harvested rainwater, maximum rice equivalent yield (REY 36904 kg/ha) and rain water use efficiency (RWUE) of 8.37 kg/ha-mm was achieved with maize-green manuring crop-potato without irrigation. However, highest B:C ratio of 3.64 was recorded maize-greengram-potato system with life saving irrigation (Table 3.1).

Cement concrete lined farm pond with harvested rainwater

Performance of maize - greengram - potato system with life saving irrigation

Table 3.1 : Efficiency of harvested rainwater application on productivity of crops in different cropping system - Biswanath Chariali

Treatment	Yield (kg/ha)			REY (kg/ha)	B:C ratio	RWUE (kg/ha-mm)
	Maize/Rice	Greengram	Potato/ toria			
Maize-greengram-potato without irrigation	4467	807	8630	26742	2.42	3.33
Maize-green manuring crop-potato without irrigation	4367	-	15400	36904	3.25	8.37
Rice-greengram-toria without irrigation	1343	771	889	6630	2.44	0.69
Rice- green manuring crop -toria without irrigation	1383	-	923	3691	1.84	0.92
Maize-greengram-potato with life saving irrigation	4233	850	6113	21952	3.64	2.68
Maize-green manuring crop-potato with life saving irrigation	3900	-	15260	31980	2.80	7.27
Rice-greengram-toria with life saving irrigation	1390	777	747	6358	3.14	0.67
Rice- green manuring crop -toria with life saving irrigation	1167	-	950	3542	1.58	0.85
CD at 5%	386	253	661	-	-	-

REY: Rice equivalent yield

Maize

Dhaincha (Green manure)

Potato

At Faizabad, the *in-situ* rainwater management in maize, the maximum seed yield of 2483 kg/ha, RWUE (8.65 kg/ha-mm) and B:C ratio (3.38) with net returns of Rs 28678/ha with ridge-furrow planting followed by broad bed (90cm) fourrow planting (Table 3.2).

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

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Flat bed planting	1355	1620	10210	1.85	4.72
T_2: Ridge-furrow planting	2483	2958	28678	3.38	8.65
T_3: Broad bed (90 cm) furrow planting	2078	2495	22082	2.84	7.24
T_4: Broad bed (150 cm) furrow planting	1601	1978	14370	2.20	5.58
T_5 : Broad bed (210 cm) furrow planting	1478	1770	12232	2.01	5.15
CD at 5%	1.74	6.35	-	-	-

At Jagdalpur, in raised and sunken bed technique of *in-situ* moisture conservation for upland situation. 1 feet sunken/raised bed gave higher grain yield (2012 kg/ha) and RWUE (1.54 kg/ha-mm) of upland rice as compared to ½ feet sunken and raised bed and plain bed. However, higher seed yield of cowpea (3875 kg/ha), maize (3264 kg/ha) and grind yield of finger millet (1647 kg/ha) was recorded in raised bed by ½ feet excavation. Similarly, higher RWUE was achieved with cowpea, maize and in finger millet with ½ feet raised bed (Table 3.3).

Table 3.3 : Evaluation of raised and sunken bed technique of *in-situ* moisture conservation under upland situation - Jagdalpur

Treatment	Rice				Cowpea			
	Grain yield (kg/ha)		RWUE (kg/ha-mm)		Green pod yield (kg/ha)		RWUE (kg/ha-mm)	
	2015	Mean (3 years)	2015	Mean (3 years)	2015	Mean (3 years)	2015	Mean (3 years)
½ feet sunken/raised bed	1896	2069	1.45	1.67	3875	4397	3.87	3.89
1 feet sunken/raised bed	2012	2314	1.54	1.87	3622	4085	3.62	3.58
Flat bed	1464	1751	1.12	1.41	2764	3224	2.76	2.82
	Maize				Finger Millet			
½ feet sunken/raised bed	3264	3743	2.51	3.03	1647	1722	1.27	1.38
1 feet sunken/raised bed	3028	3843	2.32	3.11	1560	1820	1.2	1.46
Flat bed	644	2426	2.03	2.50	1214	1316	0.93	1.06

1/2 feet raised and sunken bed

1 feet raised and sunken bed

At Jagdalpur, in an experiment on catchment-storage-command relationship for enhancing water productivity under bunded midland (*Mal*) and lowland (*Gabhar*) farming situation, two irrigations from the harvested rainwater in farm pond with sprinklers in vegetable crops (cauliflower/tomato) recorded higher yields (2645 kg/ha), net returns (Rs. 48070/ha), B:C ratio (2.66) and RWUE (19.74 kg/ha-mm) compared to other treatments (Table 3.4).

Table 3.4 : Yield and economics with supplemental irrigation using spinklers in vegetable crops - Jagdalpur

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ ha-mm)
	Yield in 2015-16	Mean yield (4years)	Stover/ stalk yield				
Fieldpea-one irrigation (sprinkler)	1234	1086	2654	13456	29741	2.21	12.10
Fieldpea-two irrigations (sprinkler)	1567	1379	3370	14656	40201	2.74	15.37

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ ha-mm)
	Yield in 2015-16	Mean yield (4years)	Stover/ stalk yield				
Fieldpea-Farmer's practice (flood irrigation)	1436	1263	3087	15856	34390	2.17	14.07
Chickpea-one irrigation (sprinkler)	1456	1281	3131	15102	37322	2.47	14.28
Chickpea-two irrigations (sprinkler)	1674	1473	3600	16448	43826	2.66	16.41
Chickpea-Farmer's practice (flood irrigation)	1223	1076	2630	17795	26247	1.47	11.99
Cauliflower/tomato-one irrigation (sprinkler)	2335	2054	9688	16870	41493	2.46	17.42
Cauliflower/tomato-two irrigations (sprinkler)	2646	2328	10979	18070	48070	2.66	19.74
Cauliflower/tomato-Farmer's practice (flood irrigation)	1898	1670	7878	19270	28188	1.46	14.17

At Phulbani, ridge furrow system with mulching of crop residues resulted in highest yield of vegetable crops *viz.*, cauliflower, tomato and okra (6450, 12650 and 6520 kg/ha, respectively). The B:C ratio (2.60, 3.24 and 2.51) and RWUE (12.31, 24.14 and 12.44 kg/ha-mm) was also higher with ridge furrow system and mulching (Table 3.5).

Table 3.5 : Crop yield and economics of vegetable crops under different moisture conservation practices - Phulbani

Treatment		Yield (kg/ha)	TEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Cauliflower	BBF	5850	7300	57000	99200	2.56	11.16
	BBF + M	6020	7500	58000	102500	2.59	11.49
	RF	6150	7600	60000	103750	2.56	11.74
	RF + M	6450	8100	62000	109250	2.60	12.31
Tomato	BBF	11250	11250	73000	178000	3.08	21.47
	BBF + M	11800	11800	75000	181000	3.15	22.52
	RF	12050	12050	76000	185000	3.17	23.00
	RF + M	12650	12650	78000	195000	3.24	24.14
Okra	BBF	5560	6950	60000	99000	2.32	10.61
	BBF + M	5830	7300	62000	103750	2.35	11.13
	RF	5920	7400	63000	105000	2.35	11.30
	RF + M	6520	8150	65000	118000	2.51	12.44

CD at 5%: crop (C): 5.22; Moisture conservation practices (M): 6.62 and C X M: 11.47; BBF - Broad bed furrow system; M – Mulching; RF – Ridge furrow system; TEY – Tomato equivalent yield

Ridge furrow system in okra

Broad bed & furrow system in tomato

At Phulbani, four vegetable crops *viz.*, cauliflower, tomato, french bean and radish recorded highest radish equivalent yield (20300, 32100, 19400 and 19200 kg/ha), net returns (Rs.102500/ha, Rs.182000/ha, Rs.90000/ha and Rs.113600/ha) and B:C ratio (2.7, 3.4, 2.4 and 3.8) when irrigation from harvested rainwater in farm pond was applied at 10% (maximum allowable depletion) of (available soil moisture) respectively. The highest water use efficiency was recorded with irrigation at 40% MAD of ASM for all the vegetable crops (Table 3.6).

Table 3.6 : Yield and economics with supplemental irrigation - major vegetable crops during *rabi* season – Phulbani

Treatment		Yield (kg/ha)	REY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
Crop	Irrigation						
Cauliflower	I_1	6500	20300	60000	102500	2.7	16.25
	I_2	5800	18120	59000	86000	2.5	18.12
	I_3	4400	13750	58000	52000	1.9	15.72
Tomato	I_1	12850	32100	75000	182000	3.4	21.42
	I_2	11800	29500	74000	162000	3.2	23.60
	I_3	9200	23000	73000	111000	2.5	20.44
French bean	I_1	6200	19400	65000	90000	2.4	15.5
	I_2	5500	17200	64000	73500	2.1	17.19
	I_3	4100	12800	63000	39500	1.6	14.64
Radish	I_1	19200	19200	40000	113600	3.8	64.0
	I_2	17600	17600	39000	101800	3.6	73.3
	I_3	12400	12400	38000	61200	2.6	62.0

CD at 5%: Crop (C): 7.92; Irrigation (I): 6.03 and C X I: 12.05; REY: Radish equivalent yield; I_1 – Irrigation at 10% MAD of ASM; I2 – Irrigation at 40% MAD of ASM; I3 – Irrigation at 60% MAD of ASM.

Lined farm pond with harvested runoff

Radish with continuous furrow irrigation

At Varanasi, in an evaluation of foliar spray with 2% KCl + Zn + Bo during dry spell of 20 days in September gave highest grain yield of rice (2110 kg/ha) with higher net returns (Rs 16705/ha), B:C ratio (2.04) and RWUE (2.2 kg/ha-mm) followed by foliar spray of 2% thiourea (2027 kg/ha) as compared to control (1560 kg/ha). The mean data over 2 years also followed the same trend Table 3.7.

Table 3.7 : Yield and economics of rice with foliar spray of chemicals, Zn and Bo– Varanasi

Treatment	Grain yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)	Straw				
Control	1560	1603	3100	14000	10180	1.72	1.6
Water spray	1832	1769	3600	15000	13403	1.89	1.9
Foliar spray of 2%KCl	2000	1917	3200	15000	16000	2.06	2.1
Foliar spray of 2% KNO_3	2020	2000	3500	15500	15810	2.02	2.1
Foliar spray of 2% Thiourea	2027	1986	3650	15500	15926	2.02	2.1
Foliar spray of 2% KCl with Zn + Bo	2110	2118	3600	16000	16705	2.04	2.2
CD at 5%	145	-	-	-	-	-	-

Foliar application of 2% KCl + Zn + Bo with supplemental irrigation

At Varanasi, in an evaluation of vegetable crops bottle gourd, okra, brinjal and chilli with supplemental irrigation (5cm) from the harvested raintwater in farm pond at growth and flowering stages, bottle gourd gave the highest yield (12500 kg/ha) with NMR of Rs. 100000/ha, B:C ratio 3.3 and RWUE (13.1 kg/ha-mm) followed by Okra (5200 k/ha, Rs.62400, 3.12 and 5.4 kg/ha-mm respectively) Table 3.8.

Table 3.8 : Performance of crops under supplemental irrigation - Varanasi

Crop	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Bottle gourd	12500	30000	100000	3.33	13.1
Okra	5200	20000	62400	3.12	5.4
Brinjal	4600	20000	46000	2.3	4.8
Chilli	3800	25000	5700	2.28	4.0

Performance of vegetable crops with supplemental irrigation

At Varanasi, in a study on efficient utilization of harvested rainwater applied as a pre-sowing irrigation for pea, among pea varieties, AP-3 gave higher seed and stover yield (1486 and 2078 kg/ha), NMR (Rs.17720 /ha), B:C ratio (2.1) and RWUE (14.65 kg/ha-mm) as compared to Malvia-15 (1152 kg/ha). Supplemental irrigation at flowering gave maximum seed yield (1448 kg/ha), NMR (Rs. 36200/ha), B:C ratio (2.2) and WUE (14.28 kg/ha-mm) followed by irrigation at pod development (1294 kg/ha) Table 3.9.

Table 3.9 : Effect of variety and supplemental irrigation on yield and economics of pea - Varanasi

Treatment	Seed yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	2015-16	Mean (3 years)	Stover				
Variety							
Malvia-15	1152	1364	1473	15115	28800	1.91:1	11.36
AP-3	1486	1737	2078	17720	37150	2.1:1	14.65
CD at 5%	327	-	499	-	-	-	-
Supplemental irrigation							
No Irrigation	1215	1339	1455	15160	30375	2.00:1	11.98
Irrigation at flowering	1448	1640	1802	16460	36200	2.2:1	14.28
Irrigation at pod development	1294	1671	2069	16346	32350	1.98:1	12.76
CD at 5%	152	-	210	-	-	-	-

3.1.2 Cropping Systems

At Biswanath Chariali, in an evaluation of maize based double cropping systems, maximum maize equivalent yield (MEY) of 9074 kg/ha was obtained with maize-potato system followed by maize-rajmah system (7819 kg/ha) whereas, maximum NMR of Rs.61162/ha was recorded by maize-rajmah system followed by maize-niger system Rs.57352/ha as compared to other double cropping systems. Further, higher B:C ratio (2.87) was recorded with maize-rajmah cropping system (Table 3.10).

Table 3.10 : Evaluation of maize based double cropping systems under rainfed upland situation - Biswanath Chariali

Treatment	Grain/seed yield (kg/ha)				MEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Maize		*Rabi* crop						
	2015	Mean (3 years)	2015	Mean (3 years)					
Maize - toria	5028	5196	667	562	6444	33788	43548	2.29	6.34
Maize - lathyrus	5562	5590	480	480	6482	28788	48996	1.70	7.01
Maize - pea	5600	5390	743	658	6900	30153	52647	2.75	7.06
Maize - lentil	5419	5453	556	478	7735	33763	59055	2.74	6.83
Maize - linseed	4440	5153	507	474	5496	32943	33008	2.00	5.59
Maize-buckwheat	5406	5335	1137	1037	6543	30573	47944	2.57	6.81
Maize -mustard	5653	5604	749	698	7275	33638	53660	2.6	7.12
Maize - niger	5329	5299	977	938	7405	31513	57352	2.82	6.71
Maize-maize	4118	5026	3850	3420	7324	51700	36192	1.7	5.19
Maize - rajmah	4441	5290	1160	921	7819	32663	61162	2.87	5.6
Maize-horsegram	5577	5572	607	517	7094	30409	54715	2.8	7.03
Maize - potato	4925	5388	6630	6110	9074	62558	46328	1.74	6.21
CD at 5%	332	480	288	359	298	-	-	-	-

At Biswanath Chariali, in an evaluation of sesame based intercropping systems with two fertility levels, intercropping of sesame with greengram and blackgram recorded significantly higher sesame equivalent yield (SEY). The maximum sesame equivalent yield (1347 kg/ha), LER (2.03), net returns (Rs.91049/ha) and RWUE (6.49 kg/ha-mm) were recorded with application of 30:20:20 kg NPK/ha in sesame + blackgram system (1:1). Application of 30:20:20 kg NPK/ha with sesame + blackgram (2:2) and 30:20:20 kg NPK/ha with sesame + greengram (2:2) recorded SEY of 983 and 985 kg/ha, net returns of Rs.61985 and Rs. 61724/ ha, B:C ratio of 4.72 and 4.60 and RWUE of 4.72 and 4.74 kg/ha-m, respectively (Table 3.11).

Table 3.11 : Evaluation of sesame based intercropping systems with different fertility levels - Biswanath Chariali

Treatment	Seed yield (kg/ha)				SEY (kg/ha)	LER	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Sesame		Intercrop							
	2015	Mean (3 years)	2015	Mean (3 years)						
F_1S_1	635	573	478	572	970	1.79	17142	60484	4.53	4.66
F_1S_2	725	624	552	719	985	1.57	17242	61728	4.60	4.74
F_1S_3	870	685	853	546	1347	2.03	16768	91059	6.43	6.49
F_1S_4	739	621	436	479	983	1.38	16668	61985	4.72	4.72
F_2S_1	471	436	421	413	786	1.10	17045	45906	3.70	3.78
F_2S_2	523	450	474	479	878	1.23	17113	53184	4.12	4.22
F_2S_3	370	412	472	471	633	0.99	16530	34185	3.07	3.05
F_2S_4	412	444	557	427	723	1.15	16748	41152	3.46	3.48
F_3S_1	508	443	489	412	875	1.23	17358	52659	4.03	4.20
F_3S_2	568	514	433	397	892	1.21	17442	53971	3.09	4.29
F_3S_3	678	600	446	416	927	1.32	16615	57558	4.46	4.45
F_3S_4	476	485	346	-	669	0.95	16778	36762	3.19	3.21
Sesame (Sole)	878	785	-	719	878	1.00	13384	56838	4.25	4.22
Greengram (Sole)	-	-	745	840	894	1.00	15516	44110	3.84	3.83
Blackgram (Sole)	-	-	816	0	734	1.00	14837	50478	4.40	3.92
CD at 5%	148	215	147	288	143	---				----

S1: sesame + greengram (1:1); S2: sesame + greengram (2:2); S3: sesame + blackgram (1:1); S4: sesame + blackgram (2:2); F1= 30:20:20 kg NPK/ha; F2= 15:35:10 kg NPK/ha; F3= 30:35:20 kg NPK/ha; LER: Land equivalent ratio; SEY: Sesame equivalent yield

Blackgram (sole)

Sesame (sole)

F_1S_3, Sesame + blackgram (1:1) with NPK 30:20:20

In an evaluation, effect of planting time and varieties of potato under rainfed condition at Biswanath Chariali, highest tuber yield of 8338 kg/ha, NMR of Rs.41335/ha and B:C ratio of 1.98 were recorded when planting was done on 16th October, while lowest tuber yield of 6688 kg/ha, NMR of Rs.24835/ha and B:C ratio of 1.59 were recorded when planting was done on 1st November. Among varieties, Kufri Pokhraj recorded maximum tuber yield (8640 kg/ha), NMR (Rs.40785/ha) and B:C ratio (1.89) as compared to other varieties (Table 3.12).

Table 3.12 : Effect of planting time and varieties of potato on tuber yield and economics – Biswanath Chariali

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Tuber	Mean (3 years)				
Dates of planting						
1st October	7398	7809	42045	31935	1.76	10.75
16th October	8338	8495	42045	41335	1.98	13.81

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Tuber	Mean (3 years)				
1st November	8044	8274	42045	38395	1.91	19.43
16th November	6688	7174	42045	24835	1.59	18.57
CD at 5%	1633		-	-	-	-
Varieties						
Recommended variety (Kufri Pokhraj)	8640	8831	45635	40785	1.89	50.18
Local small tuber (red eyed)	6710	6845	38454	28596	1.74	38.97
Local small tuber (white eyed)	7510	8031	39865	35185	1.88	43.62
CD at 5%	1154		-	-	-	-

Potato cv. Kufri Pokhraj

Local variety

At Biswanath Chariali, in an evaluation of relay cropping of *rabi* pulses, pea relayed with 150% recommended seed rate (RSR) and 15 days before harvesting of rice gave maximum seed yield (474 kg/ha), stover yield (619 kg/ha) and B:C ratio (4.54). Similarly, lathyrus relayed with 150% RSR and 15 days before harvesting of rice gave maximum seed and stover yield (170 and 203 kg/ha). Whereas, sowing of lathyrus 15 days before rice harvest with 100% seed rate gave higher B:C ratio (1.80) (Table 3.13).

Table 3.13 : Relay cropping of *rabi* pulses with *kharif* rice under rainfed medium lowland situation - Biswanath Chariali

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	B:C ratio (Rs/ha)
Sowing of pea 15 days before rice harvest with 100% seed	175	247	2.37
Sowing of pea 15 days before rice harvest with 150% seed rate	474	619	4.54
Sowing of pea at rice harvest with 100% seed rate	164	212	2.23
Sowing of pea at rice harvest with 150% seed rate	167	214	1.60
Sowing of pea after rice harvest by zero till machine with 100% seed rate	149	181	1.77
Sowing of pea after rice harvest by zero till machine with 150% seed rate	157	202	1.37
Sowing of lathyrus 15 days before rice harvest with 100% seed rate	127	160	1.80
Sowing of lathyrus 15 days before rice harvest with 150% seed rate	170	203	1.69
Sowing of lathyrus at rice harvest with 100% seed rate	131	158	1.85
Sowing of lathyrus at rice harvest with 150% seed rate	149	174	1.48
Sowing of lathyrus after rice harvest by zero till machine with 100% seed rate	102	125	1.37

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	B:C ratio (Rs/ha)
Sowing of lathyrus after rice harvest by zero till machine with 150% seed rate	120	144	1.79
Mean	174	220	1.99
CD at 5 %	243	-	--

Pea with 150% seed rate as relay crop in rice

At Biswanath Chariali, in a study on modeling crop growth parameters and yield of potato, *Pokhraj* variety of potato gave higher tuber yield (10570 kg/ha) compared to *Kufri Jyoti* 9760 kg/ha and D1 (12th Nov) planting recorded higher tuber yield (16730 kg/ha) followed by D2 (19th Nov) planting of tuber yield (11840 kg/ha) when compared to other planting dates (Table 3.14).

Table 3.14 : Crop modeling studies on potato yield – Biswanath Cahriali

Treatment	Tuber yield (kg/ha)	
	2015-16	Mean (2 years)
Variety		
Kufri Pokhraj	10570	10720
Kufri Jyoti	9760	8790
CD at 5%	570	440
Date of sowing		
D_1 (12 Nov)	16730	13100
D_2 (19 Nov)	11840	11190
D_3 (26 Nov)	8320	9130
D_4 (03 Dec)	3770	5590
CD at 5%	1720	1340

At Faizabad, in an evaluation of pigeonpea based intercropping systems. The higher pigeonpea equivalent yield (1822 kg/ha) was recorded in pigeonpea+blackgram (1:3) intercropping system followed by pigeonpea+ blackgram (1:2), pigeonpea+maize (1:2) and pigeonpea+ sesame (1:2) system (Table 3.15).

Table 3.15 : Seed yield of pigeonpea intercropping systems - Faizabad

Cropping system	Yield (kg/ha)		Pigeonpea equivalent yield (kg/ha)
	Pigeon-pea	Inter-crop	
Pigeonpea+maize (1:1)	1204	1195	1443
Pigeonpea+maize (1:2)	1185	1500	1485
Pigeonpea+ sorghum (1:1)	1176	1028	1340
Pigeonpea+sorghum (1:2)	1148	1361	1366
Pigeonpea+sesame (1:1)	1167	370	1414
Pigeonpea+sesame (1:2)	1148	491	1475
Pigeonpea+ blackgram (1:2)	1296	398	1721
Pigeonpea+blackgram(1:3)	1259	528	1822
Pigeonpea sole	1306	-	1306
Maize sloe	-	2009	402
Sorghum sole	-	1759	352
Sesame sole	-	537	358
Blackgram sole	-	556	593
CD at 5%	NS	-	1.67

At Phulbani, among rice + fodder intercropping systems, rice + rice bean gave marginally higher rice equivalent yield (2520 kg/ha), net returns (Rs.10680/ha) and B:C ratio (1.43) compared to rice + cowpea system. Among nutrient management treatments, application of FYM@2.5 t/ha + 50% RDF recorded highest rice equivalent yield (2880 kg/ha), net returns (Rs.15170/ha) and B:C ratio (1.60) followed by inorganic fertilizer and FYM @5 t/ha. The yield increased by 46, 38 and 20% in FYM@2.5 t/ha + 50% inorganic fertilizer, inorganic fertilizer and FYM@5 t/ha, respectively as compared to control (1970 kg/ha) (Table 3.16).

Table 3.16 : Yield and economics as affected by intercropping and nutrient management - Phulbani

Treatment	REY (kg/ha)	NMR (Rs/ha)	B:C ratio
Cropping system			
Rice + cowpea (F) (5:2)	2451	9714	1.39
Rice + rice bean (F) (5:2)	2520	10680	1.43
CD at 5 %	NS		
Nutrient management			
FYM@5 t/ha	2370	6130	1.23
Inorganic fertilizer	2720	13930	1.58
FYM@2.5 t/ha + 50% inorganic fertilizer	2880	15170	1.60
Control	1970	5530	1.25
CD at 5 %	2.55	-	-

REY: Rice equivalent yield ; F-Fodder

Rice + ricebean (F) system (5:2)

Rice + cowpea (F) system (5:2)

At Varanasi, in an evaluation of planting technique and weed management practices in ridge-furrow planting of pigeonpea + rice intercropping system, normal planting (onset monsoon) with 100% population of both crops (rice + pigeonpea) and one hand weeding at 30 DAS recorded highest PEY (2333 kg/ha) with NMR of Rs 68336/ha, B:C ratio of 3.7 and RWUE of 2.5 kg/ha-mm followed by 150% population of pigeonpea + 100% rice population & one hand weeding (2205 kg/ha, Rs 63199/ha, 3.5 and 2.4 kg/ha-mm, respectively) (Table 3.17).

Table 3.17 : Effect of planting method and weed management practices on ridge-furrow planted pigeonpea + rice intercropping system – Varanasi

Treatment		Yield (kg/ha)		PEY	LER	MAI	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Intercrop							
P1	W1	1680	566	1885	1.1	205	25000	50399	3.0	2.0
	W2	2150	506	2333	1.1	183	25000	68336	3.7	2.5
	W3	1650	645	1884	1.1	234	25000	50350	3.0	2.0
	W4	2000	566	2205	1.1	205	25000	63199	3.5	2.4
	W5	1720	675	1965	1.1	245	25000	53582	3.1	2.1
P2	W1	1100	764	1377	1.3	277	25000	30076	2.2	1.4
	W2	1278	566	1483	1.2	205	25000	34319	2.4	1.6
	W3	1165	675	1410	1.2	245	25000	31382	2.3	1.5
	W4	1150	823	1449	1.3	299	25000	32940	2.3	1.5
	W5	1200	466	1369	1.1	169	25000	29761	2.2	1.5

Treatment		Yield (kg/ha)		PEY	LER	MAI	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Intercrop							
P3	W1	850	615	1073	1.3	223	25000	17919	1.7	1.1
	W2	1120	595	1336	1.2	216	25000	28431	2.1	1.4
	W3	1000	456	1165	1.2	165	25000	21617	1.9	1.2
	W4	1150	397	1294	1.1	144	25000	26754	2.1	1.4
	W5	950	352	1078	1.1	128	25000	18104	1.7	1.1
CD at 5%		154	157	-	-	-	-	-	-	-

LER: Land equivalent ratio; PEY: Pigeonpea equivalent yield; MAI: Monetary advantage index; P_1 : Normal planting (onset of monsoon); P_2 : Staggered planting (rice-sown in time & pigeonpea at 30 DAS); P_3 : Pruning of normal planted pigeonpea at 60 DAS; W_1 : Control; W_2 : 100% population of both crops + hand weeding; W_3 : 150% population of pigeonpea + 100% of rice + no weeding; W_3 : 150% population of pigeonpea + 100% of rice + hand weeding; W_5 : 100% population (P + R) + pendimethalin @ 1.0 kg a.i/ha as pre-emergence.

In a field experiment on rice + okra intercropping system at Varanasi, rice variety NDR-97, intercroped with okra variety HRB-55, recorded highest okra crop equivalent yield (OCEY) of 13411 kg/ha and netreturns of Rs. 106912/ha with B:C ratio of 4.93 and RWUE of 15.6 kg/ha-mm followed by VRO-5 + NDR-97 (12407 kg/ha), VRO-5 + HUR-3022 (12199 kg/ha). The lowest yield was recorded with okra Anamika + HUR-105 (Table 3.18).

Table 3.18 : Performance of rice + okra intercropping system -Varanasi

Treatment	Yield (kg/ha)		OCEY	LER	MAI	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop							
Okra (Anamika)	9700	-	9700	1.0	-	26500	77600	2.93	11.3
HRB-55 (Varsha)	11400	-	11400	1.0	-	26500	91200	3.44	13.3
VRO-5	11607	-	11607	1.0	-	26500	92856	3.50	13.5
HUR-105	0	1600	2320	1.0	-	14500	8700	1.60	1.8
HUR-3022	0	1443	2093	1.0	-	14500	6428	1.44	1.7
NDR-97	0	1917	2779	1.0	-	14500	13292	1.92	2.2
Okra Anamika + HUR-105	7967	1108	9574	1.51	49210	27200	68538	3.52	11.1
Okra Anamika + HUR-3022	8760	1083	10331	1.65	67530	27200	76108	3.80	12.1
Okra Anamika + NDR-97	8537	1560	10799	1.69	74941	27200	80787	3.97	13.0
HRB-55 + HUR-105	9733	1217	11498	1.61	70620	27200	87775	4.23	13.4
HRB-55 + HUR-3022	10473	1060	12010	1.65	78442	27200	92903	4.42	14.0
HRB-55 + NDR-97	11007	1658	13411	1.83	111409	27200	106913	4.93	15.6
VRO-5 + HUR-105	10167	1167	11858	1.61	71755	27200	91383	4.36	13.8
VRO-5 + HUR-3022	11000	827	12199	1.52	63492	27200	94787	4.48	14.2
VRO-5 + NDR-97	10300	1453	12407	1.65	80112	27200	96873	4.56	14.5
CD at 5%	2284	245	-	-	-	-	-	-	-

OCEY: okra crop equivalent yield

3.1.3 Nutrient management

In a Permanent Manurial Trail (PMT) in rice–greengram-toria system at Biswanath Chariali, *ahu* rice gave maximum grain yield of rice (1321 kg/ ha), straw yield (4536 kg/ha), RWUE (0.92 kg/ha-mm), net returns (Rs.9987/ha) and B:C ratio of 2.17 with application of 75% RDF (inorganic) + vermicompost @ 3 t/ha over all other treatments. Similarly during *rabi*, higher seed yield of toria (1122 kg/ha), stalk yield (2438 kg/ha), RWUE (20.78 kg/ha-mm), net returns (Rs. 26824/ha) and B:C ratio of 4.03 were recorded with 75% RDF (inorganic) + vermicompost @ 3 t/ha. Where as in case of greengram the maximum seed yield (1071 kg/ha), RWUE (3.42

kg/ha-mm), net returns (Rs. 33683/ha) and B:C ratio (3.32) were recorded with the application of 50% RDF + vermicompost @ 3 t/ha which was at par with 75% RDF (inorganic) + vermicompost @ 3 t/ha. Similar trend was observed with mean seed yield of rice, greengram and toria (4 years) (Table 3.19 & 3.20).

Table 3.19 : Permanent manurial trial in rice–greengram-toria system under rainfed situation - Biswanath Chariali

Treatment	*Ahu* rice (Dehangi)				Greengram (Pratap)				Toria (JT-90-1)			
	Grain yield (kg/ha)	Mean (4 years)	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Seed yield (kg/ha)	Mean (4 years)	Stover yield (kg/ha)	RWUE (kg/ha-mm)	Seed yield (kg/ha)	Mean (4 years)	Stalk yield (kg/ha)	RWUE (kg/ha-mm)
Control	545	621	2124	0.38	486	583	1523	1.49	503	430	1224	9.31
100% RDF	936	996	3209	0.65	783	835	2302	2.50	761	706	1733	14.09
75% RDF + vermi-compost @ 3 t/ha	1321	1337	4536	0.92	1067	1136	3211	3.40	1122	951	2438	20.78
75% RDF + vermi-compost @1 t/ha	1115	1248	3878	0.78	892	1040	3792	2.85	1074	948	2245	19.89
75% RDF + *in- situ sesbania aculeata*	978	1012	3214	0.68	724	794	2315	2.31	995	847	2078	18.43
50% RDF + vermi-compost @ 3 t/ha	1227	1162	4017	0.86	1071	1054	3347	3.42	1071	858	2216	19.83
50% RDF + vermi-compost @1 t/ha	1003	1063	3325	0.70	812	934	2637	2.60	1053	848	2182	19.50
50% RDF + *in- situ sesbania aculeata*	867	898	2946	0.60	705	777	2455	2.25	897	746	1934	16.61
Vermicompost @ 3 t/ha	736	826	2537	0.51	698	786	2154	2.20	709	579	1674	13.13
vermicompost @ 1 ton/ha	698	839	2434	0.48	644	766	2178	2.05	698	590	1514	12.93
In- situ sesbania aculeata	657	740.5	2396	0.46	536	630	1828	1.71	627	538	1483	11.61
CD at 5%	286	295	379	-	187	235	364	-	148	154	244	-

100% RDF (NPK kg/ha): Rice: 20:10:10; Greegram: 15:35:10; Toria: 40:35:10;

Table 3.20 : Economics of rice-greengram-toria cropping system - Biswanath Chariali

Treatment	*Ahu* rice (Dehangi)			Greengram (Pratap)			Toria (JT-90-1)		
	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Control	7123	1451	1.20	10982	10888	1.99	7784	7306	1.93
100% RDF (20:10:10 NPK kg/ha)	8716	4853	1.61	13473	21762	2.61	8126	15704	2.93
75% RDF + vermi-compost @ 3 t/ha	8759	9987	2.14	15339	32676	3.13	8836	26824	4.03
75% RDF + vermi-compost @ 1 t/ha	8212	7816	1.95	14572	25568	2.75	8512	25708	4.02
75% RDF + *in- situ sesbania aculeata*	8176	5818	1.71	13229	19351	2.46	7823	22027	3.81
50% RDF + vermi-compost @ 3 t/ha	8558	8724	2.02	14512	33683	3.32	8774	23356	3.66
50% RDF + vermi-compost @ 1 t/ha	8170	6185	1.75	13927	22613	2.62	8353	23237	3.78

Treatment	*Ahu* rice (Dehangi)			Greengram (Pratap)			Toria (JT-90-1)		
	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
50% RDF + *in- situ sesbania aculeata*	8011	4605	1.57	12834	18891	2.47	7682	19228	3.51
Vermicompost @ 3 t/ha	8156	2741	1.34	13321	18089	2.35	7586	13684	2.81
Vermicompost @ 1 ton/ha	8012	2402	1.30	12678	16302	2.28	7539	13401	2.78
In- situ *sesbania aculeata*	8050	1916	1.24	11540	12580	2.09	7814	10996	2.41

In a Permanent Manurial Trail (PMT) in maize–greengram-rajmah system at Biswanath Chariali, maize gave maximum grain yield (4233 kg/ ha), strover yield (7968 kg/ha), RWUE (3.22 kg/ ha-mm), net returns (Rs.40638/ha) and B:C ratio of 3.10 with application of 75% RDF (inorganic) + vermicompost @ 3 t/ha over all other treatments. Similarly, in rajmah higher seed yield (1487 kg/ha), stalk yield (1816 kg/ha), RWUE (18.47 kg/ha-mm), net returns (Rs. 40026/ha) and B:C ratio of 3.05 were recorded with 75% RDF (inorganic) + vermicompost @ 3 t/ha. In case of greengram the maximum seed yield (1112 kg/ha), stalk yield (3418 kg/ ha), RWUE (3.55 kg/ha-mm), net returns (Rs. 35528/ha) and B:C ratio (3.44) were recorded with application of 50% RDF + vermicompost @ 3 t/ha which was at par with the treatment 75% RDF (inorganic) + vermicompost @ 3 t/ha (Table 3.21, 3.22, 3.23 & 3.24).

75 % vermicompost + RDF

Control

75 % vermicompost + RDF

Control

Performance of rice and toria under perment manurial trial

Table 3.21: Permanent manurial trial in maize–greengram-rajmah system under rainfed situation - Biswanath Chariali

Treatment	Maize (Gold *PAC-740*)			Greengram (Pratap)			Rajmah (HUR-301)		
	Grain yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)	Seed yield (kg/ha)	Stalk yield (kg/ha)	RWUE (kg/ha-mm)	Seed yield (kg/ha)	Stalk yield (kg/ha)	RWUE (kg/ha-mm)
Control	2468	5668	1.88	495	1512	1.57	765	1046	9.50
100% RDF	3315	6524	2.52	803	2324	2.56	936	1237	11.62
75% RDF + vermicompost @ 3 t/ha	4233	7968	3.22	1088	3226	3.47	1487	1816	18.47
75% RDF + vermicompost @ 1 t/ha	3675	7483	2.80	897	2815	2.86	1275	1675	15.84
75% RDF + *in- situ sesbania aculeata*	3396	6896	2.58	769	2237	2.45	1006	1346	12.49
50% RDF + vermicompost @ 3 t/ha	3882	7886	2.96	1112	3418	3.55	1392	1723	17.29
50% RDF + vermicompost @ 1 t/ha	3524	6724	2.68	877	2614	2.80	1168	1498	14.51
50% RDF + *in- situ sesbania aculeata*	3187	6287	2.43	716	2164	2.28	927	1237	11.52

Treatment	Maize (Gold *PAC-740*)			Greengram (Pratap)			Rajmah (HUR-301)		
	Grain yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)	Seed yield (kg/ha)	Stalk yield (kg/ha)	RWUE (kg/ha-mm)	Seed yield (kg/ha)	Stalk yield (kg/ha)	RWUE (kg/ha-mm)
Vermicompost @ 3 t/ha	2914	6014	2.22	705	2097	2.25	913	1213	11.34
Vermicompost @ 1 ton/ha	2765	5965	2.11	673	1966	2.15	875	1145	10.86
In- situ sesbania aculeata	2635	5835	2.01	569	1807	1.81	807	1127	10.02
CD at 5%	327	472	-	186	321	-	222	327	-

100% RDF (NPK kg/ha): Maize: 60:40:40; Greengram: 15:35:10; Rajmah: 60:80:40

Table 3.22 : Economics of maize–greengram-rajmah cropping system - Biswanath Chariali

Treatment	Maize			Greengram (Pratap)			Rajmah		
	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Control	15996	13757	1.86	10982	11293	2.02	16898	13800	1.8
100% RDF	17473	28937	2.65	13473	22662	2.68	17684	19861	2.12
75% RDF + vermicompost @ 3 t/ha	19349	40638	3.10	15339	33621	3.19	19559	40026	3.05
75% RDF + vermicompost @ 1 t/ha	18672	32778	2.75	14572	25793	2.77	18893	32341	2.71
75% RDF + *in- situ sesbania aculeata*	17229	30315	2.75	13229	21376	2.61	17448	23196	2.33
50% RDF + vermicompost @ 3 t/ha	18619	35729	2.91	14512	35528	3.44	18839	36842	2.96
50% RDF + vermicompost @ 1 t/ha	18325	31011	2.69	13927	25538	2.83	18546	28317	2.53
50% RDF + *in- situ sesbania aculeata*	17034	27584	2.61	12834	19386	2.51	17256	19933	2.16
Vermicompost @ 3 t/ha	16821	23975	2.42	13321	18404	2.38	16943	19685	2.16
Vermicompost @ 1 ton/ha	16578	22132	2.34	12678	17607	2.38	16797	18356	2.09
In-situ sesbania aculeata	16140	20750	2.28	11540	14065	2.21	16363	16022	1.98

Table 3.23 : Effect of treatments on soil physical properties - Biswanath Chariali

Treatment	BD (Mg/m^3)	FC	PWP	AWC
Control	1.29	19.56	5.70	13.84
100% RDF	1.17	20.28	4.84	15.45
75% RDF + vermicompost @ 3 t/ha	1.01	21.86	4.21	17.56
75% RDF + vermicompost @ 1 t/ha	1.03	21.27	4.35	16.89
75% RDF + *in- situ sesbania aculeata*	1.11	20.15	4.86	15.23
50% RDF + vermicompost @ 3 t/ha	1.02	20.41	5.44	16.76
50% RDF + vermicompost @ 1 t/ha	1.05	20.15	5.30	14.34
50% RDF + *in- situ sesbania aculeata*	1.04	20.34	4.44	16.51
Vermicompost @ 3 t/ha	1.12	19.83	5.68	13.97
Vermicompost @ 1 ton/ha	1.10	19.71	5.66	13.89
In- situ sesbania aculeata	1.10	20.44	4.84	15.58
Initial values (at the start of expt.)	1.33	16.94	5.54	11.40

FC-Field capacity; PWP - Permanent wilting point; AWC - Avaialble water capacity

Table 3.24 : Effect of treatments on soil chemical properties - Biswanath Chariali

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)		
			N	P_2O_5	K_2O
Control	4.88	0.55	296	25	145
100% RDF	5.06	0.71	429	49	192
75% RDF + vermicompost @ 3 t/ha	5.79	0.91	453	51	233
75% RDF + vermicompost @ 1 t/ha	5.56	0.85	451	50	219
75% RDF + *in- situ sesbania aculeata*	5.74	0.75	428	49	197
50% RDF + vermicompost @ 3 t/ha	5.47	0.88	430	50	229
50% RDF + vermicompost @ 1 t/ha	5.33	0.81	429	49	197
50% RDF + *in- situ sesbania aculeata*	5.26	0.83	415	46	194
Vermicompost @ 3 t/ha	5.43	0.87	414	43	189
Vermicompost @ 1 ton/ha	5.31	0.86	412	41	188
In- situ sesbania aculeata	5.23	0.69	413	41	189
Initial values (at the start of expt.)	5.05	0.34	385	28	178

75 % vermicompost + RDF in maize

Control

75 % vermicompost +RDF in rajmah

Control

Performance of maize and rajmah under perment manurial trial

At Biswanath Chariali,application of recommended dose of fertilizer + 2% KNO_3 foliar spray before flowering gave maximum toria yield of 1146 kg/ha compared to other treatments and was at par with the treatment RDF + 2.0% KCl spray before flowering and at siliqua formation (1109 kg/ha). Similarly, RDF + 2% KNO_3 spray before flowering gave higher stalk yield (2414 kg/ha), net returns (Rs.24879/ha), B:C ratio (3.08) and RWUE of 9.59 kg/ha-mm as compared to other treatments (Table 3.25).

Table 3.25 : Effect of foliar application of KNO3 on yield and economics on toria - Biswanath Chariali

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	MNR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Control	543	1055	7829	14999	2.08	4.54
100% NPK (40:35:15 NPK kg/ha)	705	1537	9886	13726	2.14	5.89
RDF + water spray	812	1598	10157	16937	2.39	6.79
RDF + 0.5% KNO_3 spray before flowering	834	1645	10235	17315	2.44	6.97
RDF + 0.5% KNO_3 spray at siliqua formation	866	1737	10287	17697	2.52	7.25
RDF + 0.5% KNO_3 spray before flowering and at siliqua formation	898	1941	10426	18676	2.58	7.51
RDF + 1.0% KNO_3 spray before flowering	1056	2263	10766	23066	2.94	8.84
RDF + 1.0% KNO_3 spray at siliqua formation	1027	2218	10698	22248	2.87	8.59

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	MNR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
RDF + 1.0% KNO_3 spray before flowering and at siliqua formation	1061	2312	10792	22912	2.94	8.88
RDF + 2.0% KNO_3 spray before flowering	1146	2414	11779	24879	3.08	9.59
RDF + 2.0% KNO_3 spray at siliqua formation	1087	2143	11584	22924	2.81	9.09
RDF + 2.0% KNO_3 spray before flowering and at siliqua formation	1098	2278	11651	22961	2.82	9.18
RDF + 2.0% KCl spray before flowering and at siliqua formation	1109	2358	11915	23525	2.96	9.28
CD at 5%	193	224	-	-	-	-

Performance of toria with RDF + KNO_3 @ 2% before flowering


Control

In INM trial on rice-toria cropping sequence at Biswanath Chariali, recommended dose of fertilizer (40:35:15 NPK kg/ha) gave significantly higher seed yield of toria (646 kg/ha), Stalk yield (825 kg/ha), net returns (Rs. 10198/ha), B:C ratio (1.65) and RWUE (6.83 kg/ha-mm), followed by application of 75% N (inorganic) + 25% N (vermicompost) + P & K as compared to other nutrient management treatments (Table 3.26).

Table 3.26 : Effect of integrated nutrient management on toria yield and economics - Biswanath Chariali

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Control	9	15	6650	-6310	0.05	0.10
RDF (40:35:15 NPK kg/ha)	646	825	15650	10,198	1.65	6.83
50% N inorganic + 50% N through VC + P & K	265	429	19820	-9232	0.53	2.81
25% N inorganic + 75% N through VC + P & K	225	370	23005	-14025	0.39	2.39
75% N inorganic + 25% N through N VC + P and K	365	485	16816	-2228	0.87	3.86
100% N through VC	28	44	26099	-24995	0.04	0.29
CD at 5%	98	55	6650	-6310	0.05	-

VC-Vermicompost

In an INM trial on sorghum + pigeonpea system at Chianki, application of 50% NPK + 50% FYM recorded maximum pigeonpea equivalent yield (2125 kg/ha) which was significantly at par with application of 50% NPK + 50% *Karanj* cake and 50% NPK + 50% *Mahua* cake (1998 and 1964 kg/ha, respectively). Similarly, maximum sorghum grain yield (1700 kg/ha) and pigeonpea seed yield (1678 kg/ ha) were also recorded with application of 50% NPK + 50% FYM as compared to other treatments. The soil porosity (38.47%), organic (1.78%) and EC (0.48 ds/m) were highest with application of 25% NPK + 25% FYM + 25% *Karanj* cake + 25% *Mahua* cake compared to other treatments. Whereas, highest bulk density (1.74 g/cm3) and water holding capacity (26.58%) were recorded with the application of 50% NPK + 50% FYM (Table 3.27 & 3.28).

Table 3.27 : Effect of INM on sorghum + pigeonpea yield and soil properties - Chianki

Treatment	Sorghum grain yield (kg/ha)		Pigeonpea seed yield (kg/ha)		PEY (Kg/ha)	Bulk density (g/cm³)	Porosity (%)	WHC (%)	Organic C (%)	EC (ds/m)
	2015	Mean (5 years)	2015	Mean (5 years)						
Control	1090	1157	853	1084	1140	1.68	33.38	22.37	1.68	0.38
100% RDF	1558	1580	1417	1356	1827	1.70	34.87	23.54	1.46	0.36
50% RDF + 50% N through FYM	1700	1564	1678	1335	2125	1.74	37.47	26.58	1.67	0.44
100% N through Karanj cake	1573	1479	1550	1363	1807	1.67	36.32	2.00	1.38	0.35
50% RDF + 50% N through Mahua cake	1610	1523	1574	1376	1998	1.69	33.68	22.58	1.61	0.32
100% N through Mahua cake	1443	1420	1395	1274	1775	1.68	36.87	24.25	1.34	0.45
50% RDF + 50% N through Mahua cake	1436	1508	1429	1317	1964	1.58	35.78	23.14	1.57	0.46
25 % RDF+ 25% N through FYM + 25% N through Karanj cake + 25% N through Mahua cake	1453	1494	1376	1307	1758	1.65	38.47	26.21	1.78	0.48
Initial value	-	-	-	-	-	1.58	36.65	22.24	1.72	0.37
CD at 5%	133	282	98	189	176	NS	NS	NS	NS	NS

100% RDF (NPK kg/ha): Sorghum: 60:30:20; Pigeonpea: 20:40:10

The available soil N and K contents were higher with 100% NPK through inorganics while available P contents were higher with 25% RDF + 25% N through FYM + 25% N through *Karanj* cake + 25% N through *Mahua* cake, 100% RDF and 50% NPK + 50% *Mahua* cake, respectively. The available K and B contents were higher with 25% RDF + 25% N through FYM + 25% N through *Karanj* cake + 25% N through *Mahua* cake (Table 3.28).

Table 3.28 : Nutrient status of soil under sorghum + pigeonpea system - Chianki

Treatment	Available N (kg/ha)	Available P	Available K	Boron (ppm)
Control	172.6	25.2	162.1	0.775
100% RDF	208.7	28.3	175.7	0.719
50% RDF+ 50% FYM	195.5	25.3	168.5	0.736
100% N through *Karanj cake*	196.7	24.3	163.9	0.774
50% RDF+ 50% N through *Karanj cake*	198.7	25.3	171.7	0.824
100% N through *Mahua cake*	192.5	25.3	169.4	0.825
50% RDF + 50% N through *Mahua cake*	196.7	27.5	169.9	0.827
25% RDF+ 25% N through FYM + 25% N through *Karanj cake* + 25% N through *Mahua cake*	198.4	28.3	175.1	0.836
Initial value	186.2	25.2	153.3	0.812
CD at 5%	NS	NS	NS	NS

100% RDF (NPK kg/ha): Sorghum: 60:30:20; Pigeonpea: 20:40:10

Sorghum + pigeonpea system under 50% NPK + 50% FYM

At Faizabad, in INM trial in rainfed maize, application of 75% NPK + FYM @ 6 t/ha + $ZnSO_4$ @ 25 kg/ha as soil application + $FeSO_4$ @ 10 kg/ha as soil application gave maximum grain yield (3828 kg/ha) with net returns of Rs.33537/ha and RWUE of 8.90 kg/ha-mm, followed by 75% NPK + FYM @ 6 t/ha+ $ZnSO_4$ @ 25 kg/ ha as soil application , 75%NPK+FYM @ 6t/ha+ $FeSO_4$ @ 10 kg / ha as soil application and 100% NPK+ $ZnSO_4$ @ 25 kg/ ha as soil application + $FeSO_4$ 10 kg/ha as soil application, the yield increased by 83, 76, 72 and 72 % as compared to control (2096 kg/ha). The higher B:C ratio of 1.22 was recorded with application of 100%NPK (RDF-80:40:30 kg NPK/ha) followed by 100% NPK+ $ZnSO_4$ @ 25 kg/ha as soil application + $FeSO_4$ 10 kg/ha as soil application (T8) (1.20) as compared to other treatments. The higher organic carbon content (0.37%) was recorded with 75%NPK+FYM @ 6 t/ha + $ZnSO_4$ @ 25 kg/ha as soil application + $FeSO_4$ @ 10 kg/ha as soil application, however the available N, P_2O_5 and K_2O values we are almost similar with different treatments (Table 3.29 & 3.30).

Table 3.29: Effect of integrated nutrient management on rainfed maize – Faizabad

Treatment	Grain yield (kg/ha)			RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	2015-16	Mean (3 years)	Straw				
Control	2096	2561	3249	4.87	19460	14310	0.73
100% NPK (RDF- 80:40:30 kg NPK/ha)	3014	3673	4581	7.00	22050	27047	1.22
75% NPK alone	2426	3117	3750	5.64	20590	19055	0.92
75% NPK + Azotobacter	2685	3398	4045	6.24	20690	22994	1.11
75% NPK+ PSB	2595	3314	3894	6.03	20700	20272	0.97
100% NPK+ $ZnSO_4$ @ 25 kg/ ha as soil application	3255	4060	4840	7.57	24037	28172	1.17
100% NPK+ $FeSO_4$ @10 kg/ ha as soil application	3226	4008	4856	7.50	25140	27318	1.08
100% NPK+ $ZnSO_4$ @ 25 kg/ ha as soil application + $FeSO_4$ 10 kg/ha as soil application	3596	4317	5286	8.36	26390	31829	1.20
75% NPK+ FYM @ 6t/ ha	3390	4036	5027	7.88	26990	27982	1.03
75% NPK +FYM @ 6t/ha+ $ZnSO_4$ @ 25 kg/ ha as soil application	3692	4430	5427	8.59	28290	31483	1.11
75% NPK+FYM @ 6t/ha+ $FeSO_4$ @ 10 kg /ha as soil application	3600	4350	5328	8.37	27090	31266	1.15
75% NPK + FYM @ 6 t/ha + $ZnSO_4$ @ 25 kg/ha as soil application + $FeSO_4$ @ 10 kg/ ha as soil application	3828	4538	5598	8.90	28380	33537	1.18
CD at 5%	4.09	4.06	5.18	-	-	-	-

Table 3.30 : Availability of nutrients in soil (kg/ha) at harvest of maize crop as influenced by INM - Faizabad

Treatments	N	P_2O_5	K_2O	Organic carbon (%)
Control	138.10	10.60	301.10	0.29
100% NPK (RDF- 80:40:30 kg NPK/ha)	157.50	13.72	316.76	0.33
75%NPK alone	150.12	12.42	311.80	0.31
75% NPK + Azotobacter	157.22	12.98	310.16	0.32
75%NPK+ PSB	151.00	16.57	313.18	0.31
100% NPK+ $ZnSO_4$ @ 25 kg/ ha as soil application	156.95	13.40	314.78	0.33
100% NPK+ $FeSO_4$ @10 kg/ ha as soil application	155.80	13.56	315.78	0.32
100% NPK+ $ZnSO_4$ @ 25 kg/ ha as soil application + $FeSO_4$ 10 kg/ha as soil application	157.65	14.00	314.82	0.33
75%NPK+ FYM @ 6t/ ha	155.10	14.10	312.90	0.36
75% NPK +FYM @ 6t/ha+ $ZnSO_4$ @ 25 kg/ ha as soil application	156.26	14.20	311.96	0.34
75% NPK+FYM @ 6t/ha+ $FeSO_4$ @ 10 kg /ha as soil application	155.72	15.00	311.05	0.35
75% NPK + FYM @ 6 t/ha + $ZnSO_4$ @ 25 kg/ha as soil application + $FeSO_4$ @ 10 kg/ ha as soil application	154.00	14.72	309.75	0.37
CD at 5%	7.77	1.84	NS	0.02

In INM trial on groundnut-onion cropping system at Jagdalpur, application of 100% recommended dose of ferilizer + 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) as compared to other nutrient management practices (Table). Higher soil available phosphorous (15.7 kg/ha) was recorded with application of 100% recommended dose (RDF) + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM @ 5 t/ha in furrow. The lower bulk density was recorded with T5 and T10 treatments (1.35mg/m^3) Table 3.31, 3.32 & 3.33.

Table 3.31 : Performance of groundnut under nutrient management practices - Jagdalpur

Treatment	Pod yield (kg/ha)		Haulm (Rs/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)					
T1-Control	923	1579	1592	31156	5608	0.18	1.10
T2-RDF (30:60:30 for groundnut and 75:60:100 for onion)	1601	1994	2625	35132	28808	0.82	1.91
T3-RDF + $ZnSO_4$ @ 25 kg/ha	1756	2197	2883	36444	33893	0.93	2.09
T4-RDF + FYM @ 5t/ha in furrow	1693	2119	2786	39493	28040	0.71	2.02
T5-RDF + FYM @ 5t/ha in furrow + $ZnSO_4$ @ 25kg	1800	2252	2859	40629	31284	0.77	2.14
T6-50% RDF + FYM @ 5t/ ha in furrow	1704	2192	2791	37672	30514	0.81	2.03
T7-50% RDF + $ZnSO_4$ @ 25 kg + FYM @ 5 t/ha in furrow	1717	2275	2860	38729	29821	0.77	2.04

Treatment	Pod yield (kg/ha)		Haulm (Rs/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)					
T8-100% RDF+ lime @ 3q/ha + FYM 5 t/ha in furrow	1926	2494	3133	41540	35309	0.85	2.29
T9-100% RDF + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow	1832	2302	3013	40549	32845	0.81	2.18
T10-100% RDF+ lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow	2002	2552	3274	42308	37654	0.89	2.38
CD at 5%	42.1	-	-	-	-	-	-

RDF - Recommended does of fertilizers

Table 3.32 : Effect of treatments on soil physical properties after groundnut harvest -Jagdalpur

Treatment	BD (Mg/m3)	Infiltration rate (mm/hr)	FC (%)	PWP (%)	AWC (%)
Initial values	1.39	23	38	12	26
T1-Control	1.40	23	37	12	25
T2-RDF (30:60:30 for groundnut and 75:60:100 for onion)	1.39	23	38	12.5	25.5
T3-RDF + $ZnSO_4$ @ 25 kg/ha	1.41	22	36	13	23
T4-RDF + FYM @ 5t/ha in furrow	1.36	24	39	11	28
T5-RDF+ FYM @ 5t/ha in furrow + $ZnSO_4$ @ 25kg	1.35	24	39	12	27
T6-50% RDF + FYM @ 5t/ha in furrow	1.36	24	39	12	27
T7-50% RDF + $ZnSO_4$ @ 25 kg + FYM @ 5 t/ha in furrow	1.36	24	39	12	27
T8-100% GRD + lime @ 3q/ha + FYM 5 t/ha in furrow	1.36	24	39	12	27
T9-100% GRD + MgSO4 @ 15 kg/ha + FYM 5 t/ha in furrow	1.36	24	39	11	28
T10-100% GRD + lime @ 3 q/ha + MgSO4 @ 15 kg/ha + FYM 5 t/ha in furrow	1.35	24	39	11	28

Table 3.33 : Effect of treatments on soil chemical properties after groundnut harvest -Jagdalpur

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P	K	Zn	Fe	Cu	Mn
Initial values	5.96	0.42	198	12.6	268	1.2	34	0.8	23
T1	5.90	0.40	224	11.8	270	1.1	34	0.8	22
T2	5.92	0.40	214	11.8	265	1.0	33	0.8	24
T3	5.88	0.41	228	15.4	260	1.4	34	0.9	23
T4	5.90	0.45	234	13.2	280	1.3	35	1.0	26
T5	5.88	0.46	244	14.9	284	1.4	34	1.0	26
T6	5.92	0.44	240	13.9	286	1.1	35	1.0	25
T7	5.96	0.43	236	10.9	273	1.4	36	1.0	24
T8	6.02	0.43	238	12.4	265	1.2	34	1.1	25
T9	5.90	0.44	230	14.6	269	1.1	33	1.0	25
T10	6.10	0.43	229	15.7	264	1.1	32	1.0	24

Similarly, application of 100% RDF + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow recorded higher onion bulb yield (20010 kg/ha) and net returns (Rs.159120/ha) compared to other nutrient management practices. Higher soil available phosphorous (23.6 and 23.5 kg/ha) was recorded with application of 100% RDF + Lime @ 3 q/ha + FYM 5 t/ha in furrow and 100% RDF + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow (Table 3.34, 3.35 & 3.36).

Table 3.34 : Performance of groundnut under nutrient management practices - Jagdalpur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Bulb yield (2015)	Mean (2 year)			
T1-Control	6210	12105	61350	12270	0.20
T2-RDF (30:60:30 for groundnut and 75:60:100 for onion)	14540	21320	68096	106230	1.56
T3-RDF + $ZnSO_4$ @ 25 kg/ha	17560	24680	74525	136380	1.83
T4-RDF + FYM @ 5t/ha in furrow	16930	24215	75271	127960	1.70
T5-RDF + FYM @ 5t/ha in furrow + $ZnSO_4$ @ 25kg	18050	25275	79883	136600	1.71
T6-50% RDF + FYM @ 5t/ha in furrow	17040	22670	72230	132180	1.83
T7-50% RDF + $ZnSO_4$ @ 25 kg + FYM @ 5 t/ha in furrow	17160	23080	77361	128420	1.66
T8-100% RDF + lime @ 3q/ha + FYM 5 t/ha in furrow	19250	26675	77256	153740	1.99
T9-100% RDF + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow	18310	24955	78539	141370	1.80
T10-100% RDF + lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow	20010	27305	81184	159120	1.96
CD at 5%	1880	-	-	-	-

Table 3.35 : Effect of treatments on soil physical properties after onion harvest - Jagdalpur

Treatment	BD (Mg/m^3)	Infiltration rate (mm/hr)	FC (%)	PWP (%)	AWC (%)
Initial values	1.39	23	38	12	26
T1	1.40	23	37	12	25
T2	1.38	24	38	12.5	25.5
T3	1.40	23	36	13	23
T4	1.37	24	39	11	28
T5	1.36	24	39	12	27
T6	1.36	25	39	12	27
T7	1.36	25	39	12	27
T8	1.36	24	39	12	27
T9	1.36	25	39	11	28
T10	1.36	25	39	11	28

Table 3.36 : Effect of treatments on soil chemical properties after onion harvest - Jagdalpur

Treatment	pH	Organic C (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P	K	Zn	Fe	Cu	Mn
Initial values	5.96	0.42	198	12.6	268	1.2	34	0.8	23
T1	5.85	0.41	182	12.3	266	1.2	36	0.9	24
T2	5.88	0.41	216	14.5	260	1.1	34	0.8	23
T3	5.80	0.42	220	15.8	266	1.5	35	0.7	24
T4	5.86	0.46	240	20.6	275	1.2	34	0.9	25
T5	5.84	0.45	232	19.7	274	1.4	36	0.9	26
T6	5.90	0.45	196	14.8	280	1.2	37	0.9	27
T7	5.97	0.44	190	14.3	270	1.4	35	1.0	24
T8	6.05	0.42	243	23.6	260	1.3	35	1.0	25
T9	5.84	0.45	235	21.9	265	1.2	36	1.1	25
T10	6.08	0.44	226	23.5	260	1.2	37	0.9	24

Performance of Groundnut with 100% RDF + lime @ 3q/ha $MgSO_4$ @15kg/ha + FYM @ 5t/ha

In an INM trial in direct seeded rice at Jagdalpur, application of full dose of NPK + FYM + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha (T8) recorded higher grain yield (4068 kg/ha) and RWUE (3.11 kg/ha-mm). However, maximum net returns and B:C ratio were recorded with application of 100% NPK + 5 t FYM (T6). The soil organic C and available N content was highest (0.72%) with application of 50% NPK with FYM @ 5 t/ha + $ZnSO_4$ @ 25 kg/ha. Application of 100% NP (T5) resulted in higher available P content and application of 100% NPK + @5 t FYM resulted in higher available K content compared to other treatments (Table 3.37 & 3.38).

Table 3.37 : Effect of integrated nutrient management on productivity and economics of direct seeded rice under rainfed midland situation - Jagdalpur

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain yield 2015	Mean of (2years)	Straw yield				
T_1-Control	2333	2496	2510	16997	18187	1.07	1.78
T_2-100% NPK (80:50:40 NPK kg/ha)	3726	3890	3923	21494	34820	1.62	2.84
T_3-100% PK	2546	2705	2685	20140	18327	0.91	1.94
T_4-100% NK	3052	3425	3256	19708	26409	1.34	2.33
T_5-100% NP	3144	3548	3341	20090	27323	1.36	2.40
T_6-100% NPK + 5 t FYM	3981	4027	4230	25255	34852	1.38	3.04
T_7-100% NPK + 5 t FYM+ $ZnSO_4$ @ 25 kg	4024	4097	4264	26405	34326	1.30	3.07
T_8-100% NPK + 5 t FYM + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha	4068	4147	4310	28437	32987	1.16	3.11
T_9-50% NPK	3304	3621	3563	19279	30654	1.59	2.52
T_{10}-50% NPK + 5 t FYM	3533	3755	3721	23091	30249	1.31	2.70
T_{11}-50% NPK + 5 t FYM + $ZnSO_4$ @ 25 kg/ha	3658	3885	3858	24181	30952	1.28	2.79
T_{12}-50% NPK + 5 t FYM + $ZnSO_4$ @ 25kg/ha + lime 3 q/ha	3726	3955	3912	26158	30082	1.15	2.84
CD at 5%	259	-	-	-	-	-	-

Table 3.38 : Effect of INM in direct seeded rice on soil fertility under rainfed midland situation - Jagdalpur

Treatment	pH	OC (%)	Av. nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P_2O_5	K_2O	Zn	Fe	Cu	Mn
Initial values	6.12	0.42	198.0	12.6	268.0	1.03	32.6	1.78	26.8
T_1-Control	6.28	0.65	211.5	23.0	177.6	1.04	31.2	1.56	25.3
T_2-100% NPK	6.11	0.68	237.0	27.3	200.4	0.94	34.4	1.53	27.0
T_3-100% PK	6.13	0.64	205.8	26.5	213.6	1.02	33.1	1.62	27.4
T_4-100% NK	6.29	0.62	235.3	22.3	207.6	0.97	30.7	1.68	26.5
T_5-100% NP	6.41	0.66	221.8	31.9	171.6	0.94	32.5	1.60	25.9
T_6-100% NPK + 5 t FYM	6.37	0.71	257.8	26.5	218.4	0.97	29.9	1.80	24.6
T_7-100% NPK + 5 t FYM+ $ZnSO_4$ @ 25 kg	6.45	0.72	258.3	26.4	212.4	1.01	31.6	1.67	26.1

Treatment	pH	OC (%)	Av. nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P_2O_5	K_2O	Zn	Fe	Cu	Mn
T_8-100% NPK + 5 t FYM + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha	6.53	0.70	245.0	30.2	207.6	1.02	28.4	1.71	24.1
T_9-50% NPK	6.12	0.69	231.5	26.7	193.2	0.96	30.1	1.70	26.8
T_{10}-50% NPK + 5 t FYM	6.15	0.70	252.8	28.8	218.4	0.97	31.3	1.73	25.1
T_{11}-50% NPK + 5 t FYM + $ZnSO_4$ @ 25 kg/ha	6.24	0.72	247.0	30.5	210	1.00	29.8	1.69	24.7
T_{12}-50% NPK + 5 t FYM + $ZnSO_4$ @ 25kg/ ha^{-}+ lime 3 q/ha	6.32	0.71	243.3	29.8	214.8	0.98	28.6	1.66	24.2

During *rabi*, higher seed, stalk yield and net returns of field pea were recorded under recommended dose of fertilizer (RDF) as compared to control. However, higher B:C ratio was recorded under control as compared to RDF. Among the *kharif* treatments T8 (100% NPK + 5 t FYM + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha) with RDF recorded higher grain and straw yield, net returns and B:C ratio compared to other treatments (Table 3.39).

Table 3.39: Effect of integrated nutrient management in direct seeded rice on productivity and economics of fieldpea under midland situation - Jagdalpur

Treat-ment	Seed yield (kg/ha)			Mean of 2 years			Straw yield (kg/ha)			NMR (Rs/ha)		B:C ratio	
	Control	GRD	Mean	Control	GRD	Mean	Control	GRD	Mean	Control	GRD	Control	GRD
T1	1083	1313	1198	1083	1313	1198	2205	2161	2183	22984	26098	2.42	1.96
T2	1202	1430	1316	1202	1430	1316	2116	2329	2223	26556	29595	2.80	2.23
T3	1225	1478	1351	1225	1478	1351	2185	1914	2050	27239	31025	2.87	2.33
T4	1054	1237	1145	1054	1237	1145	1843	2113	1978	22108	23810	2.33	1.79
T5	1116	1338	1227	1116	1338	1227	1720	1927	1824	23993	26844	2.53	2.02
T6	1184	1434	1309	1184	1434	1309	2264	2095	2180	26017	29724	2.74	2.23
T7	1187	1448	1317	1187	1448	1317	2046	2084	2065	26118	30125	2.75	2.27
T8	1243	1529	1386	1181	1394	1288	2302	2338	2320	27797	32567	2.93	2.45
T9	1119	1259	1189	1077	1267	1172	1708	2142	1925	24066	24477	2.53	1.84
T10	1034	1274	1154	1051	1282	1166	1869	2170	2020	21531	24927	2.27	1.87
T11	1068	1289	1178	1105	1304	1205	1917	2268	2093	22525	25372	2.37	1.91
T12	1142	1319	1231	1083	1313	1198	2104	2023	2064	24751	26281	2.61	1.98

At Phulbani in an evaluation on nutrient management in maize based intercropping systems, intercropping of maize + cucumber (2:1) gave higher maize equivalent yield (6880 kg/ha) with net returns of Rs.59780/ha and B:C ratio of 2.64 followed by maize + ridge gourd (2:1) and maize + cowpea (2:1) intercropping system (Table). In case of nutrient management, application of FYM 10 t/ha + vermicompost (VC) 2 t/ha basal + **pot manure** recorded higher yield (6050 kg/ha), net returns (Rs. 47860/ha) and B:C ratio (2.30) compared to other treatments (Table 3.40).

Performance of rice 100% NPK+ FYM @ 5t/ha + $ZnSO_4$ @ 25 kg/ha + lime 3 q/ha

Table 3.40: Yield and economics as affected by cropping system and organic nutrient management practices - Phulbani

Treatment	MEY (kg/ha)	LER	NMR (Rs/ha)	B:C ratio
Cropping system				
Sole maize	2640	1.0	7420	1.25
Maize + ridge gourd (2:1)	6580	1.21	55540	2.50
Maize + cowpea (2:1)	5670	1.31	42840	2.17
Maize + cucumber (2:1)	6880	1.26	59780	2.64
CD at 5%	18.54	-	-	-
Organic nutrient management				
FYM 10 t/ha	4860	-	37400	2.22
FYM 10 t/ha + VC @ 2 t/ha as basal	5540	-	40920	2.12
FYM 10 t/ha + VC @ 2 t/ha at 30 DAS	5320	-	37840	2.03
FYM + VC @ 2 t/ha at basal + pot manure	6050	-	47860	2.30
CD at 5%	9.65	-	-	-

VC- Vermicompost

The soil organic carbon content was higher (3.5 g/kg) in the plots under FYM 10t/ha + vermicompost 2 t/ha at 30DAS. However, available NPK did not vary much under different treatments (Table 3.41).

Table 3.41 : Soil chemical properties as affected by intercropping system and organic nutrient management practices - Phulbani

	pH	OC (g/kg)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Cropping system					
Sole maize	5.4	3.1	186.8	29.5	178.4
Maize + ridge gourd (2:1)	5.5	3.4	172.2	28.2	172.5
Maize + cowpea (2:1)	5.5	3.2	195.4	28.8	181.3
Maize + cucumber (2:1)	5.4	3.4	170.6	27.6	170.4
Organic nutrient management					
FYM 10 t/ha	5.2	3.0	166.4	26.3	168.5
FYM 10 t/ha + VC 2 t/ha as basal	5.6	3.3	180.2	28.4	175.7
FYM 10 t/ha + VC 2 t/ha at 30 DAS	5.6	3.5	192.3	31.2	182.2
FYM + VC 2 t/ha at basal + pot manure	5.5	3.3	186.1	28.2	176.2

3.1.4 Energy management

In longterm experiment on tillage and nutrient management in groundnut at Biswanath Chariali, higher seed yield of groundnut (736 kg/ha), haulm yield (1835 kg/ha), net returns (Rs.8390/ha), B:C ratio (0.58) and RWUE (0.83 kg/ha-mm) were recorded with minimum tillage followed by rotavator (Table 3.42). Among nutrient management practices, 50% recommended dose of fertilizer + 50% organic (vermicompost) recorded higher pod yield (673 kg/ha), haulm yield (1672 kg/ha), net returns (Rs.6899/ha), B:C ratio (0.53) and RWUE (0.75 kg/ha-mm) as compared to other treatments. The maximum field efficiency (28.50 hr/ha) was recorded by conventional tillage (three to four ploughing followed by laddering) and higher energy use efficiency (0.85) was recorded by minimum tillage (one harrowing).

Table 3.42 : Effect of tillage and nutrient management on groundnut - Biswanath Chariali

Treatment	Pod yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015-16	Mean (2 years)	Haulm				
Tillage							
Minimum tillage (one harrowing)	520	1018	1273	13330	5332	0.40	0.58
Two harrowing + one pulverization by power tiller	713	1788	1746	14256	7983	0.56	0.80
Conventional tillage (three to four ploughing followed by laddering	730	1246	1778	14600	8322	0.57	0.82
Minimum tillage followed by rotavator	736	1450	1835	14465	8390	0.58	0.83
Rotavator	466	736	1161	13300	4788	0.36	0.52
CD at 5%	230	218	0	-	-	-	-
INM							
RDF	610	1349	1522	13306	6254	0.47	0.68
50% RDF + 50% organic (vermicompost)	673	1273	1672	13016	6899	0.53	0.75
75% RDF + 25% organic (vermicompost)	615	1121	1524	13138	6306	0.48	0.69
CD at 5%	NS	-	-	-	-	-	-

At Jagdalpur, in an experiment on mechanized land preparation, crop establishment and weeding of rice, puddling with rotary tiller with cage wheel recorded higher rice yield (3400 kg/ha), B:C ratio (1.81), RWUE (3.99 kg/ha-mm), total output energy (49980 MJ/ha) and energy use efficiency (12.9 q/MJ x 10-3) compared to other treatments (Table 3.43).

Table 3.43 : Yield and economics of mechanized land preparation in rice - Jagdalpur

Treatment	Grain yield (kg/h)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Field efficiency (h/ha)	Energy (MJ/ha)		Energy use efficiency (q/MJ x 10^{-3})
							Input	Output	
Tractor with cage wheel + rotavator	3300	1917	3106	1.62	3.87	0.38	17569	8.50	48510
Tractor with cage wheel + cultivator	2900	1810	2823	1.56	3.40	0.42	16328	7.30	42630
Rotary tiller + cage wheel	3400	1456	2635	1.81	3.99	0.18	12746	12.9	49980

At Varanasi, in the lognterm experiment on tillage and nutrient management for resource conservation and improving soil quality in rice (NDR- 97), higher yield of 2006 kg/ha, net returns of Rs. 14240/ha, and B:C ratio of 3.69 with compartmental bunding (3m × 4m × 0.3m) compared to no bunding (1723 kg/ha). Among tillage treatments, conventional tillage recorded higher yield (2048 kg/ha), net returns (Rs. 15487/ha) and B:C ratio (1.97) as compared to low till and minimum tillage treatments. Two life saving irrigations (6.0 cm) were applied from harvested water at flowering and dough stages. Different INM treatments have no significant effect on rice yield. The maximum RWUE of 3.77 kg/ha-mm was recorded with conventional tillage + weed control + interculture. However, the maximum energy use efficiency (9.85:1) and output energy (104868 MJ/ha) was recorded with 100% N through organic sources (Table 3.44).

Table 3.44: Effect of treatments on crop yield and economics of rice - Varanasi

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Energy (MJ/ha)		Energy use efficiency
	Seed	Mean (11 Year)	Straw					Input	Output	
Compartmental bunding	2006	2458	3505	16600	14240	1.86:1	3.69	12012	92578	7.71:1
Without bunding	1723	2114	2614	14600	11691	1.80:1	3.17	11700	72380	6.19:1
CD at 5%	264	-	609.4	-	-	-	-	-	-	-
Conventional tillage + weed control+ interculture	2048	2420	3581	16000	15487	1.97:1	3.77	12499	94564	7.57:1
Minimum tillage + weed control+ interculture	1895	2288	3037	15200	13793	1.91:1	3.49	11856	82523	6.96:1
Low tillage+ weed control+ interculture	1650	2150	2560	14800	10405	1.70:1	3.04	11213	70335	6.27:1
CD at 5%	192	-	360.0							
100% N through inorganic	1821	2333	3136	14088	13885	1.99:1	3.35	13067	83217	6.37:1
50% N through inorganic + 50% N through organic	1973	2359	3156	14788	15399	2.04:1	3.63	11856	85811	7.24:1
100% N through organic	1800	2175	2886	15300	12243	1.80:1	3.31	10645	104868	9.85:1
CD at 5%	NS	-	NS	-	-	-	-	-	-	-

3.1.5 Evaluation of improved varieties

Evaluation of medium duration high yielding rice varieties under upland situtation at Biswanath Chariali indicated that TTB-404 was found better among 13 varieties with grain yield of 4054 kg/ha, B:C ratio of 2.86 and RWUE of 2.80 kg/ha-mm. The yields of all other varieties except MES-5 (3940 kg/ha) were less than Komal (local) (3875 kg/ha) (Table 3.45).

Table 3.45 : Performance of medium duration high yielding rice varieties under upland situtation - Biswanath Chariali

Variety	Grain yield (kg/ha)			Cost of cultivation (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015-16	Mean (4 years)	Straw			
TTB 404	4054	4404	4239	10500	2.86	2.80
Sahabhagi	3257	3559	3442	10500	2.10	2.25
Dichang	3505	4019	3690	10500	2.34	2.46
Bihari Ahu	3125	3462	3310	10500	1.98	2.19
Dehangi	3219	3836	3405	10500	2.07	2.26
Satyaranjan	3786	3773	3971	10500	2.61	2.50
Basundhara	3872	4027	4057	10500	2.69	2.55
Naveen	3581	3819	3766	10500	2.41	2.36
MES-5	3940	4031	4125	10500	2.75	2.72
Komal (local)	3875	4170	4060	10500	2.69	2.67
BPT-5204	3515	3634	3700	10500	2.35	2.42
Jaya	3461	3774	3646	10500	2.30	2.39
Baismuthi/ Basanti (local)	3379	3732	3564	10500	2.22	2.23

Peformance of rice cv TTB-404 under upland situtation

Performance of pigeonpea cv. BAC-1 under rainfed upland situtation

At Biswanath Chariali, in an evaluation of 14 genotypes of pigeonpea, BAC-1 recorded maximum seed yield of 1551 kg/ha, 2122 kg/ha of mean seed yield over 5 years with net returns of Rs.23021/ha and B:C ratio of 2.88 over other genotypes. The genotype Maruti recorded higher RWUE (1.02 kg/ha-mm) among the genotypes (Table 3.46).

Table 3.46 : Evaluation of pigeonpea genotypes under rainfed upland situation - Biswanath Chariali

Variety	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (5 years)				
ICPL-88039	1347	1861	8000	18942	2.37	0.64
ICPL-11305	1167	1845	8000	15346	1.92	0.69
ICPL-11330	1159	-	8000	15181	1.90	0.76
ICPH-2671	1047	1856	8000	12945	1.62	0.73
ICPH-2740	928	1965	8000	10552	1.32	0.68
T-21	1054	1977	8000	13073	1.63	0.68
Maruti	1157	1920	8000	15141	1.89	1.02
Bahar	1127	1945	8000	14547	1.82	0.93
Asha	1026	1703	8000	12511	1.56	0.89
TS-3R	1024	1758	8000	12486	1.56	0.87
BAC-1	1551	2122	8000	23021	2.88	0.64
BAC-2	1446	2095	8000	20915	2.61	0.69
BAC-3	1390	-	8000	19793	2.47	0.76
MAL-13	1358	1965	8000	19165	2.40	0.73

Under upland situtation, out of 20 early maturing mustard genotypes evaluated under rice-mustard sequence cropping at Biswanath Chariali, Binoy gave higher seed yield (905 kg/ha), mean seed yield (862 kg/ha), stalk yield (1101 kg/ha) and NMR (Rs.27164/ha), genotype YSC-1 gave higher B:C ratio (3.28) and RWUE (6.94 kg/ha-mm) over all other genotypes (Table 3.47).

Perforamance mustard cv. Binoy, under rice mustard sequence cropping

Table 3.47 : Evaluation of early maturity mustard genotypes under rice-mustard crop sequence under upland situtation - Biswanath Chariali

Variety	Seed yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015-16	Mean (4 years)	Stalk				
TS-66	750	-	946	7000	22510	2.22	5.21
JT-90-1	850	742	1046	7000	25504	2.64	5.91
TS-36	736	833	931	7000	22067	2.15	5.11
TS-67	761	-	956	7000	22820	2.26	5.29
TS-46	758	847	954	7000	22745	2.25	5.27
Pusa Bahar	745	775	941	7000	22359	2.19	5.18
Pusa Mahak	766	773	962	7000	22983	2.28	5.32
Binoy	905	862	1101	7000	27164	2.88	6.29
NPJ-135	816	852	1011	7000	24467	2.50	5.67
TS-59	772	761	967	7000	23150	2.31	5.36
PM-21	805	792	1001	7000	24157	2.45	5.60
PM-25	785	-	981	7000	23564	2.37	5.46
PM-26	792	-	988	7000	23763	2.39	5.50
PM-27	803	-	999	7000	24095	2.44	5.58
Pusa Agrani	750	-	946	7000	22510	2.28	5.32
TS-38	850	742	1046	7000	25504	2.65	5.92
Pusa Bijoy	736	833	931	7000	22067	2.37	5.46
Pusa Jagannath	761	-	956	7000	22820	2.30	5.35
YSC-1	758	847	954	7000	22745	3.28	6.94
YSC-2	745	775	941	7000	22359	3.27	6.92

In a varietal evaluation of new and underutilized crops *viz.,* niger, buckwheat and linseed under rice-*rabi* crop sequence cropping at Biswanath Chariali, among 6 niger genotypes NG-1 genotype gave higher seed yield (589 kg/ha), stalk yield (789 kg/ha), NMR (Rs.5890/ha), B:C ratio (1.18) and RWUE (3.51 kg/ha-mm), and the genotype NB-1 gave higher mean seed yield (587 kg/ha) over all other genotypes. Among 4 buckwheat varieties, BWC-3 recorded higher seed yield (985 kg/ha), mean grain yield (1135kg/ha), stalk yield (870 kg/ha), net returns (Rs.9855/ha), B:C ratio (1.97) and RWUE (5.85 kg/ha-mm) as compared to other varieties. Among 6 linseed varieties, BLC-3 recorded higher grain yield (951kg/ha), stalk yield (1007 kg/ha), net returns (Rs.9512/ha), B:C ratio (1.90) and RWUE (5.56 kg/ha-mm) as compared to other varieties (Table 3.48).

Niger cv.NG-1

Linseed cv.BLC-3

Buckwheat cv. BWC-3

Table 3.48 : Evaluation of new and underutilized crop species under rice-*rabi* crop sequence - Biswanath Chariali

Variety	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2015-16)	Mean (3 years)	Stover/stalk				
Niger							
NB-1	457	587	657	5000	4573	0.91	2.72
BNC-1	485	533	685	5000	4851	0.97	2.89
GA-10	515	524	715	5000	5151	1.03	3.07
NG-1	589	467	789	5000	5891	1.18	3.51
BNC-2	478	496	678	5000	4784	0.96	2.85
JNC 6	526	490	726	5000	5257	1.05	3.13
Buckwheat							
BWC-1	959	1055	844	5000	9595	1.92	5.72
BWC-2	931	1049	816	5000	9311	1.86	5.55
BWC-3	986	1135	870	5000	9856	1.97	5.87
BWC-4	950	1050	835	5000	9503	1.90	5.66
Linseed							
BLC-1	750	-	807	5000	7503	1.50	4.47
BLC-2	850	-	906	5000	8501	1.70	5.07
BLC-3	951	-	1008	5000	9512	1.90	5.67
BLC-4	876	-	932	5000	8756	1.75	5.22
BLC-5	845	-	901	5000	8451	1.69	5.04
BLC-6	785	-	842	5000	7854	1.57	4.68

Collection and evaluation of *Ahu* rice germplasm of Assam at Biswanath Chariali, among 13 *Ahu* rice varieties, Dehangi genotype gave higher grain yield (1850 kg/ha), higher mean seed yield (1925 kg/ha) straw yield (1966 kg/ha), NMR (Rs.18502/ ha), B:C ratio (2.18) and RWUE (1.28 kg/ha-mm) over all other genotypes (Table 3.49).

Table 3.49 : Performance of *Ahu* rice germplasm of Assam - Biswanath Chariali

Variety	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)				
Dehangi	1850	1925	8500	18502	2.18	1.28
Rangadoria	1312	1289	8500	13125	1.54	0.91
Banglami	1526	1680	8500	15255	1.79	1.06
Haccha	1672	1764	8500	16723	1.97	1.16
Inglongkiri	1543	1772	8500	15431	1.82	1.07
Ranghang	1223	1571	8500	12235	1.44	0.85
Kola ahu	1020	996	8500	10203	1.20	0.71
Safalu	1787	1851	8500	17871	2.10	1.24
Jaha ahu	967	1070	8500	9665	1.14	0.67
Bihari ahu	1629	1816	8500	16287	1.92	1.13
Boga ahu	1457	1618	8500	14566	1.71	1.01
Dimrou	1260	1374	8500	12598	1.48	0.87
Mala	1125	1101	8500	11250	1.32	0.78

Performance of rice cv. Dehangi

In an evaluation of rice varieties under organic management (FYM 10 t/ha and Azolla) at Biswanath Chariali, among 68 rice varieties, Prafulla variety of rice gave higher grain yield (4623 kg/ha) followed by Gitesh (4529 kg/ha) and Ranjit (4524 kg/ha). Similarly, Prafulla gave higher straw yield (4778 kg/ha), NMR (Rs.37225/ha), B:C ratio (4.14) and RWUE (3.24 kg/ha-mm) over all other varieties. The lowest grain yield was produced by Rangadoria and Boga ahu varieties (1010 and 1026 kg/ha respectively) (Table 3.50).

Table 3.50 : Evaluation of rice varieties under organic management - Biswanath Chariali

Variety	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Dichang	4021	9000	31211	3.47	3.06
Ranjit	4524	9000	36235	4.03	3.12
TTB-404	4210	9000	33102	3.68	2.95
Changopan	3547	9000	26466	2.94	2.49
Piyolee	3011	9000	21114	2.35	2.11
Jyotiprasad	3044	9000	21436	2.38	2.13
Monohar Sali	2312	9000	14121	1.57	1.59
Ranga Sali	2510	9000	16102	1.79	1.73
NV-1	2461	9000	15615	1.73	1.73
MES -5	2725	9000	18248	2.03	1.91
Prafulla	4623	9000	37225	4.14	3.24
Betguti	3246	9000	23456	2.61	2.27
Nagaland-1	4218	9000	33182	3.69	2.96
Joybangla	2385	9000	14851	1.65	1.67
Mashuri	3787	9000	28865	3.21	2.65
MES-9	4110	9000	32104	3.57	2.88
BNR-1	3250	9000	23504	2.61	2.28
Komal	3502	9000	26023	2.89	2.45
Bishnu Prasad	3216	9000	23161	2.57	2.22
Bhogali (black)	3055	9000	21551	2.39	2.11
Swarna sab	4115	9000	32151	3.57	2.88
Basudev	3250	9000	23505	2.61	2.28
Kanaklata	2019	9000	11187	1.24	1.41
Manipuri joha	2311	9000	14112	1.57	1.62
Lachit	3544	9000	26442	2.94	2.48
BPT-5204	4117	9000	32166	3.57	2.89
Hakay Nagaland	4123	9000	32230	3.58	2.89
Gandhari	3003	9000	21027	2.34	2.10

Variety	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Kola joha	2415	9000	15145	1.68	1.69
Mohan	3119	9000	22188	2.47	2.19
NBR-1	2578	9000	16782	1.86	1.81
Satyaranjan	3106	9000	22064	2.45	2.18
Gaya	2948	9000	20484	2.28	2.07
Nobin dhan	3570	9000	26698	2.97	2.46
Moinagiri	2855	9000	19552	2.17	1.97
Bakul	4012	9000	31116	3.46	2.77
Gopinath	3128	9000	22277	2.48	2.19
Gandhaka sala	2100	9000	12005	1.33	1.47
Bogakonjoha	3066	9000	21662	2.41	2.11
Gitesh	4529	9000	36286	4.03	3.17
Padumoni	3512	9000	26118	2.90	2.42
Nagaland -1	3165	9000	22654	2.52	2.18
Baishmuthi	2987	9000	20875	2.32	2.06
Kolakonjoha	2532	9000	16316	1.81	1.75
Sangamohini	3095	9000	21952	2.44	2.13
Dabra bao	2019	9000	11192	1.24	1.53
Swarna mashuri	1988	9000	10882	1.21	1.37
Mukunda	3105	9000	22054	2.45	2.18
Sahabhagi	3522	9000	26222	2.91	2.68
Black Njevera	2123	9000	12233	1.36	1.61
Panindra	2054	9000	11536	1.28	1.44
BBS-1	2338	9000	14380	1.60	1.64
Luit	3115	9000	22151	2.46	2.37
Swarna (tall)	3614	9000	27143	3.02	2.49
Konguti	3145	9000	22451	2.49	2.17
Dehangi	2985	9000	20853	2.32	2.27
Boga ahu	1026	9000	1262	0.14	0.78
2014-1	1856	9000	9559	1.06	1.41
Bihari ahu	1785	9000	8851	0.98	1.36
Ronghang	2878	9000	19777	2.20	2.19
2014-2	1910	9000	10102	1.12	1.45
Rangadoria	1010	9000	1097	0.12	0.77
Safalu	1712	9000	8115	0.90	1.30
Haccha	2504	9000	16036	1.78	1.90
Inglongkiri	2485	9000	15850	1.76	1.89
Kola ahu	1249	9000	3488	0.39	0.95
Mala	2032	9000	11315	1.26	1.42
Banglami	1741	9000	8411	0.93	1.32

Performance of rice ODR 12-3

At Phulbani, among 30 rice genotypes evaluated under rainfed upland situation, the grain yield of ODR-12-3 was highest (3151 kg/ha) followed by ODR-41 (2408 kg/ha). The lowest yield (589 kg/ha) and RWUE (0.92 kg/ha-mm) was observed in Ghanteswari. Days taken to 50% flowering varied from 47 days in ODR-2 to 81 days in Sahabhagi. Highest straw yield of 3204 kg/ha was produced by ODR-24-1 followed by ODR-41 (2735 kg/ha). Rice genotype ODR-12-3 exhibited highest RWUE of 5.35 kg/ha-mm. Based on the mean grain yield of different genotypes over three years (2013 to 2015), the yield of ODR 12-3 was highest (3230 kg/ha) followed by ODR 12C (2815 kg/ha), ODR - 41(2794 kg/ha) and ODR 24 (2736 kg/ha). The varieties maturing above 100 days, generally exhibited poor performance due to terminal dry spells (Table 3.51).

Table 3.51: Performance of new rice genotypes - Phulbani

Genotype	Days to 50% flowering	Plant height (cm)	Tillers/ plant	Panicle length (cm)	Flag leaf length (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)	Grain yield (kg/ha) (2013 -15)	RWUE (kg/ha-mm)
ODR- 1- 3	49	94	16	26	31	1499	2260	2162	3.04
ODR-2	47	71	15	23	27	1499	2401	1633	3.05
ODR-24-1	57	84	10	25	27	2158	3204	2624	4.26
ODR 1- 2	62	80	12	23	23	1761	2500	2256	2.93
ODR12- 1 -1	51	83	11	18	23	1596	2543	2379	3.24
ODR-12- 1	63	77	18	18	28	1550	2167	1904	2.58
ODR -1	48	86	16	26	30	1884	2068	2293	3.82
ODR -38	53	95	17	22	24	1553	1944	1814	3.15
ODR -41	63	80	20	21	25	2408	2735	2794	4.09
ODR -17	62	76	15	20	25	1356	2044	1559	2.30
ODR- 58	53	107	12	25	36	1120	1432	1782	2.27
ODR- 5	57	69	8	24	23	1341	2130	2127	2.66
DDR -121	60	79	5	22	31	1236	1630	1894	2.10
ODR -55 -1	58	60	10	20	29	2123	2370	2654	4.20
ODR -10	59	86	9	27	32	1311	1463	1652	2.23
ODR 12C	55	82	11	22	32	1499	1420	2815	2.97
ODR 12	51	87	12	19	32	1691	2284	2474	3.43
ODR -1-1	50	81	11	20	32	1961	2179	2481	3.98
ODR -24	57	88	23	22	31	2168	2228	2736	4.28
ODR -59	56	92	8	21	30	2039	1673	1826	4.03
ODR 3- 14	58	80	7	20	24	1260	2222	1720	2.14
ODR -12- 3	60	80	11	23	26	3151	2216	3230	5.35
ODR-30	58	113	3	22	27	2090	2148	2370	3.61
Yogesh	77	69	6	19	23	750	2024	1239	1.18
Lalitagiri	76	77	5	22	30	714	1673	925	1.12
Ghanteswari	77	68	5	20	27	589	1469	988	0.92
N- 22	68	95	3	19	23	1446	1457	1352	2.40
CRR-616- B-66- 2	77	101	4	22	31	1845	1846	1674	2.89
ZHU- 11- 26	52	74	6	24	27	2090	1840	2232	4.24
Sahabhagi	81	88	6	20	28	1260	1814	1261	1.98
CD at 5 %	1.08	1.99	0.46	0.43	0.85	1.98	1.22	3.34	

At Phulbani, among 10 fingermillet genotypes evaluated, under inorganic and organic nutrient management, under organic management, the grain yield of different genotypes varied from 957 kg/ha in DP/AK-2198 to 1917 kg/ha in DP/AK- 2191 (Table). Under inorganic nutrient management, DP/AK- 2191 produced highest grain yield (1939 kg/ha) followed by DP/AK-2211 (1764 kg/ha). Plant height ranged from 97 cm in DP/AK-2201 to 134 cm in DP/AK- 2193 (Table 3.52 & 3.53).

Table 3.52 : Performance of locally collected fingermillet germplasm under organic nutrient management - Phulbani

Genotype	Plant height (cm)	Tillers/ plant	Fingers/ panicle	Panicle length (cm)	Flag leaf length (cm)	Grain yield (kg/ha)
DP/ AK- 2208	129.3	6.7	5.5	11.0	42.5	997
DP/ AK- 2198	110.0	4.7	5.3	8.9	43.1	957
DP/ AK- 2222	124.5	3.2	5.5	11.1	37.2	1553
DP/ AK- 2191	126.6	5.4	7.7	8.9	32.4	1917
DP/ AK- 2201	97.3	7.6	7.1	8.6	44.9	1519
DP/ AK- 2211	111.1	6.1	5.3	8.4	36.1	1594
DP/ AK- 2215	115.0	3.5	4.9	9.8	35.5	1472
DP/ AK- 2193	132.5	4.5	5.5	8.4	35.3	1289
DP/ AK- 2223	118.8	3.9	6.7	12.1	33.1	1700
DP/ AK- 2206	115.4	4.3	6.1	7.2	44.0	1256
CD at 5 %	7.98	0.34	0.35	0.19	0.34	3.34

Table 3.53 : Performance of locally collected millet germplasm under inorganic nutrient management - Phulbani

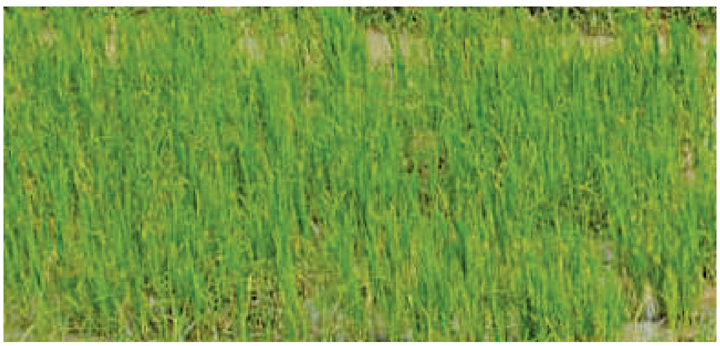
Variety	Plant height (cm)	Tillers/ plant	Fingers/ panicle	Panicle length (cm)	Flag leaf length (cm)	Grain yield (kg/ha)
DP/ AK- 2208	130.5	6.8	5.5	11.1	42.6	1106
DP/ AK- 2198	109.4	4.8	5.2	8.9	43.1	989
DP/ AK- 2222	126.4	3.2	5.3	11.1	37.5	1047
DP/ AK- 2191	126.3	5.3	7.6	8.9	32.3	1939
DP/ AK- 2201	96.9	7.1	6.7	8.4	44.9	1314
DP/ AK- 2211	111.2	6.0	5.4	8.5	36.1	1764
DP/ AK- 2215	113.9	4.0	4.8	9.8	35.8	1167
DP/ AK- 2193	133.5	4.6	5.4	8.4	35.4	1569
DP/ AK- 2223	119.8	4.3	6.8	12.1	33.6	1592
DP/ AK- 2206	113.9	4.2	6.0	7.2	44.0	1331
CD at 5 %	6.37	0.32	0.41	0.18	0.64	2.50

Among ten rice varieties *viz.,* Shusk samrat, HUR-3022, NDR-97, Sahbhagi, Vandana, Rajendra Bhagwati, Virendra, Anjali, Rabi and APO evaluated at Varanasi, NDR-97 produced maximum yield (2289 kg/ha) with net returns of Rs.29179/ha, B:C ratio of 2.9 and RWUE of 3.5 kg/ha-mm followed by HUR-3022 (2017 kg/ha) with B:C ratio of 2.6. Two supplemental irrigation (5 cm each) were given at the time of flowering and dough stages to cope with dry spells (Table 3.54).

Table 3.54 : Evaluation Improve varieties of rice - Varanasi

Variety	Grain yield (kg/ha)			DSI	DTE	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (3 years)	Straw					
Shusk samrat	1731	1826	3367	0.386	72.14	18569	2.2	2.6
HUR3022	2017	2608	3967	0.388	72.02	24191	2.6	3.1
NDR-97	2289	2345	4350	0.166	88.04	29179	2.9	3.5
Sahbhagi	1578	1690	3267	0.345	75.14	15992	2.1	2.4
Vandana	1230	1315	2517	0.439	68.35	9103	1.6	1.9
Rajendra Bhagwati	1200	1091	2500	0.487	64.86	8600	1.6	1.8
Virendra	1500	1665	2883	0.320	76.92	14016	1.9	2.3
Anjali	1407	1458	2850	0.458	66.98	12503	1.8	2.1
Rabi	1635	1732	3167	0.480	65.40	16675	2.1	2.5
APO	1600	1720	3300	0.443	68.09	16400	2.1	2.4
CD at 5%	149.4	-	-	-	-	-	-	-

DSI: Drought susceptibility index; DTE: Drought tolerance efficiency; cost of cultivation: Rs.15000/ha


Perforamance of rice cv. NDR-97


Performance of mutant lentil - 10 kR of gamma rays

At Varanasi, in a study on genetic improvement of lentil for terminal heat tolerance under two sowing dates, two supplemental irrigations (5 cm each) were given at the time of flowering and grain filling stages. The mutant variety- Gama-rays 10kR gave higher seed yield (1017 kg/ha), net returns (Rs. 22750/ha), B:C ratio (2.63) and RWUE (5.6 kg/ha-mm) over check verity HUL-5 (833 kg/ha), while Gamma-rays 20 kR (T2) gave seed yield of 937 kg/ha (Table 3.55).

Table 3.55 : Effect of different mutagenic treatments on seed yield and economics of lentil - Varanasi

Variety	Yield (kg/ha)		DSI	DTE	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover						
Untreated control	833	1506	0.137	87.72	14000	16511	2.18	4.6
Gamma-rays 10 kR	1017	1600	0.171	84.72	14000	22750	2.63	5.6
Gamma-rays 20 kR	937	1483	0.110	89.24	14000	19888	2.42	5.2
30 kR of Gamma-Rays	819	1392	0.101	90.95	14000	15794	2.13	4.5
EMS (0.3%)	874	1358	0.056	95.01	14000	17561	2.25	4.8
10 kR of Gamma-rays + EMS (0.3%)	848	1303	0.065	94.24	14000	16594	2.19	4.7
20 kR of Gamma-rays + EMS (0.3%)	896	1293	0.135	87.87	14000	18163	2.30	5.0
30 kR of Gamma-rays + EMS (0.3%)	833	1506	0.137	87.72	14000	16511	2.18	4.6
CD at 5%	148	-	-	-	-	-	-	-

DSI: Drought susceptibility index; DTE: Drought tolerance efficiency; cost of cultivation: Rs.14000/ha

3.1.6 Alternate land use system

At Faizabad, in an evaluation of ber, anola, guara and kajurina based agri-horti system, pigeonpea equivalent yield was almost similar in ber + pigeonpea (1495 kg/ha) and in sole pigeonpea (1564 kg/ha), while ber + maize-mustard sequence recorded lowest pigeonpea equivalent yield (363 kg/ha) (Table 3.56).

Table 3.56 : Evaluation of most remunerative land use system for rainfed areas - Faizabad

Treatment	Grain/seed yield (kg/ha)		Pigeonpea equivalent yield (kg/ha)
	Maize	Pigeonpea	
Ber + Maize- mustard	1817	-	363
Ber + pigeonpea	-	1495	1495
Aonla + maize- mustard	1732	-	366
Aonla + pigeonpea	-	1520	152
Guava + kajurina + maize- mustard	1638	-	330
Guava + kajurina + pigeonpea	-	1366	1366
Kajurina + maize - mustard	1812	-	362
Kajurina + pigeonpea	-	1475	1475
Maize- mustard	1901		380
Pigeonpea	-	1564	1564

In an experiment to evaluate the effect of nutrient management and intercropping in mango orchard at Phulbani, higher tomato equivalent yield (7400 kg/ha), net returns (Rs.103440/ha) and B:C ratio (3.32) was recorded in chemical fertilizer treatment compared to other treatments. Among intercrops, tomato registered highest TEY (1050 kg/ha), net returns (Rs.153120/ha) and B:C ratio (3.69) compared to other crops (Table 3.57).

Table 3.57: Yield and economics as affected by crops and nutrient management-Phulbani

Treatment	TEY (kg/ha)	NMR (Rs/ha)	B:C ratio
Nutrient management			
Organic (N equivalent FYM)	6540	87950	3.05
Conventional (fertilizer for intercrop)	7400	103440	3.32
CD at 5%	7.78	-	-
Intercrop			
Cowpea	6525	99960	4.27
Groundnut	2680	23060	1.76
Tomato	1050	153120	3.69
Yambean	8175	106620	2.87
CD at 5%	25.86	-	-

TEY: Tomato equivalent yield

At Varanasi, the performance of pearlmillet was evaluated under different integrated nutrient management practices in guava based agri-horti system. Among different treatments, application of 50% RDF + 50% poultry manure recorded higher grain yield (2240 kg/ha), stover yield (5671 kg/ha), ear diameter (6.99 cm), earhead perimeter (10.92 cm), length of earhead (24.63 cm) and test weight (22.40 g) followed by application of 50% RDF + 50% vermicompost (2126 kg/ha) compared to other nutrient management practices (Table 3.58).

Table 3.58 : Performance of pearlmillet under guava based agri-horti system - Varanasi

Treatment	Earhead diameter (cm)	Perimeter of earhead (cm)	Length of earhead (cm)	Test weight (g)	Grain yield (kg/ha)	Stover (kg/ha)
FYM (@ 10 t /ha	5.76	9.17	15.36	7.07	1787	4109
Poultry manure (@ 5t/ha	6.11	9.83	17.31	7.83	1890	4336
Vermicompost (@ 5 t /ha	5.92	9.60	16.32	7.60	1798	4962
100% RDF ((60:40:30 NPK kg /ha)	6.26	10.15	19.36	8.23	1996	5367
50% RDF +50% FYM	6.45	10.43	20.97	8.63	2043	5555
50% RDF + 50% poultry manure	6.99	10.92	24.63	9.43	2240	5671
50% RDF + 50% vermicompost	6.75	10.72	22.91	9.00	2126	5633
Control	5.64	8.74	14.84	6.60	1577	3437
CD at 5%	-	-	-	-	103	-

Among different nutrient management treatments, the highest available N (181.67 kg/ha), P (14.07 kg/ha) and K (148.23 kg/ha) were recorded with application of 50% RDF + 50% poultry manure, FYM (@ 10 t/ha and 50% RDF +50% FYM, respectively. The minimum cost of cultivation was observed in control while maximum cost of cultivation was incurred with vermicompost @5 t/ha. The highest net returns (Rs.50340/ha) and B: C ratios of 2.99 were recorded with application of 50% RDF + 50% poultry manure compared to other treatments (Table 3.59).

Table 3.59 : Effect of nutrient management on available NPK and economics of pearlmillet under guava based agri-horti system – Varanasi

Treatment	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio
FYM (@ 10 t /ha	152.67	14.07	143.10	17161	41582	2.42
Poultry manure (@ 5t/ha	152.78	12.83	136.16	19202	41141	2.14
Vermicompost (@ 5 t /ha	151.68	13.33	143.83	23198	60988	1.63
100% RDF (60:40:30 NPK kg /ha)	162.70	13.03	137.33	16165	47813	2.96
50% RDF +50% FYM	159.90	13.70	148.23	16556	48357	2.92
50% RDF + 50% poultry manure	181.67	12.93	145.40	16834	50340	2.99
50% RDF + 50% vermicompost	163.11	12.93	147.40	19562	46380	2.37
Control	146.90	14.03	148.10	14205	40757	2.87

3.1.7 Integrated farming systems

At Varanasi, integrated animal based system (three buffaloes + two buffaloes calf) gave highest net returns (Rs. 257800/ha) and employment generation (200-mandays/ha/year) with a rice yield of 2050 kg/ha while agri- horti system recorded net returns of Rs. 42500/ha and employment generation was 75 mandays/ha/year with aonla and sesame yield of 100 and 110 kg/ha respectively (Table 3.60).

Table 3.60 : Yield and economics of integrated animal based system - Varanasi

Farming system	Productivity (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Employment generation (man-days/ ha/year)
	Crop	Livestock				
Integrated animal based system	Rice (2050)	Three buffaloes (7200 litre) + two buffaloes calf	138000	257800	1.86	200
Agri-horti-system	Aonla (100) Sesame (110)	-	14000	42500	3.0	75

3.2 Maize Based Production System

3.2.1 Rainwater management

At Arjia, in the experiment on catchment storage - command relationship, 286.9 mm with rainfall runoff of 12.9% was recorded in July followed by 29.2% runoff with 164.4 mm rainfall in August. During June to December, a total of 421.7 mm rainfall with 41.1% runoff was recorded. The mean data of 14 years revealed that, the maximum runoff (484.2 $m^{3)}$, runoff producing rainfall (177.3 mm), monthly rainfall (276.8 mm), 13.1% runoff of producing rainfall and 8% runoff of monthly rainfall was recorded in August (Table 3.61).

Table 3.61 : Runoff from the small agricultural watershed– Arjia

Month	Rainfall (mm)				Runoff (m^3)	Mean runoff (14 years)	% runoff of monthly rainfall	Mean % runoff (14 years)	% runoff producing rainfall	Mean (14 years)
	Monthly	Mean (14 years)	Runoff producing rainfall	Mean (14 years)						
June	53.4	85.0	-	44.2	0	71.5	0.0	2.1	0	3.5
July	286.9	252.9	107.0	139.6	177.5	303.2	4.9	5.0	12.9	12.0
August	164.4	276.8	89.5	177.3	122.6	484.2	16.9	8.0	29.2	13.1
September	17.0	80.5	0	36.1	0	74.0	5.7	3.1	0	5.2
October	0.0	3.5	0	0.0	0	0.0	0.0	0.0	0	0.0
November	0.0	13.3	0	9.0	0	21.4	0.0	0.6	0	0.8
December	0.0	2.7	0	0.0	0	0.0	0.0	0.0	0	0.0
Total	421.7	707.6	196.5	396.7	300.05	954.4	27.5	18.9	41.1	34.6

During *kharif* 2015, different vegetables and maize at different irrigation depths were evaluated. Ridge gourd recorded highest maize equivalent yield (MEY) of 5541 kg/ha with water productivity of 2.04 kg/m^3, net returns of Rs.67440/ha and B:C ratio of 3.21 followed by lady's finger and *Kachri* over maize with one irrigation of 5 cm. Drip irrigation saved the water by 58.5% over surface irrigation and increased MEY by 12%. Maize (10 ha cm) gave highest MEY (2083 kg/ha) with lowest B:C ratio (1.26), because of higher cost of cultivation (Rs. 39433/ ha). Runoff water was 18.20% of runoff producing rainfall which could be harvested in on farm reservoir for providing supplemental irrigation to crops during dry spell periods. The best water lifting device for providing supplemental irrigation to crops from farm pond was the electric motor followed by the gassifier pump set (Table 3.62).

Table 3.62 : Productivity and economics of vegetables crops as influenced by supplemental irrigation from harvested rainwater through different methods - Arjia

Treatment	MEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Water productivity (kg/m3)
Crop					
Bhendi	4207	20810	46509	2.24	1.81
Cabbage	0	0	0	0	0.00
Ridge gourd	5541	21211	67440	3.21	2.04
Kachri	2333	16259	21074	1.30	2.21
Chilli	0	0	0	0	0.00
CD at 5%	420	-	-	-	-
Irrigation					
Surface irrigation	2643	20029	22259	1.14	0.94
Drip irrigation	2960	19144	28216	1.52	1.49
CD at 5%	175	-	-	-	-
Maize (5 ha cm)	1667	26667	0.59	2.137	2.14
Maize (10 ha cm)	2083	39433	1.35	1.263	1.26

In an field experiment at Arjia, on rainwater harvesting *nadi* system and recycling the stored rain water, clusterbean (RGC-986) with surface irrigation (T18) method gave the higher grain and stover yield (6485 & 4645 kg/ha) and net returns of Rs 88881/ha with B:C ratio and WUF of 7.09 and 9.44 kg/ha-mm, respectively followed by clusterbean with furrow irrigation (T17), clusterbean with surface irrigation (T15) and clusterbean with furrow irrigation (T14). The lowest yield was recorded by Maize (PEHM 2) with control (no irrigation) (T1). Application of supplemental irrigation in blackgram gave higher net returns as compared to maize (Table 3.63).

Table 3.63 : Effect of supplemental irrigation on yield, net returns and water use efficiency in different crop during *kharif* – Arjia

Treatment	Maize grain eqivalent yield (kg/ha)			Maize stover eqivalent yield (kg/ha)			NMR (Rs/ha)	B:C ratio	Water use (m^3/ha)	RWUE (kg/ha-mm)
	2012	2014	Mean	2012	2014	Mean				
T_1	1258	1748	1503	2914	3715	3315	14615	2.07	0.00	0.00
T_2	2723	2072	2398	6324	4641	5483	30629	3.18	392	6.13
T_3	3017	2292	2655	7157	4768	5963	34676	3.38	638	4.16
T_4	1410	1771	1591	3168	3761	3465	16473	2.25	0	0.00
T_5	2992	2055	2524	7030	4194	5612	32914	3.44	395	6.39
T_6	3263	2211	2737	7633	4618	6126	36451	3.61	664	4.13
T_7	1457	2087	1772	3468	2156	2812	20187	3.16	0	0.00
T_8	2062	2460	2261	5191	2134	3663	27757	3.76	450	5.03
T_9	2455	2643	2549	6334	2093	4214	32357	4.10	667	3.82
T_{10}	1673	2420	2047	3448	1898	2673	23709	3.51	0	0.00
T_{11}	2477	2778	2628	5358	2134	3746	32989	4.24	437	6.01
T_{12}	2537	2817	2677	6238	2338	4288	34318	4.24	653	4.10
T_{13}	4270	1085	2678	4094	1368	2731	30998	3.89	0	0.00
T_{14}	9854	1356	5605	5200	1955	3578	72775	7.24	430	12.77
T_{15}	10443	1457	5950	7207	2013	4610	79158	7.50	664	9.14
T_{16}	4439	1064	2752	4087	1732	2910	31441	3.49	0	0.00
T_{17}	10622	1424	6023	5197	2033	3615	77730	6.73	428	14.37
T_{18}	11465	1505	6485	7127	2162	4645	88881	7.09	689	9.44
T_{19}	1696	2244	1970	4107	1898	3003	18216	2.23	0	0.00
T_{20}	3792	2572	3182	4542	2134	3338	34901	3.34	428	7.46
T_{21}	4189	2748	3469	5701	2636	4169	40115	3.59	686	5.07
T_{22}	1741	2294	2018	3484	3091	3288	19226	2.22	0	0.00
T_{23}	4086	2622	3354	4379	2165	3272	36765	3.35	419	8.01
T_{24}	4336	2773	3555	5393	2542	3968	40487	3.50	666	5.34
CD at 5%	226	716		145	675					

T_1: Maize (PEHM 2) with control (no irrigation); T_2: Maize (PEHM 2) with furrow irrigation; T_3: Maize (PEHM 2) with surface irrigation; T_4: Maize (PM1) with control (no irrigation); T_5: Maize (PM 1) with furrow irrigation; T6: Maize (PM 1) with surface irrigation; T_7: Blackgram (T) with control (no irrigation); T_8: Blackgram (T) with furrow irrigation; T_9: Blackgram (T) with surface irrigation; T_{10}: Blackgram (TAU-2) with control (no irrigation); T_{11}: Blackgram (TAU-2) with surface irrigation; T_{12}: Blackgram (TAU-2) with surface irrigation; T_{13}: Clusterbean (RGC-936) with control (no irrigation); T_{14}: Clusterbean (RGC-936) with furrow irrigation; T_{15}: Clusterbean (RGC-936) with surface irrigation; T_{16}: Clusterbean (RGC-986) with control (no irrigation); T_{17}: Clusterbean (RGC 986) with furrow irrigation; T_{18}: Clusterbean (RGC-986) with surface irrigation;

T19: Groundnut (TAG-24) with control (no irrigation); T_{20}:Groundnut (TAG-24) with furrow irrigation; T_{21}: Groundnut (TAG-24) with surface irrigation; T_{22}: Groundnut (TAG-37A) with control (no irrigation); T_{23}: Groundnut (TAG-37A) with furrow irrigation; T_{24} : Groundnut (TAG-37A) with surface irrigation.

At Arjia, in an assessment to raise the *rabi* crops with rainwater harvesting through *nadi* system, lentil recorded significantly higher mustard equivalent yield (1573 kg/ha), net returns (Rs. 51139/ha) and B:C ratio (4.10) compared to linseed. Application of one supplemental irrigation at 45 DAS recorded highest WUE (1.70) as compared to two supplemental irrigations at 45 & 60 DAS. Application of supplemental irrigation at 45 DAS (1049 kg/ha) and 45 & 60 DAS (1275 kg/ha) increased mustard grain equivalent yield by 47 and 79% over no irrigation, respectively. Application of two supplemental irrigations at 45 DAS & 60 DAS recorded higher B:C ratio (2.56) and net returns (Rs.32150/ha) as compared to other treatments (Table 3.64).

Table 3.64 : Mustard equivalent yield and economics of different crops influenced by supplemental irrigation in *nadi* system - Arjia

Treatment	Mustard equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Crop						
Lentil	1573	2516	16500	51139	4.10	2.59
Mustard	843	2199	17050	21328	2.25	1.39
Linseed	618	910	14767	11610	1.79	1.02
CD at 5%	137	202	-	-	-	-
Supplemental irrigation						
No irrigation	711	1480	12550	17449	2.39	0
One irrigation at 45 DAS	1049	1931	15217	28409	2.87	1.70
Two irrigation at 45 & 60 DAS	1275	2214	20550	32150	2.56	1.05
CD at 5%	133	245	-	-	-	-

At Arjia, the growth and yield attributes of maize did not differ significantly due to different tillage treatments. Among three mulch treatments, soil mulch, recorded significantly higher plant height (176.5 cm), plant population/m row length (964.37) and maximum maize grain yield (1546 kg/ha), net return (Rs. 26933/ha), B:C ratio (1.37) and RWUE (2.98 kg/ha-mm) compared to no mulch (1014 kg/ha). The mean data of five years also followed the same trend (Table 3.65).

Table 3.65 : Effect of mulching practices under minimum tillage on growth, yield and economics of maize – Arjia

Treatment	Plant height (cm)	Yield (kg/ha)		Mean grain yield (5 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Stover					
No mulch	166.2	1014	3083	2146	16285	14649	0.90	1.95
Farm waste mulch	171.4	1231	3538	2010	20710	15795	0.76	2.37
Polythene	174.2	1395	3721	2470	24035	15863	0.66	2.68
Soil mulch	176.5	1546	4588	2658	19660	26933	1.37	2.98
CD at 5%	9.10	208	571	-	-	-	-	-

The 4 years result indicated that minimum tillage with soil mulch recorded the highest maize grain and stover yield (3189 and 6006 kg/ha), net returns (Rs. 45836/ha), B:C ratio (2.72) and RWUE (4.24 kg/ha-mm), followed by P1M3, P2M2 and P1M2. The lowest yield (1878 kg/ ha) and B:C ratio (1.08) was recorded with conventional tillage + farm waste mulch (P1M1) (Table 3.66).

Table 3.66 : Yield and economics of maize under different treatment combinations (2010-14) - 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)
P1M0	2280	5139	14855	32485	2.19	3.03
P1M1	1878	4594	19280	20790	1.08	2.50
P1M2	2738	5641	22605	32644	1.44	3.64
P1M3	2968	5724	18230	40491	2.22	3.94
P2M0	2219	5134	13455	33013	2.45	2.95
P2M1	2318	4823	17880	29033	1.62	3.08
P2M2	2836	5833	21205	36000	1.70	3.77
P2M3	3189	6006	16830	45836	2.72	4.24
P3M0	2325	5802	15800	34156	2.16	3.09
P3M1	2284	5384	20225	27895	1.38	3.03
P3M2	2682	5900	22875	32365	1.41	3.56
P3M3	2692	6138	19550	36549	1.87	3.58

P1: Conventional tillage; P2: Minimum tillage; P3: Raised bed sowing; M0: No mulch; M1: Farm waste mulch; M2: Polythene mulch; M3: Soil mulch

At Ballowal Saunkhri, in a experiment on catchment-storage-command relationship, application of one supplemental irrigation during dry spell gave 52% higher maize yield over rainfed maize. In case of okra, 12500 kg/ha yield was recorded with supplemental irrigation while rainfed crop gave no yield. During *rabi* season, one supplemental irrigation at CRI stage in wheat gave 56% higher yield over rainfed crop. In case of pea, 3600 kg/ha yield was recorded with supplemental irrigation while rainfed crop gave no yield (Table 3.67).

Table 3.67 : Effect of supplemental irrigation on yield of *kharif* and *rabi* crops - Ballowal Saunkhri

Treatment	Grain/fruit yield (kg/ha)	
	With supplemental irrigation	Without supplemental irrigation
Maize	3829	1837
Okra	12500	-
Wheat	3368	1475
Pea	3600	-

With supplemental irrigation

Without supplemental irrigation

Performance of maize

At Ballowal Saunkhri, in an assessment of the effect of vegetative barriers on yield and water use efficiency in *kharif* crops, *kana* as vegetative barrier was effective and maize recorded higher grain yield (2546 kg/ha) and RWUE of 6.16 kg/ha-mm with maximum net returns of Rs.15805/ha and B:C ratio of 1.49 compared to other vegetative barriers. Similar trend was also observed in sesame and blackgram. The yield increased by 30% as compared to control. Similarly, averaged across 8 years, *Kanna* as vegetative barrier was effective due to which maize recorded higher mean grain yield (2965 kg/ha) compared to other vegetative barriers (Table 3.68).

Table 3.68 : Effect of vegetative barriers on yield and economics of *kharif* crops – Ballowal Saunkhri

Treatment	Grain yield (kg/ha) 2015	Grain yield (kg/ha) Mean (8 years)	Stalk/stover yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Maize							
Control	1955	2224	4246	4.73	29024	6670	1.23
NH bajra	2467	2854	5195	5.97	30860	12363	1.45
Vetiver	2224	2572	4670	5.39	30671	11735	1.42
Babbar	2304	2695	4856	5.58	30733	10344	1.36
Kanna	2546	2965	5321	6.16	30921	15805	1.49
Subabul	2174	2443	4714	5.26	30631	9744	1.29
CD at 5%	356.2		650.8	0.86	277	NS	NS
Sesame							
Control	383	338	2389	0.93	17164	21136	2.23
NH bajra	457	439	2844	1.02	18868	29799	2.58
Vetiver	418	397	2612	1.21	18868	23932	2.27
Babbar	422	418	2629	1.11	18868	25332	2.34
Kanna	473	459	3026	1.12	19152	29115	2.52
Subabul	405	388	2527	1.25	18868	22599	2.20
CD at 5%	55		337	0.36		5515	NS
Blackgram							
Control	539	1516	2148	1.29	21969	5915	1.28
NH bajra	648	1945	2647	1.43	23647	11704	1.51
Vetiver	576	1748	2150	1.72	23477	7274	1.32
Babbar	618	1852	2408	1.53	23576	10275	1.45
Kannah	657	2021	2588	1.64	23667	11117	1.49
Subabul	565	1638	2317	1.74	23451	6750	1.30
CD at 5%	81		550	NS	192	3875	0.17

Among *rabi* crops, *napier bajra* as vegetative barrier gave maximum wheat yield of 2068 kg/ha during 2015-16 with net returns of Rs. 19033/ha, B:C ratio of 1.76 and RWUE of 12.50 kg/ha-mm. In raya, *napier bajra* gave maximum yield of 411 kg/ha, B:C ratio (0.93) and RWUE (2.49 kg/ha-mm) with negative net returns. Similarly, *napier bajra* as vegetative barrier gave maximum wheat mean yield of 2575 kg/ha over 8 years (Table 3.69).

Table 3.69 : Effect of vegetative barriers on yield and economic of *rabi* crops – Ballowal Saunkhri

Treatment	Grain yield (kg/ha) 2015-16	Grain yield (kg/ha) Mean (8 years)	Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Wheat							
Control	1722	2353	2990	24774	11946	1.48	10.4
Napier bajra	2068	2575	3607	25133	19033	1.76	12.5
Vetiver	2002	2462	3502	25065	17724	1.71	12.1
Babbar	1773	2457	3051	24827	12894	1.52	10.7
Kanna	1862	2499	3168	24920	14569	1.58	11.3
Subabul	1780	2325	2938	24834	12589	1.51	10.8
CD at 5%	NS	-	NS	NS	NS	NS	NS
Raya							
Control	358	807	1424	16789	-2469	0.85	2.17
Napier bajra	411	788	1939	17652	-1225	0.93	2.49
Vetiver	363	767	1592	17652	-3145	0.82	2.20
Babbar	390	793	1703	17652	-2052	0.88	2.36

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015-16	Mean (8 years)					
Kana	389	843	1962	17652	-2078	0.88	2.36
Subabul	385	722	1624	17652	-2252	0.87	2.33
CD at 5%	NS	-	NS	-	NS	NS	NS

At Ballowal Saunkhri, in a study on monitoring of discharge from Makkowal type water harvesting system (MTWHS), the maximum discharge (16.5 lps) was observed in the month of July 2015, while minimum (7.0 lps) was observed in the month of April 2016. The water table depth varied from shallow (116 cm) during June 2015 to deep (146.3 cm) during January 2016. The silt loss during the months varied from 0.09 to 0.39% with maximum loss in May and minimum in September and October. The pH values varied from 7.3 to 7.9 (Table 3.70, Fig. 3.1 & 3.2)

Table 3.70 : Average monthly discharge of the makkowal type water harvesting system - Ballowal Saunkhri

Month	Average discharge (lps)					
	2011-12	2012-13	2013-14	2014-15	2015-16	Mean of 5 years
May	9.1	6	5.6	5.9	8.7	7.1
June	9.3	5.6	7.5	6.1	10.2	7.7
July	27.9	5.3	9	8.9	16.5	13.5
August	15.2	5.5	20.4	10.1	13.8	13.0
September	20.5	9	30.9	8.1	8.5	15.4
October	6.1	8.5	30.1	7.7	9.7	12.4
November	6.6	9.5	27.4	7.4	8.8	11.9
December	9.3	10.3	26.2	7.2	8.4	12.3
January	7.4	10.2	25	5.8	8.3	11.3
February	10.6	12.2	12.2	4.8	8.9	9.7
March	9.5	1.9	27.2	3.7	9.0	10.3
April	7.7	6.6	20.2	1.4	7.0	8.6
Mean	11.6	7.6	20.1	6.4	9.8	11.1
Rainfall (mm)	1260.6	667.7	1177.3	896.9		

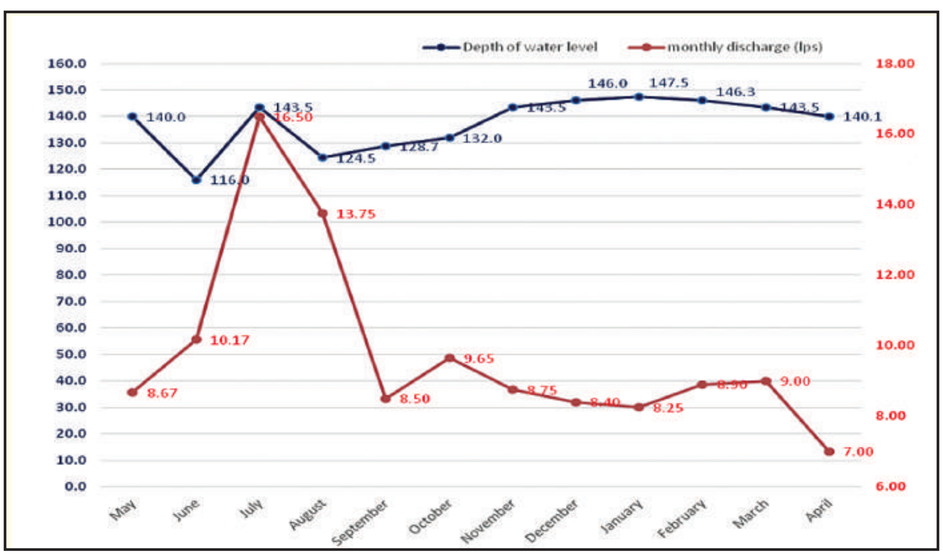


Fig 3.1 : Monthly discharge and depth of water level at Makkowal type base flow harvesting system – Ballowal Saunkhri

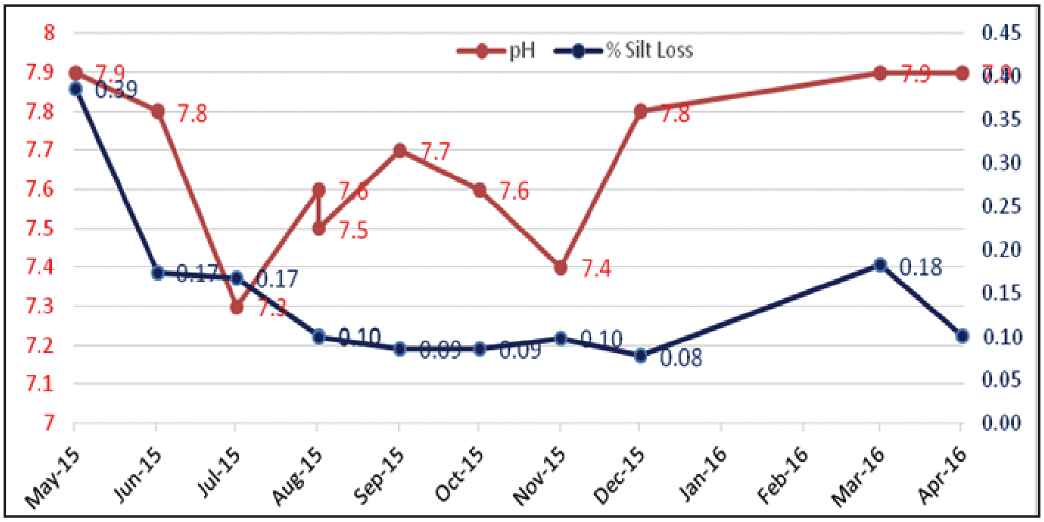


Fig 3.2 : Change in per cent silt load and pH value of water level at Makkowal type base flow harvesting system -Ballowal Saunkhri

In an evaluation of different *in-situ* soil moisture conservation practices in maize-wheat system at Rakh Dhiansar, significantly highest maize grain yield (2777 kg/ha) was obtained in broad bed furrow (BBF) + mulching with *leucaena* leaves with higher net returns, B:C and RWUE of Rs. 27564/ha, 2.23 and 10.51 kg/ha-mm, respectively followed by broad bed furrow (BBF) + mulching with *in-situ* raised *sunhemp* and broad bed furrow (BBF) + mulching with *in-situ* raised *dhaincha* which were statistically at par with each other. However, lowest maize grain yield was obtained in farmers practice and no mulching (Table 3.71).

Table 3.71 : Yield and economics of maize under different *in-situ* soil moisture conservation practices - Rakh Dhiansar

Treatment	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Flat bed	2070	19716	16063	1.81	7.84
Broad bed furrow (BBF)	2207	19716	20262	2.03	8.36
Flat bed + mulching with *in-situ* raised dhaincha	2660	22566	25979	2.15	10.07
BBF + mulching with *in-situ* raised dhaincha	2755	22566	27382	2.21	10.43
Flat bed + mulching with *in-situ* raised sunhemp	2669	22366	26183	2.17	10.11
BBF + mulching with *in-situ* raised sunhemp	2750	22366	27285	2.22	10.41
Flat bed + mulching with *Leucaena* leaves	2655	22491	25724	2.14	10.05
BBF + mulching with *Leucaena* leaves	2777	22491	27564	2.23	10.51
Farmer's practice	1815	19716	12796	1.64	6.91
CD at 5%	76	-	-	-	-

*One life saving irrigation was given

Rainwater collected in the furrow under BBF method

Performance maize at vegetative stage under BBF system

At Rakh Dhiansar, the highest grain yield of maize (1780 kg/ha), net returns (Rs.12550/ha), B:C ratio (1.7) and RWUE (2.73 kg/ha) was obtained with two life saving irrigation from harvested rainwater at critical stage and the lowest grain yield (1410 kg/ha) was obtained in farmers practice (Table 3.72).

Table 3.72 : Effect of yield and economics with supplemental irrigation in maize - 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)
No supplemental irrigation	1410	3068	17500	7547	1.4	2.16
One life saving irrigation	1560	3370	18200	9475	1.5	2.39
Two life saving irrigations	1780	3760	18900	12550	1.7	2.73

3.2.2 Cropping systems

At Arjia, under strip cropping system, the crops were sown late due to late onset of monsoon. Further, long dry spell occurred during initial stage, crop growth and maturity. Therefore, maize crop could not set grain and black gram crop also recorded very low yield. However, blackgram (grain) + sorghum (fodder) (2:2) gave highest net returns (Rs.32577/ha), B:C ratio (2.75) and RWUE (16.9 kg/ha-mm) as compared to rest of treatments. Further, blackgram (grain) 2/3 area + sorghum (f) 1/3 area strip cropping produced highest maize equivalent grain yield (570kg/ha) (Table 3.73).

Table 3.73: Yield and economics of different strip cropping systems - Arjia

Treatment	Maize equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (RS/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Maize (grain) 2/3 area + sorghum (f) 1/3 area	0	7877	12570	27604	2.20	16.9
Maize (grain) 2/3 area + maize chari (1/3) area	0	7555	12618	25910	2.05	16.2
Blackgram (grain) 2/3 area + sorghum (f) 1/3 area	570	5358	13180	22694	1.72	11.5
Blackgram (grain) 2/3 area + maize chari (f) 1/3 area	479	5476	13228	21888	1.65	11.8
Blackgram (grain) + sorghum (f) 2:2	285	7869	11830	32577	2.75	16.9
Blackgram (grain) + maize (f) 2:2	258	7700	11943	31203	2.61	16.6
Maize sole (grain)	-	-	-	-	-	-
CD at 5%	67	-	1211	-	-	-

Blackgram (grain) 2/3 area + sorghum (f) 1/3 area

Maize (grain) 2/3 area + maize (f) (1/3) area

At Arjia, foliar spray of $ZnSO_4$ @ 0.5% + NPK (soluble) @ 2% at knee high and tasseling stages gave significantly higher maize grain and stover yield (1775 and 6992 kg/ha) which was 54.1% higher grain yield over control (1152 kg/ha) with higher net returns (Rs.44387/ha), B:C ratio 2.48 and RWUE of 3.4 kg/ha-mm (Table 3.74).

Table 3.74 : Effect of foliar spray of nutrients/chemicals for mitigating the dry spell stress in maize- Arjia

Treatment	Grain yield (kg/ha)		Mean grain yield (3 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Stover					
Absolute control	1152	5094	2032	16285	26975	1.66	2.2
Water spray	1179	5414	2067	16545	28748	1.74	2.3
NPK 2%	1424	6372	2473	16697	37158	2.23	2.7
$ZnSO_4$ 0.5%	1515	6003	2461	16697	36647	2.19	2.9
NPK 2% + $ZnSO_4$ 0.5%	1775	6992	2683	17905	44387	2.48	3.4
Selenium @ 20 g/ha	1603	7002	2363	17125	42635	2.49	3.1
KNO_3 2%	1585	6628	2400	16905	40666	2.41	3.0
CD at 5%	256	923	-	-	-	-	-

Performance of maize without any spray

Performance of maize with foliar spray of $ZnSo_4$ @ 0.5% + NPK (soluble) @ 2% at tasseling and grain filling stages

At Ballowal Saunkhri, in a study on different slopes and maize and cowpea strip width, cultivation of maize and cowpea on different land slopes showed no significant difference in maize equivalent yield (MEY). The strip intercropping system with maize strip width of 4.8 m and cowpea strip width of 1.2 m (4.8:1.2) gave significantly higher maize equivalent yield (2252 kg/ha), LER (1.13), net returns (Rs.8083/ha), B:C ratio (1.13) and WUE (6.01 kg/ha-mm) over maize:cowpea strip width of 3 m: 3m, 1.2 m : 4.8 m and sole cowpea (Table 3.75). Soil moisture ranged from 11-13 mm at sowing and from 7-10 mm at harvest.

Table 3.75 : Yield and economics as influenced by different slopes and maize and cowpea strip widths –Ballowal Saunkhri

Treatment	MEY (kg/ha)	LER	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Slope (S)						
1%	2028	1.15	26619	6663	1.22	5.41
2%	1946	1.12	26557	5375	1.18	5.19
3%	1911	1.11	26572	4734	1.15	5.10
CD at 5%	NS		NS	1531.6	NS	NS
Maize cowpea strip width (m)						
6:00	2137	-	29128	7720	1.26	5.70
4.8:1.2	2252	1.13	30041	8083	1.13	6.01

Treatment	MEY (kg/ha)	LER	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
3:3	2051	1.15	27531	6412	1.20	5.47
1.2:4.8	1852	1.10	24951	4288	1.27	4.94
0:6	1514	-	21262	1449	1.07	4.04
CD at 5%	127.9		86.7	1971.5	0.07	0.34

Maize: cowpea strip (4.8 m: 1.2 m)

Maize: cowpea strip (1.2 m : 4.8 m)

Performance of maize based strip cropping system

In an evaluation of the most efficient maize-based intercropping systems at Rakh Dhiansar, the highest maize equivalent yield (MEY) was obtained with paired rows of maize with 2 rows of cowpea with the MEY and LER of 2423 kg/ha and 1.32, respectively with the highest B:C ratio of 1.63, followed by two rows of maize + 3 rows of cowpea with MEY of 2226 kg/ha and B:C ratio of 1.43 compared to all other systems. The yield of sesame reduced because of phyllody disease while groundnut crop failed. (Table 3.76).

Table 3.76 : Yield and economics of maize based intercropping systems - Rakh Dhiansar

Treatment	Yield (kg/ha)		MEY (kg/ha)	LER	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Maize	Intercrop						
Maize + cowpea (2:2)	1250	260	2423	1.32	21950	13698	1.63	5.86
Maize + cowpea (2:3)	1179	230	2226	1.15	23000	9945	1.43	5.39
Maize + sesame (2:2)	1238	40	1731	0.99	21400	4225	1.20	4.19
Maize + sesame (2:3)	1083	62	1677	1.03	22150	2671	1.12	4.06
Maize + groundnut (2:2)	1510	*	-	-	27400	111	1.00	3.65
Maize + groundnut (2:3)	1596	*	-	-	31350	-2463	0.92	3.86
Sole maize	1650	-	-	-	19716	10026	1.51	3.99
Sole cowpea		460	1672	-	14450	11400	1.59	4.05
Sole sesame	-	165	891	-	12700	500	1.04	2.16
Sole groundnut	-	-	-	-	-	-	-	-

Maize + cowpea (2:2)

Maize + cowpea (2:3)

Maize + sesame (2:2)

Maize + sesame (2:3)

Performance of maize based intercropping systems

At Arjia, in maize, sand mix with atrazine @ 0.50 kg a.i./ha at 15 DAS + one interculture at 35 DAS (T9) gave higher grain and stover yield (1747 and 5193 kg/ha) with highest net returns (Rs.39030/ha), B:C ratio (2.86) and RWUE (3.36 kg/ha-mm), followed by atrazine @ 0.5 kg a.i./ha + one hand weeding at 35 DAS but the highest grain (1810 kg/ha) and stover (5245 kg/ha) yield was recorded with weed free condition. The grain yield increased by 92% with T9 and 88% with T10 as compared to control (908 kg/ha) (Table 3.77).

Table 3.77 : Yield and economics of maize as influenced by different weed management practices - Arjia

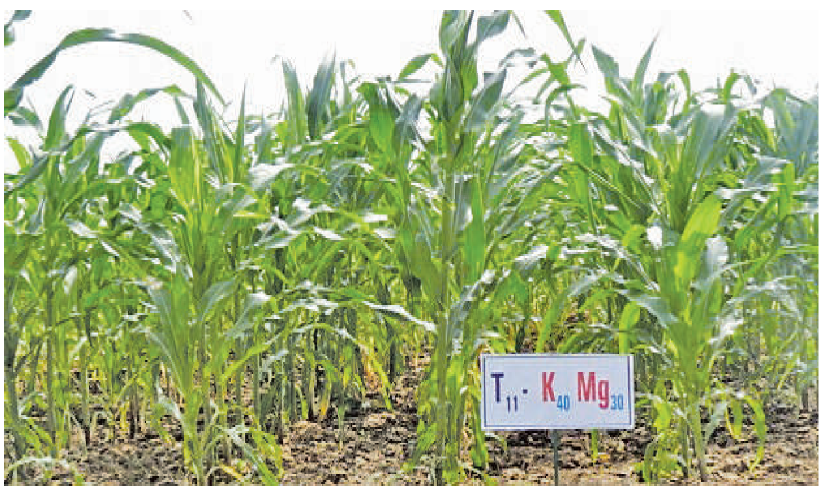
Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1 - Weedy check	908	2840	9485	18617	1.96	1.75
T_2 - Weed free	1810	5245	16285	37620	2.31	3.48
T_3 - Atrazine @ 0.5 kg a.i./ha (pre-emergience: PE)	1295	3724	10425	28002	2.69	2.49
T_4 - Urea mix with atrazine @ 0.5 kg a.i./ha at 15 DAS	1261	3759	10255	27828	2.71	2.43
T_5 - Sand mix with atrazine @ 0.5 kg a.i./ha at 15 DAS	1330	3805	10255	29105	2.84	2.56
T_6 - Urea mix with atrazine @ 0.5 kg a.i./ha at 25 DAS	1226	3401	10255	25479	2.48	2.36
T_7 - Sand mix with atrazine @ 0.5 kg a.i./ha at 25 DAS	1307	3551	10255	27460	2.68	2.51
T_8 - T_4 + one interculture operation at 35 DAS	1515	4314	13655	31077	2.28	2.92
T_9 - T_5 + one interculture operation at 35 DAS	1747	5193	13655	39030	2.86	3.36
T_{10} -T_3 + one hand weeding at 35 DAS	1706	5118	13655	38039	2.79	3.28
CD at 5%	245	825	-	-	-	-

3.2.3 Nutrient management

At Arjia, in the experiment evaluation of K and Mg levels in maize crop could not set grain due to two long dry spells (first dry spell was 30 days from 19th August to 17th September and second dry spells was from 19th September to till harvest). Therefore, only biological yield of maize was recorded which revealed that application of K up to 40 kg K_2O/ha (4431 kg/ha) and application of Mg up to level of 30 kg $MgSo_4.7H_2O$/ha significantly increased biological yield (4420 kg/ha) with higher net returns (Rs.6839/ha & Rs.6891/ha) and B:C ratio 1.38 in both the treatments (Table 3.78).

Table 3.78 : Effect of potassium and magnesium on biological yield and economics of maize - Arjia

Treatment	Biological yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
K_0	3596	16848	3219	1.19
K_{20}	4242	17379	6277	1.36
K_{40}	4431	17910	6839	1.38
K_{60}	4653	18441	7627	1.41
CD at 5%	815	-	-	-
Mg_0	3735	17082	3706	1.21
Mg_{15}	4128	17457	5588	1.32
Mg_{30}	4420	17832	6891	1.38
Mg_{45}	4638	18207	7777	1.43
CD at 5%	815	-	-	-



Performance of maize with 40 kg/ha K and Mg 30 kg/ha

At Arjia, the long-term application of various INM treatments on yield of blackgram under maize-blackgram rotation, maize crop could not set grain due to severe drought and long dry spell during growth stages. However, application of 25 kg N through FYM and 25 kg N through chemical fertilizer + 30 kg P_2O_5 gave higher biological yield of maize (7058 kg/ha) over control (4328 kg/ha) with higher net returns (Rs.20967/ha) and B:C ratio (2.18). On the basis of 7 years experimentation, 25 kg N through FYM and 25 kg N through inorganic fertilizer + 30 kg P_2O_5 gave highest maize grain equivalent yield (3136 kg/ha) as compared to control (2106 kg/ha) closely followed by 100% RD of NP and 15 kg N (FYM) and 10 kg N (green leaf) + 25 kg N (inorganic fertilizer) + 30 kg P_2O_5(Table 3.79).

Table 3.79 : Effect of integrated nutrient management on biological yield and economics of maize - Arjia

Treatment	Biological yield (kg/ha)	Mean grain yield (7 years) (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Control	4328	2106	13640	9873	1.72
100% RD of NP (50:30: kg/ha)	5916	2922	15629	16759	2.07
25 kg N through FYM and 25 kg N through inorganic fertilizer + 30 kg P_2O_5/ha	7058	3136	17774	20967	2.18
25 Kg N through compost and 25 kg N through inorganic fertilizer + 30 kg P_2O_5/ha	6879	2830	18274	19442	2.06
25 kg N through crop residues and 25 kg N through inorganic fertilizer + 30 kg P_2O_5/ha	6187	2787	19774	14192	1.72
15 kg N through FYM + 10 kg N through crop residues and 25 kg N through inorganic fertilizer + 30 kg P_2O_5/ha	6860	2831	18574	18874	2.02
15 kg N through FYM + 10 kg N through compost and 25 kg N through inorganic fertilizer + 30 kg P_2O_5/ha	6779	2839	17974	19084	2.06
15 kg N through FYM + 10 kg N through greenleaf and 25 kg N through inorganic fertilizer +30 kg P_2O_5/ha	6537	2943	17314	18586	2.07
100% recommended. N through inorganic fertilizer without P	5539	2593	14350	15731	2.10
CD at 5%	907	-	-	-	-

FYM – Farm yard manure, IF-Inorganic fertilizer, *During 2013, maize crop failed due to severe drought

Performance of maize with 25 kg N through FYM and 25 kg N through inorganic fertilizer + 30 kg P_2O_5

The available nitrogen content of the soil was affected by application of organic manure and chemical fertilizers. It varied from 206.8 kg/ha (control) to 250.1 kg/ha in the treatment receiving 15 kg N through FYM + 10 Kg N through greenleaf and 50% N through chemical fertilizer. The variation in available phosphorous and available potassium was found to be significant by the application of organic manure, chemical fertilizers and their combinations. The bulk density was less in plots where organic matter was added (Table 3.80).

Table 3.80 : Effect of INM in maize - blackgram rotation soil chemical and physical properties -Arjia

Treatment	Organic C (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)	Bulk density (g/cc)
Control	0.350	206.8	28.0	336.9	1.52
100% RD of NP (50:30 kg/ha)	0.368	241.4	36.5	361.5	1.54
25 kg N through FYM and 25 kg N through IF +30 kg P_2O_5/ha	0.405	245.8	39.9	373.7	1.48

Treatment	Organic C (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)	Bulk density (g/cc)
25 Kg N through compost and 25 kg N through IF+30 kg P_2O_5/ha	0.400	234.7	35.1	374.4	1.46
25 kg N through crop residues and 25 kg N through IF+30 kg P_2O_5/ha	0.383	223.2	39.4	365.6	1.48
15 kg N through FYM + 10 kg N through crop residues and 25 kg N through IF+30 kg P_2O_5/ha	0.393	231.9	37.4	375.2	1.49
15 kg N through FYM + 10 kg N through compost and 25 kg N through IF+30 kg P_2O_5/ha	0.423	247.6	37.8	376.1	1.47
15 kg N through FYM + 10 kg N through greenleaf and 25 kg N through IF+30 kg P_2O_5/ha	0.420	250.1	37.9	381.6	1.49
100% recommended. N through IF without P	0.361	238.9	32.8	359.4	1.50
CD at 5%	0.019	4.0	2.0	16.8	-

At Ballowal Saunkhri, the evaluation of K and Mg level, in maize indicated application of 40 kg K_2O/ha resulted in significant increase in grain yield (2952 kg/ha) which was 28 and 16% higher over control and 20 kg K_2O/ha, respectively with highest net returns (Rs. 20222/ha), B:C (1.65) and RWUE (6 kg/ha-mm). Magnesium sulphate application @ 45 kg/ha showed significant improvement in yield (2954 kg/ha), net returns (Rs. 20330/ha), B:C (1.70) and RWUE (6.0 kg/ha-mm) over control and $MgSO_4.7H_2O$ @ 15 kg/ha (Table 3.81).

Table 3.81 : Effect of potassium and magnesium on the yield and economics of maize - 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)
Potassium level						
K_0	2304	5265	28977	10531	1.37	4.7
K_{20} (20 kg K_{20}/ha)	2543	5684	29813	14016	1.49	5.2
K_{30} (30 kg K_{20}/ha)	2793	6447	30335	18012	1.61	5.7
K_{40} (40 kg K_2O/ha)	2952	6701	30787	20222	1.65	6.0
CD at 5%	281.2	631.4	219	4606	0.1	0.57
Magnesium sulphate level						
Mg_0	2373	5453	29763	11288	1.37	4.8
Mg_{15} (15 kg $MgSO_4$/ha)	2594	5837	29935	14815	1.48	5.3
Mg_{30} (30 kg $MgSO_4$/ha)	2682	6126	30003	16348	1.57	5.5
Mg_{45} (45 kg $MgSO_4$/ha)	2945	6682	30211	20330	1.70	6.0
CD at 5%	281.2	631.4	219	4606	0.1	0.57

At Ballowal Saunkhri, foliar spray of 1% KNO_3 in maize at critical moisture sensitive stages (tasseling and dough stages) significantly improved the yield of maize as compared to control and water spray. Foliar spray of 1% KNO_3 twice gave highest grain yield (2438 kg/ha), RWUE (7.91 kg/ha-mm), net returns (Rs.10285/ha) and B:C ratio (1.33) followed by KNO_3 spray (1%) once, thiourea 1000 ppm, $ZnSO_4$ spray (0.5%) once and $ZnSO_4$ spray (0.5%) twice . The KNO_3 spray (1%) twice increased grain yield by 28% over no spray and 26% over water spray, respectively (Table 3.82).

Table 3.82 : Effect of foliar spray on yield and economics of rainfed maize - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)	Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
No spray	1907	4030	28949	3692	1.13	6.19
Water spray	1935	4081	29539	3569	1.12	6.28
Thiourea @ 1000 PPM	2183	4673	29991	7427	1.25	7.08
KNO_3 spray @ 1% once	2318	5107	31912	7970	1.25	7.52
KNO_3 spray @ 1% twice	2438	5205	31486	10285	1.33	7.91
$ZnSO_4$ spray @ 0.5% once	2141	4504	29792	6895	1.23	6.94
$ZnSO_4$ spray @ 0.5% twice	2121	4641	29822	6640	1.22	6.88
CD at 5%	388	753	302	NS	NS	1.26

At Ballowal Saunkhri, in Permanent Manurial Trial (PMT) one spray at tassiling; two spray - at tassiling and dough stage in maize-wheat system, yield of maize improved with nutrient management treatments as compared to control. Highest yield (3049 kg/ha) was recorded with 100% NPK + FYM 10 t/ha which was statistically at par with all treatments except control and 100% N RDF. The same treatment also gave highest RWUE (9.84 kg/ha-mm), but the net returns (Rs.21858/ha) and B:C ratio (1.71) was higher with 125% NPK which might be due to the higher cost of FYM (Table 3.83).

Table 3.83 : Permanent Manurial Trial in maize - wheat system - Effect on yield and economics - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)		Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015-16	Mean (2 years)					
Control	1215	2198	3090	25,290	-2430	0.90	3.92
N (100% RDF)	1755	2735	4403	26,704	6226	1.23	5.66
NP (100% RDF)	2286	3053	5579	29,159	13499	1.46	7.38
NPK (100% RDF) (DAP)	2531	3325	6053	29,478	17567	1.60	8.17
NPK (100% RDF (SSP)	2635	3412	5643	29,777	18213	1.61	8.50
NPK (100% RDF) + $ZnSO_4$	2620	3424	5783	31,496	16478	1.52	8.45
NPK (50% RDF) + FYM 10 t/ha	2911	3482	6672	40,282	13391	1.33	9.39
NPK (100% RDF) + FYM 10 t/ha	3049	3821	6826	40,390	15584	1.39	9.84
NPK (125% RDF)	2904	3640	6040	30,762	21858	1.71	9.37
CD at 5%	786	-	1429	-	-	-	-

RDF100% (NPK kg/ha): Maize: 80:40:20; Wheat: 80:40:30

The soil pH of different treatments ranged from 7.6 to 7.7. The maximum organic carbon content (0.5%) was recorded with application of NPK 100% RDF + FYM 10 t/ha followed by NPK 50% RDF + FYM 10 t/ha, NPK 125% RDF and NPK 100% RDF- DAP. Application of NPK 50% RDF + FYM 10 t/ha recorded maximum phosphorus (38.7 kg/ha) and NPK 100% RDF + FYM 10 t/ha recorded maximum potassium (279.6 kg/ha) compared to other treatments (Table 3.84).

Table 3.84 : Permanent Manurial Trial in maize - wheat system- Effect on soil properties after maize crop – Ballowal Saunkhri

Treatment	pH	OC (%)	Phosphorus (kg/ha)	Potassium (kg/ha)
Control	7.6	0.32	26.1	149.9
N 100% RDF	7.7	0.41	27.5	183.0
NP 100% RDF	7.7	0.44	31.5	198.0

Treatment	pH	OC (%)	Phosphorus (kg/ha)	Potassium (kg/ha)
NPK 100% RDF- DAP	7.6	0.46	32.4	204.4
NPK 100% RDF- SSP	7.7	0.41	27.5	187.5
NPK 100% RDF + $ZnSO_4$	7.6	0.40	24.5	217.0
NPK 50% RDF + FYM 10 t/ha	7.7	0.49	38.7	259.1
NPK 100% RDF + FYM 10 t/ha	7.6	0.50	31.4	279.6
NPK 125% RDF	7.7	0.46	29.7	213.6
CD at 5%	NS	0.05	5.9	67

In the Permanent Manurial Trial (PMT) in maize based cropping system at Rakh Dhiansar, maximum grain yield of maize (1705 kg/ha) was obtained with application of 50% recommended NPK + 50% N through FYM. However, highest net returns of Rs.5521/ha were realized with the application of 100% recommended NPK + $ZnSO_4$ @ 20 kg/ha. Similar trend was observed in B:C ratio. Application of 50% recommended NPK + 50% N through FYM recorded maximum RWUE of 2.91 while control evinced the minimum RWUE of 1.34 kg/ha-mm. The combined data for the last 13 years (2003-2015) revealed that recommended dose of NPK (60:40:20) coupled with 20 kg $ZnSO_4$/ha recorded the highest mean grain yield of 2110 kg/ha followed by application of 100% recommended dose of NPK and application of 50% recommended NPK + 50% N through FYM with grain yield of 1956 and 1935 kg/ha, respectively (Table 3.85).

Table 3.85 : Effect of nutrient management in maize on yield and economics - Rakh Dhiansar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2015)	Mean grain (13 years)	Stover				
Control	783	1054	2057	17100	-2657	0.84	1.34
100% recommended NPK (60:40:20 kg/ha)	1467	1956	2928	20245	5173	1.26	2.48
50% recommended NPK	1008	1454	2438	18673	-395	0.98	1.72
50% recommended N (crop residue)	1042	1419	2377	20400	-1730	0.92	1.78
50% recommended N (FYM)	1075	1447	2235	23100	-4160	0.82	1.84
50% recommended NPK + 50% N (crop residue)	1517	1808	3077	23073	3534	1.15	2.59
50% recommended NPK + 50% N (FYM)	1705	1935	3233	24673	4826	1.20	2.91
FYM @ 10 t/ha	1417	1610	2788	25100	-376	0.99	2.42
100% recommended NPK + $ZnSO_4$ @ 20 kg/ha	1482	2110	2981	20445	5521	1.27	2.54
Farmer's method (FYM @ 4 t/ha + 40 kg urea/ha)	1375	1642	2722	21566	2454	1.11	2.35
CD at 5%	241	-	-	-	-	-	-

The soil pH of different treatments ranged from 6.34 to 6.45. The maximum organic carbon content (0.5%) was recorded with application of FYM @ 10 t/ha followed by 50% recommended NPK + 50% N through FYM, and 50% recommended NPK + 50% N through crop residue. Integration of 50% recommended NPK + 50% N through FYM recorded maximum available nitrogen of 217.9 kg/ha followed by application of 50% recommended NPK + 50% N through crop residue (213.7 kg/ha) (Table 3.86).

Table 3.86 : Effect of nutrient management on soil chemical properties - Rakh Dhiansar

Treatment	pH	OC (%)	Available nutrients (kg/ha)		
			N	P	K
Control	6.39	0.29	138.3	12.8	79.8
100% recommended NPK	6.34	0.35	173.9	14.5	108.3
50% recommended NPK	6.35	0.30	163.4	13.1	85.5
50% recommended N (crop residue)	6.34	0.33	165.5	14.7	96.9
50% recommended N (FYM)	6.35	0.34	178.1	15.5	100.7
50% recommended NPK + 50% N (crop residue)	6.40	0.44	213.7	17.3	134.9
50% recommended NPK + 50% N (FYM)	6.45	0.49	217.9	17.1	131.1
FYM @ 10 t/ha	6.38	0.51	199.1	16.6	133.0
100% recommended NPK + $ZnSO_4$ @ 20 kg/ha	6.35	0.37	180.2	15.3	117.8
Farmer's method (FYM @ 4 t/ha + 40 kg urea/ha)	6.37	0.38	190.7	15.4	106.4
CD at 5%	0.04	0.05	22.7	2.34	19.04

The residual effect of organic and inorganic sources of plant nutrition in maize gobi sarson system under PMT at Rakh Dhiansar, significantly higher gobhi sarson yield of 875 kg/ha, highest net returns (Rs. 15805/ ha), B:C ratio (2.13), and RWUE (7.40 kg/ha/mm) were recorded with FYM @ 10 t/ha applied during *Kharif* and it was followed by application of 50% recommended NPK + 50% N through FYM with seed yield of 792 kg/ha. The lowest gobhi sarson yield was obtained (358 kg/ha) in the control. The combined analysis of thirteen years data revealed that the highest gobhi sarson equivalent yield of 1175 kg/ha was recorded with application of FYM @ 10 t/ha to maize (Table 3.87).

Table 3.87 : Effect of nutrient management 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)
	Grain 2015-16	Mean yield (13 years)				
Control	358	546	13950	-1778	0.87	3.03
100% recommended NPK (60:40:20 NPK kg/ha)	523	839	13950	3845	1.28	4.42
50% recommended NPK	414	748	13950	127	1.01	3.50
50% recommended N (crop residue)	448	728	13950	1282	1.09	3.79
50% recommended N (FYM)	542	896	13950	4470	1.32	4.58
50% recommended NPK + 50% N (crop residue)	561	978	13950	5130	1.37	4.74
50% recommended NPK + 50% N (FYM)	792	1106	13950	12982	1.93	6.70
FYM @ 10 t/ha	875	1175	13950	15805	2.13	7.40
100% recommended NPK + $ZnSO_4$ @ 20 kg/ha	506	895	13950	3250	1.23	4.28
Farmer's method (FYM @ 4 t/ha + 40 kg urea/ha)	582	982	13950	5845	1.42	4.92
CD at 5%	59.4	-	-	-	-	-

At Rakh Dhiansar, in the experiment on INM in pearlmillet, significantly higher grain yield of 2798 kg/ha was obtained with application of 100% NPK through fertilizer which was at par with application of 75% N through inorganic + 25% N through vermicompost (2648 kg/ha). The maximum B:C ratio, net returns and RWUE of 4.79, Rs.32696/ha and 4.79, respectively were obtained with 100% NPK. The combined data for the last three years revealed that the recommended dose of NPK recorded highest mean grain yield of pearlmillet (2887 kg/ha) followed by 75% N inorganic + 25% N through vermicompost with grain yield of 2637 kg/ha (Table 3.88).

Table 3.88: Effect of nutrient management on pearlmillet yield and economics - Rakh Dhiansar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain 2015	Mean yield (3 years)	Stover				
Control	1593	1554	3735	14200	14097	1.99	2.72
100% NPK (50:30:15)	2798	2887	5730	15772	32696	3.07	4.79
75% N inorganic +25% N FYM	2491	2470	5380	16909	26654	2.58	4.26
50% N inorganic + 50% N FYM	2328	2240	5135	18048	22826	2.26	3.98
100% N FYM	2259	2188	5259	18400	21683	2.18	3.86
75% N inorganic +25% N VC	2648	2637	5537	18659	27383	2.47	4.53
50% N inorganic + 50% N VC	2519	2431	5407	21548	22452	2.04	4.31
100% N VC	2343	2331	5269	24650	16635	1.67	4.01
CD at 5%	310	-	405	-	-	-	-

VC: Vermicompost

The effect of nutrient management on soil properties showed that pH of different treatments ranged from 6.50 to 6.56. Organic carbon varied from 0.28 to 0.41% and highest organic carbon was obtained with application of 100% N through vermicompost followed by 100% N through FYM. The higher value of nitrogen and phosphorus (197.0 and 16.96 kg/ha), respectively was recorded with application of 75% N inorganic + 25% N through vermicompost (Table 3.89).

Table 3.89 : Nutrient managment in pearlmillet - Effect on soil chemical properties - Rakh Dhiansar

Treatment	pH	OC (%)	Available nutrients (kg/ha)		
			N	P	K
Control	6.55	0.28	153.0	12.61	106.4
100% NPK (50:30:15)	6.50	0.31	178.1	14.93	119.7
75% N inorganic + 25% N (FYM)	6.52	0.33	173.9	14.83	117.8
50% N inorganic + 50% N (FYM)	6.53	0.36	182.3	15.76	129.2
100% N (FYM)	6.51	0.40	177.9	15.58	125.4
75% N inorganic + 25% N (VC)	6.54	0.36	190.7	16.69	131.1
50% N inorganic + 50% N (VC)	6.56	0.38	197.0	16.96	133.0
100% N (VC)	6.54	0.41	184.4	16.04	127.3
CD at 5%	NS	0.03	17.3	1.15	14.53

VC-Vermicompost

At Rakh Dhiansar, significantly higher seed yield (806 kg/ha) of gobhi sarson was obtained with the application of 100% N through vermicompost (VC) which was statistically at par with application of 100% N through FYM. Similarly, maximum B:C ratio, net returns and RWUE (2.20, Rs. 14964/ha and 6.81, respectively) was obtained with application of 100% N through VC. The combined data for the last three years revealed that the 100% N through vermicompost recorded highest mean seed yield of gobhi sarson (1030 kg/ha) followed by 100% N through FYM (Table 3.90).

Table 3.90 : Effect of nutrient management on gobhi sarson yield and economics-Rakh Dhiansar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (kg/ha)	Mean yield (3 years)	Stover				
Control	352	571	1524	12425	-462	0.96	2.97
100% NPK (50:30:15)	444	726	1761	12425	2686	1.22	3.76
75% N inorganic +25% N (FYM)	491	773	1796	12425	4260	1.34	4.15
50% N inorganic + 50% N (FYM)	630	868	2260	12425	8982	1.72	5.32
100% N (FYM)	759	993	2672	12425	13390	2.08	6.42
75% N inorganic +25% N (VC)	593	827	2135	12425	7723	1.62	5.01
50% N inorganic + 50% N (VC)	716	922	2566	12425	11910	1.96	6.05
100% N (VC)	806	1030	2843	12425	14964	2.20	6.81
CD at 5%	114	-	367	-	-	-	-

In an evaluation of foliar application of nutrients on wheat performance at Rakh dhiansar, significantly higher wheat grain yield of 2044 kg/ha was obtained with combined foliar spray of 0.5% K (KCl) + 0.5% N (urea) during dry spells and it was statistically at par with the T3 with combined foliar spray of 0.5% K (KNO_3) + 0.5% N (urea) with grain yield of 1819 kg/ha. The lowest grain yield (1055 kg/ha) was obtained in the control. The highest net returns of Rs. 27556/ha were obtained with treatment T5 followed by T6 where in foliar spray of 0.5% N (urea) was applied (Rs 20917/ha). Similar trend was observed in B:C ratio. RWUE was found to be maximum in T5 (22.88 kg/ha-mm) (Table 3.91).

Table 3.91 : Effect of foliar spray 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)
	Grain	Straw				
T_1: Control (no spray)	1055	2209	17800	7392	1.42	11.62
T_2: Foliar spray of 0.5% K (KNO_3)	1614	3214	40588	-2717	0.93	17.77
T_3: T_2 + foliar spray of 0.5% N (urea)	1819	3408	42073	-238	0.99	20.04
T_4: Foliar spray of 0.5% K (KCl)	1708	3361	19637	20287	2.03	18.81
T_5: T_4 + foliar spray of 0.5% N (urea)	2044	3756	19672	27556	2.40	22.88
T_6: Foliar spray of 0.5% N (urea)	1742	3383	19612	20917	2.07	19.18
T_7: Foliar spray of water	1475	3039	19571	15447	1.79	16.24
CD at 5%	290	-	-	-	-	-

Wheat crop under different treatments

3.2.4 Energy management

In tillage and nutrient management study for maize-wheat cropping sequence at Ballowal Saunkhri, conventional tillage + interculture was better than other treatments in terms of yield. In case of nitrogen application, 100% recommended N through inorganic source gave highest yield, however it was statistically at par with application of 50% N through organic source+ 50% N through inorganic source. Conventional tillage (CT) + interculture with 100% recommended N through inorganic source gave highest maize yield (2322 kg/ha) with higher net returns (Rs.11182/ha), B:C ratio (1.39) and RWUE (7.52 kg/ha-mm) followed by 50% conventional tillage + interculture with 50% N through organic + 50% through inorganic source and both the treatments were statistically at par. Similar trend was observed in case of wheat crop (Table 3.92 & 3.93).

Table 3.92 : Influence of tillage and sources of nitrogen on the yield and economics of maize in maize-wheat sequence – Ballowal Saunkhri

Treatment	Grain yield (kg/ha)	Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1F_1	1890	3989	36083	-3738	0.90	6.12
T_1F_2	1946	4242	31422	2005	1.06	6.30
T_1F_3	2322	5144	28786	11182	1.39	7.52
T_2F_1	1548	3201	31895	-5468	0.83	5.02
T_2F_2	1895	3956	30075	2300	1.08	6.14
T_2F_3	2262	4599	27433	11096	1.40	7.33
T_3F_1	1842	3983	31183	428	1.01	5.97
T_3F_2	1926	4107	29094	3903	1.13	6.24
T_3F_3	2034	4394	26251	8660	1.33	6.59
Mean	1963	4180	30247	3374	1.13	6.36

T_1 = Conventional tillage (CT) + interculture; T_2 = 50% CT + interculture; T_3 = 50% CT + interculture + chemical weed control; F_1 = 100% N through organic source; F_2 = 50% N through organic source + 50% N through inorganic source; F_3 = 100% N through inorganic source

Table 3.93 : Influence of tillage and sources of nitrogen on the yield and economics of wheat in maize-wheat sequence – Ballowal Saunkhri

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1F_1	1792	2548	40448	-4205	0.90	10.9
T_1F_2	1847	2929	39733	-1316	0.97	11.2
T_1F_3	2131	3406	34100	10313	1.30	12.9
T_2F_1	1470	2291	36350	-5906	0.84	8.9
T_2F_2	1531	2503	35640	-3538	0.90	9.3
T_2F_3	1790	2839	29980	7254	1.24	10.8
T_3F_1	1576	2579	37929	-4860	0.87	9.6
T_3F_2	1834	2664	34567	2729	1.08	11.1
T_3F_3	1798	2652	30873	5830	1.19	10.9
Mean	1752	2712	35513	700	0.90	10.6

T_1 = Conventional tillage (CT) + interculture; T_2 = 50% CT + interculture; T_3 = 50% CT + interculture + chemical weed control; F_1 = 100% N through organic source; F_2 = 50% N through organic source + 50% N through inorganic source; F_3 = 100% N through inorganic source

At Ballowal Saunkhri, during *kharif* 2015, conventional tillage + interculture was better than other treatments with highest maize yield (2053 kg/ha), net returns (Rs.3150/ha), B:C ratio (1.12) and RWUE (6.6 kg/ha-mm). In case of nitrogen application, 100% through inorganic source gave highest yield (2206 kg/ha), net returns (Rs.10313/ha), B:C ratio (1.37) and RWUE (7.1 kg/ha-mm). However, it was statistically at par with application of 50% N through organic source + 50% N through inorganic source. The input energy requirement of maize increased with increase in inorganic source of nitrogen. Application of 100% N through organic source and 50% N through organic source + 50% N through inorganic source saved 24.9% and 7.9% input energy over 100% N through inorganic source in case of maize. The output energy production was highest with 100% N through inorganic source followed by 50% N through organic source + 50% N through inorganic source. The energy use efficiency of maize was maximum under 50% (CT) + interculture + herbicide followed by 100% CT and 50% (CT) + interculture treatments (Table 3.94).

Table 3.94 : Influence of tillage and sources of nitrogen on the yield and economics of maize in maize-wheat sequence – 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)	Input energy (MJ/ha)	Output energy (MJ/ha)	Energy use efficiency
	2015	Mean (15 years)								
Tillage										
T_1	2053	2582	4459	32097	3150	1.12	6.6	9362	85905	9.17
T_2	1902	2266	3919	29801	2643	1.10	6.2	8434	76939	9.08
T_3	1934	2401	4161	28843	4331	1.16	6.3	8699	80449	9.32
CD at 5%	NS		NS	233	NS	NS	NS		NS	NS
Source of nitrogen										
F_1	1760	2185	3724	33054	-2926	0.91	5.7	7777	72430	9.31
F_2	1922	2412	4102	30197	2736	1.09	6.2	9004	79528	8.85
F_3	2206	2652	4712	27490	10313	1.37	7.1	9715	91334	9.40
CD at 5%	153		443	119	2489	0.08	0.5		7230	NS

T1 = Conventional tillage (CT) + interculture; T2 = 50 % CT + interculture; T3 = 50 % CT + interculture + chemical weed control; F1 = 100% N through organic source; F2 = 50 % N through organic source + 50% N through inorganic source; F3 = 100% N through inorganic source

Similarly, during *rabi* 2015-16, rainfed wheat with conventional tillage + interculture recorded higher yield (1923 kg/ha), net returns (Rs. 1597/ha) and B:C ratio (1.05). In case of nitrogen application, 100% N through inorganic source gave highest yield (1906 kg/ha) with net returns (Rs. 7799/ha) and B:C ratio (1.24). However, it was statistically at par with application of 50% N through organic source + 50% N through inorganic source. The input energy requirement of wheat increased with increase in inorganic source of nitrogen. Application of 100% N through organic source and 50% N through organic source + 50% N through inorganic source saved 21.1% and 7.9% input energy over 100% N through inorganic source. The output energy production was highest with 100% N through inorganic source followed by 50% N through organic source + 50% N through inorganic source. The energy use efficiency of wheat was maximum under 100% CT followed by 50% CT + interculture + herbicide and 50% CT + interculture (Table 3.95).

Table 3.95 : Influence of tillage and sources of nitrogen on the yield and economics of wheat in maize-wheat sequence – Ballowal Saunkhri

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Input energy (MJ/ha)	Output energy (MJ/ha)	Energy use efficiency
	2015-16	Mean (15 years)							
Tillage									
T_1	1923	2384	2961	38093	1597	1.05	10424	65279	6.26
T_2	159	1988	2544	33990	-730	0.99	9451	55281	5.86
T_3	173	2196	2632	34456	1233	1.05	9601	58420	6.12
CD at 5%	235.0		356	266	3932	0.11		6518	0.69
Source of nitrogen									
F_1	1613	1983	2473	38242	-4990	0.87	8797	54621	6.22
F_2	1737	2189	2698	36646	-708	0.98	10025	59268	5.91
F_3	1906	2397	2966	31651	7799	1.24	10655	65091	6.11
CD at 5%	181.5		255	205	2744	0.08		4230	0.43

T1 = Conventional tillage (CT) + interculture; T2 = 50 % CT + interculture; T3 = 50 % CT + interculture + chemical weed control; F1 = 100 % N through organic source; F2 = 50% N through organic source + 50% N through inorganic source; F3 = 100% N through inorganic source

At Ballowal Saunkhri, among the two tillage practices i.e. conventional and tillage with rotavator in maize, no significant difference was observed in terms of yield. Highest grain yield (2572 kg/ha), net returns (Rs. 10982/ha) B:C ratio (1.34) and RWUE (7.0 kg/ha-mm) was recorded with the conventional tillage whereas in case of fertility treatments the highest grain yield (2944 kg/ha) with a net returns (Rs. 20255/ha), B:C ratio (1.70) and RWUE (8.0 kg/ha-mm) was recorded with 80 kg/ha N through urea followed by 40 kg/ha N through compost + 40 kg/ha N through urea (2862 kg/ha). High input energy was required for maize crop sown with conventional tillage (CT) than sowing with rotavator. The output energy production was highest with conventional tillage in maize (86424 MJ/kg). Among nitrogen sources, lowest input energy for maize (5481 MJ/kg) cultivation was consumed under control (no nitrogen application). But maximum output energy in maize was recorded when recommended dose of nitrogen (80 kg/ha) was applied to maize and it was 47.8% higher than control. However, maximum energy use efficiency of 11.1 was recorded when only 50% recommended nitrogen (40 kg/ha) was applied to maize (Table 3.96).

Table 3.96 : Influence of tillage and sources of nitrogen on the yield and economics of maize in maize-wheat sequence - Ballowal Saunkhri

Treatment	Grain yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Input energy (MJ/ha)	Output energy (MJ/ha)	Energy use efficiency
	2015-16	Mean (5 years)							
Tillage									
T1	2572	2835	32124	10982	1.34	7.0	9466	86424	9.3
T2	2361	2489	28223	11342	1.40	6.4	8871	79149	9.3
CD at 5%	NS		276	NS	NS	NS		NS	NS
Source of N									
F1	1593	1759	27216	-572	0.98	4.3	5481	52828	9.7
F2	2607	2798	28509	15150	1.54	7.1	7933	87103	11.1
F3	2944	3238	29267	20255	1.70	8.0	10357	101064	9.8
F4	2522	2597	30274	11958	1.40	6.8	10262	84246	8.6
F5	2862	3100	32861	15028	1.46	7.8	9315	95107	10.3
F6	2271	2480	32915	5152	1.16	6.2	11663	76372	6.5
CD at 5%	281		222	4396	0.15	0.76		8629	1.00

T1: Conventional tillage (CT) ; T2: Tillage with Rotavator ; F1: Control; F2: 40 kg N/ha (urea); F3: 80 kg N/ha; F4: 20 kg N/ha (compost) + 20 kg N/ha; (urea); F5: 40 kg N/ha (compost) + 40 kg N/ha (urea); F6: 20 kg N/ha (compost) + 20 kg N/ha (green leaf)

At Ballowal Saunkhri, among the two tillage practices i.e. conventional and Tillage with rotavator in wheat, no significant difference was observed in terms of yield. Highest grain yield (2234 kg/ha), net returns (Rs.11167/ha) B:C ratio (1.31) and RWUE (13.54 kg/ha-mm) was recorded with the conventional tillage whereas in case of fertility treatments the highest grain yield (2493 kg/ha), net returns (Rs.19733/ha), B:C ratio (1.59) and RWUE (15.11 kg/ha-mm) was recorded with 80 kg/ha N through urea followed by 40 kg/ha N through compost + 40 kg/ha N through urea (2402 kg/ha). High input energy was required for wheat crop sown with conventional tillage (CT) than sowing with rotavator. The output energy production was highest with conventional tillage in wheat (78914 MJ/kg). The energy use efficiency of wheat was highest i.e. 8.84 with rotavator sowing. Among nitrogen sources, lowest input energy for wheat (5592 kg/ha) cultivation was consumed under control (no nitrogen application). But maximum output energy in wheat was recorded when recommended dose of nitrogen (80 kg/ha) was applied. However, maximum energy use efficiency of 10.1 in wheat was under control treatment (Table 3.97).

Table 3.97 : Influence of tillage and sources of nitrogen on the yield and economics of rainfed wheat in maize-wheat cropping sequence – Ballowal Saunkhri

Treatment	Grain yield (kg/ha) 2015-16	Grain yield (kg/ha) Mean (5 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Inputenergy (MJ/ha)	Output energy (MJ/ha)	Energy use efficiency
Tillage									
T1	2234	2249	35518	11167	1.31	13.54	9382	78914	8.62
T2	2091	2170	31716	13201	1.41	12.67	8974	74985	8.84
CD at 5%	NS		279	NS	NS	NS		NS	NS
Source of N									
F1	1572	1563	28592	4809	1.17	9.53	5592	55623	10.06
F2	2199	2327	32489	14131	1.44	13.33	8016	77913	9.78
F3	2493	2610	33309	19733	1.59	15.11	10440	89146	8.56
F4	2183	2175	34242	12019	1.35	13.23	10213	80315	8.33
F5	2402	2514	36868	13751	1.38	14.56	9216	84143	9.20
F6	2126	2069	36202	8662	1.24	12.88	11592	74558	6.43
CD at 5%	171		195	3520	0.11	1.03		6954	0.94

T1: Conventional tillage (CT) ; T2: Tillage with rotavator (RTV); F1: Control; F2: 40 kg N/ha (urea); F3: 80 kg N/ha; F4: 20 kg N/ha (compost) + 20 kg N/ha; (urea); F5: 40 kg N/ha (compost) + 40 kg N/ha (urea); F6: 20 kg N/ha (compost) + 20 kg N/ha (green leaf)

At Rakh Dhiansar, the effect of different tillage and nutrient management practices indicated that there were significant differences among the tillage treatments as well as treatments on nutrient management. The tillage treatment 50% conventional tillage + herbicide + interculture recorded the highest grain yield of 1850 kg/ha and among the nutrient management treatments 100% N through inorganic fertilizer recorded higher grain yield. Data on interactions of different tillage and nutrient management practices revealed that treatment combination 50% CT + herbicide + interculture and 100% N through inorganic fertilizers recorded highest grain yield in wheat (1995 kg/ha). Similar trend was observed in case of net returns, B:C ratio and RWUE (Table 3.98).

Table 3.98 : Effect of different tillage and nutrient management practices on wheat yield and economics –Rakh Dhiansar

Main treatment	Sub treatment	Yield (kg/ha) Grain	Yield (kg/ha) Stover	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Conventional tillage (CT) + interculture	100% N (organic manure)	1510	3355	21940	14885	1.68	16.63
	50% N (inorganic + 50% N organic)	1620	3940	22010	18860	1.86	17.84
	100% N (inorganic fertilizers)	1710	4260	19615	23930	2.22	18.83

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				
50% CT + interculture	100% N (organic manure)	1625	3080	20275	17232.5	1.85	17.90
	50% N (inorganic + 50% N organic)	1685	3610	20015	20542.5	2.03	18.56
	100% N (inorganic fertilizers)	1810	3990	17660	26355	2.49	19.93
50% CT + herbicide + interculture	100% N (organic manure)	1710	3440	20750	19515	1.94	18.83
	50% N (inorganic + 50% N organic)	1845	3980	20670	23847.5	2.15	20.32
	100% N (inorganic fertilizers)	1995	4295	19910	28192.5	2.42	21.97
CD at 5%		170	-	-	-	-	-

3.2.5 Evaluation of improved varieties

At Arjia, in a trial to assess the performance of 13 horsegram cultivars, cultivar BSP 15-2 recorded highest seed yield, B:C ratio and RWUE (352 kg/ha, 2.72 and 0.78 kg/ha-mm) closely followed by VLG 41 (338 kg/ha, 2.68 and 0.74 kg/ha-mm). The cultivar VLG 41 gave highest stover yield (2764 kg/ha) followed by "CRHG 22" (2704 kg/ha) (Table 3.99).

Table 3.99 : Yield and economics of horsegram cultivars – Arjia

Cultivar	Days to maturity	Seed yield (kg/ha)	Stover yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
BSP 15-1	110	102	1422	-462	0.97	0.23
CRHG 25	100	92	1569	-792	0.94	0.20
BHG 13-1	105	145	1741	4133	1.30	0.32
VLG 15 ©	93	172	1514	5453	1.40	0.38
BSP 15-2	99	352	2578	23659	2.72	0.78
VLG 40	98	101	598	-3566	0.74	0.22
BGHG 1	96	165	1243	3936	1.29	0.36
AK 42 ©	89	182	1420	5921	1.43	0.40
VLG 41	97	338	2764	23189	2.68	0.74
Bastar Kulthi 15	103	101	485	-3945	0.71	0.22
CRHG 22 ©	99	277	2704	18112	2.31	0.61
CRHG 24	102	205	1958	9664	1.70	0.45
CRHG 19 ©	98	127	753	-885	0.94	0.28
C D at 5%	3.88	26.43	235.37	-	-	-

Performance of horsegram variety AK 53 (Pratap Kulthi-2)

At Arjia, in a study on ten blackgram cultivars, cultivar KPU 11-39 gave highest seed and stalk yield (219 and 619 kg/ha), net returns (Rs.14847/ha) B:C ratio (1.93) and RWUE (0.48 kg/ha-mm) followed by KPU 129-104 (206 kg/ha) under *in-situ* moisture conservation practice (Table 3.100).

Table 3.100 : Yield and economics of blackgram cultivars with *in-situ* moisture conservation - Arjia

Cultivar	Days to maturity	Seed yield (kg/ha)	Stalk yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
KPU 11-39	71	219	619	14847	1.93	0.48
KPU 129-104	74	206	590	13124	1.83	0.45
KPU 12-1733	77	150	398	5039	1.32	0.33
KPU 525-64	73	179	427	8845	1.56	0.39
KPU 524-65	72	185	552	10209	1.64	0.41
KPU 12-1730A	76	171	473	8055	1.51	0.38
KPU 12-213 A	77	98	329	-1850	0.88	0.22
Pratap U -1 ©	76	119	352	880	1.06	0.26
KU 96-3 ©	73	158	458	6413	1.40	0.35
Pant U - 31 ©	72	151	377	5080	1.32	0.33
CD at 5%	2.0	25.2	68.5			

Performance of blackgram cultivars with *in-situ* moisture conservation practice

At Arjia, among eight pigeonpea cultivars evaluated, cultivar ICPL 88039 recorded highest seed yield (1147 kg/ha), net returns (Rs. 130473/ha) B:C ratio (9.21) and RWUE (2.53 kg/ha-mm) closely followed by Pusa 992 (1098 kg/ha, Rs.124515/ha, 8.83 and 2.42 kg/ha-mm respectively). The cultivar Pusa 992 gave highest stalk yield (3154 kg/ha) followed by ICPL 88039 (3036 k g/ha). The maturity of the cultivars ranged from 133 days (Manak) to 141 days (ICPL-87) (Table 3.101).

Table 3.101 : Yield and economics of pigeonpea cultivars - Arjia

Cultivar	Days to maturity	Seed yield (kg/ha)	Stalk yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
ICPL 88039	134	1147	3036	130473	9.21	2.53
Pusa 991	137	997	2817	111483	8.01	2.20
Pusa 992	135	1098	3154	124515	8.83	2.42
Pusa Siphani	135	773	2073	82744	6.20	1.70
Paras	137	479	1759	45711	3.87	1.06
Manak	133	584	1633	58758	4.70	1.29
ICPL-87	141	679	2363	71315	5.49	1.50
UPAS 120	139	755	2445	80946	6.09	1.66
CD at 5%	6.49	112.7	345.1	-	-	-

At Ballowal Saunkhri, among the four castor varieties evaluated, DCH 177 gave highest seed yield (1443 kg/ha) followed by DCH 519 (1355 kg/ha) with net returns of Rs. 32462/ha, B:C ratio of 2.36 and RWUE of 6.71 kg/ha-mm. The yield increased by 64 and 54%, respectively over the local variety (Table 3.102).

Table 3.102 : Yield and economics of different cultivars of castor – Ballowal Saunkhri

Cultivar	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	2015	Mean (2 years)				
GCH 07	1301	1279	22917	27822	2.21	6.05
DCH 177	1443	1505	23815	32462	2.36	6.71
DCH 519	1355	1376	23319	29526	2.27	6.30
Local	881	735	20979	13380	1.64	4.09
CD at 5%	227.81	-	-	-	-	-

At Ballowal Saunkhri, among the 10 maize hybrids evaluated under rainfed conditions, highest grain yield (5867 kg/ha), stover yield (6106 kg/ha), net returns (Rs. 56062/ha), B:C ratio (2.77) and RWUE (14.14 kg/ha-mm) was recorded in PMH 4 (check) followed by PMH 2 (checks) and no genotype under evaluation was superior to the check genotypes (Table 3.103).

Table 3.103 : Yield and economics of maize hybrids - Ballowal Saunkhri

Hybrid	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
JH31820	4253	5306	30554	34294	2.12	10.25
JH31605	4867	5456	31000	42444	2.37	11.73
PMH 1 (C)	4353	4762	30626	35078	2.15	10.49
JH 31613	3933	4464	30321	29205	1.96	9.48
Prakash (C)	4144	4688	30474	32230	2.06	9.99
JH 31604	4350	4784	30624	35060	2.14	10.49
PMH 2 (C)	5772	6032	31657	53935	2.70	13.92
JH 31610	5386	5650	31376	50060	2.60	12.98
PMH 4 (C)	5867	6106	31726	56062	2.77	14.14
JH 31784	4894	5232	31019	43603	2.41	11.80
CD at 5%	1267.5	1536.4	-	-	-	-

At Ballowal Saunkhri, among the four taramira varieties evaluated, TMLC 2 gave highest seed yield of 824 kg/ha with net returns of Rs. 37013/ha, B:C ratio of 3.98 and RWUE of 7.92 kg/ha-mm. The mean of two years yield (855 kg/ha) was highest in TMLC 2 followed by RTM 2002 (678 kg/ha) (Table 3.104)

Table 3.104 : Yield and economics of varieties of taramira - Ballowal Saunkhri

Variety	Seed yield (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015-16	Mean (2 years)			
RTM 2002	649	678	26513	3.13	6.24
RTM 314	418	492	12653	2.02	4.02
RTM 1355	560	560	21173	2.70	5.38
T 27	382	615	10493	1.84	3.67
TMLC 2	824	855	37013	3.98	7.92
CD at 5%	108.53	-	-	-	-

At Ballowal Saunkhri, among five varieties of barley, all growth attributes were non significant among varieties, days to flowering ranged from 53 to 54, the plant height ranged from 100 cm in RTM 2002 to 121 cm in TMLC 2, primary branches ranged from 4 to 5, secondary branches ranged from 9 to 10, number of pods/plant ranged from 133 to 183 and 1000-seed wt. ranged from 2.72 to 3.45 g. The highest yield (824 kg/ha) was recorded with variety TMLC 2 followed by RTM 2002 (649 kg/ha) (Table 3.105).

Table 3.105 : Yield attributes and yield of barley varities - Ballowal Saunkhri

Variety	Days to flowering	Plant height (cm)	Primary branches	Secondary branches	Number of pods/plant	Grain yield (kg/ha)	1000-seed wt. (g)
RTM 2002	54	100	4	9	162	649	2.72
RTM 314	53	101	4	10	134	418	3.01
RTM 1355	53	105	5	9	183	560	3.34
T 27	54	105	4	9	154	382	3.11
TMLC 2	57	121	3	10	183	824	3.45
CD at 5%	NS	7	NS	NS	25	108.5	0.35

3.2.6 Alternate land use system

At Arjia, in the existing neem tree rows on marginal land under different methods of sowing of grasses. *Cenchrus* grass sown with mud ball/pellet gave significantly higher dry grass yield (2157 kg/ha) with additional returns of Rs.6927/ha, B:C ratio of 1.70 and RWUE of 3.2 kg/ha-mm. While, lowest grass yield (1876 kg/ha) was recorded in direct seeded sowing, which was 15% higher yield. Further, application of 20 kg N+30 kg P_2O_5/ha increased significantly dry grass yield (2478 kg/ha) but at par with 10 kg N + 15 kg P_2 O_5 /ha (2172 kg/ha). It was 81 & 59% higher over control (1365 kg/ha), respectively. Mean data of four years (2012-2015) revealed that sowing of *Cenchrus* grass with mud ball/pallet gave highest dry grass yield (2098 kg/ha), while, lowest grass yield (1820 kg/ha) was recorded in direct seed sowing. Further, application of 20 kg N + 30 kg P_2O_5 /ha, increased dry grass yield (2246 kg/ha) as compared to control (1532 kg/ha) (Table 3.106).

Table 3.106 : Effect of establishment method and nutrient levels on yield and economics of *Cenchrus* grass in neem plantation - Arjia

Treatment	Grass yield (kg/ha)	Mean (4 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Establishment method						
E1-Direct seed sowing	1876	1820	4038	5529	1.37	2.8
E2-Mud ball/pallet sowing	2157	2098	4076	6927	1.70	3.2
E3- Seed socked 16 hrs in 50 ppm CuSO4	1981	1954	4045	6060	1.50	2.9
CD at 5%	244	-	-	-	-	-
Nutrient level						
N0-Control	1365	1532	3395	3565	1.05	3.2
N1-10kg N+15 kg P	2172	2096	4054	7024	1.73	3.7
N2-20 kg N+ 30 kg P	2478	2246	4712	7925	1.68	0.1
CD at 5%	244	-	-	-	-	-
Interaction	E1		E2			
N0	1261	-	1444	-	-	-
N1	2044	-	2250	-	-	-
N2	2322	-	2778	-	-	-
CD at 5%	423	-	-	-	-	-

The *Cenchrus spp.* recorded highest no. of clumps/m row length (25.2 and 24.1), no. of slips/clump (27.00 and 28.11) and height (85 and 84 cm) with mud ball/pellet sowing (E2) and application of 20 kg N + 30 kg P_2O_5 (N2) treatments, respectively (Table 3.107).

Table 3.107 : Effect of establishment method and nutrient levels on growth attributes of *Cenchrus spp*. - Arjia

Treatment	No. of clumps/m row length	No. of slips/clump	Plant height (cm)
Establishment method			
E_1-Direct seed sowing	20.9	25.11	74
E_2- Mud ball/Pallet sowing (E_2)	25.2	27.00	85
E_3- Seed socked 16 hrs in 50 ppm CuSO4	22.1	26.44	79
CD at 5%	1.8	2.73	5.9
Nutrient level			
N_0 - No fertilizer	20.7	24.67	74
N_1 - 10 kg N+15kg P_2O_5	23.4	25.78	80
N_2- 20 kg N+30 kg P_2O_5	24.1	28.11	84
CD at 5%	1.8	2.73	5.9

Performance of *Cenchrus spp*. with 20 kg N+30 kg P_2O_5/ha

At Ballowal Saunkhri, in a study on guava and amla based agri-horti systems, the growth data in terms of average plant height, collar girth and biomass was 126 cm, 6.4 cm & 51.3 kg/ha in case of amla, while 145 cm, 7.3 cm & 114.3 kg/ha in case of guava, respectively (Table). The yield of blackgram was 224 & 346 kg/ha, respectively in guava and amla plantation. Guava and amla yielded 24550 and 13954 kg/ha fruits, respectively in case of sole fruit plants. However in association with crops, guava gave 28845 kg/ha fruit yield and amla gave 19480 kg/ha fruit yield. The net returns from amla (Rs. 142802/ha) as well as guava (Rs. 512270/ha) based system were higher than sole cultivation of crops and fruit plants (Table 3.108 & 3.109) .

Table 3.108 : Growth of guava and amla crops - Ballowal Saunkhri

Treatment	Plant height (cm)*	Collar diameter (cm)	Canopy spread (cm)		Biomass (kg/tree)
			North - South	East-west	
Guava	145	7.3	128	123	114.3
Amla	126	6.4	142	117	51.3

* Pruning treatment was given to the plants to reduce canopy volume

Table 3.109: Crops yield and economics under different Agro-horti system - Ballowal Saunkhri

Treatment	Yield (kg/ha)			MCEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Main crop (fruit/plantation)	Intercrop (annual crop)	Stover/stalk yield				
Kharif							
Sole blackgram	-	428	1862	1602	20598	5240	1.03
Sole gauva	24550	-	-	24550	56875	434125	8.63
Sole amla	13954	-	-	13954	49734	89806	2.80
Blackgram + guava	28845	224	988	29398	75690	512270	7.77
Blackgram + amla	19480	346	1240	21161	68808	142802	3.08

The area under alternate land use has been divided into three blocks to develop three models *viz.,* i) agriculture + trees on boundary, ii) agriculture + tree in block plantation and iii) silvi-pasture. Among maize, sesame and blackgram sown during *kharif* in model (i) and (ii), sesame gave highest net returns of Rs.6779/ha under situation I & maize Rs.5158/ha under situation II along with B:C ratio of 2.18 & 1.55, respectively and B:C ratio was highest with sesame in both cases. The horticultural plants are in fifth year and in full bearing. So, the net returns from the system/situation-I were Rs. 9580/ha with B:C ratio of 2.99, however from situation-II were Rs.20935/ha with B:C ratio of 6.55. In addition to this, there was employment generation of 93 man-days/ha from situation-I (agriculture + trees on boundary) and 98 from situation-II (agriculture + tree in block plantation) (Table 3.110 & 3.111).

Table 3.110 : Performance of various crops during *kharif* in the farming system-I – Ballowal Saunkhri

Crop	Yield (kg)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	Employment generation (man-days/ ha/yr)
	Grain/Fruit	Straw				
Situation-I (agriculture + trees on boundary) -1 ha						
Maize	1024	1580	9403	6513	1.69	30
Sesame	125	1408	5721	6779	2.18	25
Blackgram	189	840	6697	2648	1.40	25
Guava (6)	234	-	1950	3470	2.42	7
Pomegranate (6)	103	-	2250	6110	3.49	6
System productivity	-	-	26021	25520	11.18	93
Situation-II (agriculture + tree in block plantation) - 1 ha						
Maize	940	1380	9382	5158	1.55	30
Sesame	105	1268	5721	4779	1.84	25
Blackgram	164	640	6679	1341	1.20	25
Guava (14)	643	-	2175	11505	6.02	10
Pomegranate (8)	122	-	1550	9430	7.08	8
System productivity	-	-	25507	32213	17.69	98

Table 3.111 : Yield and growth parameters of kinnow, guava and peach fruit plants – Ballowal Saunkhri

Treatment	Fruit plant growth parameters				
	Fruit yield (kg/tree)	Plant height (m)	Collar diameter (cm)	Tree spread (m)	
				East-West	North-South
Situation-I (agriculture + trees on boundary)					
Kinnow	23.5	4.1	13.3	2.8	2.7
Guava	56.3	3.2	14.6	3.3	3.5
Peach	18.2	4.2	12.3	4.2	4.1
Situation-II (agriculture + tree in block plantation)					
Kinnow	57.0	4.3	15.1	3.3	3.2
Guava	67.3	3.4	13.7	3.7	3.5
Peach	28.1	4.4	10.1	8.7	8.5

During *rabi* 2015-16, no crop was sown due to low moisture in the soil. Kinnow fruit yield (674 kg/ha), with net returns (Rs. 9530/ha) and B:C ratio (2.98) was highest under situation-II (agriculture + tree in block plantation) followed by situation-I (agriculture + trees on boundary) kinnow fruit yield (358 kg/ha), with net returns (Rs. 5610/ha) and B:C ratio (2.92) (Table 3.112).

Table 3.112 : Performance of various crops during *rabi in the farming system-I**

Crop	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Fruit	Straw			
Situation-I (agriculture + trees on boundary) - 1 ha					
Kinnow (24)	358		2650	5610	2.92
Situation-II (agriculture + tree in block plantation) - 1ha					
Kinnow (43)	674		4550	9530	2.98

* No crop was sown during rabi due to low moisture in the soil.

3.2.7 Integrated farming system

At Ballowal Saunkhri, in a study on crop-based integrated farming system, among *kharif* crops sesame gave highest net returns (Rs.23936/ha) and B:C ratio (2.39) followed by greengram (Rs.6389/ha and 1.30, respectively). Among *rabi* crops, linseed gave highest net returns (Rs. 33483/ha) with B:C ratio of 2.51 and it was followed by taramira and wheat with net returns of Rs.12887/ha and Rs.10491/ha. In addition, income was also generated from the sale of fruits (kinnow) (Table 3.113).

Table 3.113 : Performance of different kharif and rabi crops in crop based farming system – Ballowal Saunkhri

Crop	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Seed/grain	Stalk/straw			
Kharif					
Maize	1907	3508	28949	3164	1.11
Blackgram	431	2110	21714	770	1.04
Greengram	486	2819	21371	6389	1.30
Sesame	411	3576	17164	23936	2.39
System productivity			22300	8565	1.46
Rabi					
Wheat	1824	2608	26453	10491	1.40
Raya	478	3631	16789	2331	1.14
Lentil	361	1769	20459	1201	1.06
Taramira	583	3967	10433	12887	2.24
Linseed	556	3722	22117	33483	2.51
Average			19250	12079	1.67
Kinnow (20)	360		3000	4920	2.64
System productivity			16929	11056	1.81

Crop based integrated farming system

3.3 Nutritious Cereal Based Production System

3.3.1 Sorghum Based Production System

3.3.1.1 Rainwater management

In a micro-watershed at Vijayapura, chickpea + sorghum (4:2) recorded highest sorghum equivalent yield of 1268 kg/ha, net returns (Rs.22800/ha), with highest B: C ratio (3.6) and RWUE of 13.0 kg/ha-mm, compared to other crops (Table 3.114).

Table 3.114 : Increasing water productivity in micro-watershed – Vijayapura

Crop	SEY (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha -mm)
	Grain	Stalk				
Kharif						
Cucumber	333	-	9000	4332	1.5	10.4
Bt cotton	395	770	12000	11700	2.0	0.90
Rabi						
Chickpea + sorghum (4:2)	1268	1360	8900	22800	3.6	13.0
Sorghum	974	2000	7500	16860	3.2	10
Sapota + chickpea	230	555	8000	1200	1.2	2.0

SEY: sorghum equivalent yield

In an experiment on catchment-storage-command relationship, during June three runoff events were recorded and 84.7 mm rainfall was received and 150.58 m^3 of water was harvested. During August, only 20 mm rainfall was received and 20.15 m^3 of water was harvested. During September, 137 mm rainfall received and 2000.5 m^3 of water was harvested. On 5.10.2015 one high rainfall event of 89.2 mm occurred in one spell with rainfall intensity of 13.9 mm/hr and the farm pond received 210 m^3 of water (Table 3.115).

Table 3.115 : Amount and intensity of rainfall and volume of water harvested in farm pond - Vijayapura

Date	Rainfall (mm)	Rainfall intensity, * (mm/hr)		Volume of water harvested (cum)	Cumulative volume of water harvested (cum)
		1	2		
30.05.2015	15.5	2.00	3.33	20.15	20.15
01.06.2015	25.0	32.27	3.20	20.45	40.60
12.06.2015	17.2	22.53	0.90	59.22	99.82
16.06.2015	42.5	8.50	-	71.21	171.03
26.08.2015	20.0	10.00	-	20.15	191.16
07.09.2015	41.8	-	-	196.20	387.36
08.09.2015	44.0	22.00	-	600.30	987.66
10.09.2015	51.2	12.80	-	1204.00	2191.66
05.10.2015	89.2	13.90	-	210.00**	2401.00

*Event wise rainfall intensity **Farm pond overflowed

The harvested rainwater was utilized for giving one supplemental irrigation of 5 cm depth at the flowering stage of both chickpea and sorghum crops to mitigate long dry spell, through the sprinkler irrigation system from the harvested rainwater in farm pond. An additional yield of 48.2 and 21.7% was recorded in sorghum + chickpea and chickpea crops, respectively (Table 3.116).

One supplementary irrigation of 5 cm at flowering stage in chickpea and sorghum crops

Table 3.116 : Impact of supplemental irrigation on yield (kg/ha) of sorghum and chickpea - Vijayapura

Crop	SI with 5 cm depth of water		Yield without SI	% yield increase over control
	Seed yield/grain yield (2015-16)	Mean seed/grain yield (5 years)		
Chickpea (in sapota)	560	498	460	21.7
Sorghum* (equivalent yield)	1214	1150	819	48.2

*Sorghum+ chickpea (2:4); SI - Supplemental irrigation

In an SI-Supplemental irrigation for determination of crop factor values, the greengram yield was in the range of 216 to 266 kg/ha. The average greengram yield recorded was 242 kg/ha, with the B:C ratio of 1.8 and RWUE of 8.6 kg/ha-mm. The average sunflower seed yield was 849 kg/ha with the B:C ratio of 4.87 and RWUE of 2.65 kg/ha-mm (Table 3.117).

Table 3.117 : Determination of crop factor values for the prevailing cropping systems - Vijayapura

Crop	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Greengram	242	8250	14709	1.8	8.6
Sunflower	849	5500	26800	4.9	2.6

The crop factor is the ratio of soil loss from land cropped under specified conditions to corresponding soil loss from continuous fallow on identical soil slope and rainfall conditions. The crop factor assessed for the greengram was 0.5 while for sunflower, the crop factor value was 0.56 (Table 3.118).

Table 3.118 : Runoff, soil loss and crop factor values for greengram and sunflower – Vijayapura

Treatment	Rainfall (mm)	Runoff (m^3/ha)	Soil loss (kg/ha)	Crop factor
Greengram				
With crop	9.8	5.97 (6.1%)	0.74	0.5
Without crop	9.8	7.45 (7.6%)	1.47	
Sunflower				
With crop	321.8	1087.88 (33.8%)	2,851.52	0.56
Without crop	321.8	1375.75 (42.7%)	5,092.67	

Runoff plots with multislot measuring divices in Sorghum and Sunflower

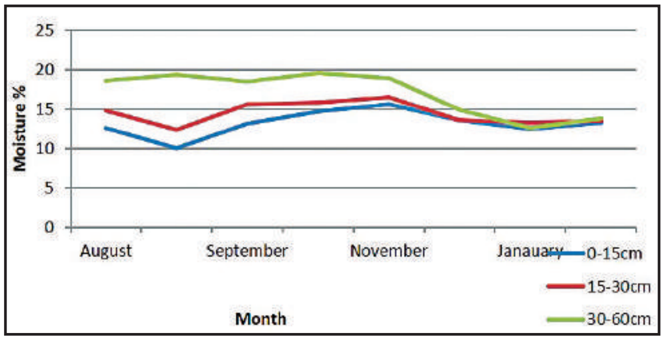


Fig. 3.3 Effect of seasonal moisture variation in sunflower

At Solapur, total rainfall received during the year 2015 was 480.8 mm which was deficit by 36.4% as against normal of 721.4 mm in 32 rainy days. However, there were three runoff producing storms. On 10th and 11th September, 2015 rainfall of 55.0 mm and 37.9 mm, respectively and 3rd October, 2015 rainfall was 38.0 mm which produced the runoff. The water balance components of unlined farm pond are given in Table ... The water was available from 10th September, 2015 (37 SMW) to 22nd October, 2015 (41 SMW) (43 days). The results indicated that total runoff was1479.04 m^3, evaporation losses were 179.62 m^3 (12.14%) and seepage losses were 1296.0 m^3 (87.62%) (Table 3.119).

Table 3.119 : Water balance components of unlined farm pond - Solapur

SMW	Rainfall (mm)	Inflow/runoff (m^3)	Evapo. volume (m^3)	Outflow (m^3)	Seepage losses (m^3)	Balance (m^3)
37	116.0	1085.15	31.08	0	634.19	419.88
38	3.7	0	33.96	0	252.59	133.33
39	0.8	0	42.34	0	88.59	2.4
40	57.5	393.89	33.92	0	224.45	137.92
41	0	0	38.32	0	96.18	3.42
	178.0	1479.04	179.62	0.00	1296.0	0.00
	% of inflow		12.14	0.00	87.62	

The water balance components of concrete lined farm pond are given in Table…. The water was available from 10th September, 2015 (37 SMW) to 22nd October, 2015 (41 SMW) (43 days). The results indicated that total runoff was 501.99 m^3, evaporation losses were 71.85 m^3 (14.31%), seepage losses were 375.86 m^3 (74.83%) and 53.84 m^3(10.73%) water was used for giving protective irrigation to pomegranate and custard apple. Due to which, the yield received from custard apple was 50 kg (Table 3.120).

Table 3.120 : Water balance components of concrete lined farm pond - Solapur

SMW	Rainfall (mm)	Inflow/runoff (m^3)	Evaporation volume (m^3)	Seepage losses (m^3)	Irrigation (m^3)	Balance (m^3)
37	116.0	343.77	6.53	94.67	0	242.57
38	3.7	0	8.07	64.11	0	170.39
39	0.8	0	9.30	32.01	0	129.08
40	57.5	158.22	8.09	53.06	0	226.15
41	0	0	8.72	58.56	0	158.87
42	0	0	8.62	42.38	26.94	80.93
43	0	0	8.22	20.88	0	51.83
44	0	0	6.69	9.31	26.90	8.93
45	0	0	7.61	0.88	0	0.44
	178.00	501.99	71.85	375.86	53.84	
% of inflow			14.31	74.87	10.73	

Outflow: Nil ; SMW-standard meteorological week

Harvested rainwater in farm pond for supplemental irrigation in pomegranate and custard apple

3.3.1.2 Cropping systems

At Vijayapura, the seed cotton yield of Bt. cotton was significantly higher in the planting geometry of 120 cm x 60 cm (770 kg/ha) followed by 120 cm x 45 cm (764 kg/ha). Application of 60:30:30 kg NPK/ha produced significantly higher mean seed cotton yield (1005 kg/ha) compared to application of 30:15:15 kg NPK/ha (955 kg/ha) (Table 3.x). Crop geometry of 120 cm x 45 cm with the application of 60:30:30 kg NPK/ha produced significantly higher seed cotton yield of 1231 kg/ha compared to rest of the treatments (Table 3.121 & 3.122).

Crop geometry of 120 cm x 45 cm with the application of 60:30:30 kg NPK/ha in Bt cotton

Crop geometry of 90 cm x 45 cm with the application of 30:15:15 kg NPK/ha in Bt cotton

Table 3.121 : Effect of crop geometry and nutrient management on Bt. cotton yield and economics - Vijayapura

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton	Mean (2 years)	Stalk				
Crop geometry							
90 cm x 45 cm	624	816	2009	16905	31948	3.06	1.40
90 cm x 60 cm	633	902	1512	16265	34991	3.35	1.47
120 cm x 45 cm	764	1154	1585	16265	34641	3.33	1.46
120 cm x 60 cm	770	1053	1157	15765	33724	3.48	1.42
CD at 5%	62	44	60.28	-	4339	0.30	0.13
Nutrient management ($N:P_2O_5:K_2O$ kg/ha)							
30:15:15	748	955	1588	14037	38334	3.73	1.55
45:22.5:22.5	711	963	1582	14455	35344	3.44	1.47
60:30:30	682	1005	1559	15324	32398	3.11	1.41
75:37.5:37.5	650	1003	1533	16300	29229	2.79	1.34
CD at 5%	44	37	27.42	-	3084	020	0.09

Table 3.122 : Interaction effect of crop geometry and nutrient management on seed cotton yield of cotton- Vijayapura

Crop geometry	Nutrient management ($N:P_2O_5:K_2O$ kg/ha)				Mean
	30:15:15	45:22.5:22.5	60:30:30	75:37.5:37.5	
90 cm x 45 cm	779	824	810	850	816
90 cm x 60 cm	903	885	914	907	902
120 cm x 45 cm	1118	1119	1231	1148	1154
120 cm x 60 cm	1019	1025	1063	1107	1053
Mean	955	963	1005	1003	-

At Solapur, in a study on sorghum + maize fodder strip cropping systems, yield was low due to scarcity of rainfall and lower soil moisture availability in *rabi* season crops. Therefore only fodder yield was obtained. The highest green fodder yield (8574 kg/ha) with B:C ratio (0.48) was obtained in sorghum + maize (2:6) followed by sorghum + maize (2:4), sorghum + maize (3:3), sorghum + maize (4:4), sorghum + maize (6:6), sorghum + maize 45 cm (2:1) and sorghum + maize 30 cm (2:1). (Table 3.123).

Table 3.123 : Yield and economics of sorghum + maize fodder strip cropping systems - Solapur

Treatment	Fodder yield of sorghum (kg /ha)	Stover yield of maize (kg/ha)	Cost of cultivation (Rs/ha)	B:C ratio
sole sorghum	1402	0.0	23450	0.34
sole maize	0.00	10819	23450	0.37
sorghum + maize (2:4)	918	8178	23450	0.47
sorghum + maize (2:6)	857	8574	23450	0.48
sorghum + maize (3:3)	872	6834	23450	0.42
sorghum + maize (4:4)	969	5791	23450	0.40
sorghum + maize (6:6)	1113	5373	23450	0.42
sorghum + maize 45 cm (2:1)	907	3980	23450	0.33
sorghum + maize 30 cm (2:1)	836	4132	23450	0.32
CD at 5%	272.0	1294.1	-	0.08

3.3.1.3 Nutrient management

In the Permanent Manurial Trial (PMT) in *rabi* sorghum + chickpea (2:4) rotated with safflower + chickpea (2:4) at Vijayapura, 100% RD (F+FYM) gave maximum equivalent yield of sorghum (2598 and 2162 kg/ha) during 2012 and 2014 and 1362 and 1187 kg/ha of safflower during 2013 and 2015, respectively. Application of crop residue @ 5 t/ha with decomposing culture + RDF was the next best treatment during 2012-2014. The control treatment gave lowest sorghum yield of 1502 and 1478 kg/ha and safflower yield of 690 and 665 kg/ha (Table 3.124).

Table 3.124 : Permanent manurial trial in *rabi* sorghum + chickpea (2:4) rotated with safflower + chickpea (2:4) – Vijayapura

Treatment	Seed yield (kg/ha)		Equivalent yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Safflower	Chickpea	Safflower (2015-16)	Sorghum (2012-13)	Safflower (2013-14)	Sorghum (2014-15)				
Control	292	254	665	1502	690	1478	12838	7109	1.55	6.03
100% RD (F+FYM)	584	412	1187	2598	1362	2162	18430	17185	1.93	10.77
RDN alone	340	330	825	1942	864	1043	13538	11210	1.83	7.49
RD P_2O_5 alone	384	307	834	1900	777	1508	14138	10875	1.77	7.57
RDN and P_2O_5	408	352	924	2037	1033	1418	14732	12974	1.88	8.38
FYM to meet 100% N	344	288	767	1860	948	1657	17138	5862	1.34	6.96
FYM to meet 50% N + 50% RDF	477	404	1070	2280	1301	1727	16486	15601	1.95	9.71
Green manuring to meet 100% N	415	361	945	1906	949	1188	14838	13504	1.91	8.58
Green manuring to meet 50% N + 50% RDF	419	378	973	2245	1275	1704	13838	15357	2.11	8.83
Crop residue with decomposing culture to meet 50% N + 50% RDF	337	344	842	2245	1250	1505	14338	10907	1.76	7.64
Crop residue (5 t/ha) with decomposing culture + RDF	379	284	796	2349	1273	1298	16130	7750	1.48	7.22
CD at 5%	NS	NS	NS	107	110	NS				

100% RDF (NPK kg/ha) : *Rabi* sorghum; 50:25:0; Chickpa; 10:25:0

Different treatments had no significant effect on soil pH. The soil organic C was highest with the treatments involving FYM, green manuring and crop residues compared to control and application of fertilizers alone. The soil available N was higher (208.7 kg/ha) in 50% N through green manuring + 50% RDF application (208.7 kg/ha), available P was higher with RDN and P_2O_5 application (14.9 kg/ha) and available K was higher (439.3 kg/ha) with 50% N through crop residue with decomposing culture + 50% RDF (Table 3.125).

Table 3.125 : Effect of treatments on soil chemical properties – Vijayapura

Treatment	pH	OC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Control	7.73	0.43	164.3	12.5	415.0
100% RD (F+FYM)	7.80	0.37	201.7	13.2	407.0
RDN alone	7.82	0.38	175.3	13.8	394.0
RD P_2O_5 alone	7.96	0.37	194.0	14.2	419.0
RDN and P_2O_5	7.77	0.37	182.7	14.9	424.0
FYM to meet 100% N	7.81	0.49	204.7	12.9	429.7
FYM to meet 50% N + 50% RDF	7.87	0.49	186.3	12.3	437.3
Green manuring to meet 100% N	7.99	0.49	197.7	12.7	436.3
Green manuring to meet 50% N + 50% RDF	7.95	0.46	208.7	11.8	433.3
Crop residue with decomposing culture to meet 50% N + 50% RDF	7.88	0.43	190.3	13.5	439.3
Crop residue (5 t/ha) with decomposing culture + RDF	7.65	0.49	198.0	14.5	434.0
CD at 5%	NS	0.06	12.8	0.5	6.2

RDN-Recommended dose of N

In a study on foliar spray of nutrients for *rabi* sorghum at Vijayapura, RDF + KNO_3 (0.5%) sprays at 45 and 75 DAS was superior with maximum grain yield of 1996 kg/ha, while RDF + foliar spray of mono potassium phosphate (1%) gave lowest yield of 1626 kg/ha. Similarly, spraying KNO_3 (0.5%) resulted in production of higher stover yield (4907 kg/ha), net returns (Rs.38082/ha), B:C ratio (3.14) and RWUE (18.54 kg/ha-mm) (Table 3.126).

Table 3.126 : Effect of foliar spray of nutrients on *rabi* sorghum yield and economics - Vijayapura

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Fodder				
RDF only (50; 25; 0 NPK kg/ha)	1636	3549	16922	28886	2.71	15.20
RDF + water spray at 60 & 90 DAS	1647	3642	17422	28666	2.65	15.30
RDF + KNO_3 (0.5%) spray at 60 & 90 DAS	1996	4907	17806	38082	3.14	18.54
RDF + KNO_3 (1%) spray at 60 & 90 DAS	1821	4856	18190	32798	2.80	16.92
RDF + KCl (0.5%) spray at 60 & 90 DAS	1739	3827	18672	30010	2.61	16.15
RDF + KCl (1%) spray at 60 & 90 DAS	1687	3580	20422	26823	2.31	15.67
RDF + mono potassium phosphate (0.5%) spray at 60 & 90 DAS	1647	3416	17797	28300	2.59	15.30
RDF + Mono potassium phosphate (1%) spray at 60 & 90 DAS	1626	3426	19547	25962	2.33	15.10
CD at 5%	NS	908	-	NS	NS	-

In a study on iron and zinc application in chickpea at Vijayapura, application of 10 kg $FeSO_4.7H_2O$ + 15 kg $ZnSO_4.\ 7H_2O$/ha + RDF recorded higher grain yield (777 kg/ha), net returns (Rs.40256/ha), B:C ratio (4.94) and RWUE (7.22 kg/ha-mm) compared to other treatments (Table 3.127).

Table 3.127 : 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)
Control (RDF) (10:25:0 NPK kg/ha)	324	8777	12283	2.40	3.01
RDF + 10 kg $FeSO_4.7H_2O$/ha	453	9027	20396	3.26	4.21
RDF + 15 kg $FeSO_4.7H_2O$/ha	463	9177	20918	3.28	4.30
RDF + 10 kg $ZnSO_4.7H_2O$/ha	535	9527	25248	3.65	4.97
RDF + 15 kg $ZnSO_4.7H_2O$/ha	339	9927	12151	2.22	3.15
RDF + 10 kg each FeSO4.$7H_2O$ and $ZnSO_4.7H_2O$/ha	576	9837	27624	3.81	5.35
RDF + 10 kg $FeSO_4.7H_2O$ + 15 kg $ZnSO_4.7H_2O$/ha	777	10227	40256	4.94	7.22
RDF + 15 kg $FeSO_4.7H_2O$ +10 kg $ZnSO_4.7H_2O$/ha	679	9977	34158	4.42	6.31
RDF + 15 kg each of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$/ha	700	10377	35101	4.38	6.51
Gypsum 6.1 kg/ha equivalent to sulphur content in 10 kg $FeSO_4.7H_2O$	350	9093	13635	2.50	3.25
Gypsum 9.0 kg/ha equivalent to sulphur content in 15 kg $FeSO_4.7H_2O$	343	9276	12997	2.40	3.19
Gypsum 5.8 kg/ha equivalent to sulphur content in 10 kg $ZnSO_4.7H_2O$	391	9593	15800	2.65	3.63
Gypsum 8.7 kg/ha equivalent to sulphur content in 15 kg $ZnSO_4.7H_2O$	340	10026	12030	2.20	3.16
CD at 5%	220.9	-	13818	1.46	-

In the Permanent Manurial Trial (PMT) in *rabi* sorghum at Solapur, application of 25 kg N/ha through crop residue (CR) + 25 kg N/ha through *Leucaena* loppings was superior with maximum sorghum grain yield (602 kg/ha), stover yield (1715 kg/ha) and RWUE (8.88 kg/ha-mm) and it was on par with 25 kg N/ha (FYM) + 25 kg N/ha (urea) in case of grain yield (448 kg/ha). The control treatment gave lowest grain yield of 236 kg/ha with RWUE of 3.48 kg/ha-mm. Due to very low rain fall and terminal drought during crop growth period (67.8 mm in 4 rainy days) the yields were below average (Table 3.128).

Table 3.128 : Permanent Manurial Trial effect on yield and economics of *rabi* sorghum – Solapur

Treatment	Yield (kg/ha)		Mean yield (29 years) (kg/ha)		Cost of Cultivation (Rs/ha)	RWUE (kg/ha-mm)
	Grain	Fodder	Grain	Fodder		
0 kg N/ha-control	236	674	701	1952	29148	3.48
25 kg N/ha -urea	347	988	1013	2824	30520	5.12
50 kg N/ha-urea	293	835	1152	3079	30829	4.32
25 kg N/ha-CR	290	828	957	2499	32570	4.28
25 kg N/ha-FYM	348	991	1058	2839	35113	5.13
25 kg N/ha-CR + 25 kg N/ha-urea	405	1221	1069	3101	32879	5.97
25 kg N/ha-FYM + 25kg N/ha urea	448	1343	1233	3284	35422	6.61
25 kg N/ha-CR + 25 kg N/ha-*Leucaena* loppings	602	1715	1680	3406	34333	8.88
25 kg N/ha-*Leucaena* loppings	357	884	982	2464	31974	5.27
25 kg N/ha-*Leucaena* loppings + 25 kg N/ha urea	236	672	1040	3056	32283	3.48
CD at 5%	0.53	1.44	-	-	-	-

CR-Crop residue

The soil organic C was influenced by different treatments and highest organic C (0.65) was recorded in the plots under 25 kg N/ha-*Leucaena* loppings whereas the organic C was lowest (0.49) in the control plots. Among different treatments, available N and total uptake of N was higher with treatment involving N applied through crop residues (25 kg/ha) + *Leucaena* loppings (25 kg/ha) (Table 3.129).

Table 3.129 : Effect of treatments on soil chemical properties – Solapur

Treatment	Organic C (%)	Av. N (kg/ha)	Total N uptake
0 kg N/ha-control	0.49	104	19.8
25 kg N/ha -urea	0.55	121	32.2
50 kg N/ha-urea	0.56	124	36.3
25 kg N/ha-CR	0.59	120	28.2
25 kg N/ha-FYM	0.59	133	33.4
25 kg N/ha-CR + 25 kg N/ha-urea	0.62	129	36.2
25 kgN/ha-FYM + 25kg N/ha urea	0.62	141	38.5
25 kg N/ha-CR + 25 kg N/ha - *Leucaena* loppings	0.64	143	43.3
25 kg N/ha-*Leucaena* loppings	0.65	133	33.1
25 kg N/ha-*Leucaena* loppings + 25 kg N/ha urea	0.64	140	36.0

25 kg N/ha–CR + 25 kg N/ha – Leucaena loppings

Without nitrogen

In a balanced nutrition study on *rabi* sorghum at Solapur, foliar spray of 0.5% $ZnSO_4$ at 35 and 55 DAS recorded maximum grain (498 kg/ha) and fodder yield (1195 kg/ha), RWUE (7.35 kg/ha-mm), net returns (Rs.16035/ha) and it was on par with water sprays at 35 and 55 DAS treatment. Due to very low rainfall during crop growth period (67.8 mm in 4 rainy days) the yields were below average (Table 3.130).

Table 3.130: Effect of balanced nutrition on *rabi* sorghum yield and economics - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	RWUE (kg/ha-mm)
	Grain	Stover		
Absolute control	206	514	29148	3.04
RDF (50:25:25 N:P_2O_5:K_2O Kg/ha)	348	870	31529	5.13
Water sprays at 35 and 55 DAS	433	1017	33329	6.39
Foliar sprays of 1% water soluble NPK fertilizer (19:19:19) at 35 and 55 DAS	374	935	34729	5.52
Foliar spray of 0.5% $ZnSO_4$ at 35 and 55 DAS	498	1195	33309	7.35
Foliar spray of 1% DAP at 35 and 55 DAS	249	623	33309	3.67
Foliar spray of 1% KNO_3 at 35 and 55 DAS	345	861	34729	5.09
Foliar spray of selenium @ 20 g/ha at 35 and 55 DAS	357	893	34471	5.27
CD at 5%	0.71	0.95	-	-

Foliar spray of 0.5% $ZnSO_4$ at 35 and 55 DAS

Absolute control

3.3.1.4 Energy management

At Vijayapura, pooled data analysis of sunflower over 7 years indicated that the conventional tillage (1 ploughing + 2 harrowings + 2 hoeings + 1 hand weeding) was superior with mean maximum grain yield of 835 kg/ha. However, net returns were higher in low till (LT1) (Rs.8724/ha) compared to other treatments. Among different nutrient management treatments, farmer's practice of nutrient application plus sunhemp as green manuring was superior with mean maximum grain, stalk yield and net returns (948, 894 kg/ha and Rs.9051/ha, respectively) compared to other treatments (Table 3.131).

Table 3.131 : 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	Mean (7 years)	Stalk				
Tillage							
Conventional tillage (1 ploughing + 2 harrowing + 2 hoeing + 1 hand weeding)	582	835	749	17335	7995	1.70	5.42
Low till – LT1 (2 harrowing + 1 hoeing + 1 hand weeding)	547	791	764	16210	8724	1.78	5.09
Low till – LT2 (1 harrowing + 1 hoeing + weedicide)	461	805	857	16210	6591	1.63	4.29
CD at 5%	84.30	74.10	144.08	-	NS	NS	-
Nutrient Management							
Sunnhemp incorporation @ 5 t/ha	524	551	747	15852	8007	1.77	4.88
Sunnhemp incorporation @ 2.5 t/ha +50% RDF through fertilizer	480	864	820	15847	5352	1.59	4.47
100% RDF through inorganic fertilizer	514	928	744	15845	7670	1.70	4.79
Farmer's practice	538	759	744	16345	8768	1.73	5.01
Farmer's practice + sunnhemp green manuring	593	948	894	17345	9051	1.72	5.52
CD at 5%	NS	61.8	134.6	-	NS	NS	-

Among different treatments, the soil pH was higher (8.07) in the plots under low till (LT1) with sunnhemp incorporation @ 5 t/ha closely followed by low till (LT2) with 100% RDF through fertilizer (8.05). Sunnhemp incorporation @ 5 t/ha in both conventional tillage and low tillage (LT1) also recorded higher soil organic C (0.54-0.55%) compared to other treatments. The available N was highest (235 kg/ha) in the plots under LT1 + 100%

RDF through fertilizer. Low till (LT2) with sunnhemp incorporation @ 5 t/ha also recorded marginally higher available P compared to other treatments, whereas available K content was highest (389 kg/ha) with low till (LT1) with sunnhemp incorporation @ 5 t/ha (Table 3.132).

Table 3.132 : Effect of tillage and nutrient management on soil properties - Vijayapura

Main plot	Sub plot	pH	OC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Conventional tillage (CT)	T1- Sunnhemp incorporation @ 5 t/ha	7.94	0.54	216	14.43	352
	T2 - Sunnhemp incorporation @ 2.5 t/ha + 50% RDF through fertilizer	7.82	0.51	213	13.78	376
	T3 - 100% RDF through fertilizer	7.92	0.45	231	14.49	371
	T4 - Farmer's practice	7.76	0.42	194	12.64	369
	T5 - Farmer's practice + Sunnhemp green manuring	7.79	0.50	205	15.23	376
Low till (LT1)	T1 - Sunnhemp incorporation @ 5 t/ha	8.07	0.55	220	14.61	389
	T2 - Sunnhemp incorporation @ 2.5 t/ha + 50% RDF through fertilizer	7.83	0.52	212	14.32	366
	T3 - 100% RDF through fertilizer	7.90	0.47	235	15.10	355
	T4 - Farmer's practice	7.76	0.44	197	13.60	380
	T5 - Farmer's practice + Sunnhemp green manuring	7.99	0.52	183	13.81	374
Low till (LT2)	T1 - Sunnhemp incorporation @ 5 t/ha	7.69	0.54	201	15.41	330
	T2 - Sunnhemp incorporation @ 2.5 t/ha + 50% RDF through fertilizer	7.74	0.49	205	13.50	340
	T3 - 100% RDF through fertilizer	8.05	0.45	216	13.72	334
	T4 - Farmer's practice	7.95	045	201	12.58	328
	T5 - Farmer's practice + Sunnhemp green manuring	8.01	0.51	209	14.35	326

At Vijayapura, sowing of chickpea with bullock drawn CRIDA seed drill recorded 5.8% higher seed yield than the ordinary seed drill. In case of tractor drawn seed drills, 7.5% higher yield (407 kg/ha) was recorded with the CRIDA automatic tractor drawn seed drill over the control. However, there was no difference amongst the seed drills in respect of field efficiency and soil moisture. Field efficiency was in the range of 0.25-0.27 hr/ha in bullock drawn seed drills, while it was 0.84-0.85 hr/ha for the tractor drawn seed drill. Higher RWUE was recorded with CRIDA seed drills both bullock drawn (4.78 kg/ha-mm) and tractor drawn 5.20 (kg/ha-mm) compared to other treatments (Table 3.133).

Control (ordinary bullock drawn)

CRIDA- bullock drawn

Table 3.133 : Evaluation of different seed drills for chickpea sowing – Vijayapura

Seed drill	Field efficiency (hr/ha)	Average soil moisture (%)	Average spacing of seed placement (cm)	Avg. depth of seed placement (cm)	Seed yield (kg/ha)	Mean seed yield (3 years)	B:C ratio	RWUE (kg/ha-mm)
Bullock drawn								
CRIDA seed drill	0.27	18.56	10.5	5.1	367	7.17	2.80	4.78
Bhopal seed drill	0.26	18.32	5.74	5.5	350	6.82	2.61	4.61
Ordinary seed drill (control)	0.25	17.90	7.38	4.5	337	6.29	2.23	4.49
Tractor drawn seed drill								
CRIDA seed drill	0.85	18.39	10.2	4.3	407	2.99	2.99	5.20
Ordinary seed drill (control)	0.84	19.21	87	2.2	372	2.36	2.36	4.84

At Solapur, medium tillage was significantly superior over low tillage for rabi sorghum with maximum grain yield of 373 kg/ha, stover yield of 1213 kg/ha and RWUE of 5.50 kg/ha-mm. It was followed by CT and LT. Among different fertilizer treatments, 100% N application through chemical fertilizer recorded significantly higher grain yield (404 kg/ha) and stover yield (1301 kg/ha) and it was significantly superior over N2 and N1 treatments. Similar trend was noticed in RWUE for grain of *rabi* sorghum. The interaction effect was non-significant for grain and significant for stover yield of *rabi* sorghum. Due to very low rainfall during crop growth period (67.8 mm in 4 rainy days) the yields were below average (Table 3.134).

Table 3.134: Yield and economics of *rabi* sorghum as influenced by tillage and nutrient management - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	RWUE (kg/ha-mm)
	Grain	Stover			
Tillage (T)					
Low tillage (LT)	315	1053	14143	11034	4.65
Medium tillage (MT)	373	1213	18143	12964	5.50
Conventional tillage (CT)	339	1119	30393	11832	5.00
CD at 5%	NS	0.43	-	-	-
Source of N					
N_1-(100% organic-N)	277	946	22139	9763	4.09
N_2-(50% organic-N+50% fertilizer-N)	346	1139	20893	12067	5.10
N_3-(100% fertilizer-N)	404	1301	19648	14003	5.96
CD at 5%	0.27	0.49	-	-	-
Interaction (T x N)					
CD at 5%	NS	0.85	-	-	-

MT (Medium tillage) N3-(100% fertilizer-N) (2015-16)

Low tillage (LT) N1-(100% organic-N) (2015-16)

In another field experiment at Solapur, the conventional tillage (CT) recorded significantly higher grain (508 kg/ha) and stover yield (1438 kg/ha). RWUE for *rabi* sorghum grain was in the order of CT > RT > ZT. Keeping black gram- green manuring (S2), recorded significantly higher grain (409 kg/ha) and stover (1160 kg/ha) yield than rest of residue management treatments (S1and S3), and it was followed by *kharif* fallow (S1) (Table). The interaction effects were significant for *rabi* sorghum grain and stover yield. The treatment of black gram for green manuring (S2) with conventional tillage (CT) recorded significantly higher grain (453 kg/ha) and stover yield (1281 kg/ha) (Table 3.135 & 3.136). Due to very low rainfall during crop growth period (67.8 mm in 4 rainy days) the yields were below average.

Table 3.135 : Yield and economics of *kharif* black gram-*rabi* sorghum sequence as influenced by tillage systems and residue management - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	RWUE (Kg/ha-mm)
	Grain	Stover		
Tillage (T)	508			
Conventional Tillage(CT)	375	1438	24312	7.49
Reduced Tillage (RT)	293	1061	19062	5.56
Zero Tillage (ZT)	0.40	830	13980	4.32
CD at 5%		1.13	-	-
Residue management (S)				
S_1-*Kharif* Fallow	393	1111	20654	5.80
S_2- Black gram- green manuring	409	1160	17956	6.03
S_3- Black gram- grain	374	1058	18744	5.52
CD at 5%	NS	NS	-	-
Interaction (T x S)				
CD at 5%	0.55	1.56	-	-

Conventional tillage + blackgram- green manuring

Zero tillage + blackgram - grain

Table 3.136: Interaction effect of residue and tillage management on grain and straw yield of *rabi* sorghum – Solapur

Treatment	*Kharif* fallow (kg/ha)		Blackgram green manuring (kg/ha)		Blackgram - grain (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
Conventional tillage	541	1530	453	1281	531	1503
Residuced tillage	357	1011	444	1257	323	915
Zero tillage	280	791	333	941	267	756
Mean	393	1110	410	1160	374	1058
CD at 5%	0.55	1.56	-	-	-	-

The soil organic C ranged from 0.65-0.68% among different tillage treatments and 0.63-0.70% among nutrient management treatments. The available N and K contents also did not vary significantly among tillage and nutrient management treatments. Among various treatments, application of N through 100% inorganic fertilizer recorded marginally higher available N (168 kg/ha) than other treatments. Medium tillage and conventional tillage being at par recorded significantly higher P content compared to low tillage. Similarly, application of 100% through fertilizer recorded significantly higher available P (18.4 kg/ha) compared to 100% N through organic manure (Table 3.137).

Table 3.137 : Effect of tillage and nutrient management on soil properties - Solapur

Treatments	OC (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)
Tillage (T)				
Low tillage (LT)	0.65	153	14.22	715
Medium tillage (MT)	0.68	165	16.38	732
Conventional tillage (CT)	0.66	168	16.78	739
CD at 5%	NS	NS	1.11	NS
Source of nutrition (N)				
100% organic-N	0.63	151	11.54	706
50% organic-N+ 50% fertilizer-N	0.70	167	17.43	737
100% fertilizer-N	0.66	168	18.40	744
CD at 5%	NS	NS	2.43	NS
Interaction (T x N)				
CD at 5%	NS	NS	NS	NS

3.3.1.5 Evaluation of improved varieties

On a varietal evaluation trial of horsegram at Vijayapura with 14 entries, DS-22 gave higher seed yield (714 kg/ha) followed by IC-100938 (692 kg/ha) and BL-44 (690 kg/ha) when compared to check GPM 6 (623 kg/ha). The entry AK-22 gave higher number of pods/plant (22) (Table 3.138).

Table 3.138 : Performance of horsegram genotypes - Vijayapura

Entry	Days to 50% flowering	Plant height (cm)	No. of branches/plant	No. of pods/plant	100 seed wt (g)	No. of seeds/ pod	Seed yield (kg/ha)
CRHG-09	72	36.8	2.4	19.2	3.01	4.1	615
DS-22	75	35.4	2.4	20.3	2.93	4.2	714
DEH-1	73	38.9	2.3	16.8	2.87	4.1	665
IC-100938	71	34.6	2.5	15.2	2.95	3.9	692
GPM-30	72	34.5	2.3	12.5	2.93	4.2	523
GPM-23	74	32.0	2.5	16.2	2.82	4.1	633
IC-100935	74	34.9	2.4	16.3	3.03	4.5	583
GPM-06	77	37.0	2.4	18.1	2.88	4.1	623
KBHG-1	76	38.8	2.4	17.0	3.04	4.2	639
PHG-09	75	37.3	2.5	17.1	2.97	4.0	656
AK-22	73	38.7	2.4	22.0	2.97	4.1	681
AK-44	71	40.6	2.4	17.5	3.02	3.9	625
BL-15	78	36.5	2.4	17.8	2.71	4.3	667
BL-44	77	38.0	2.5	14.5	2.81	4.1	690
CD at 5%	0.53	7.14	0.135	6.8	0.206	0.37	168.0

Another trial consisted of 27 horsegram entries evaluated in three replications at Vijayapura. The entries CRHG-19 (601 kg/ha), CRHG-06 (497 kg/ha) and BHL-128 (494 kg/ha) gave higher seed yield (Table). However, entry BHL-16, BHL-113, BHL-144 and BHL-159 recorded higher number of pods/plant (22.7, 22.7, 22.6 and 22.6, respectively) compared to other entries (Table 3.139).

Table 3.139 : Performance of horsegram genotypes - Vijayapura

Entry	Plant height (cm)	No. of branches plant	No. of pods/plant	No. of seeds/pod	Seed yield (kg/ha)
BHL-1	26.1	2.8	17.4	4.0	348
BHL-15	26.4	2.8	19.5	4.2	393
BHL-16	24.7	2.5	22.7	4.1	324
BHL-20	22.4	2.5	17.5	3.8	491
BHL-30	25.5	2.9	18.5	3.9	342
BHL-34	23.5	2.6	15.3	4.3	438
BHL-37	25.1	2.6	18.7	3.9	279
BHL-40	24.8	2.5	17.9	4.0	337
BHL-48	24.4	2.6	18.7	3.9	331
BHL-60	25.2	2.8	18.9	4.1	335
BHL-69	27.2	2.5	19.6	4.2	277
BHL-78	26.5	2.6	16.1	4.1	335
BHL-83	26.7	2.5	20.3	4.3	338
BHL-87	25.3	2.5	19.2	4.1	362
BHL-96	25.7	2.7	18.5	4.1	267
BHL-98	25.6	2.4	18.2	4.1	427
BHL-101	26.0	2.5	18.9	4.3	398
BHL-108	25.1	2.7	19.1	4.3	365
BHL-113	26.4	2.4	22.7	3.9	393
BHL-128	25.9	2.7	19.9	4.1	494
BHL-144	26.1	2.5	22.6	4.1	420
BHL-159	26.0	2.4	22.6	3.9	455
BHL-165	25.6	2.7	22.3	4.3	449
CRHG-04	25.0	3.0	20.9	4.1	385
CRHG-06	25.4	2.5	19.5	4.0	497
CRHG-08	25.9	2.7	19.3	4.1	406
CRHG-19	26.9	2.8	20.7	4.1	601
CD at 5%	8.3	0.19	9.2	0.7	234.3

Horsegram with best varieties CRHG-19, CRHG-06 and BHL-128.

In a trial on evaluation of mothbean entries at Vijayapura, the genotypes BL-12-32 and BL-12-47 recorded higher seed yield (512 and 501 kg/ha) compared to other entries and local variety. Similarly, the entry BL-12-32 gave higher number of pods/plant (22.7) compared to other entries (Table 3.140).

Table 3.140 : Performance of mothbean genotypes - Vijayapura

Entry	Plant height (cm)	No. of branches plant	No. of pods/plant	No. of seeds/pod	Seed yield (kg/ha)
Local	26.1	2.8	17.4	4.0	423
KBMB-1	26.4	2.8	19.5	4.2	374
BL-12-32	24.7	2.5	22.7	4.1	512
BL-12-47	22.4	2.5	17.5	3.8	501
BL-12-18	25.5	2.9	18.5	3.9	433
BL-12-49	23.5	2.6	15.3	4.3	312
BL-12-37	25.1	2.6	18.7	3.9	441
BL-12-23	24.8	2.5	17.9	4.0	419
BL-12-25	24.4	2.6	18.7	3.9	379
BL-12-52	25.2	2.8	18.9	4.1	284
BL-12-26	27.2	2.5	19.6	4.2	298
CD at 5%	12.53	0.59	24.92	175.2	12.53

In another trial on evaluation of mothbean entries at Vijayapura, the genotype RMO-225-1-6-1-3 recorded higher seed yield (409 kg/ha), followed by other-16 and BHL-local which produced seed yield of 322 and 317 kg/ha, respectively. Remaining all the varieties produced lower seed yield when compared to BLH-local (Table 3.141).

Table 3.141 : Performance of mothbean genotypes - Vijayapura

Entry	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ pod	Seed yield (kg/ha)
BLH-Local	24.0	3.5	36.4	4.2	317
Kalaghatagi local	25.0	3.9	32.8	3.8	283
Belgaum local	22.2	3.3	23.3	4.2	195
BJMB-I	22.7	3.6	28.6	4.2	263
MBS-27	24.1	3.9	26.9	4.2	79.0
RMO-225-1-6-1-3	23.1	4.1	32.1	4.2	409
JADIA - 100-10-8-10	24.6	4.0	31.5	4.2	228
CZM-2	21.4	2.9	25.3	4.2	218
RMO-M-2011-2	24.3	4.0	33.6	4.0	171
RMO-225	25.3	3.8	29.3	4.1	88
RMO-40.300.17-14.7	24.5	3.3	30.5	4.2	154
CZM-03	24.7	3.6	24.8	4.2	222
RMO-M-2011-1	25.0	3.8	35.5	4.2	290
Other-14	22.1	3.0	36.8	4.3	228
Other-15	23.9	3.7	25.1	4.1	213
Other-16	23.0	3.9	38.6	4.2	322
Other-18	23.0	3.9	31.2	4.3	278

In an initial varietal trial on clusterbean (kharif) at Vijayapura, none of the test entries were superior to the local check RGC 1033 (Ch) (836 kg/ha) (Table 3.142).

Table 3.142 : Performance of cluster bean genotypes in initial varietal trial (IVT-*Kharif*) - Vijayapura

Entry	Plant height (cm)	Days to 50% flowering	No. of branches/plant	No. of pods/ plant	No. of seeds/ pod	100 seed weight (g)	Seed yield (kg/ha)
RGr 15-6	37.7	28	6.4	21.6	5.8	3.6	548
GAUG 1210	46.7	29	9.9	36.8	6.6	3.2	584
RGr 15-4	43.5	27	9.1	33.0	6.1	3.3	593
HG 2-20 (Ch)	48.5	28	11.9	36.3	6.4	3.7	712
RGr 15-10	35.4	28	6.4	21.5	6.9	3.3	468
RGr 15-7	42.5	28	9.7	34.6	6.7	2.5	462
RGr 1066 (Ch)	45.9	27	5.7	24.2	5.0	3.3	519
CAZG 2015-1	35.9	28	7.6	22.5	7.0	3.1	394
RGr 15-8	38.9	28	8.1	27.1	7.2	3.0	490
RGC 1033 (Ch)	45.7	28	10.9	41.6	7.5	3.3	836
RGr 15-5	41.1	28	12.3	42.6	6.8	3.2	549
RGr 15-9	47	28	6.9	27.6	7.5	3.3	517
GAUG 1104	48	29	14.3	57.9	7.0	3.5	568
HG 563 (C)	44	28	11.3	36.3	6.9	3.4	562
CAZG 2015-2	50	29	6.8	32.8	7.1	3.3	566
X-8 (AVT 1)	46	28	7.8	27.3	7.3	3.3	691
CD at 5%	8.6	1.5	2.2	8.0	0.7	0. 6	134

In the initial hybrid trial on sunflower (*kharif*) genotypes conducted at Vijayapura, none of the test entries were superior to the local check LSHF-171 (1335 kg/ha). The oil content was significantly higher (40.2%) in entry CSFH-12205 compared to other entries, whereas the local check LSHF-171 recorded lowest oil content (30.8%) than other entries (Table 3.143).

Table 3.143 : Performance of sunflower genotypes in initial hybrid trial - Vijayapura

Entry	Plant height (cm)	Days to 50% flowering	Days to maturity	Head diameter (cm)	100 seed wt (g)	Oil content (%)	Seed yield (kg/ha)
KBSH-74	130	62	97	7.0	4.8	34.7	879
KSFH-473	130	62	97	7.8	4.6	39.4	875
NSFH 1016	150	65	100	9.2	4.6	35.8	972
LSFH-171	149	62	97	9.3	5.5	31.6	1097
KBSH-71	135	61	96	9.4	5.1	35.4	1106
KSFH-011-384	136	61	96	7.9	4.8	37.6	1065
S-2150	130	60	95	6.9	5.1	34.5	948
CSFH-12205	130	63	98	8.5	5.0	40.2	916
KBSH-44 ©	135	62	97	8.1	4.6	31.4	851
Laxmi-225	151	65	100	9.2	4.8	37.0	1164
KBSH-72	150	57	92	8.1	4.5	36.2	1106
DRSH-1©	164	64	99	9.4	4.6	38.2	1177
LSFH-171©	146	62	97	9.0	5.4	30.8	1335
CD at 5%	21	2.3	2.3	2.0	0.6	1.4	189

Among 16 genotypes of chickpea evaluated at Solapur, genotype BDNG 2013-1 was found earlier to 50% flowering (41 days) and days to maturity (91 days). The genotype BDNG- 203-1 recorded maximum number of fruiting branches/per plant (6) and maximum number of pods/plant (71). The genotype BDNG- 2013-1 recorded maximum 100 seed weight (29.14 g) among the entries tested (Table). Genotype BDNG 203-1 recorded highest nodule count (35) per plant, relative leaf water content (58%) and highest seed yield (779 kg/ha) followed by Phule G-13107 (769 kg/ha) and AKG-1146 (766 kg/ha) over the check variety BDNG 797 (511 kg/ha) indicating that genotype BDNG 203-1 was found to be drought tolerant among the genotypes tested (Table 3.144 & 3.145).

Table 3.144 : Performance of chickpea genotypes – Solapur

Genorype	Plant population/ha	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of fruiting branches /plant	No. of pods / plant	No. of seeds /pod	100 seed wt (g)
Phule G-08108	207716	48	108	36	4	37	1.40	20.0
Phule G-0611-14	204115	46	95	31	4	44	1.30	18.0
Phule G-13107	210288	42	92	31	5	65	1.10	20.9
BDNG-2013-1	188683	41	91	28	3	37	1.00	29.1
BDNG-2013-2	168621	44	93	26	4	41	1.20	27.0
BDNG-203-1	221605	42	101	29	6	71	1.60	22.0
BDNG-2015-2	140329	46	112	24	4	37	1.20	17.5
AKG-1146	216975	43	105	22	4	32	1.20	14.9
AKG-1216	230864	53	120	25	3	25	1.50	17.4
AKG 1301	226235	49	95	29	4	30	1.30	21.0
Vjiay (C)	191770	44	101	22	3	42	1.40	22.2
Vishal (C)	160905	44	108	29	4	39	1.30	20.6
Digvijay (C)	200514	42	98	25	6	48	1.40	21.6
BDNG-797 (C)	183539	45	102	24	3	32	1.20	18.1
JAKI-9218 (C)	227263	46	108	23	4	42	1.40	20.9
SAKI-9516 (C)	228807	46	106	26	3	35	1.50	18.7

Table 3.145 : Drought tolerant parameters of chickpea genotypes - Solapur

Genotype	No. of nodules/ plant	Nodules fresh weight (g)	Relative leaf water content (%)	Harvest index (%)	Seed yield (kg/ha)
Phule G-08108	30	2.800	51	27	520
Phule G-0611-14	27	2.300	50	22	619
Phule G-13107	26	3.100	57	28	769
BDNG-2013-1	22	2.250	52	23	586
BDNG-2013-2	31	3.100	53	23	628
BDNG-203-1	35	3.550	58	29	779
BDNG-2015-2	23	2.400	50	29	650
AKG-1146	24	2.300	52	42	766
AKG-1216	27	2.200	49	19	485
AKG 1301	21	2.150	47	17	501
Vjiay (C)	26	2.800	53	28	680
Vishal (C)	27	1.780	50	22	696
Digvijay (C)	29	2.850	56	29	765
BDNG-797 (C)	24	2.500	53	23	511
JAKI-9218 (C)	26	2.400	54	23	619
SAKI-9516 (C)	24	2.300	50	26	503
CD at 5%	-	-	-	-	193.5

3.3.1.6 Alternate land use system

At Vijayapura, the fruit yield of tamarind was significantly higher in the planting geometry of 10 m x 6 m (205 kg/ha) than 10 m x 3 m (149 kg/ha) and 10 m x 9 m (168 kg/ha). There was no significant difference in the fruit yield of tamarind, due to different grasses as intercrops. Similarly, there was no significant difference in the production of green fodder due to the geometry of tamarind. The guinea grass recorded significantly higher green fodder than signal grass. Among the planting geometry, the net returns was significantly higher in tamarind geometry of 10 m x 6 m (Rs.19012/ha) as compared to 10 m x 3 m (Rs.12777/ha) and 10 m x 9 m (Rs.15529/ha). Among different grasses, the net returns was significantly higher in intercropped guinea grass (Rs.17536/ha) than signal grass (Rs.14009/ha) (Table 3.146)

Table 3.146 : Evaluation of tamarind based horti-pasture system in eroded soils - Vijayapura

Treatment	Yield (kg/ha)		TEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	RWUE (kg/ha-mm)
	Main crop (tamarind)	Intercrop				
Geometry of tamarind						
10 m X 3 m	149	3008	179	5172	12777	1.80
10 m X 6 m	205	3014	235	4538	19012	2.38
10 m X 9 m	168	3008	198	4324	15529	2.01
CD at 5%	28.9	NS	34	-	3440	0.35
Grass						
Guinea grass	186	3602	222	4678	17536	2.25
Signal grass	163	2418	187	4678	14009	1.87
CD at 5%	NS	23	13	-	1339	0.14

TEY: Tamarind equivalent yield

At Vijayapura among aonla, henna and custard apple based agri-horti systems intercropped with chickpea and safflower, the chickpea equivalent yield was highest with aonla + henna + custard apple (826 kg/ha). Among the arable crops, the chickpea equivalent yield was highest with chickpea + safflower intercropping (866 kg/ha). While for interaction, the chickpea equivalent yield was highest with intercropping of safflower + chickpea (2:4) with aonla + henna + custard apple (1093 kg/ha) as compared to other treatments (Table 3.147 & 3.148).

Table 3.147 : Performance of aonla based agri-horti system in medium black soils – Vijayapura

Horticulture crop	Arable crop	Yield (kg/ha)			CEY (kg/ha)	Mean yield (5 years)
		Custard apple	Henna leaf	Intercrop		
Aonla alone	No intercrop	-	-	0	0	0
	Chickpea	-	-	310	310	506
	Chickpea + safflower (2:4)	-	-	253 + 318	433	676
Aonla + henna	No intercrop	-	2006	0	701	363
	Chickpea	-	1815	308	942	785
	Chickpea + safflower (2:4)	-	2015	250 + 349	1153	962
Aonla + custard apple (CA)	No intercrop	346	-	0	134	108
	Chickpea	277	-	333	459	566
	Chickpea + safflower (2:4)	274	-	276 + 290	565	732
Aonla + CA + henna	No intercrop	177	2131	0	826	169
	Chickpea	167	2065	346	1144	896
	Chickpea + safflower (2:4)	144	2015	327 + 246	1236	1093

CEY: Chickpea equivalent yield

Table 3.148 : Interaction effect of aonla based agri-horti system in medium black soils – Vijayapura

Crop	Aonla alone	Aonla+ henna	Aonla + custard apple (CA)	Aonla + CA + henna	Mean
No intercrop	0	363	108	169	160
Chickpea	506	785	566	896	688
Chickpea + safflower (2:4)	676	962	732	1093	866
Mean	591	703	469	719	

Among sapota based agri-horti systems evaluated on shallow to medium deep black soils at Vijayapura, sapota, guava, custard apple and drumstick seedlings have been planted. Among the main plots, significantly higher net returns of Rs.45228/ha were obtained with plantation of sapota + guava as compared to other horticulture components. Among the sub-plots, inter planting of guava recorded significantly higher net returns of Rs.38133/ha. There was no chickpea yield during the year due to the closure of canopy by the horticulture component (Table 3.149).

Table 3.149 : Performance of sapota based agri-horti system in shallow to medium deep black soils – Vijayapura

Treatment	Chickpea equivalent yield 2015-16 (kg/ha)	Pooled chickpea equivalent yield 2008-15 (kg/ha)	Net returns (Rs/ha)	B:C ratio
Intra-row planting				
Sapota alone	385	784	10895	6.49
Sapota + guava	1478	1392	45228	25.54
Sapota + custard apple	335	781	8708	3.20
Sapota + drumstick	370	768	10425	6.96
Inter-row planting				
No intercrop	429	764	12948	10.05
Guava	1265	1407	38133	16.61
Custard apple	396	723	9955	3.30
Drumstick	477	831	14221	12.21

In an experiment on simarouba based agri-horti system at Vijayapura, significantly higher net returns of Rs.49991/ha was obtained with plantation of simarouba + guava as compared to other horticulture components. Among the sub-plots, guava plantation recorded significantly higher net returns of Rs.92830/ha. There was no chickpea yield due to the closure of canopy by the horticulture component (Table 3.150).

Table 3.150 : Performance of simarouba based agri-horti system in shallow to medium deep black soils - Vijayapura

Treatment	Chickpea equivalent yield 2015-16 (kg/ha)	Pooled chickpea equivalent yield 2008-15 (kg/ha)	Net returns (Rs/ha)	B:C ratio
Intra-row planting				
Simaruba alone	822	1038	27706	4.94
Simaruba + guava	1431	1469	49991	7.02
Simaruba + custard apple	744	985	22189	3.16
Simaruba + drumstick	730	931	23102	4.14
Inter-row planting				
No intercrop	349	933	8773	1.59
Guava	2478	1762	92830	15.00
Custard apple	328	847	5626	0.68
Drumstick	572	881	15758	1.99

3.3.2 Pearlmillet Based Production System

3.3.2.1 Rainwater management

At Hisar, in a study on the effect of pond silt and fertilizer application on growth and yield of pearlmillet, maximum grain yield (1196 kg/ha) of pearlmillet was obtained with N 60 + P_2O_5 30 kg/ha followed by pond silt application @ 60 t/ha (1158 kg/ha) which was at par with pond silt application at 40 t/ha and but significantly higher compared to control. Similarly, treatment N 60 + P_2O_5 30 kg/ha gave higher net returns (Rs.1517/ha), B:C ratio (1.08) and RWUE (5.6 kg/ha/mm) (Table 3.151).

Table 3.151 : Yield and economics of pearlmillet as affected by pond silt and fertilizer application - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Pond silt						
Control	991	2586	18300	-1791	0.90	4.7
20 t/ha	1048	2714	18740	-1310	0.93	4.9
40 t/ha	1108	2867	19220	-791	0.96	5.2
60 t/ha	1158	2998	19720	-455	0.98	5.5
CD at 5%	70	-	-	-	-	-
Fertilizer						
Control	957	2591	16800	-712	0.96	4.5
N40 + P20	1076	3090	18300	54	1.00	5.1
N60 + P30	1196	3352	18760	1517	1.08	5.6
CD at 5%	105	-	-	-	-	-

At Hisar, in a study on the effect of pond silt and fertilizer on growth and yield of mustard, yield of mustard was statistically non-significant among the pond silt treatments. However, the maximum seed yield of mustard (1476 kg/ha), higher net returns (Rs.32357/ha), B:C ratio (2.42) and RWUE (39.9 kg/ha-mm) was recorded with the application of fertilizer N 60 + P2O5 30 kg/ha. Pond silt @ 60 t/ha recorded higher stover yield (3362 kg/ha) than other treatments (Table 3.152).

With pond silt @ 60 t/ha + N60P30 kg/ha

Without pond silt application

Performance of pearllmilet

Table 3.152 : Yield and economics of mustard as affected by pond silt and fertilizer application –Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Pond silt						
Control	1209	2906	22400	23061	2.03	32.7
20 t/ha	1266	2997	22840	24684	2.08	34.2
40 t/ha	1364	3172	23300	27826	2.19	36.9
60 t/ha	1409	3362	23780	29173	2.23	38.1
CD at 5%	NS	-	-	-	-	-
Fertilizer	-	-	-	-	-	-
Control	1082	2835	20900	20141	1.96	29.2
N40 + P20	1377	3149	22400	29142	2.30	37.2
N60 + P30	1476	3315	22800	32357	2.42	39.9
CD at 5%	132					

At Hisar, in a study on the effect of different foliar spray on yield and economics of pearlmillet and mustard under mid season drought, spraying of thiourea at 250 g/ha (2 sprays) resulted in higher yield of pearlmillet (1189 kg/ha) and mustard (1450 kg/ha) when compared to other treatments. Similarly, the treatment also recorded higher stover yield, net returns, B:C ratio and RWUE in both the crops compared to other treatments (Table 3.153 & 3.154).

Table 3.153 : Effect of different foliar sprays on yield and economics of pearlmillet -Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
No spray	1041	2697	18300	-980	0.95	4.91
Water spray (twice)	1081	2805	18500	-505	0.97	5.10
KNO_3 1% (twice)	1166	3045	18700	735	1.04	5.50
KCl 1% (twice)	1159	3007	18600	690	1.04	5.47
Thiourea 250 g/ha	1189	3097	18550	1252	1.07	5.61
CD at 5%	NS	-	-	-	-	-

Table 3.154 : Effect of different foliar sprays on yield and economics of mustard - Hisar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
No spray	1,200	2820	22400	22630	2.01	32.4
Water spray (twice)	1,317	3087	22600	26797	2.19	35.6
KNO_3 1% (twice)	1,433	3300	22800	30883	2.35	38.7
KCl 1% (twice)	1,383	3208	22700	29145	2.28	37.4
Thiourea 250 g/ha	1,450	3323	22650	31635	2.40	39.2
CD at 5%	NS					

At SK Nagar, in study on effect of hydrogel in castor, the seed and stalk yield of castor was not affected significantly by different treatments, higher yield of castor (618 kg/ha) and RWUE (0.66 kg/ha.mm) was recorded with application of hydrogel @ 5 kg/ha but maximum B:C ratio was recorded under control (2.17). However, mean data of 2 years revealed that maximum seed yield (990 kg/ha) was recorded with application of hydrogel @ 7.5 kg/ha (Table 3.155).

Table 3.155 : Effect of different treatments on yield and economics of castor – SK Nagar

Treatment	Yield (kg/ha)		Seed yield mean (2 years)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Straw					
No hydrogel	517	662	627	8500	9915	2.17	0.55
Hydrogel 2.5 kg/ha	588	753	685	10750	10206	1.95	0.63
Hydrogel 5 kg/ha	618	796	915	13000	9036	1.70	0.66
Hydrogel 7.5 kg/ha	602	777	990	15250	6208	1.41	0.65
Hydrogel 10 kg/ha	515	658	672	17500	841	1.05	0.55
CD at 5%	NS	NS					

Castor without hydrogel

With hydrogel @ 5 kg/ha

Performance of castor

At SK Nagar, in a study on the feasibility of growing *rabi* crops using harvested rainwater through drip irrigation system, among the three cops, cumin crop was failed due to continuous cloudy weather condition during critical crop growth stages. In case of mustard, the plant height (183.3 cm), no. of siliqua of main branch (46.3), length of pod (4.6 cm), total no of branches (11.4), seed yield (1334 kg/ha), stalk yield (3966 kg/ha), net returns (Rs.43982/ha) and B:C ratio (3.75) were recorded. while in case of fennel, the plant height (125 cm), total no of branches (10.6) , no. of effective umbels (11.1), seed yield (1105 kg/ha), stalk yield (3966 kg/ha), net returns (Rs.55286/ha) and B:C ratio (3.13) was recorded and found more profitable than mustard (Table 3.156).

Table 3.156: Feasibility of *rabi* crops cultivation using harvested rainwater - SK Nagar

Parameter	Mustard	Fennel
Plant height (cm)	183.3	125
No. of siliqua of main branch	46.3	-
No. of effective umbels	-	11.1
length of pod (cm)	4.6	-
Total no of branches	11.4	10.6
Seed yield (kg/ha)	1334	1105
Stalk yield (kg/ha)	3966	3966
Cost of cultivation (Rs/ha)	16000	26000
Net returns (Rs./ha)	43982	55286
B:C ratio	3.75	3.13

3.3.2.2 Cropping systems

At Hisar, a study on Sesbania-pearlmillet intercropping systems revealed that, the treatment with paired row of Sesbania at 45 : 120 + 2 rows of pearlmillet resulted in highest pearlmillet equivalent yield (PEY) (1930 kg/ha), net returns (Rs.6832/ha), B:C ratio (1.38) and RWUE (9.11 kg/ha-mm) compared to other treatments (Table 3.157).

Table 3.157 : Performance of *Sesbania*-pearlmillet intercropping system – Hisar

Treatment	Yield (kg/ha)		PEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter-crop					
Pearl millet sole at 45 cm spacing	1700	-	1700	20210	1465	1.07	8.02
Sesbania sole at 45 cm spacing	-	990	1400	15794	2026	1.13	6.59
Sesbania sole at 60 cm spacing	-	1000	1410	15505	2495	1.16	6.66
Sesbania at 90 cm spacing + 1 row of pearlmillet	960	540	1720	17418	4542	1.26	8.12
Paired row of *Sesbania* at 45:90 + 1 row of pearlmillet	980	420	1570	17622	2433	1.14	7.42
Sesbania at 120 cm spacing + 1 row of pearlmillet	990	440	1610	17833	2709	1.15	7.60
Sesbania at 120 cm spacing + 2 row of pearlmillet	1110	450	1750	18306	3946	1.22	8.23
Paired row of *sesbania* at 45:120 + 2 rows of pearlmillet	1140	560	1930	17783	6832	1.38	9.11
Paired row of *sesbania* at 60:120 + 2 rows of pearlmillet	1070	450	1710	17828	3914	1.22	8.04
Paired row of *sesbania* at 60 : 120 + 1 row of pearlmillet	880	530	1630	17266	3494	1.20	7.68
CD at 5%	140	78					

PEY-Pearlmillet equivalent yield

At SK Nagar, in an experiment on cotton based intercropping systems, the pooled cotton equivalent yield (CEY) was significant. Mothbean sole 45 cm gave significantly higher CEY (2335 kg/ha), but it was statistically at par with greengram sole 45 cm and blackgram sole 45 cm as well as Bt. cotton + greengram (1:2), with higher net returns (Rs.78082/ha) B:C ratio (4.16) and RWUE (4.16) (Table 3.158).

Table 3.158 : Yield and economics of different cotton based intercropping systems - SK Nagar

Treatment	Mean yield (kg/ha) (6 years)				CEY (kg/ha)		Cost of cultivation (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton	Stalk	Seed	Stover	2015	Pooled				
Cotton + greengram (1:1)	430	1001	408	878	1534	1541	32550	29100	1.89	2.74
Cotton + blackgram (1:1)	645	1135	339	735	1417	1478	32550	26559	1.82	2.63
Cotton + mothbean (1:1)	571	1014	415	1023	1708	1593	32550	31179	1.96	2.84
Cotton + greengram (1:2)	534	928	700	1504	2302	2233	32550	56755	2.74	3.98
Cotton + blackgram (1:2)	589	1030	550	1188	1846	1928	32550	44576	2.37	3.43
Cotton + mothbean (1:2)	511	874	684	1684	2477	2187	32550	54910	2.69	3.89
Cotton sole 120 cm	691	1250	-	-	710	707	24900	3372	1.14	1.26
Greengram sole 45 cm	-	-	960	2119	2370	2320	15300	77496	6.07	4.13
Blackgram sole 45 cm	-	-	916	2046	2050	2215	15300	73296	5.79	3.94
Mothbean sole 45 cm	-	-	963	2239	2536	2335	15300	78082	6.10	4.16

3.3.2.3 Nutrient management

In a study on nutrient management in mustard, combined application of nutrients i.e. 100% N&P+K addition along with KCl and NPK spray was found to be effective in increasing the seed yield of mustard as compared to yield obtained with 100% RDF (Table). The plot receiving RDF + 50 kg K/ha as basal dose + 2% NPK spray (19:19:19) at siliqua formation produced significantly higher yield (658 kg/ha) than control (60+40 kg N & P/ha) and RDF with 40 kg K application. Spray of 2% KCl and 2% NPK (19:19:19) at flowering and at siliqua formation increased seed yield by 11 and 13, 18 and 25%, respectively over basal application of RDF (60+40+40 kg NPK). Higher RWUE of 4.42 kg/ha-mm was recorded with 100% N&P + 50 kg K + 2% NPK spray (19:19:19) at siliqua formation followed by 100% N&P + 75 kg K + 2% NPK spray (19:19:19) at siliqua formation (4.34 kg/ha/mm). 100% N&P + 50 K kg as basal + 2% NPK spray (19:19:19) at siliqua formation gave higher net returns (Rs.15197/ha) and B:C ratio (1.94) followed by 100% N&P + 75 kg K as basal + 2% NPK spray (19:19:19) at siliqua formation (Rs.12595/ha) (Table 3.159).

Table 3.159 : Nutrient management in mustard - Effect on yield and economics - Agra

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Seed	Stalk				
T_1- Control (60 kg N+ 40 kg P_2O_5/ha)	456	638	4.08	14064	7413	1.53
T_2- 100% RDF (60:40:40 kg/ha NPK)	524	786	4.16	15397	9362	1.61
T_3- 100% N & P + 75 kg K basal	553	871	4.16	16187	1004	1.62
T_4- 1000% N & P + 50 kg K basal	562	931	4.15	15480	11206	1.72
T_5- T_3 + 2% KCl spray before flowering	582	967	4.25	16562	11078	1.67
T_6- T_4 + 2% KCl spray before flowering	593	997	4.31	15854	12326	1.78
T_7- T_3 + 2% NPK spray (19:19:19) at siliqua formation	619	1052	4.34	16838	12595	1.75
T_8- T_4 + 2% NPK spray (19:19:19) at siliqua formation	658	1145	4.42	16130	15197	1.94
CD at 5%	110	193	---	---	---	---

In a field experiment on nutrient management in mustard at Agra, INM involving 75 kg N + 50 kg P_2O_5 + 50 kg K_2O + Zn + B + S recorded significantly higher seed yield (605 kg/ha) than control and RDF treatments but was on par with other treatments (Table 3.160).

Table 3.160: Effect of various soil fertility treatments on seed yield of mustard - Agra

Treatment	Yield (kg/ha)				Mean yield (4 years) (kg/ha)
	2012-13	2013-14	2014-15	2015-16	
T_1- Control (no fertilizer)	1110	915	635	282	735
T_2- RDF (60 kg N + 40 kg P_2O_5/ha)	2110	1880	975	450	1354
T_3- 75 kg N + 50 kg P_2O_5 + 50 kg K_2O/ha (Sol test based)	2350	2090	1150	554	1536
T_4- T3 + Zn	2385	2120	1175	568	1562
T_5- T3 + B	2360	2100	1160	560	1545
T_6- T3 +S	2460	2210	1208	585	1616
T_7- T3 + Zn + B + S	2495	2250	1225	605	1644
T_8- T2 + K	2296	2050	1082	525	1488
CD at 5%	364	332	245	103	---

At Hisar, in a study on long-term fetilizer experiment, application of recommended dose of fertilizer (RDF) gave higher yield of pearlmillet and mustard (1145 kg/ha and 1542 kg/ha, respectively) followed by application of nitrogen equivalent through vermincompost (1089 kg/ha and 1156 kg/ha) and nitrogen equivalent through FYM (1026 kg/ha and 1024 kg/ha, respectively) (Table 3.161& 3.162). The net returns were negative in all the treatments during *kharif* due to low crop yield. In *rabi*, the net returns were highest (Rs.26282/ha) with RDF compared to other treatments.

Table 3.161 : Effect of long-term manure application on yield and economics of pearlmillet - Hisar

Treatment	Grain/seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Control	857	17754	-3296	0.81	4.0
RDF (40:20:0 NPK kg/ha)	1145	20321	-1005	0.95	5.4
N equivalent through FYM	1026	19140	-1831	0.90	4.8
N equivalent through vermi-compost	1089	18451	-80	1.00	5.1
CD at 5%	185				

Table 3.162 : Effect of long-term manure application on crop yield and economics of mustard - Hisar

Treatment	Grain/seed in 2015-16	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Control	865	20400	6415	1.31	23.70
RDF (40:20:0 NPK kg/ha)	1542	21520	26282	2.22	42.25
N equivalent through FYM	1024	21470	10274	1.48	28.05
N equivalent through vermi-compost	1156	21500	14336	1.67	31.67
CD at 5%	377				

At SK Nagar, in the Permanent Manurial Trial (PMT) on pearlmillet/clusterbean/castor rotation, application of 50% RDN inorgnic + 50% RDN through castor cake + seed inoculation with Azotobactor (Azo 8) + PSB registered significantly higher castor seed (846 kg/ ha) and stalk yield (1060 kg/ ha), with maximum net returns (Rs.20906/ha), B:C ratio (2.84) and RWUE (0.91 kg/ ha-mm). However it was found at par with 50% RDN inorgnic + 50% RDN through castor cake , 50% RDN inorgnic + 50% RDN through FYM, and 50% RDN inorgnic + 50% RDN through vermicompost + seed inoculation with Azotobactor (Azo 8) + PSB than rest of the treatments (Table 3.163).

Significantly higher values of available N (154 kg/ ha), P_2O_5 (33 kg/ha) and K_2O (178 kg/ha) in soil were recorded with 50% RDN inorgnic + 50% RDN through vermicompost+ seed inoculation with Azotobactor (Azo 8) + PSB, but were at par with rest of treatments except 100% RDN through chemical fertilizers (50% RDN as basal + 50% RDN at 30-40 DAS. Organic carbon (0.31%) was significantly increased due to application of 50% RDN inorgnic + 50% RDN through FYM compared to rest of the treatments except 50% RDN through chemical fertilizers (TD) + 50% RDN through vermicompost (Table 3.164).

Table 3.163 : Permanent Manurial Trial (PMT) in castor – SK Nagar

Treatment	Seed yield (kg/ha) 2015	Stalk yield (kg/ha) 2015	Mean yield (3 years) (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
100% RDN inorgnic (60:40:0 NPK kg/ha) (50% RDN as basal + 50% RDN at 30-40 DAS TD)	521	550	570	7635	12171	2.59	0.56
50% RDN inorgnic + 50% RDN through FYM	708	984	706	16217	10837	1.67	0.76
50% RDN inorgnic + 50% RDN through castor cake	735	1013	795	11312	16771	2.48	0.79
50% RDN inorgnic + 50% RDN through vermicompost	653	883	676	17217	7703	1.45	0.70
50% RDN inorgnic + 25% RDN through FYM + *Azotobactor* (*Azo* 8) + PSB	666	897	688	11767	13638	2.16	0.71
50% RDN inorgnic + 50% RDN through castor cake + *Azotobactor* (*Azo* 8) + PSB	846	1060	894	11362	20906	2.84	0.91
50% RDN inorgnic +50 RDN% through vermicompost + *Azotobactor* (*Azo* 8) + PSB	667	897	693	17267	3868	1.22	0.79
CD at 5%	179	225					

TD: Top dressing

Table 3.164 : PMT effect on soil properties – SK Nagar

Treatments	OC (%)	Available nutrients (kg/ha)		
		N	P_2O_5	K_2O
100% RDN inorgnic (60:40:0 NPK kg/ha) (50% RDN as basal + 50% RDN at 30-40 DAS TD)	0.24	134	25	156
50% RDN inorgnic + 50% RDN through FYM	0.31	143	29	177
50% RDN inorgnic + 50% RDN through castor cake	0.28	145	27	172
50% RDN inorgnic + 50% RDN through vermicompost	0.30	145	29	174
50% RDN inorgnic + 25% RDN through FYM + *Azotobacter* (*Azo* 8) + PSB	0.28	150	32	177
50% RDN inorgnic + 50% RDN through castor cake + *Azotobacter* (*Azo* 8) + PSB	0.27	147	29	179
50% RDN inorgnic +50 RDN%through vermicompost + *Azotobacter* (*Azo* 8) + PSB	0.29	154	33	178
CD at 5%	0.02	9.6	2.7	14.3

TD: Top dressing

At SK Nagar, in a study on the effect of foliar and soil application of nutrients on cotton, significantly higher seed cotton yield (1788 kg/ha), net returns (Rs.41184/ha) and RWUE (2.10 kg/ha-mm) were recorded with soil application of $MgSO_4$ @ 15 kg/ha + three foliar sprays of KNO_3 @ 3%, but is was found at par with soil application of $MgSO_4$ @ 30 kg/ha + three foliar sprays of KNO_3 @ 3% and T9 + foliar application of $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 1% (T10). However, higher B:C ratio (2.36) was recorded with foliar application of $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 1% (T10) (Table 3.165).

Table 3.165 : Effect of foliar sprays on yield and economics of cotton – SK Nagar

Treatment	Seed cotton yield (kg/ha)	Cost of Cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T1:Control (three water sprays)	1290	27600	27884	2.01	1.52
T2: Three foliar sprays of KNO_3 @ 1.5%	1171	31200	19139	1.61	1.38
T3: Three foliar sprays of KNO_3 @ 3.0%	1533	34800	31105	1.89	1.80
T4: Soil application of $MgSO_4$ @ 15 kg/ha	1290	27900	27584	1.99	1.52
T5: Soil application of $MgSO_4$ @ 30 kg/ha	1416	28650	32224	2.12	1.66
T6: $T_4 + T_2$	1233	32100	20933	1.65	1.45
T7: $T_4 + T_3$	1788	35700	41184	2.15	2.10
T8: $T_5 + T_2$	1554	32850	33958	2.03	1.83
T9: $T_5 + T_3$	1712	36450	37152	2.02	2.01
T10: Foliar spray of $ZnSO_4$ @ 0.5% +$FeSO_4$ @ 1.0%	1543	28160	38203	2.36	1.81
T11: $T_7 + T_{10}$	1420	36860	24186	1.66	1.67
T12: $T_9 + T_{10}$	1689	37610	35031	1.93	1.99
CD at 5%	207				

The foliar application of different nutrients had no significant effect on the available N, P_2O_5, K_2O, Fe and Zn contents in soil. However, soil available magnesium (35.8 ppm) was significantly increased due to soil application of $MgSO_4$ @ 30 kg/ha + three foliar sprays of KNO_3 @ 3.0% (T9), but it was found at par with the treatments involving soil application of Mg @ 15 and 30 kg/ha. (Table 3.166).

Table 3.166 : Effect of foliar sprays on nutrient content in soil after harvest of cotton – SK Nagar

Treatment	Fe (ppm)	Zn (ppm)	Mg (ppm)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
T1:Control (three water sprays)	4.1	0.4	26.9	158	34.6	202
T2: Three foliar sprays of KNO_3 @ 1.5%	4.5	0.4	26.2	161	35.5	184
T3: Three foliar sprays of KNO_3 @ 3.0%	4.4	0.4	26.4	159	33.5	216
T4: Soil application of $MgSO_4$ @ 15 kg/ha	4.7	0.4	31.5	162	35.5	213
T5: Soil application of $MgSO_4$ @ 30 kg/ha	4.9	0.4	35.5	163	38.5	216
T6: $T_4 + T_2$	4.8	0.4	32.5	157	36.3	214
T7: $T_4 + T_3$	4.9	0.5	32.2	163	37.5	215
T8: $T_5 + T_2$	4.9	0.5	35.6	164	38.5	216
T9: $T_5 + T_3$	4.9	0.5	35.8	162	40.3	221
T10: Foliar spray of $ZnSO_4$ @ 0.5% +$FeSO_4$ @ 1.0%	5.3	0.5	26.0	161	33.3	206
T11: $T_7 + T_{10}$	5.1	0.5	33.3	170	38.3	214
T12: $T_9 + T_{10}$	5.3	0.5	35.0	166	40.5	218
CD at 5%	8.8	10.3	12.1	NS	NS	NS
Initial values	4.1	0.4	26.9	168.00	37.80	212.00

At SK Nagar, in a study on nutrient management in greengram-sesame rotation, application of recommended dose of nitrogen @ 20 kg/ha to greengram and 50 kg N/ha to sesame gave highest yields either through vermicompost (582 kg/ha and 329 kg/ha) or FYM (555 kg/ha and 305 kg/ha). However, maximum net returns (Rs.57894/ha) and B:C ratio (0.75) was recorded in RDF through vermicompost followed by RDF through FYM. The yield increased by 47 and 43% in greengram and sesame, respectively with RDF through vermicompost as compared to control (397 and 230 kg/ha) (Table 3.167).

Table 3.167 : Effect of nutrient management on yield and economics of greengram-sesame rotation – SK Nagar

Treatment	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	
	Greengram	Sesame				Greengram	Sesame
Control (No fertilizer)	397	230	14145	40240	3.84	0.51	0.34
100% RDN through chemical fertilizer	520	318	19131	53764	3.81	0.67	0.47
100% RDN through FYM	555	305	35895	57312	2.60	0.71	0.45
100% RDN through vermicompost	582	329	41145	57894	2.41	0.75	0.49

100% RDN (NPK kg/ha): Greengram: 20:40:0; Sesame: 50:30:0

At SK Nagar, significantly higher build up of available N (187 kg/ha) and organic carbon (0.29%) was recorded under 100% RDN (recommended dose of N) through vermicompost, whereas higher P_2O_5 (48.5 kg/ha) and K_2O (48.5 kg/ha) in soil were recorded with 100% RDN through FYM in greengram. In case of sesame, significantly higher build up of available N (175 kg/ha), P_2O_5 (52.9 kg/ha) and K_2O (185 kg/ha) in soil were recorded under 100% RDN through FYM compared to other treatments. But organic carbon (0.31%) was highest with100% RDN through vermicompost (Table 3.168 & 3.169).

Table 3.168 : Effect of nutrient management on soil fertility after harvest of greengram –SK Nagar

Treatment	Av. N (kg/ha)	Av. P_2O_5 (kg/ha)	Av. K_2O (kg/ha)	Organic C (%)
Control	158	35.2	35.2	0.22
100% RDF (inorganic)	167	44.2	44.2	0.23
100% RDN (FYM)	180	48.5	48.5	0.27
100% RDN (VC)	187	47.3	47.3	0.29
CD at 5%	12.7	3.5	3.5	-
Initial value	165.8	45.8	212	-

Table 3.169 : Effect of nutrient management on soil fertility after harvest of sesame – SK Nagar

Treatment	Soil available N (kg/ha)	Soil available P_2O_5 (kg/ha)	Soil available K_2O (kg/ha)	Organic C (%)
Control	150	157	175	0.24
100% RDF (inorganic)	172	36.5	43.8	0.26
100% RDN (FYM)	52.9	51	157	0.28
100% RDN (VC)	169	185	183	0.31
CD at 5%	19.7	6	15.1	-
Initial value	150	157	175	-

VC-Vermicompost

Greengram RDN - vermicompost

Control

At SK Nagar, in a study on nutrient management in pearlmillet, the grain and stover yield of pearlmillet was significantly affected due to different treatments. Application of 50% RDN (urea) along with 50% RDN (FYM) recoded significantly higher grain yield (310 kg/ha) and tover yield (1416 kg/ha). The maximum net returns (Rs 2872/ha) and B:C ratio (1.85) were recorded under 100% RDN (urea). Due to drastic reduction in yield and more input cost of FYM, net returns and B:C ratio were negative under treatments T4, T5 and T6 (Table 3.170).

Table 3.170 : Effect of nutrient management on yield and economics of pearlmillet – SK Nagar

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
T_1: Control	173	906	2800	1890	1.67	0.19
T_2: 100% RDN – urea (80 kg N/ha)	244	1134	3380	2872	1.85	0.26
T_3: 50% RDN – urea	207	1080	3090	2507	1.81	0.22
T_4: 50% RDN–FYM	228	1115	11891	-5918	0.50	0.24
T_5:T_3 + T_4	310	1416	12181	-4299	0.65	0.33
T_6: Farmers' method	216	1084	9050	-3311	0.63	0.23
CD at 5%	45.5	147.4				

RDN-Recommended dose of Nitrogen)

The maximum water holding capacity (23.6%) was recorded in the plots under 50% RDN (urea) + 50% RDN (FYM) over rest of the treatments, except 50% RDN (FYM). The maximum reduction in bulk density (1.57 g/cc) was recorded under 50% RDN (urea) + 50% RDN (FYM), but it was found non-significant. Significantly higher values of available N (188 kg/ha), P_2O_5 (48.2 kg/ha) and K_2O (206 kg/ha) in soil were recorded due to integration of 50% RDN (FYM) + 50% RDN (urea) over rest of the treatments. However, P_2O_5 content in soil was found at par with all the treatments except T1 and T2, while soil available K_2O was found at par with farmers' method (Table 3.171).

Table 3.171 : Effect of nutrient management on physical and chemical properties of soil at harvest of pearlmillet – SK Nagar

Treatment	Bulk density (g/cc)	Max. WHC (%)	Available nutrients (kg/ha)		
			N	P_2O_5	K_2O
T_1: Control	1.689	20.4	119	33.1	147
T_2: 100% RDN – urea (80 kg N/ha)	1.638	21.5	168	42.3	177
T_3: 50% RDN – urea	1.635	21.2	150	45.8	182
T_4: 50% RDN–FYM	1.584	23.6	166	47.8	206
T_5:T_3 + T_4	1.571	23.6	188	48.2	206
T_6: Farmers method	1.612	20.9	155	48.2	194
CD at 5%	NS	1.5	16.1	5.6	20.6

3.3.2.4 Evaluation of improved varieties

In an evaluation of different mustard varieties at Agra, variety NRCDR-2 produced marginally higher seed yield as compared to other varieties. The highest moisture use (146.85 mm), RWUE (3.97 kg/ha-mm), net returns (Rs.10018/ha) and B:C ratio (1.71) was also recorded with variety NRCDR-2, compared to other varieties (Table 3.172).

Table 3.172 : Yield and economics of mustard varieties –Agra

Variety	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk			
Rohini	521.7	755.7	7416	1.53	3.66
NRCHB -101	538.3	776.7	8095	1.58	3.75
Urvashi	565.7	840.3	9259	1.66	3.87
Laxmi	546.3	826.0	8481	1.60	3.73
NRCDR-2	583.3	888.7	10018	1.71	3.97
CD at 5%	NS	NS	7416	1.53	-

At Hisar, in a final yield trial (population) of pearlmillet; TPC-II recorded the highest grain yield (706 kg/ha) followed by HPC (542 kg/ha), ATC (536 kg/ha) and TPC-I (439 kg/ha). Stover yield was highest for WHC 901-445 x HMS-36B (5926 kg/ha) followed by DMRC (5741 kg/ha). Plant height ranged from 116-160 cm; total tillers from 3.6-5.2; spike length from 17.9-26.9 cm; and spike girth from 3.1-3.8 cm (Table 3.173).

In a final yield station trial (Hybrid), none of the pearlmillet hybrids recorded higher grain yield over the recently identified hybrid HHB-272 (964 kg/ha) followed by another check HHB 67 improved (736 kg/ha). Stover yield was also highest for HHB-272 (7593 kg/ha) followed by hybrid HMS 48A x PT-1-10-1131, HMS 47A x HPT-2-12-32 and ICMA 04888 x PT-1-10-1047 (6852 kg/ha). Plant height ranged from 131-168 cm; total tillers from 3.8-5.1; spike length from 19.2-24.7 cm; and spike girth from 3.1-3.9 cm (Table 3.174).

Table 3.173 : Performance of pearlmillet genotypes in FYT (Population) -Hisar

Genotype	Plant height (cm)	Total tillers /plant	Spike length (cm)	Spike girth (cm)	Grain yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)
LPRC	138	4.1	26.9	3.7	270	5556	1.17
DMRC	140	3.3	25.9	3.4	340	5741	1.47
ATC	154	4.1	24.8	2.9	536	5556	2.32
98109 SL	144	5.1	21.8	3.4	337	4444	1.46

Genotype	Plant height (cm)	Total tillers /plant	Spike length (cm)	Spike girth (cm)	Grain yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)
BRBC	145	4.8	22.1	3.4	363	5000	1.57
HPC	142	4.3	22.6	3.1	542	4815	2.35
ASRC 1	146	4.2	23.7	3.7	307	5185	1.33
TPC-I	142	3.9	23.1	3.6	439	5185	1.90
TPC-II	160	4.6	24.3	3.4	706	5185	3.06
RTC	140	4.0	19.4	3.3	367	4630	1.59
TPBL	114	4.6	21.7	3.8	248	4815	1.07
HRC	130	4.8	20.8	3.4	422	5556	1.83
HIC	116	4.9	17.9	3.3	293	4815	1.27
WHC 901-445 X HMS-36B	120	3.6	22.4	3.3	305	5926	1.32
WHC 901-445 (M)	143	4.2	22.8	3.4	410	5556	1.77
WHC 901-445 (E)	127	5.2	21.8	3.6	386	5370	1.67
HC-10 (C)	142	5.2	24.1	3.2	361	4630	1.56
HC-20 (C)	144	3.7	21.9	3.4	351	5556	1.52
CD at 5%	16.21	0.67	2.85	0.47	133.13	718.66	-

Table 3.174 : Performance of pearlmillet hybrids in FYT (early) -Hisar

Hybrid	Plant height (cm)	Tiller/ plant	Spike length (cm)	Spike girth (cm)	Grain yield (kg/ha)	Stover yield (kg/ha)	RWUE (kg/ha-mm)
HMS 48A X PT-1-10-1131	139	4.6	22.7	3.8	530	6852	2.29
HMS 47A X HPT-2-12-32	151	5.0	23.2	3.1	662	6852	2.87
ICMA04999 X TCH 26-1	154	5.1	24.3	3.4	404	6111	1.75
ICMA 94555 X HPT-2-12-32	137	4.2	19.2	3.5	597	5926	2.58
HMS 60A X HTP-10-129	141	3.9	22.9	3.9	634	5556	2.74
ICMA 04888 X PT-1-10-1047	132	4.6	21.9	3.8	553	6852	2.39
ICMA 04999 X H 1305	131	4.4	22.0	3.9	307	6111	1.33
HMS 41A X HTP-1-12-84	141	4.1	20.4	3.5	399	6296	1.73
ICMA 94222 X HTP-1-12-84	142	5.1	22.9	3.9	293	6296	1.27
ICMA 08111 X RAJ 3	138	4.9	19.2	3.5	668	6111	2.89
HHB 265	144	4.9	21.0	3.8	194	5185	0.84
ICMA 05222 X 110(SONI-R)	131	4.1	20.4	3.6	338	5370	1.46
HHB 300	140	4.3	19.4	3.6	541	5556	2.34
HHB 301	149	3.9	20.7	3.7	587	5926	2.54
HHB 302	168	3.9	24.7	3.8	470	5185	2.03
HHB 67 Improv. (C)	155	4.6	22.9	3.7	736	6111	3.19
HHB 234 (C)	157	5.1	23.8	3.8	466	6667	2.02
HHB 272 (C)	149	3.8	21.6	4	964	7593	4.17
CD at 5%	-	-	-	-	135.23	919.13	-

At Hisar, in a large scale varietal trial (LST) of sesame, genotype CST 2001-9 recorded the highest seed yield (180 kg/ha) followed by HT-24 (178 kg/ha), OC 251 & T 78 (143 kg/ha) and AVT 11-5 & HT 2000 (135 kg/ha). Plant height ranged from 70-94 cm; branches/plant from 3.9-5.1; and pods/plant from 20.4-77.2 cm. In general, the yields were quite low due to two dry spells during crop season and infestation of white fly, stem rot and wilt diseases (Table 3.175).

Table 3.175 : Performance of sesame genotypes in LST (Sesame/Til) - Hisar

Genotype	Plant height (cm)	Branches/plant	Pods/plant	Seed yield (kg/ha)	RWUE (kg/ha-mm)
CST 2001-9	84	4.8	77.2	180	1.13
RT 125	79	4.9	60.6	61	0.38
HT 115	86	4.8	49.8	33	0.21
HT 20	84	4.7	46.4	61	0.38
OC 201	85	4.9	40.6	63	0.40
AVT 11-5	82	5.0	40.7	135	0.85
OC 251	94	5.0	50.9	143	0.90
HT 24	90	4.4	48.2	178	1.12
RT 54	85	3.9	55.8	57	0.36
Pragati	83	3.9	44.6	41	0.26
NG 187	78	4.3	45	57	0.36
Shankar	76	4.3	49.5	54	0.34
HT 9913	76	4.1	29.4	33	0.21
TKG 22	79	4.0	42.8	50	0.31
HT 9907	74	4.1	23.9	33	0.21
T 78	90	4.7	48.6	143	0.90
HT 2000	87	4.8	34.5	135	0.85
HT 45	80	4.4	24.8	111	0.70
KMR 60	78	3.9	25.6	81	0.51
HT 9316	70	3.9	20.4	106	0.66
HT 115	70	3.9	28.9	59	0.37
HT 2 (LC)	76	4.5	28.9	81	0.51
HTC 1 (black)	78	5.1	47.8	100	0.63
KMR 41	89	5.1	43.1	89	0.56
CD at 5%	8.08	0.58	2.88	13.47	

At Hisar, in Final Yield Trial-1 (FYT-1m Hisar), among 12 mustard genotypes, three genotypes, RH-1019 (1991 kg/ha), RH-923 & RH-1202 (1944 kg/ha) recorded numerically at par seed yield over the best check (RH-0749. Days to maturity ranged from 143 days (RH-749 & RH-1209) to 158 days (RH-923); plant height from 159 (RH-1209) to 208 cm (RH-673) and siliqua/plant from 148 (RH-30) to 171 (RH-725, RH-749 & RH-1019) (Table 3.176).

Table 3.176 : Performance of mustard genotypes FYT-1- Hisar

Genotype	Days to maturity	Plant height (cm)	Branches/ plant	Siliqua/plant	Seeds/siliqua	Seed yield (kg/ha)	RWUE (kg/ha-mm)
RH-30 ©	149	182	9.3	148	12.0	1620	44.4
RH-630	154	176	7.3	169	12.7	1759	48.2
RH-673	149	208	9.3	165	12.8	1748	47.9

Genotype	Days to maturity	Plant height (cm)	Branches/ plant	Siliqua/plant	Seeds/siliqua	Seed yield (kg/ha)	RWUE (kg/ha-mm)
RH-725	146	207	11.0	171	12.8	1609	44.1
RH-0749	143	174	8.4	171	13.0	2060	56.4
RH-761	155	189	9.4	160	12.5	1667	45.7
RH-923	158	186	8.1	159	12.3	1944	53.3
RH-1019	146	185	9.0	171	12.7	1991	54.5
RH-1134	157	187	8.7	158	12.5	1609	44.1
RH-1135	151	162	9.3	164	12.0	1713	46.9
RH-1202	148	168	7.1	152	12.7	1944	53.3
RH-1209	143	159	9.6	162	11.8	1609	44.1
CD at 5%	2.01	16.54	1.87	NS	NS	239.21	

In a chickpea Multi-location Trial (MLT) at Hisar, among 18 genotypes, none of the genotypes performed statistically better over the best national check (DCP-92-3). However, three genotypes, H 13-01 & H 13-36 (2245 kg/ha) and H 12-22 (2130 kg/ha) recorded numerically at par seed yield over the best national check, DCP 92-3 (2315 kg/ha). Days to flowering ranged from 68 (H 12-22) to 79 days (H-13-36); days to maturity from 134 days (H 13-09) to 153 days (H-13-36); plant height from 41 cm (H 13-38) to 66 cm (H 13-02); pods/plant from 47 (H 12-22) to 68 (HC 5); and test weight from 15 g (HC 12-64) to 20 g (H-13-03) (Table 3.177).

Performance of chickpea genotypes MLT (H12-12)

Table 3.177 : Performance of chickpea genotypes MLT (RF) - Station Trial - Hisar

Genotype	Days to maturity	Plant height (cm)	Branches /plant	Pods /plant	Seeds /pod	100- seed wt. (g)	Seed yield (kg/ha)	RWUE (kg/ha-mm)
H 12-17	144	64	14.5	48	1.9	15.6	1505	41.2
H 12-22	138	50	10.3	47	1.8	15.9	2130	58.3
H 12-29	140	52	10.5	53	1.9	18.3	2025	55.5
H 12-63	144	59	11.8	54	1.9	19.3	1435	39.3
H 12-64	144	53	10.3	50	2	15.0	1817	49.8
H 13-01	138	48	11.2	62	2	18.2	2245	61.5
H 13-02	139	66	11.2	63	2	18.6	2049	56.1
H 13-03	137	61	12.7	63	2	20.0	1574	43.1
H 13-09	134	56	10.2	65	2	16.9	1840	50.4
H 13-12	142	61	11.9	64	1.8	19.7	2049	56.1
H 13-15	138	57	12.8	66	1.8	16.9	2014	55.2

Genotype	Days to maturity	Plant height (cm)	Branches /plant	Pods /plant	Seeds /pod	100- seed wt. (g)	Seed yield (kg/ha)	RWUE (kg/ha-mm)
H 13-28	140	48	11.0	54	1.9	16.2	1736	47.6
H 13-29	146	56	12.6	63	1.8	15.1	2245	61.5
H 13-36	153	49	12.1	67	2	15.4	2083	57.1
H 13-38	150	41	11.8	54	2	16.2	2002	54.9
HC-1©	145	50	13.3	66	2	16.3	2095	57.4
HC-5©	140	64	12.3	68	1.8	17.3	2234	61.2
DCP 92-3©	140	53	10.9	53	1.9	18.0	2315	63.4
CD at 5%	2.7	7	1.8	10.4	-	0.5	217.1	-

In a trial on evaluation of castor hybrids/varieties at SK Nagar, hybrid SHB 974 performed better and gave significantly higher seed yield (469 kg/ha), net returns (Rs.5785/ha), B:C ratio (1.49), but it was found at par with JHB 1018 (467 kg/ha), GCH 7 (459 kg/ha), SHB 982(437 kg/ha), SHB 966 (441 kg/ha). However the lowest seed yield (389 kg/ha) was recorded by JHB 1027 (Table 3.178).

Table 3.178 : Yield and economics of castor hybrids/varieties – SK Nagar

Genotype	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
SHB 960	398	11800	3125	1.26
SHB 966	441	11801	4737	1.40
SHB 970	395	11802	3011	1.26
SHB 974	469	11803	5785	1.49
SHB 982	437	11804	4584	1.39
JHB 1013	428	11805	4245	1.36
JHB 1018	467	11806	5707	1.48
JHB 1022	391	11807	2856	1.24
JHB 1027	389	11808	2780	1.24
GCH 7 (C)	459	11809	5404	1.46
CD at 5%	39.737			

3.3.2.5 Energy management

In an experiment on tillage and residue management at Hisar, the seed yield of mustard under low tillage with two intercultures (1299 kg/ha) was found significantly better than other treatments. The stalk yield (3021 kg/ha), net returns (Rs.26098/ha), B:C ratio (2.2) and RWUE (35.1 kg/ha-mm) were also found higher with low tillage (Table 3.179).

Table 3.179 : Yield and economics of mustard as affected by tillage and residue management

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Tillage						
Zero tillage	943	2206	21120	14251	1.7	25.5
Low tillage	1299	3021	22600	26098	2.2	35.1
Conventional tillage	1211	2814	23350	22045	1.9	32.7
CD at 5%	57					

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Cutting height from ground (cm)						
HG0	1181	2763	22400	21899	2.0	31.9
HG15	1085	2528	22400	18282	1.8	29.3
HG30	1179	2735	22400	21789	2.0	31.9
CD at 5%	NS					

Mustard under zero (left) and low tillage

At SK Nagar, in a study on different tillage practices in clusterbean, the highest seed (246 kg/ha) and stalk yield (300 kg/ha), net returns (Rs.6556/ha) B:C ratio (2.11) and RWUE (0.26 kg/ha-mm) were recorded with tillage under roto till drill and was at par with tillage. It was at par with tillage of strip till drill (227 kg/ha), raised bed planter (219 kg/ha), and zero till drill (211 kg/ha) and yield increased by 48.2, 36.7, 31.9 and 27.1% as compared to control (166 kg/ha), respectively (Table 3.180).

Table 3.180 : Effect of treatments on yield and economics of clusterbean – SK Nagar

Treatment	Seed yield (kg/ha)	Mean seed yield (6 years)	Stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Zero till drill	211	265	266	5500	5215	1.95	0.23
Strip till drill	227	301	284	5900	5621	1.95	0.24
Roto till drill	246	351	300	5900	6556	2.11	0.26
Raised bed planter	219	256	252	6700	4351	1.65	0.24
Control	166	217	202	5700	2727	1.48	0.18
CD at 5%	50.2		55.7				

Raised bed planter

Roto till drill

Tillage in clusterbean

3.3.2.6 Alternate land use

At Hisar in a silvi-pasture system, *Cenchrus setiger* grass yielded highest green fodder (5401 kg/ha) followed by *Cenchrus ciliaris* (4230 kg/ha), *Lasirus sindicus* (3520 kg/ha) and *Cymbopogon javarancausa* (Boor grass) yielded herb yield of 2231 kg/ha in two cuttings. After 84 months of transplanting, the main crops *Azadirachta indica* (neem) attained a height of 669.1 cm, while *Prosopis cineraria* could grow only up to 374.0 cm (Table 3.181).

Table 3.181: Plant height and growth rate of neem and khejri - Hisar

Age of trees (Month)	*Azadirachta indica* (neem)		*Prosopis cineraria* (khejri)	
	Plant height (cm)	Growth rate (cm/day)	Plant height (cm)	Growth rate (cm/day)
0	33.0	-	23.0	-
6	55.6	0.12	37.0	0.08
12	126.5	0.39	51.7	0.13
18	147.0	0.13	67.2	0.03
24	174.0	0.15	78.0	0.06
30	192.0	0.10	102.9	0.14
36	201.2	0.05	110.6	0.04
42	227.1	0.14	137.1	0.14
48	249.0	0.14	141.0	0.02
54	265.0	0.10	151.0	0.06
60	341.4	0.42	220.4	0.38
66	478.5	0.76	276.7	0.31
72	540.8	0.34	300.5	0.18
78	615.5	0.41	345.0	0.25
84	669.1	0.30	374.0	0.16

At SK Nagar in drumstick based agri-horti system, pearlmillet grain filling to maturity stage (maturity stage experienced logn dry spell, in castor at seed filling to maturity stage). The grain yield of pearlmillet was not recorded, while seed yield of castor (613 kg/ha), pulses (436 kg/ha) and fodder yield of sorghum was drastically reduced with net returns (Rs.10012/ha and Rs.25923/ha) and B:C ratio (1.85 and 4.39) in castor and greengram respectively, but highest RWUE (5.19 and 5.08 kg/ha-mm) was recorded in fodder sorghum sole and drumstick + fodder sorghum. Due to first year of drumstick plantation, no yield was obtained (Table 3.182).

Table 3.182 : Yield and economics of drumstick based agri-horticultural system – SK Nagar

Treatment	Grain/seed yield (kg/ha)	Straw/stalk yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio	RWUE (kg/ha-mm)
Drumstick sole	-	-	3000	-3000	0.00	0.00
Greengram sole	436	1012	7650	25923	4.39	0.47
Pearlmillet sole	-	2387	9150	-3183	0.65	2.56
Fodder sorghum sole	-	4733	8500	5698	1.67	5.08
Castor sole	613	621	11760	10012	1.85	0.66
Drumstick + greengram	469	1062	10650	25376	3.38	0.50
Drumstick + pearlmillet	-	2449	12150	-6028	0.50	2.63
Drumstick + fodder sorghum	-	4836	11500	3007	1.26	5.19
Drumstick + castor	638	667	14760	7899	1.54	0.69

3.3.3 Fingermillet Based Production System

3.3.3.1 Rainwater management

At Bangaluru in a field experiment on evaluation of different polymers in fingermillet, grain and straw yield of fingermillet with different levels of polymers were statistically at par among different levels and control. Application of polymer aquasorb recorded negative net returns. However, application of polymer aquapod @ 75 kg/ha recorded higher grain yield (2680 kg/ha) with RWUE of 4.49 kg/ha-mm. However, application of aquapod @25 kg/ha recorded higher net returns (Rs 23402/ha) and B:C ratio (1.68) than other treatments. (Table 3.183).

Table 3.183 : Effect of polymers on yield, economics and rain water use efficiency in finger millet - Bengaluru

Treatment	Grain yield (kg/ha)	Mean grain yield (2 years)	Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Control	2405	2699	3867	25206	30611	2.21	4.30
Polymer aquasorb @ 25 kg/ha	2437	2719	4009	70206	-13588	0.81	4.35
Polymer aquasorb @ 50 kg/ha	2509	2760	4135	115206	-56896	0.51	4.48
Polymer aquasorb @ 75 kg/ha	2566	2842	4198	160206	-100599	0.37	4.58
Polymer aquapod @ 25 kg/ha	2497	2753	4104	34606	23402	1.68	4.46
Polymer aquapod @ 50 kg/ha	2541	2820	4167	44006	15022	1.34	4.54
Polymer aquapod @ 75 kg/ha	2680	2950	4261	53406	8748	1.16	4.79
CD at 5%	NS	NS	NS	-	-	-	-

Fingermillet with aquapod @ 75 kg/ha

Control

Similarly, in another field experiment at Bengaluru, the grain and straw yield of fingermillet under long term use of polymers was on par during the first year of study. The net returns were higher with control (Rs. 31899/ha) compared to treatments involving polymers due to high cost of polymers and no significant increase in grain yield. (Table 3.184).

Table 3.184 : Effect of polymers on yield and economics of fingermillet - Bengaluru

Treatment	Grain yield (kg/ha)	Mean grain yield (kg/ha) (2 years)	Straw yield (kg/ha)	Cost of cultivation (Rs/ ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Polymer aquasorb once in 2 years	2626	2880	4167	81456	-20553	0.75	4.69
Polymer aquasorb once in 3 years	2535	2858	3977	62706	-3864	0.94	4.53
Polymer aquasorb once in 4 years	2554	2844	4040	53331	5927	1.11	4.56
Polymer aquasorb once in 5 years	2592	2879	4293	47706	12528	1.26	4.63
Polymer aquapod once in 2 years	2768	3000	4609	36956	27403	1.74	4.94
Polymer aquapod once in 3 years	2674	2972	4451	33039	29118	1.88	4.77
Polymer aquapod once in 4 years	2633	2931	4388	31081	30126	1.97	4.70
Polymer aquapod once in 5 years	2655	2956	4356	29906	31764	2.06	4.74
Control	2456	2776	4104	25206	31899	2.27	4.39
CD at 5%	NS	NS	NS	-	-	-	-

Performance of fingermillet with polymer aquapod once in 2 years

Performance of fingermillet without polymer application

At Bengaluru, in a study on microsite improvement in the existing three amla plots (3200 m^2), higher yield and net returns were recorded with trench–cum-crescent bund (3273 kg/ha and Rs. 123320/ha) followed by continuous trenches (2568 kg/ha & Rs. 97020/ha) and no trenches (1611kg/ha & Rs.60,640/ha). In the year 2015, rainfall of 1061.2 mm was received and 5, 6 and 7 runoff events were noticed in T_1, T_2 and $_{T3}$ respectively. Less runoff (mm), soil loss and nutrient losses were noticed under T_1 followed by T_2 and T_3 T_1 recorded higher average soil moisture content followed by T_2 and T_3 (Table 3.185 & 3.186).

Table 3.185 : Yield and economics of amla plants under moisture conservation techniques - Bengaluru

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1: Trench–cum-crescent bund	3273	7600	123320	17.23	3.08
T_2: Continuous trenches using deep trencher	2568	5700	97020	18.02	2.42
T_3: No trench (control)	1611	3800	60640	16.96	1.52

Table 3.186 : Runoff, soil loss and nutrient loss in relation to rainfall intensity in different conservation techniques - Bengaluru

Date	Rainfall (mm)	Runoff (m^3)	Soil loss (kg)	Total N loss (g/lt) x runoff (lt)	Total P loss (g/lt) x runoff (lt)	Total K loss (g/lt) x runoff (lt)
$T_{1:}$ Trench–cum-crescent bund						
17.05.2015	45.4	1.20	2.15	26.8	39.9	4.4
01.06.2015	47.2	5.00	8.99	117.5	158.1	18.3
07.09.2015	92.4	9.72	13.6	223.3	315.9	35.9
26.09.2015	52.2	1.82	2.55	40.9	62.4	6.6
28.09.2015	50.8	2.71	3.25	62.2	81.1	9.8
T2: Continuous trenches using deep trencher						
17.05.2015	45.4	5.47	10.9	91.9	168.4	14.8
01.06.2015	47.2	9.04	18.07	237.9	270.5	27.9
07.09.2015	92.4	25.63	41.0	617.3	745.2	91.8
26.09.2015	52.2	2.42	4.35	59.5	74.4	9.0
28.09.2015	50.8	5.68	9.09	152.7	170.0	20.6
06.10.2015	35.8	2.29	4.58	60.3	70.5	8.4
T3: No trench (control)						
17.05.2015	45.4	5.92	11.8	132.6	167.0	19.4
01.06.2015	47.2	11.4	22.2	305.6	361.8	41.1
07.09.2015	92.4	56.63	102.0	1363.6	1791.5	210.1
26.09.2015	52.2	9.40	13.15	252.6	305.3	34.0
28.09.2015	50.8	13.72	27.43	361.1	457.5	49.9
05.10.2015	23.2	5.75	10.35	138.5	186.9	20.6
06.10.2015	35.8	6.16	12.31	168.9	205.3	22.0

Performance of amla with trench cum crescent bund

Performance of amla with no microsite improvement

Among the live barriers evaluated Bengalururu, *Nase* plots recorded higher yield of pigeonpea (774 and 855 kg/ha, respectively) followed by *Khus* live barrier plots (765 and 785 kg/ha, respectively) as compared to control plots (615 kg/ha) (Table 3.187). Trends were similar with respect of B:C ratio and RWUE. *Nase grass* (lower) recorded higher net returns (Rs 57912/ha) compared to other treatments.

Table 3.187 : Pigeon pea yield as influenced by live barriers during *kharif*, 2015 - - Bengaluru

Treatment	Pigeonpea yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Khus grass upper	765	27574	48941	2.77	0.97
Lower	785	27574	50877	2.85	1.00
Mean	775	27574	49909	2.81	0.99
Nase grass upper	774	27574	49867	2.81	0.99
Lower	855	27574	57912	3.10	1.09
Mean	815	27574	53890	2.95	1.04
Control	615	27574	33923	2.23	0.78

Performance of pigeonpea with nase grass on live barriers

3.3.3.2 Cropping systems

At Bengaluru, in a study on efficient utilization of farm pond water for intensive and profitable crop production, the forage yield of giant bajra was significantly higher (52059 kg/ha) with higher main crop equivalent yield (75427 kg/ha), net returns (Rs. 67539/ha) and B:C ratio (3.19) followed by SA maize (49879 kg/ha). Significantly higher chickpea seed yield was recorded in early sown giant bajra (584 kg/ha) followed by South Africa maize (537 kg/ha). Between the varieties of chickpea, JG-11 recorded significantly higher seed yield (541 kg/ha) as compared to Annigeri-1 (499 kg/ha). Chickpea receiving 100% RDF recorded significantly higher seed yield (562 kg/ha) compared to 75% of recommended dose of fertilizer (477 kg/ha). Higher system B:C ratio was obtained with giant bajra (3.19) followed by SA maize (2.93) under fodder and chickpea double cropping system. JG-11 recorded higher B:C ratio (2.20) as compared to Annigeri-1 (2.11) (Table 3.188).

Table 3.188 : Double cropping of forage crops followed by chickpea with protective irrigation during dry spells utilizing harvested rainwater in farm pond – Bengaluru

Treatment	Yield (kg/ha)		FCEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	
	Crop 1	Crop 2					Crop 1	Crop 2
Forage crops								
South African maize (SA tall)	49879	537	71351	47834	59192	2.24	224	2.93
Sweet sorghum (SSV-74)	32940	438	50470	43326	32378	1.75	148	2.39
Giant bajra	52059	584	75427	45601	67539	2.48	233	3.19
CD at 5%	-	80.97	7152.4	-	-	-	-	-

Treatment	Yield (kg/ha)		FCEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	
	Crop 1	Crop 2					Crop 1	Crop 2
Chickpea variety								
Annigeri-1		499	64268	45587	50816	2.11	-	2.72
JG-11		541	67230	45587	55257	2.20	-	2.96
CD at 5%		30.85	1952.2	-	-	-	-	-
Fertilizer								
100% RDF (13:25:25 NPK kg/ ha)		562	67483	45855	55369	2.20	-	3.07
75% RDF		477	64015	45320	50703	2.11	-	2.61

Chickpea cv. JG-11 with 100% RDF

Chickpea cv.Annegeri-1 with 100% RDF

Performance of chickpea genotypes

FCEY: Forage crop equivalent yield

3.3.3.3 Nutrient management

Different foliar sprays were applied in fingermillet to different treatments after a dryspell of eight days. Foliar spray of thiourea (250 g/ha) was applied after retrieving drought. The results of application of different dose and different chemicals for foliar spray to finger millet during drought revealed that higher grain and straw yield was recorded with foliar spray of 2% KNO_3 at panicle initiation stage (2637 and 5139 kg/ha, respectively) with highest B:C ratio of 2.35. The lower grain yield was obtained with foliar spray of water (1864 kg/ha). Also, highest RWUE was recorded with foliar spray of 2% KNO_3 at panicle initiation (5.08 kg/ha-mm) (Table 3.189).

Table 3.189 : Yield and economics of fingermillet as influenced by different foliar sprays– 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)
Foliar spray of water	1864	2796	25966	17137	1.66	3.59
Foliar spray of sodium selenite @ 10g/ha	2088	3796	26538	22244	1.84	4.03
Foliar spray of sodium selenite @ 20 g/ha	2083	3695	27111	21494	1.79	4.02
Foliar spray of 1% KNO_3	2576	4556	26166	33931	2.30	4.97
Foliar spray of 2% KNO_3	2637	5139	26366	35493	2.35	5.08
Foliar spray of thiourea (2250 g/ha)	1998	3356	25786	20680	1.80	3.85
Foliar spray of 1% KCl	2512	4515	26166	32475	2.24	4.84
CD at 5%	543.86	616.00	-	-	-	-

The available NPK content of soil increased with the application of foliar spray of sodium selenite @ 10g/ha (209.90, 64.86 and 93.65 N, P_2O_5 & K_2O kg/ha) compared to other treatments. Higher exchangeable calcium and magnesium was recorded with foliar spray of KNO_3 at 2%. Significantly higher available sulphur (18.56 ppm) was recorded with application of foliar spray of sodium selenite @ 20 g/ha (Table 3.190).

Table 3.190 : Soil chemical properties after harvest of fingermillet as influenced by foliar sprays– Bengaluru

Treatment	pH	EC (dS/m)	OC (%)	Available nutrients (kg/ha)			Exchangeable cations (meq/100 g)		Available S (ppm)
				N	P_2O_5	K_2O	Ca	Mg	
Initial	5.11	-	0.49	204.80	64.4	101.16	1.53	0.83	28.11
Foliar spray of water	5.22	0.023	0.47	195.68	45.26	89.17	1.50	0.76	16.82
Foliar spray of sodium selenite @ 10g/ha	5.03	0.020	0.50	209.90	64.86	93.65	1.59	0.79	17.56
Foliar spray of Sodium selenite @ 20 g/ha	5.05	0.020	0.48	205.53	49.06	86.31	1.66	0.75	18.56
Foliar spray of 1% KNO_3	4.94	0.023	0.42	178.64	50.94	85.71	1.58	0.73	16.48
Foliar spray of 2% KNO_3	5.12	0.023	0.44	188.89	46.63	110.54	1.70	0.81	16.87
Foliar spray of Thiourea (250 g/ha)	5.13	0.020	0.46	194.20	53.25	104.65	1.54	0.71	16.17
Foliar spray of 1% KCl	5.16	0.020	0.48	211.13	43.08	85.98	1.60	0.77	16.94
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Foliar spray of 2% KNO_3

Foliar spray of water

Performance fingermillet with foliar spray

At Bengaluru INM in fingermillet – groundnut cropping system indicated that application of *ex-situ* green manure (7.5t/ha) + 75% N & P + 100% K + bio- fertilizers recorded higher finger millet grain yield (2956 kg/ha) followed by 10t/ ha FYM+ Rec. NPK + bio- fertilizers (2708 kg/ha) as compared to recommended NPK (2352 kg/ha) resulting in 26% yield increase with a higher net returns of Rs. 50681/ha. The straw yield was also higher (5009 kg/ha) with application of *ex-situ* green manure (7.5 t/ha) + 75% N & P + 100% K + bio- fertilizers. The lowest grain and straw yield was recorded in control (970 and 1602 kg/ ha, respectively) (Table 3.191).

Table 3.191 : Yield maximization through integrated nutrient management in fingermillet-groundnut cropping system - 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)
	2015	Mean (2 years)					
Control	970	1327	1602	14200	8339	1.59	1.87
NPK (50 :40 :25 kg NPK/ha)	2352	2674	3870	17706	36938	3.09	4.54

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B: C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)					
10 t/ha FYM + NPK	2792	3009	4400	25206	39511	2.57	5.38
Rec.NPK + bio-fertilizers	2356	2862	4213	18000	37002	3.06	4.54
10 t/ha FYM + Rec.NPK + bio-fertilizers	2708	3166	4665	25300	37782	2.49	5.22
10 t/ha FYM + 75% N & P + 100% K + bio- fertilizers	2688	3003	4815	23708	39028	2.65	5.18
Ex-situ green manure (7.5 t/ha) + 75% N & P+ 100% K + bio-fertilizers	2956	3214	5009	18108	50681	3.80	5.70
In situ Green manure + 75% N & P + 100% K + bio- fertilizers	2402	2705	4009	18628	37219	3.00	4.63
10 t/ha FYM+ 100% N & P + 150% K + bio- fertilizers	2595	3029	4612	25729	34818	2.35	5.00
CD at 5%	489	-	530	-	-	-	-

Chemical properties after the harvesting of finger millet as influenced by integrated nutrient management revealed that organic carbon, available N, and K content of soil was significantly increased with the application of ex-situ green manure (7.5 t/ha) + 75% N & P+ 100% K + bio- fertilizers compared to application of NPK alone and control. Significantly, higher available P (65.37 kg/ha) was recorded with application of 10 t/ha FYM + 100% N and P+ 150% K + bio- fertilizers (T5) compared to NPK only (T2) (33.95 kg/ha). Higher exchangeable calcium and magnesium was observed with ex-situ green manure (7.5 t/ha) + 75% N & P+ 100% K + bio- fertilizers (T7) compared to only inorganic fertilizers and available S was significantly highest with application with exsitu green manure (75% N&P +100% K + Biofertilizers compared to control (Table 3.192).

Table 3.192 : Soil chemical properties after the harvest of groundnut as influenced by integrated nutrient management-Bengaluru

Treatment	pH (1:2.5)	OC (%)	Available nutrients (kg/ha)			Exchangeable cations(meq /100 g)		Available S (ppm)
			N	P_2O_5	K_2O	Ca	Mg	
Initial	5.30	0.49	143.4	64.4	101.5	1.53	0.83	14.20
Control	5.13	0.36	138.2	28.2	101.7	1.33	0.70	12.84
NPK (50 :40 :25 kg NPK/ha)	5.00	0.38	161.9	34.0	109.0	1.25	0.93	14.13
10 t/ha FYM + NPK	5.23	0.51	213.3	31.1	146.3	2.28	1.06	22.24
Rec.NPK + bio-fertilizers	5.24	0.43	204.9	33.6	121.9	2.01	1.05	18.80
10 t/ha FYM + Rec.NPK + bio- fertilizers	5.34	0.50	213.3	65.4	147.9	2.22	1.07	21.54
10 t/ha FYM + 75% N & P + 100% K + bio- fertilizers	5.48	0.49	234.2	49.8	175.4	2.13	1.06	19.29
Ex-situ green manure (7.5 t/ha) + 75% N & P+ 100% K + bio- fertilizers	5.24	0.53	250.9	62.1	182.0	2.24	1.08	23.65
In situ Green manure + 75% N & P + 100% K + bio- fertilizers	5.16	0.50	209.1	49.6	133.4	2.18	1.08	21.90
10 t/ha FYM+ 100% N & P + 150% K + bio- fertilizers	5.26	0.52	195.3	52.1	160.8	1.67	1.07	20.79
CD at 5%	NS	0.08	31.7	10.4	38.3	0.27	0.19	2.56

In a field experiment at Bengaluru with different levels of K and Mg in fingermillet, among different treatments, application of 150 % rec. K/ha + magnesium @ 30 kg/ha recorded higher grain and straw yield (566 kg/ha and 2071 kg/ha respectively) compared to control (264 kg/ha and 756 kg/ha respectively) resulting in 114% yield increase with a higher net returns (Rs. 27352/ha) and B:C ratio (1.94). Among the different levels of magnesium, application of magnesium @ 30 kg/ha recorded higher grain, straw yield and B:C ratio (484 kg/ha, 1689 kg/ha and 1.68 respectively), while among potassium levels, potassium application at 150% rec. K/ha recorded higher grain yield, straw yield and B:C ratio (553 kg/ha, 1959 kg/ha and 1.94 respectively) (Table 3.193).

Table 3.193 : Yield and economics of finger millet cultivation as influenced by levels of potassium and magnesium - 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)
K_1:No K	317	1043	27510	4172	1.15	0.49
K_2:100% Rec. K (37.5 kg/ha)	465	1367	28215	18251	1.65	0.72
K3:125% Rec. K	470	1618	28388	18646	1.66	0.73
K4: 150% Rec. K	553	1958	28565	26731	1.94	0.86
CD at 5%	41.22	164.6	-	-	-	-
M_1:No Mg	422	1313	27525	14706	1.53	0.66
M_2:Magnesium @ 15 kg/ha	448	1487	28169	16599	1.59	0.70
M_3:Magnesium @ 30 kg/ha	484	1689	28814	19546	1.68	0.75
CD at 5%	35.69	142.6	-	-	-	-
K_1M_1	264	756	26865	-475	0.98	0.41
K_1M_2	326	1092	27510	5071	1.18	0.51
K_1M_3	361	1280	28154	7920	1.28	0.56
K_2M_1	422	1115	27570	14677	1.53	0.66
K_2M_2	473	1321	28215	19067	1.68	0.74
K_2M_3	499	1664	28859	21009	1.73	0.78
K_3M_1	449	1571	27743	17184	1.62	0.70
K_3M_2	452	1541	28388	16853	1.59	0.70
K_3M_3	509	1742	29032	21903	1.75	0.79
K_4M_1	554	1811	27920	27440	1.98	0.86
K_4M_2	540	1993	28565	25403	1.89	0.84
K_4M_3	566	2071	29209	27352	1.94	0.88
CD at 5%	NS	NS	-	-	-	-

Different levels of potassium and magnesium application did not differ significantly with respect to pH, EC, available N and available S (Table….). Among different levels of potassium application, significantly higher available K_2O and exchangeable Mg was recorded with application of 150% recommended K compared to control. Significantly higher exchangeable Ca was recorded with application of 100% recommended K compared to other treatments. Among the different levels of magnesium, application of magnesium @ 30.0 kg/ha recorded significantly higher exchangeable Ca and Mg (3.60 meq/100 g and 2.51 meq/100 g respectively). Interaction effect of application of different levels of potassium and magnesium on soil chemical properties was non significant except available potassium and calcium (Table 3.194) .

Table 3.194 : Soil chemical properties after the harvest of finger millet as influenced by levels of potassium and magnesium- Bengaluru

Treatment	pH	EC (dS/m)	OC (%)	Available nutrients (kg/ha)			Exchangeable cations (meq/100 g)		Av.S (ppm)
				N	P_2O_5	K_2O	Ca	Mg	
Initial	5.38	-	0.44	170.5	97.4	90.7	3.45	1.72	15.12
K_1:No K	5.33	0.029	0.45	210.4	40.5	102.5	2.42	1.89	14.53
K_2:100% Rec. K (37.5 kg/ha)	5.34	0.029	0.47	236.6	31.1	112.8	3.60	2.34	14.89
K_3:125% Rec. K	5.38	0.033	0.48	234.3	57.6	124.1	3.58	2.26	15.18
K_4: 150 % Rec. K	5.38	0.031	0.41	218.4	53.9	127.8	3.44	2.39	15.46
CD at 5%	NS	NS	0.05	NS	11.4	11.1	0.28	NS	0.637
M_1:No Mg	5.35	0.027	0.44	216.2	32.1	119.3	2.88	1.86	14.78
M_2:Magnesium @ 15 kg/ha	5.34	0.031	0.44	219.4	62.7	117.3	3.31	2.29	15.33
M_3:Magnesium @ 30 kg/ha	5.38	0.034	0.48	239.1	42.6	113.8	3.60	2.51	14.94
CD at 5%	NS	0.005	NS	NS	9.9	NS	0.25	0.35	NS
K_1M_1	5.25	0.023	0.42	202.0	22.3	91.9	1.40	0.95	14.47
K_1M_2	5.34	0.027	0.41	209.6	59.4	110.6	2.87	2.23	15.07
K_1M_3	5.42	0.037	0.51	219.6	39.8	105.1	3.00	2.50	14.06
K_2M_1	5.41	0.027	0.48	237.6	29.6	116.7	3.20	2.27	14.17
K_2M_2	5.30	0.030	0.43	223.8	30.6	113.2	3.67	2.30	15.17
K_2M_3	5.31	0.030	0.51	248.4	33.1	108.5	3.93	2.47	15.33
K_3M_1	5.40	0.030	0.45	219.2	38.3	130.4	3.57	1.93	14.83
K_3M_2	5.39	0.040	0.48	235.4	78.1	122.3	3.33	2.23	15.53
K_3M_3	5.34	0.030	0.51	248.4	56.6	119.5	3.83	2.60	15.19
K_4M_1	5.37	0.027	0.42	206.2	38.3	138.0	3.33	2.30	15.65
K_4M_2	5.32	0.027	0.43	208.9	82.7	123.0	3.37	2.40	15.56
K_4M_3	5.44	0.040	0.39	240.2	40.8	122.3	3.63	2.47	15.18
CD at 5%	NS	NS	NS	NS	19.72	NS	0.50	NS	NS

In a Permanent Manurial Trial (PMT), the 38th year under mono-cropping of finger millet, the finger millet grain and straw yield was found to be significantly higher (2,588 and 4,788 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 (1502 and 2779 kg/ha, respectively) with a higher B:C ratio of 2.43. Also, the highest RWUE (5.02 kg/ha-mm) was recorded with application of FYM @ 10 t/ha+ 100% rec. NPK and least was with control (0.86 kg/ha-mm). Similar trends were also observed in maize residue (MR) series but with lower values (Table 3.195).

Table 3.195 : Influence of long term use of FYM/maize residue (MR) and fertilizers on productivity and economics of fingermillet under mono-cropping (38th 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
	2015	(38 years mean)						
FYM Series								
Control	446	683	825	14200	-3770	0.73	0.86	-0.08
FYM (10 t/ha)	1283	2321	2374	21700	8312	1.38	2.49	0.44
FYM (10 t/ha) + 50% N, P_2O_5 and K_2O	1860	2773	3442	23059	20450	1.89	3.60	0.58

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
	2015	(38 years mean)						
FYM (10 t/ha) + 100% N, P_2O_5 and K_2O	2588	3138	4788	24860	35664	2.43	5.02	0.70
Rec. N, P_2O_5 and K_2O	1502	2010	2779	17360	17775	2.02	2.91	0.34
CD at 5%	416.23		770.02	-	-	-	-	-
Maize Residue Series								
Control	404	619	934	14200	-2829	0.80	0.78	-0.06
MR (5 t/ha)	754	1022	1342	21700	-4115	0.81	1.46	0.10
MR (5 t/ha) + 50%N,P_2O_5 and K_2O	1607	1940	2967	23059	14512	1.63	3.11	0.47
MR (5 t/ha) + 100% N,P_2O_5 and K_2O	2134	2512	3646	24860	24813	2.00	4.14	0.70
Rec. N,P_2O_5 and K_2O	1290	1903	2409	17360	12820	1.74	2.50	0.45
CD at 5%	235.68	-	668.57	-	-	-	-	-

Note: 100% NPK kg/ha: 50:40:25

In the 12th year of crop rotation with groundnut under FYM series, the finger millet grain and straw yield was found to be significantly higher (2764 and 4667 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 (T5) (2313 and 4374 kg/ha, respectively). Also, the highest RWUE (5.36 kg/ha-mm) was recorded with application of FYM @ 10 t/ha+ 100 % rec. NPK and lower RWUE was in control (1.47 kg/ha-mm). Under maize residue (MR) series, similar trend of result was obtained but with lower values (Table 3.196).

Table 3.196 : Influence of long-term use of FYM/MR and fertilizers on productivity and economics of groundnut under rotation (12th year) -Bengaluru

Treatment	Yield kg/ha			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C Ratio	RWUE (kg/ha- mm)	SYI
	Pod	Mean pod (12 years)	Straw					
Fingermillet-groundnut rotation (FYM series)								
T1	758	720	1477	14200	3594	1.09	1.47	-0.01
T2	1886	2863	2632	21700	21775	2.30	3.66	0.40
T3	2417	3440	4178	23059	39443	2.71	4.68	0.59
T4	2764	3737	4667	24860	43881	2.77	5.36	0.72
T5	2313	2462	4374	17360	38271	3.20	4.48	0.56
CD at 5%	466.91		733.9	-	-	-	-	-
Fingermillet-groundnut rotation (MR series)								
T1	485	520	766	14200	-4745	0.67	0.93	-0.16
T2	1168	1202	2236	21700	5665	1.26	2.26	0.06
T3	2355	2408	4267	23059	31954	2.39	4.56	0.47
T4	2732	2991	4864	24860	38899	2.56	5.29	0.66
T5	2123	2373	3706	17360	32123	2.85	4.11	0.46
CD at 5%	561.07		479.37	-	-	-	-	

FYM @ 10 t/ha+100%NPK

Control

FYM @ 5 t/ha+100%NPK

Control

Performance of fingermillet under different treatment

Under fingermillet monocropping (FYM series), the soil pH and EC decreased significantly in control compared to application of FYM (10 t/ha) + 100% N, P_2O_5 and K_2O. Significantly higher organic carbon content (0.58 %) and all available nutrients (212.9, 64.1 and 69.8 N P_2O_5 K_2O kg/ha) were recorded with application of FYM (10 t/ha) + 100% N, P_2O_5 and K_2O compared to control. Almost similar results were reported with maize residue application (Table 3.197).

Table 3.197 : Soil properties as influenced by continuous application of FYM, MR and NPK fertilizers under fingermillet monocropping - Bengaluru

Treatment	pH	EC dS/m	OC (%)	Available nutrients (kg/ha)			Exch.cations (meq/100 g Soil)		Available S (ppm)
				N	P_2O_5	K_2O	Ca	Mg	
Initial	5.00	0.2	0.40	159-180	6-12	160	-	-	-
FYM series									
T_1	5.26	0.01	0.35	100.4	5.5	50.8	1.00	0.68	9.973
T_2	5.71	0.02	0.51	136.6	16.6	62.9	1.93	1.30	16.991
T_3	5.88	0.03	0.53	161.9	34.9	63.6	3.45	1.47	13.690
T_4	5.87	0.03	0.58	212.9	64.1	69.8	3.95	2.30	19.968
T_5	5.46	0.02	0.50	124.6	22.5	62.6	2.15	1.25	13.604
CD at 5%	0.46	0.01	0.53	15.4	6.9	15.5	0.50	0.20	1.269
MR series									
T_1	5.26	0.01	0.29	91.5	7.7	44.6	0.85	0.67	8.142
T_2	5.51	0.02	0.41	129.2	18.5	63.9	1.50	1.15	16.625
T_3	5.69	0.03	0.41	135.3	34.4	59.0	2.73	1.45	13.874
T_4	5.75	0.03	0.46	131.7	33.4	69.9	3.63	2.35	17.615
T_5	5.49	0.02	0.38	114.1	24.7	59.8	2.25	1.25	13.015
CD at 5%	0.69	0.003	0.41	29.8	5.6	8.8	0.47	0.20	2.836

Monocropping of fingermillet with FYM (10 t/ha) + 100% N, P_2O_5 and K_2O

Control

Rotation of fingermillet with groundnut with FYM (10 t/ha) + 100% N, P_2O_5 and K_2O

Control

Under rotation system (FYM series), the soil pH and EC increased with application of FYM (10 t/ha) + 100% N, P_2O_5 and K_2O compared to control. Significantly lower organic carbon (0.33%) was observed in control and NPK alone compared to application of FYM (10 t/ha) + 100% N, P_2O_5 and K_2O. The available nutrient also followed the similar trend as that of organic carbon. Similar trends of results were observed in maize residue series with lower values (Table 3.198).

Table 3.198 : Soil properties as influenced by continuous application of FYM, MR and NPK fertilizers under fingermillet-groundnut rotation - Bangalore

Treatment	pH	EC dS/m	OC (%)	Available nutrients (kg/ha)			Exchechable cations meq/100 g Soil		Available S (ppm)
				N	P_2O_5	K_2O	Ca	Mg	
FYM series									
T_1	5.15	0.01	0.33	102.9	6.1	51.2	1.1	0.58	9.08
T_2	5.88	0.03	0.53	143.9	31.7	77.2	2.5	1.38	16.62
T_3	5.81	0.02	0.56	162.9	44.2	64.0	3.6	2.00	16.17
T_4	5.98	0.03	0.61	238.3	50.7	113.0	4.0	2.55	18.36
T_5	5.41	0.02	0.40	128.1	23.1	56.0	2.3	1.30	13.41
CD at 5%	0.66	0.01	0.04	49.5	2.7	9.8	0.62	0.27	2.83
MR series									
T_1	5.19	0.01	0.31	104.4	9.2	49.7	0.93	0.54	8.09
T_2	5.41	0.03	0.50	138.4	20.1	65.3	2.48	1.40	15.23
T_3	5.56	0.02	0.52	156.6	33.8	55.3	3.30	1.95	14.72
T_4	5.45	0.03	0.57	215.4	35.2	73.1	3.40	2.56	17.04
T_5	5.22	0.02	0.42	116.6	17.9	58.8	2.00	1.35	13.14
CD at 5%	0.60	0.003	0.03	20.5	6.2	10.8	0.55	0.37	2.66

3.3.3.4 Evaluation of improved varieties

Among the 7 promising groundnut genotypes evaluated, genotype ICGV-0350 (2363 kg/ha) followed by GKVK-5 (2105 kg/ha) recorded significantly higher pod yield over check TMV-2 (1078 kg/ha). Genotype ICGV-0350 also recorded higher B:C ratio (3.91), SPAD value (49) and RWUE (3.78 kg/ ha-mm). Mean performance of groundnut genotypes over 6 years (2010-2015) revealed that GKVK-5 (3512 kg/ha) and KCG-6 (3501 kg/ha) were promising genotypes (Table 3.199).

Table 3.199 : Evaluation of groundnut genotypes - Bengaluru

Genotype	Pod yield (kg/ha)		Haulm 2015 (kg/ha)	SPAD	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (6 years)				
GKVK-5	2105	3512	2631	48	3.49	3.36
KCG-6	1534	3501	3048	41	2.54	2.45
KCG-2	1349	1955	2315	40	2.23	2.16
TMV-2	1078	1777	1902	41	1.79	1.85
ICGV-0351	1843	2796	2600	39	3.05	2.95
ICGV-9114	1583	1677	1997	39	2.62	2.53
ICGV-0350	2363	3030	1890	49	3.91	3.78
CD at 5% 463						

Out of 12 promising finger millet genotypes evaluated, KMR-316 recorded higher yield (3814 kg/ha), B:C ratio (3.33) and RWUE (6.87 kg/ha-mm) followed by KMR-301 (3611 kg/ha). Among all the genotypes KMR-128 gave lower yield (2557kg/ha). Data on mean performance of over 5 years (2010-2015) indicated that long duration variety MR-1 gave the highest yield (4298 kg/ha), while under the medium duration group, GPU-28 (4119kg/ha) receded higher yield (Table 3.200).

Performance of fingermillet cv. KMR-316

Table 3.200 : Evaluation of fingermillet varieties - Bengaluru

Variety	Grain yield (kg/ha)		B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (5 years)		
MR-1	2973	4298	2.59	5.36
MR-6	3377	3893	2.95	6.09
KMR-316	3814	3989	3.33	6.87
KMR-301	3611	3903	3.15	6.51
KMR-128	2557	3225	2.23	4.61
KMR-204	2860	3425	2.50	5.16
KMR-126	2778	2975	2.42	5.01
GPU-28	3084	4119	2.69	5.56
GPU-48	3199	3705	2.79	5.77
GPU-84	2870	3843	2.50	5.17
CD at 5%	420.36			

3.4 Oilseed Based Production System

3.4.1 Groundnut Based Production System

3.4.1.1 Rainwater management

At Anantapuramu, supplemental irrigation (SI) from harvested rainwater in farm pond (10 mm and 20 mm) was given to groundnut crop with sprinklers system at flowering and pod formation stage. The pod yield of 1641 kg/ha was achieved with supplemental irrigation when compared to without any supplemental irrigation (1486 kg/ha). The net returns (Rs 78520/ha) and B:C ratio was also highest with 20 mm of supplemental irrigation (Table 3.201).

Table 3.201 : Effect of supplemental irrigation on groundnut yield and economics – Anantapuramu

Treatment (supplementary irrigation)	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Pod yield in 2015	Haulm yield (kg/ha)			
SI:10 mm irrigation	1641	2183	22,000	76,460	3.47
SI: 20 mm irrigation	1667	2231	22,510	78,520	3.48
Control	876	-	-	-	-

Farm pond filled with water – Anantapuramu

At Anantapuramu, in an experiment on minimizing the evaporation losses using different materials, in small cement structures, bamboo material was found effective in preventing evaporation losses. Among different chemicals, steryl alcohol was found effective in minimizing evaporation losses followed by silicon oil and cetyl alcohol. The chemicals were found effective for a period of one week, later on their efficiency decreased (Table 3.202).

Table 3.202 : Evaporation loss minimization using different materials – Anantapuramu

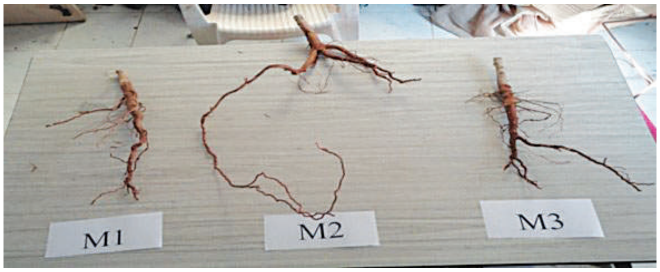
Treatment	Cumulative evaporation (cm/day)
Steryl alcohol	10.85
Azolla	13.25
Cetyl alcohol	13.35
Groundnut shell	12.05
Saw dust	15.05
Neem oil	13.85
Bamboo mat	6.7
Control	13.9
Paddy husk	15
Silicon oil	10.4

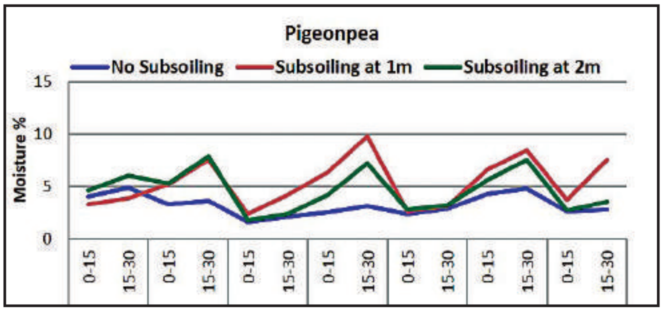
In an experiment on subsoiling at Ananthapuramu, there was no significant difference between no subsoiling, subsoiling at 1 m distance and subsoiling at 2 m distance with respect to pigeonpea equivalent yield of castor, clusterbean, pearlmillet, and cotton. However, highest root length and soil moisture was recorded with subsoiling at 1 m distance treatment. Among different crops, castor recorded higher pigeonpea equivalent yield (283 kg/ha) whereas higher root length (71.5 cm), net returns (Rs.20844/ha) and B:C ratio (2.66) was recorded with pigeonpea (Table 3.203).

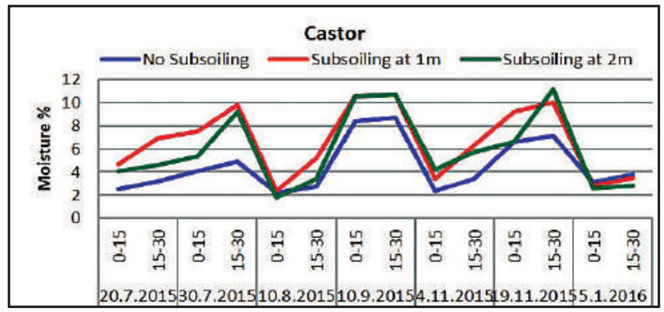
Table 3.203: Root length, pigeonpea equivalent yield and economics of dryland crops as influenced by subsoiling - Ananthapuramu

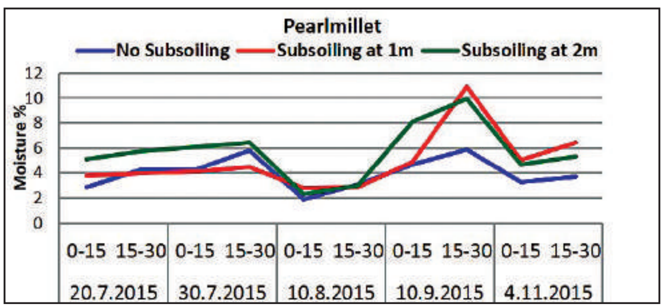
Treatment	Root length (cm)	Pigeonpea equivalent yield (kg/ha)	NMR (Rs/ha)	B:C Ratio
No subsoiling	23.6	212	2655	1.88
Subsoiling at 1 m distance	65.9	229	2998	1.19
Subsoiling at 2 m distance	57.9	238	4180	1.28
CD at 5%	-	NS	-	-
Pigeonpea	71.5	422	20844	2.66
Castor	48.6	283	6144	1.37
Clusterbean	27.6	99	-4276	0.63
Pearlmillet	24.2	246	7759	1.65
Bt. cotton	35.3	78	-14079	0.30
CD at 5%	-	89.7	-	-

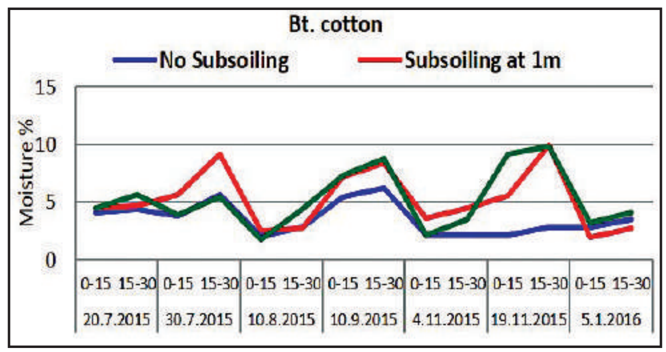
Pigeonpea **Castor**











Effect of sub soiling on root length and soil moisture % in different crops - Ananthapuramu

Performance of pigeonpea without subsoiling (left) with subsoiling at 1 m distance (right)

At Rajkot, in an evaluation of different *in-situ* moisture conservation practices, ridge and furrow system recorded significantly higher seed cotton and stalk yield (2573 and 4196 kg/ha respectively), highest B:C ratio (3.34) and soil moisture content (24.31%) compared to control and the yields were at par with broad bed and furrow system (2388 kg/ha). Similarly among mulching practices, plastic mulching (25 micron sheet) recorded significantly higher seed cotton and stalk yield (2474 and 4209 kg/ha) with highest B:C ratio (3.11) and soil moisture content (22.64%) compared to control and the yields were at par with straw mulch (Table 3.204).

Table 3.204 : Evaluation of *in-situ* moisture conservation and mulching practices in cotton - Rajkot

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton	Stalk				
***In-situ* moisture conservation**						
Ridge and furrow system	2573	4196	33033	77369	3.34	4.38
Broad bed furrow system	2388	3944	32633	69843	3.14	4.07
Control	2001	3444	32233	53671	2.67	3.41
CD at 5%	369	538				
Mulching						
Plastic mulch (25 micron)	2474	4209	34100	72097	3.11	4.21
Straw mulch @5 t/ha	2369	3846	32900	68744	3.09	4.03
Control	2119	3531	30900	60040	2.94	3.61
CD at 5%	271.4	401.5				

At Rajkot, in an assessment of rainfall erosivity index and soil erodibility factor, maximum groundnut pod equivalent yield (1419 kg/ha) was obtained with sole cotton with higher net returns (Rs.14843/ha) and B:C ratio (1.47) followed by groundnut + castor intercropping system (3:1) (808 kg/ha) as compared to sole groundnut GG-20 (767 kg/ha). Maximum soil loss (536.49 kg/ha) and maximum runoff (15.41%) was recorded under cultivated follow. Maximum RWUE was also higher with sole cotton (2.42 kg/ha-mm) followed by groundnut + castor (3:1) intercropping system (1.38 kg/ha-mm) (Table 3.205).

Table 3.205 : Evaluation of rainfall erosivity index and soil erodibility factor in medium black soil under sole and intercropping systems - Rajkot

Treatment	Pod equivalent yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (4 years)	Haulm/stalk				
Sole groundnut (GG-20)	767	627	3513	27700	14793	1.53	1.31
Sole cotton (G.Cot.Hy-8)	1419	2095	1700	31700	14843	1.47	2.42
Groundnut (GG-5) + castor (GCH-7) (3:1)	808	856	2033 (groundnut) 1067 (castor)	27700	8992	1.32	1.38

In an evaluation of tillage (ploughing every year/ alternate year up to 30 cm) and nutrient management (FYM/gypsum application and kaiolin/guar gum spray) practices in cotton at Rajkot, there were no significant differences among tillage treatments. However, among nutrient management practices, higher seed cotton yield was obtained with application of FYM @ 10 t/ha with kaolin spray @ 4% (2202 kg/ha). Similarly, higher net returns (Rs.55945/ha) and RWUE (2.46 kg/ha-mm) was also recorded with the same treatment followed by application of FYM @ 10 t/ha with gaur gum spray @ 0.3% (2102 kg/ha) (Table 3.206).

Table 3.206 : Response of cotton to tillage, nutrient management and foliar sprays - Rajkot

Treat-ments	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton (2015)	Mean seed cotton yield (4 years)	Stalk yield (2015)				
Tillage							
Ploughing every year up to 30 cm in set row	1999	1618	2897	35787	49895	2.39	3.40
Ploughing alternate year up to 30 cm in set row	1875	1571	2765	35787	44592	2.25	3.19
CD at 5%	NS	-	NS	-	-	-	-
Nutrient management							
FYM @ 10 t/ha + kaolin @ 4% spray	2202	1751	3046	38402	55945	2.46	3.75
FYM @ 10 t/ha + guar gum @ 0.3% spray	2102	1654	2951	38440	51633	2.34	3.58
Gypsum @ 1 t/ha + kaolin @ 4% spray	1969	1647	2852	35177	49219	2.40	3.35
Gypsum @ 1t/ha + guar gum @ 0.3% spray	1811	1564	2735	35215	42436	2.21	3.08
Control	1738	1447	2684	31700	42836	2.35	2.96
CD at 5%	217		257				

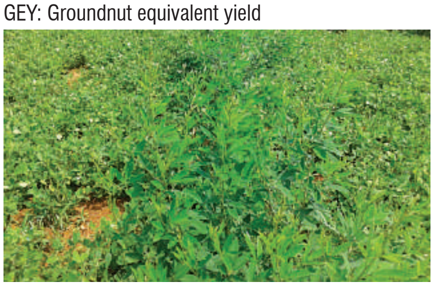
3.4.1.2 Cropping systems

At Anantapuramu, in an experiment on intercropping systems, the mean (3 years) groundnut equivalent yield (GEY) revealed that groundnut + pigeonpea intercropping system (15:1) recorded higher GEY (1041 kg/ha), land equivalent rate (1.14), net returns (Rs.31280/ha) and B:C ratio (1.48) followed by groundnut + castor intercropping system (15:1) with groundnut equivalent yield of 975 kg/ha, LER of 1.09, net returns (Rs.28292/ha) and B:C ratio (1.34) and sole groundnut crop with equivalent yield of 960 kg/ha, net returns (Rs.27057/ha), B: C ratio of 1.28, where as sole crop of pigeonpea given higher B:C ratio of 1.34 (Table 3.207).

Table 3.207 : Performance of intercropping systems - Anantapuramu

Treatment	GEY (kg/ha)				LER	NMR (Rs/ha)	B:C ratio
	2013-14	2014-15	2015-16	Mean			
Sole clusterbean	186	817	335	446	1.00	7358	0.66
Sole pigeonpea	477	326	968	590	1.00	16191	1.34
Sole groundnut	607	573	1701	960	1.00	27057	1.28
Sole castor	683	527	604	605	1.00	9581	0.60
Clusterbean + pigeonpea (15:1)	157	553	529	413	0.87	5929	0.53
Clusterbean + castor (15:1)	410	379	325	371	0.95	4277	0.38
Groundnut + pigeonpea (15:1)	750	687	1987	1041	1.14	31280	1.48
Groundnut + castor (15:1)	687	650	1587	975	1.09	28292	1.34
CD at 5 %	188	173	512	279	--	-	-

GEY: Groundnut equivalent yield



Groundnut + pigeonpea (15:1)

Groundnut + castor (15:1)

Cowpea + Pigeonpea (8:1)

At Anantapuramu, in an evaluation of different fodder crops under late onset of monsoon situation, fodder pearlmillet produced highest green fodder yield (18.6 t/ha) followed by wild foxtail millet (11.4 t/ha). In case of dry fodder yield, the highest yield was obtained with fodder maize (7.5 t/ha) followed by wild foxtail millet (5.7 t/ha) and fodder pearlmillet (5.5 t/ha). The higher seed yield of 1147 kg/ha was obtained with fodder pearlmillet (Table 3.208).

Table 3.208 : Green fodder yield, seed yield and dry fodder yield of different fodder crops-Anantapuramu

Treatments	Green fodder yield (t/ha)			Seed/grain yield (kg/ha)	Dry fodder yield (t/ha)
	1st cutting	2nd cutting	Total		
Fodder sorghum	8.0	1.7	9.7	321	4.5
Fodder maize	10.7	0.0	10.7	0	7.5
Fodder pearlmillet	15.1	3.5	18.6	1147	5.5
Clusterbean	3.8	0.0	3.8	264	1.5
Cowpea	6.9	2.3	9.2	147	2.8
Fieldbean	4.5	1.5	6.0	505	4.5
Wild foxtail millet	11.4	0.0	11.4	878	5.7
Horsegram	6.3	1.6	7.9	573	4.0
Sunhemp	5.8	0.3	6.0	0	4.3
CD at 5%	1.64	-	2.03	-	0.32


Performance of different fodder crops - Ananthapuramu

Among cotton based intercropping systems evaluated at Rajkot, higher seed cotton yield was recorded with cotton + green gram (1:1) intercropping system (2322 kg/ha) which was at par with sole cotton (2437 kg/ha). Whereas, highest seed cotton equivalent yield (3360 kg/ha), net returns (Rs.124229/ha), B:C ratio (3.36) and RWUE (5.72 kg/ha-mm) was recorded with cotton + cowpea (1:1) intercropping system. (Table 3.209).

Table 3.209 : Performance of cotton based intercropping systems - Rajkot

Treatment	Yield (kg/ha)		CEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Cotton	Intercrop (seed)					
Sole cotton	2437	-	2437	35229	82373	2.34	4.15
Cotton + groundnut (1:1)	1612	645	2223	38197	80221	2.10	3.79
Cotton + greengram(1:1)	2322	291	2738	37214	94699	2.54	4.66
Cotton + blackgram (1:1)	2088	271	2505	37276	83410	2.24	4.27
Cotton + gumguar (1:1)	1589	586	2082	36447	64922	1.78	3.55
Cotton + sesame (1:1)	1734	375	2287	36135	74516	2.06	3.89
Cotton + soybean (1:1)	1480	549	1917	37504	55344	1.48	3.26
Cotton + cowpea (1:1)	2138	968	3360	36964	124229	3.36	5.72
CD at 5%	448.3	-	370.7	--	-	-	-

CEY: Cotton equivalent yield

Cotton + Cowpea (1:1)

Cotton + Cowpea (1:1)

Cotton + Soybean (1:1)

Cotton + Soybean (1:1)

3.4.1.3 Nutrient management

In the Permanent Manurial Trial (PMT) study in groundnut at Anantapuramu, application of 50% RDF + groundnut shells @ 4 t/ha recorded significantly higher pod yield (1449 kg/ha) which was closely followed by application of 100 % RDF + $ZnSO_4$ @ 50 kg/ha (once in 3 years) (1445 kg/ha). However, higher groundnut mean pod yield (952 kg/ha) was recorded with application of 50% RDF + FYM @ 4 t/ha (Table 3.210). In depletion studies, non-significant yields were observed. Higher B:C ratio of 2.87 and 2.75 were recorded with treatment groundnut shells @ 4 t/ha, and 50% RDF + groundnut shells @ 4 t/ha, respectively. Slightly increase in soil pH towards neutral was observed in treatments applied with organics alone or combination of organics and inorganics. Higher soil available phosphorous (99 kg/ha) was recorded with application of 100% RDF + $ZnSO_4$ @ 50 kg/ha (once in 3 years). The lower bulk density was recorded with application of groundnut shells @ 4 t/ha in treated (1.31 Mg/m^3) and depleted (1.1.33 Mg/m^3) treatments compared to other treatments (Table 3.211).

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

Control

Permanent Manural Trial in groundnut - Anantapuramu

Table 3.210 : Permanent manurial trial in groundnut: Effect on yield, economics and RWUE – Anantapuramu

Treatment	Pod yield (kg/ha) (2015)		Pod yield (kg/ha) Mean (31 years)		Haulm		Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio		RWUE (kg/ha-mm)	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D
Control	985		721	599	1153		19375		25907		2.34		2.75	
100% RDF (20:40:40 NPK kg/ha)	1316	954	932	672	1697	1147	22681	19375	38635	24617	2.70	2.27	3.67	2.66
50% RDF	1156	963	864	636	1512	1354	21028	19375	32950	26111	2.57	2.35	3.23	2.69
Groundnut shells @ 4 t/ha	1374	956	840	662	1685	1495	22175	19375	41366	26610	2.87	2.37	3.83	2.67

Treatment	Pod yield (kg/ha)						Cost of cultivation (Rs/ha)		NMR (Rs/ha)		B:C ratio		RWUE (kg/ha-mm)	
	(2015)		Mean (31 years)		Haulm									
	T	D	T	D	T	D	T	D	T	D	T	D	T	D
FYM @ 4 t/ ha	1363	935	889	686	1980	1667	24175	19375	40554	26726	2.68	2.38	3.80	2.61
50% RDF + groundnut shells @ 4 t/ha	1449	922	867	647	1519	1337	23828	19375	41762	24398	2.75	2.26	4.04	2.57
50% RDF + FYM @ 4 t/ ha	1404	976	952	672	2290	1885	25828	19375	42225	29545	2.63	2.52	3.92	2.72
100% RDF + $ZnSO_4$ @ 50 kg/ha (one in 3 years)	1445	985	914	646	2328	2008	22681	19375	47201	31127	3.08	2.61	4.03	2.75
FYM @ 5 t/ha	1377	962	890	675	1948	1777	25375	19375	39731	28398	2.57	2.47	3.84	2.68
100% RDF + groundnut shells @ 4 t/ha	1235	993	--	--	2151	2035	25481	19375	35132	31591	2.38	2.63	3.67	2.66
CD at 5%	201.7	NS	--	--	278.9	391.3	--	--	--	--	--	--	--	--

T: Treated; D: Depleted

Table 3.211 : Permanent Manural Trial (PMT) : Effect on physical and chemical properties of soil – Anantapuramu

Treatment	pH		OC (%)		Available N		Available P_2O_5		Available K_2O		Zn		Fe		Cu		Mn	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
Control	6.28		0.23		129		18		189		0.34		3.64		0.39		4.49	
100% RDF (20:40:40 NPK kg/ha)	6.24	0.28	0.28	0.26	183	175	93	29	366	223	0.68	0.35	10.5	8.89	0.43	0.31	5.36	3.61
50% RFD	6.23	0.31	0.31	0.30	183	167	61	32	288	194	0.72	0.30	4.82	2.86	0.37	0.67	4.64	5.47
Groundnut shells @ 4 t/ha	6.49	0.43	0.43	0.35	158	149	29	21	315	214	0.61	0.30	4.09	2.03	0.66	0.57	5.06	3.84
FYM @ 4 t/ ha	6.93	0.38	0.38	0.29	159	148	35	21	461	228	0.87	0.32	8.12	3.71	0.50	0.25	1.60	3.85
50% RFD + groundnut shells @ 4 t/ha	6.64	0.31	0.31	0.27	171	150	60	26	515	224	0.71	0.14	12.2	7.38	0.43	0.29	4.92	5.99
50% RFD + FYM @ 4 t/ ha	6.74	0.51	0.51	0.31	192	186	61	28	507	309	0.81	0.33	8.59	7.31	0.69	0.56	2.94	4.73
100% RDF + $ZnSO_4$ @ 50 kg/ ha (one in 3 year)	6.23	0.31	0.31	0.28	179	154	99	32	490	248	0.94	0.41	10.9	3.93	0.59	0.31	5.14	5.56
FYM @ 5 t/ha	6.88	0.47	0.47	0.29	175	163	32	26	498	242	0.74	0.32	12.2	6.02	0.44	0.45	0.99	3.36

Treatment	pH		OC (%)		Available N		Available P_2O_5		Available K_2O		Zn		Fe		Cu		Mn	
	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D
100% RDF + groundnut shells @ 4 t/ha	6.30	0.44	0.44	0.31	179	156	85	54	494	338	0.76	0.31	6.55	5.11	0.74	0.54	3.66	4.39
CD at 5%	0.43	0.43	0.14	NS	28.54	NS	14.54	7.99	129.3	NS	0.20	NS	5.86	NS	NS	NS	--	--
Initial values	6.6	6.6	0.30	--	139	--	20	--	155	--	--	--	--	--	--	--	--	--

T: Treated; D: Depleted

In a study on response of castor to nutrient management at Anantapuramu, application of 75:50:40 kg/ha N, P_2O_5 & K_2O recorded higher castor seed yield (485 kg/ha) during year 2015 and 508 kg/ha over mean of four years, with higher net returns (Rs.2233/ ha) and B:C ratio (1.13) compared to other treatments. However, maximum RWUE (1.38 kg/ha-mm) was recorded with soil test based fertilizer application for treatment T2 (Table 3.xx). In case of soil properties, higher available phosphorus (49 kg/ha) was found with the treatment T5 (soil test based fertilizer application for T2) while statistically non significant results were obtained for all other nutrients (Table 3.212 & 3.213).

Table 3.212 : Effect of nutrient management on yield and economics of castor -Anantapuramu

Treatment	Seed yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (4 years)				
T1 - 60-40-30 (N, P_2O_5& K_2O)	421	432	16068	562	1.03	1.17
T2 - 75-50-40 (N, P_2O_5 & K_2O)	485	508	16998	2160	1.13	1.35
T3 - 45-30-20 (N, P_2O_5& K_2O)	376	415	15139	-287	0.98	1.05
T4 - Soil test based fertilizer application for T1	389	445	16290	-925	0.94	1.09
T5 - Soil test based fertilizer application for T2	494	558	17280	2233	1.13	1.38
T6 - Soil test based fertilizer application for T3	364	439	15300	-922	0.94	1.02
CD at 5 %	NS	70.2	-	-	-	-

Table 3.213 : Nutrient management in castor - Effect on soil properties - Anantapuramu

Treatment	pH	OC (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Zn	Fe	Cu	Mn
T1 - 60-40-30 (N, P_2O_5& K_2O)	5.90	0.22	159	38	266	0.68	10.41	0.65	2.95
T2 - 75-50-40 (N, P_2O_5 & K_2O)	5.70	0.32	175	49	246	0.66	10.04	0.52	3.10
T3 - 45-30-20 (N, P_2O_5& K_2O)	5.80	0.35	175	35	277	0.69	11.09	0.67	2.92
T4 - Soil test based fertilizer application for T1	5.83	0.25	172	35	274	0.61	9.26	0.47	3.72
T5 - Soil test based fertilizer application for T2	5.63	0.23	175	42	259	0.73	11.81	0.52	4.28
T6 - Soil test based fertilizer application for T3	5.60	0.25	169	32	261	0.69	6.43	0.83	3.78
Initial values	6.3	0.29	168 (L)	38.5 (M)	241 (M)	--	--	--	--
CD at 5 %	NS	NS	NS	19.24	NS	NS	NS	NS	--

PSB: *Bacillus megatherium* var. phosphoticum @ 5 kg/ha; PSF: *Aspergillus awamori* @ 5kg/ha; AM Fungi: *Arbuscular mycorrhiza* @ 12.5kg/ha; FYM @ 500 kg/ha as starter dose for microbes

Soil test based fertilizer application for T2 in castor
(75-50-40 N, P2O5& K2O)

Control

In a field experiment on nutrient management in groundnut at Anantapuramu, application of 50% RDF with PSB (*Bacillus megatherium* var. phosphoticum) + PSF (*Aspergillus awamori*) + AM (*Arbuscular mycorrhiza*) fungi recorded highest pod yield (2314 kg/ha) followed by STBF + PSB+PSF+AM fungi with pod yield of 2232 kg/ha (Table 3.214). The higher mean pod yield (1078 kg/ha) was recorded with STBF with PSB + PSF + AM fungi followed by 50% RDF + PSB + PSF + AM fungi with mean pod yield of 1066 kg/ha. Higher net returns of Rs. 86861/ha was recorded with application of 50% RDF + PSB + PSF + AM fungi followed by application of STBF + PSB + AM fungi. Similarly, STBF with PSB + PSF + AM fungi recorded highest B:C ratio (4.96) and higher RWUE (6.46 kg/ha-mm). There were no significant differences with pH, OC (%), available N, P, K and also micronutrients. Higher soil available phosphorous (78 kg/ha) was recorded with 50% RDF (10:20:20 kg N,P_2O_5, K_2O) along with consortia of PSF + AM fungi. Organic carbon (0.56%) was highest with 50% RDF (10:20:20 kg N, P_2O_5, K_2O) along with consortia of PSB+PSF+AM fungi (Table 3.215).

Table 3.214 : Effect on nutrient management practices on groundnut yield and economics – Anantapuramu

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod 2015	Mean pod yield (4 years)	Haulm yield				
T_1 - Control	1485	735	2036	19375	50481	3.61	4.14
T_2 - 50% RDF (10:20:20 NPK kg/ha)	1751	905	2599	21028	62431	3.97	4.89
T_3 - T_2 + PSB + AM fungi	1833	938	2340	21728	63546	3.92	5.11
T_4 - T_2 + PSF + AM fungi	2033	966	2932	21728	74702	4.44	5.67
T_5 - T_2 + PSB + PSF + AM fungi	2314	1066	3161	21928	86861	4.96	6.46
T_6 - STBF	1767	870	2778	21028	64048	4.05	4.93
T_7 - T_6 + PSB +AM fungi	1922	961	2694	21728	69008	4.18	5.36
T_8 - T_6 + PSF + AM fungi	2108	989	3051	21728	78319	4.60	5.88
T_9 - T_6 + PSB + PSF + AM fungi	2232	1078	2981	22628	81932	4.62	6.23
T_{10} - PSB + PSF +AM fungi	1803	905	2499	20275	64188	4.17	5.03
CD at 5 %	458.13	163.80	434.2	--	--	--	--

Table 3.215 : Soil properties as influenced by nutrient management in groundnut - Anantapuramu

Treatment	pH	OC (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P_2O_5	K_2O	Zn	Fe	Cu	Mn
T_1 :Control	5.57	0.41	142	45	276	0.67	5.49	0.90	5.07
T_2 : 50% RDF (10:20:20 NPK kg/ha)	5.43	0.42	175	78	361	0.81	9.27	0.77	5.03
T_3 : T_2 +PSB+AM fungi	5.20	0.43	163	67	378	0.62	7.13	1.05	4.93
T_4 : T_2 +PSF+AM fungi	5.17	0.48	158	78	380	0.75	3.49	1.27	5.01
T_5 : T_2 +PSB+PSF+AM fungi	5.27	0.56	171	63	375	0.50	2.09	1.05	1.56
T_6 : STBF	5.13	0.38	175	59	355	0.67	6.78	0.92	4.28
T_7 : T_6 +PSB+AM fungi	5.43	0.46	188	62	361	0.69	2.19	0.91	3.18
T_8 : T_6 +PSF+AM fungi	5.17	0.51	154	61	369	0.81	7.26	1.24	5.13
T_9 : T_6 +PSB+PSF+AM fungi	5.07	0.52	179	66	386	0.60	2.87	1.31	0.99
T_{10} : PSB+PSF+AM fungi	5.47	0.48	171	72	368	0.85	10.15	1.33	3.78
Initial	6.22	0.50	142	52	361	--	--	--	--
CD at 5%	NS	0.10	NS	17.38	NS	NS	4.71	NS	--

Performance of groundnut crop with STBF + PSB + PSF + AM fungi

Performance of groundnut crop without fertilizer application

In a study on effect of K and Mg application on enhancement of nutrient use efficiency in groundnut at Anantapuramu, among various levels of K_2O, application of K_2O @ 40 kg/ha as basal recorded higher pod and haulm yield (1098 and 2161 kg/ha respectively) over all other levels of K_2O (Table 3.216). The higher B:C ratio (2.51) was recorded with 20 kg/ha K_2O as basal whereas higher RWUE (3.06 kg/ha-mm) as recorded with K_2O @ 40 kg/ha. Among different magnesium levels, $MgSO_4$ @ 10 kg/ha as basal recorded higher pod and haulm yield (1068 and 638 kg/ha) and RWUE (2.98 kg/ha-mm) in groundnut. Whereas, application of 20 kg/ha $MgSO_4$ as basal gave higher B:C ratio (2.71). There were no significant differences in case of soil chemical properties (Table 3.217).

Table 3.216 : Effect of levels of K and Mg on groundnut yield and economics - Anantapuramu

Treatment	Pod yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)	Haulm				
K levels (kg/ha)							
Control	973	584	2049	19375	25976	2.34	2.71
20	1025	618	2145	19875	29931	2.51	2.86
40	1098	650	2161	20375	28368	2.39	3.06

Treatment	Pod yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)	Haulm				
60	1085	662	2059	20875	29386	2.41	3.03
CD at 5%	92.04	--	NS	--	--	--	--
Mg levels (kg/ha)							
Control	985	597	2218	19375	25976	2.34	2.75
10	1068	638	1992	19699	29040	2.47	2.98
20	1054	632	2043	20023	34217	2.71	2.94
30	1033	626	2161	20347	31807	2.56	2.88
CD at 5%	NS	--	NS	--	--	--	2.75

Performance of groundnut crop with K (40 kg/ha) and Mg (10 kg/ha) application

Control

Table 3.217 : Soil chemical properties as influence by various levels of potassium and magnesium in groundnut – Anantapuramu

Treatments	pH	Organic C (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P_2O_5	K_2O	Zn	Fe	Cu	Mn
K levels (kg/ha)									
Control	5.37	0.35	158	34	171	0.41	6.87	0.97	3.84
20	5.05	0.41	160	34	162	0.57	7.62	0.99	3.54
40	5.30	0.49	175	32	255	0.76	8.52	1.01	4.72
60	5.13	0.42	172	33	206	0.73	4.20	0.95	3.23
CD at 5%	NS	NS	NS	NS	67.93	0.08	2.25	NS	0.84
Mg levels (kg/ha)									
Control	5.29	0.41	160	30	230	0.60	7.07	0.90	3.82
10	5.18	0.43	166	34	202	0.64	7.15	1.05	3.34
20	5.17	0.40	170	33	175	0.58	7.00	1.05	4.08
30	5.20	0.42	170	35	187	0.65	5.98	0.93	4.09
CD at 5%	NS	NS	NS	NS	NS	NS	NS	0.10	NS
Initial values	5.82	0.33	165	62	264	--	--	--	--

In an experiment on effect of foliar sprays on performance of groundnut at Anantapuramu, higher pod yield (2042 kg/ha) and haulm yield (2163 kg/ha) were recorded with application of soil test based fertilizer (STBF) + 1% KCl spray (2 times) followed by application of STBF + 1% KNO_3 (2 sprays) with pod yield of 1991 kg/ha and haulm yield of 2153 kg/ha, respectively. Similarly, (STBF) + 1% KCl spray (2 times) gave higher net returns (Rs.71180/ha), B:C ratio (4.33) and RWUE (5.70 kg/ha-mm) when compared to other treatments (Table). There were no significant differences with various foliar sprays on soil chemical properties (Table 3.218 & 3.219).

Table 3.218 : Response of groundnut to various foliar sprays – Anantapuramu

Treatments	Pod yield (kg/ha)			COC (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)	Haulm				
STBF + no spray	1689	1030	2047	21176	56798	3.68	4.71
STBF + water spray	1976	1214	2165	22176	67784	4.06	5.51
STBF + KNO_3 (1% spray –2 sprays)	1991	1178	2153	22476	68010	4.03	5.56
STBF + KCl (1% spray – 2 sprays)	2042	1270	2163	21376	71180	4.33	5.70
STBF + thiourea @ 250 g/ha	1849	1146	2143	21662	63160	3.92	5.16
STBF + $ZnSO_4$ (0.2% spray – 2 sprays)	1987	1213	2265	22112	68832	4.11	5.54
CD at 5 %	NS	--	NS	--	--	--	--

1st spray at 61 DAS (21.08.2015) ; 2nd spray at 74 DAS (03.09.2015)

Table 3.219 : Effect of various foliar sprays on chemical properties of soil - Anantapuramu

Treatment	pH	OC (%)	Available nutrients (kg/ha)			DTPA extractable micronutrients (ppm)			
			N	P_2O_5	K_2O	Zn	Fe	Cu	Mn
STBF + no spray	5.90	0.32	159	42	266	0.57	7.66	0.92	2.37
STBF + water spray	5.70	0.32	175	43	246	0.77	8.41	0.88	2.85
STBF + KNO_3 (1% spray –2 sprays)	5.80	0.35	175	38	277	0.75	8.89	0.92	3.20
STBF + KCl (1% spray – 2 sprays)	5.83	0.25	172	39	274	0.85	6.89	0.96	4.55
STBF + thiourea @ 250 g/ha	5.63	0.29	175	38	259	0.87	12.00	0.70	3.44
STBF + $ZnSO_4$ (0.2% spray – 2 sprays)	5.60	0.28	169	42	261	0.77	7.54	1.25	3.53
CD at 5 %	0.33	0.05	NS	NS	NS	NS	NS	NS	-
Initial values	6.0	0.34	204	46.4	284	-	-	-	-

1st spray at 61 DAS (21.08.2015) ; 2nd spray at 74 DAS (03.09.2015)

In a study on response of sesame to phosphorus management at Rajkot, application of 50 kg P_2O_5/ha through single super phosphate (SSP) was superior with higher seed yield (862 kg/ha), mean seed yield (870 kg/ha), stalk yield (1881 kg/ha), net returns (Rs.47493/ha) and RWUE (1.47 kg/ha-mm) as compared to other treatments. However, the highest B:C ratio (5.12) was recorded with application of RDN + S equal to 25 kg SSP through gypsum compared all other treatments (Table 3.220).

Table 3.220 : Effect of phosphorus management on yield and economics of sesame - Rajkot

Treatment	Seed yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (3 years)	Stalk				
Absolute control	697	636	1418	10000	39499	4.95	1.19
25 kg P_2O_5/ha through DAP	726	739	1447	11936	39608	4.32	1.24
25 kg P_2O_5/ha through SSP	807	800	1563	12225	45047	4.68	1.37
25 kg P_2O_5/ha through rock phosphate	694	660	1476	10941	38377	4.51	1.18
25 kg P_2O_5/ha through rock phosphate + PSM	657	663	1331	11061	35595	4.22	1.12
50 kg P_2O_5/ha through DAP	747	749	1649	13183	39932	4.03	1.27
50 kg P_2O_5/ha through SSP	862	870	1881	13788	47493	4.44	1.47
50 kg P_2O_5/ha through rock phosphate	657	667	1389	11219	35466	4.16	1.12
50 kg P_2O_5/ha through rock phosphate + PSM	663	687	1403	11339	35773	4.15	1.13
RDN + S equal to 25 kg SSP through gypsum	749	763	1620	10403	42837	5.12	1.28
RDN + S equal to 50 kg SSP through gypsum	666	743	1534	10474	36913	4.52	1.13
RDN + 40kg K_2O/ha	639	687	1374	11123	34294	4.08	1.09
CD at 5%	131.6	76.8	NS	-	-	-	-

In a study on effect to foliar nutrition on groundnut at Rajkot, the maximum pod yield (1667 kg/ha), haulm yield (4506 kg/ha), mean pod yield (900 kg/ha), mean haulm yield (28223 kg/ha), net returns (Rs.64902/ha) and RWUE (2.93 kg/ha-mm) was recorded with foliar spray of 2 % urea at 30 to 35 DAS + KNO_3 2% at 60 DAS, with higher B:C ratio (2.34) when compared to other treatments (Table 3.221).

Table 3.221: Response of groundnut to foliar nutrition - Rajkot

Treatment	Yield (kg/ha)				Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod (2015)	Haulm (2015)	Mean pod (3 years)	Mean haulm (3 years)				
Absolute control	1285	3622	2454	926	25723	50212	1.95	2.26
Water spray-no nutrients	1337	3656	2497	940	25923	52352	2.02	2.35
Foliar spray of water soluble fertilizer @ 1% (NPK-19-19-19) at 30 to 35 DAS	1424	4022	2723	1008	26673	55517	2.08	2.50
Foliar spray of Fe & Zn @ 1 % at 30 to 35 DAS	1444	4244	2844	1056	26223	56867	2.17	2.54
Foliar spray of water soluble fertilizer @ 1% and Fe & Zn @ 1% at 30 to 35 DAS	1438	3800	2619	1036	26973	55847	2.07	2.53
Foliar spray of selenium @ 20 g/ha at 30 to 35 DAS	1510	3911	2711	1033	26723	59337	2.22	2.65
Foliar spray of 2 % urea at 30 to 35 DAS	1528	4000	2764	1096	25986	60884	2.34	2.68
Foliar spray of KNO_3 2% at 30 to 35 DAS	1563	4089	2826	27723	60722	60722	2.19	2.75
Foliar spray of KNO_3 2% at 60 DAS	1493	4200	2847	27723	57572	57572	2.08	2.62
Foliar spray of 2% urea at 30 to 35 DAS + KNO_3 2% at 60 DAS	1667	4506	3087	28223	64902	64902	2.30	2.93

In a study at Rajkot on application of different levels of RDF (12.5: 25: 0 N: P_2O_5:K_2O/ha) in groundnut + castor (3:1) system, no significant differences were found among the treatments for groundnut pod yield. Whereas, in castor application of 125% of RDF gave higher pod equivalent yield (1521 kg/ha), net returns (Rs.59217/ha), B:C ratio (2.20) and RWUE (2.59) (Table 3.222).

Table 3.222 : Fertilizer management in groundnut+castor (3:1) intercropping system - Rajkot

Treatment	Yield (kg/ha)		GEY (kg/ha)	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Seed		Haulm	Stalk				
Fertilizer application to groundnut									
100% RDF	732	1042	1380	2587	2645	27268	51677	1.89	2.35
75% RDF	664	1039	1363	2608	2664	26988	51327	1.90	2.32
50% RDF	686	1003	1311	2567	2616	26710	48995	1.83	2.23
CD at 5%	NS	NS	NS	NS	NS				
Fertilizer application to castor									
125% RDF	801	1157	1521	2706	2922	26925	59217	2.20	2.59
100% RDF	629	973	1290	2536	2494	26770	47743	1.78	2.20
75% RDF	652	945	1243	2521	2448	26615	45670	1.62	2.12
CD at 5%	123	143	116	NS	376				

Groundnut: RDF = 12.5: 25: 0 N: P_2O_5:K_2O/ha; Castor: RDF =45: 40: 0 N: P_2O_5:K_2O/ha ; CEY - Groundnut equivalent yield

3.4.1.4 Energy management

In a study on sowing groundnut with aqua planter at Anantapuramu, the pod yield of 1710 kg/ha was recorded. The higher field efficiency (2.5 hr/ha) and higher output energy (67243.5 MJ/ha) was also recorded with aqua planter sowing of groundnut. In a study on the performance of clusterbean planter at Anantapuramu, the seed yield (462 kg/ha), the higher field efficiency (2.5 hr/ha) and higher output energy (11547.6 MJ/ha) was recorded (Table 3.223).

Table 3.223 : Performance of aqua planter for sowing of groundnut and clusterbean planter – Anantapuramu

Treatment	Pod yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Field efficiency (hr/ha)	Energy (MJ/ha)		Energy use efficiency
	2016	Stover/stalk						Input	Output	
Groundnut sown with aqua planter	1710	2646	23000	79600	3.46	5.4	2.5	4697	67243.5	14.31
Clusterbean sown with developed planter	462.8	1123.8	12046	12630	1.05	1.46	2.5	121	11548	9.52

Sowning of Groundnut with aquaplanter

Sowing of clusterbean with newly developed planter

Metering mechanisim

Bumper clusterbean crop

3.4.1.5 Evaluation of improved varieties

Among fourteen entries of groundnut evaluated for their performance at Anantapuramu, entry No. MLTG (SG) 15-4 recorded highest pod yield (1903 kg/ha), net returns (Rs.76533 kg/ha), B:C ratio (4.27) and RWUE (5.4 kg/ha-mm) followed by MLTG (SG) 15-3 (1880 Kg/ha) and MLTG (SG) 15-13 (1875 kg/ha) (Table 3.224).

Table 3.224 : Performance of groundnut genotypes in multilocation trial on groundnut (SB) – Anantapuramu

Entry	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Haulm				
MLTG-SG-15-4	1903	3620	23,396	76533	4.27	5.40
MLTG-SG-15-3	1880	2389	23,396	69389	3.97	5.33
MLTG-SG-15-13	1875	4522	23,396	79839	4.41	5.32
Dharani (C)	1819	2472	23,396	67181	3.87	5.16
MLTG-SG-15-5	1750	4731	23,396	75509	4.23	4.96
MLTG-SG-15-7	1611	4819	23,396	69972	3.99	4.57
MLTG-SG-15-1	1606	4861	23,396	69967	3.99	4.55
MLTG-SG-15-2	1586	2620	23,396	57902	3.47	4.50
MLTG-SG-15-10	1552	5218	23,396	69430	3.97	4.40
MLTG-SG-15-8	1410	3528	23,396	54874	3.35	4.00
MLTG-SG-15-9	1385	3819	23,396	55254	3.36	3.93
MLTG-SG-15-6	1331	2380	23,396	45737	2.95	3.77
MLTG-SG-15-12	1170	3148	23,396	42654	2.82	3.32
MLTG-SG-15-11	807	2810	23,396	25355	2.08	2.29

Source of entries: Agricultural Research station-Kadiri

Groundnut entries - Multi location Trial

In an evaluation of 10 entries of groundnut at Anantapuramu, entry MLTG –VG-15-9 gave maximum pod yield (1550 kg/ha) followed by MLTG (VG) 15-3 (1528 kg/ha) which gave highest NMR (Rs.64648/ha) and B:C ratio (3.76) when compared to other entries. The entry MLTG (VG)-15-5 recorded highest haulm yield of 4537 kg/ha (Table 3.225).

Table 3.225 : Performance of groundnut genotypes in multilocation trial – Anantapuramu

Entry	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Haulm				
MLTG- VG-15-9	1550	3690	23396	61704	3.64	4.40
MLTG- VG-15-3	1528	4468	23396	64648	3.76	4.33
MLTG- VG-15-2	1415	2986	23396	52379	3.24	4.01
MLTG- VG-15-8	1450	2741	23396	52659	3.25	4.11
MLTG- VG-15-5	1428	4537	23396	60693	3.59	4.05
MLTG- VG-15-4	1188	4282	23396	49098	3.10	3.37
MLTG- VG-15-6	1098	1962	23396	33628	2.44	3.11

Entry	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Haulm				
MLTG- VG-15-7	1080	3796	23396	42024	2.80	3.06
MLTG- VG-15-1	1068	4028	23396	42668	2.82	3.03
K 6 (C)	619	1616	23396	11301	1.48	1.76
MLTG- VG-15-10	578	1912	23396	11018	1.47	1.64

Source of entries: Agricultural Research station-Kadiri

In an evaluation of 12 entries of horsegram at Anantapuramu, entries HG-2, HG-13, ATPHG-11(C) and HG-8 were superior with significantly higher seed yield of 1544,1431, 1246 and 1152 kg/ha, respectively. Similarly higher net returns (Rs.23880, 21620, 17920 and 16040/ha), B:C ratio (4.41, 4.09, 3.56 and 3.29) and RWUE (4.27, 3.96, 3.45 and 3.19 kg/ha-mm) were also recorded with HG-2, HG-13, ATPHG-11(C) and HG-8 entries of horsegram, respectively compared to other entries (Table 3.226).

Table 3.226 : Performance of horsegram enteries – Anantapuramu

Entry	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
HG-2	1544	7000	23880	4.41	4.27
HG-13	1431	7000	21620	4.09	3.96
ATPHG-11(C)	1246	7000	17920	3.56	3.45
HG-8	1152	7000	16040	3.29	3.19
HG-12	855	7000	10100	2.44	2.36
HG-1	789	7000	8780	2.25	2.18
HG-11	518	7000	3360	1.48	1.43
HG-6	478	7000	2560	1.37	1.32
HG-4	328	7000	-440	0.94	0.91
HG-7	245	7000	-2100	0.70	0.68
HG-10	223	7000	-2540	0.64	0.62
HG-5	221	7000	-2580	0.63	0.61
HG-9	113	7000	-4740	0.32	0.31

Source of entries: All India Network Research Project on Arid Legumes

Field view of horsegram varieties

Field view of cowpea varieties

In a cowpea Advanced Varietal Trial (AVT) with 27 entries at Anantapuramu, the entry CP-31 recorded highest seed yield (1074 kg/ha) with net returns of Rs.38024/ha and B:C ratio of 3.81 as compared to all other entries (Table 3.227).

Table 3.227 : Performance of cowpea entries – Anantapuramu

Entry	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (Kg/ha-mm)
CP-31	872	13528	28328	3.09	3.67
CP-23	762	13528	23048	2.70	3.21
CP-29	722	13528	21128	2.56	3.04
CP-24	670	13528	18632	2.38	2.82
CP-21	663	13528	18296	2.35	2.79
CP-25	593	13528	14936	2.10	2.50
CP-22	513	13528	11096	1.82	2.16
CP-30	338	13528	2696	1.20	1.42
CP-28	329	13528	2264	1.17	1.38
CP-26	324	13528	2024	1.15	1.36
CP-27	317	13528	1688	1.12	1.33
CP-15	1074	13528	38024	3.81	2.97
CP-1	919	13528	30584	3.26	2.54
CP-2	844	13528	26984	2.99	2.33
CP-14	833	13528	26456	2.96	2.30
CP-3	826	13528	26120	2.93	2.28
CP-10	753	13528	22616	2.67	2.08
CP-13	744	13528	22184	2.64	2.06
CP-8	739	13528	21944	2.62	2.04
CP-4	674	13528	18824	2.39	1.86
CP-6	577	13528	14168	2.05	1.60
CP-16	514	13528	11144	1.82	1.42
CP-11	360	13528	3752	1.28	1.00
CP-12	356	13528	3560	1.26	0.98
CP-5	303	13528	1016	1.08	0.84
CP-9	258	13528	-1144	0.92	0.71
CP-7	194	13528	-4216	0.69	0.54

Source of entries: All India Network Research Project on Arid Legumes

In a guar varietal trial with 17 entries at Anantapuramu, GR-8 recorded highest seed yield of 704 kg/ ha with net returns of Rs.13328/ha, B:C ratio of 2.91 and RWUE of 2.33 kg/ha-mm. The entry GR-6 was the next best entry (Table 3.228).

Table 3.228 : Performance of guar genotypes in Initial Varietal Trial - Anantapuramu

Entries	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
GR-8	704	13328	25392	2.91	2.33
GR-6	677	13328	23907	2.79	2.24
GR-3	631	13328	21377	2.60	2.09
GR-15	629	13328	21267	2.60	2.08
GR-10	625	13328	21047	2.58	2.07
GR-11	541	13328	16427	2.23	1.79
GR-4	539	13328	16317	2.22	1.78
RGC-936(C)	537	13328	16207	2.22	1.78

Entries	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
GR-13	533	13328	15987	2.20	1.76
GR-14	529	13328	15767	2.18	1.75
GR-16	525	13328	15547	2.17	1.74
GR-12	510	13328	14722	2.10	1.69
GR-5	510	13328	14722	2.10	1.69
GR-2	489	13328	13567	2.02	1.62
GR-9	465	13328	12247	1.92	1.54
GR-7	436	13328	10652	1.80	1.44
GR-1	424	13328	9992	1.75	1.40

Source of entries: All India Network Research Project on Arid Legumes

In a groundnut varietal trial at Rajkot, genotype JSP-60 gave maximum pod yield and mean pod yield (3028 & 3028 kg/ha, respectively), net returns (Rs.142758/ha), B:C ratio (5.15) and RWUE (5.16 kg/ha-mm) compared to other varieties. Whereas, the haulm yield was maximum in genotype JSP-59 (7288 kg/ha) followed by JVR-584 (7124 kg/ha) and GG-11 check (7059 kg/ha) (Table 3.229 & Fig. 3.4).

Performance of groundnut - JSP-60 - Rajkot

Performance of groundnut - JVR-584 - Rajkot

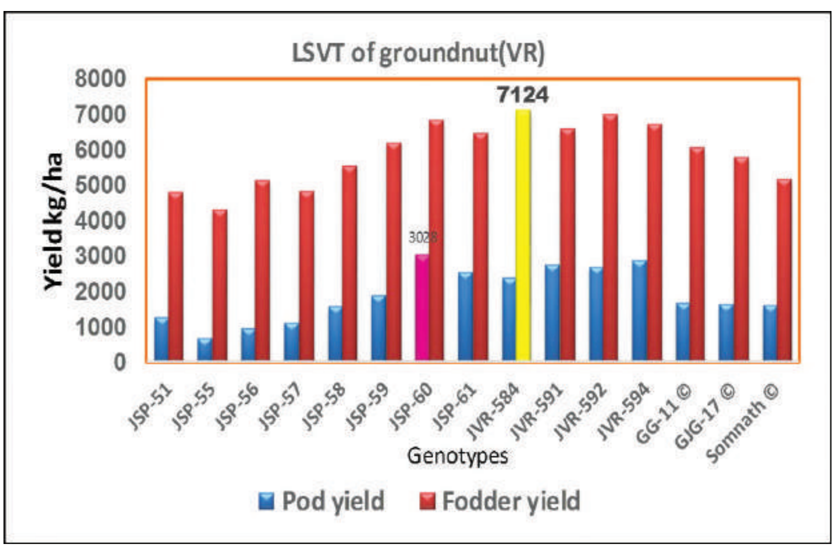
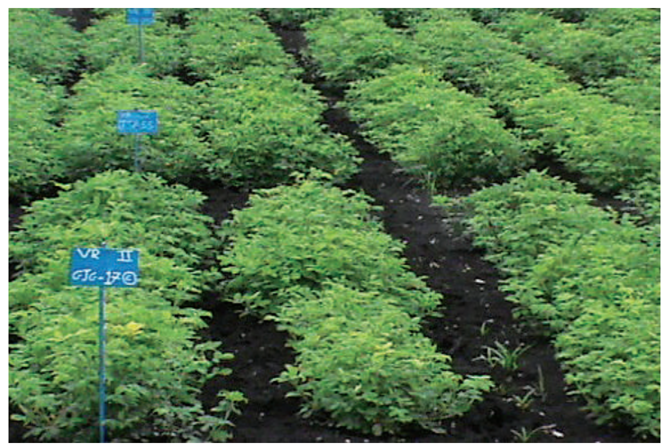


Fig. 3.4 Groundnut pod and fodder yield with respect to different genotypes - Rajkot

Table 3.229 : Performance of groundnut genotypes - Rajkot

Genotype	Pod yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (3 years)	Haulm (2015)				
JSP-58	2286	1555	6536	27732	107818	3.89	3.89
JSP-59	2604	1885	7288	27732	125888	4.54	4.43
JSP-60	3028	3028	6846	27732	142758	5.15	5.16
JSP-61	2523	2523	6487	27732	118238	4.26	4.30
JVR-584	2377	2377	7124	27732	114853	4.14	4.05
JVR-591	2743	2743	6601	27732	128708	4.64	4.67
JVR-592	2698	2698	7010	27732	128728	4.64	4.59
JVR-594	2863	2863	6716	27732	134683	4.86	4.88
GG-11 (c)	2352	1268	7059	27732	113403	4.09	4.01
GJG-17 (c)	2483	1914	6732	27732	117663	4.24	4.23
Somnath	2135	1201	4755	-	-	-	-
CD at 5%	372.8	-	780.7	-	-	-	-

Performance of groundnut - JSP-60



Performance of groundnut check GJG-17

In another varietal trial of groundnut at Rajkot, the highest mean pod yield (3382 kg/ha) was recorded with genotype JSSP-2336 which was 105, 134.5 and 130.3% higher over check varieties GG-20, GJG-22 and Kadiri-3, respectively. However, Kadiri-3 gave highest haulm yield (8268 kg/ha) followed by genotypes GJG-22 (c) (7633 kg/ha), JSSP-46 (7467 kg/ha), ICGV-05155 (7333 kg/ha) and JSSP-50 (7158 kg/ha) (Table 3.230).

Table 3.230 : Performance of groundnut genotypes in varietal trial (VB) –Rajkot

Genotype	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod (2015)	Mean pod yield (3 years)	Haulm				
JSSP-46	3090	2317	7467	27645	148740	5.38	5.26
JSSP-49	3597	2373	5633	27645	162385	5.87	6.13
JSSP-50	3773	2301	7158	27645	177930	6.44	6.43
JVB-2335	2656	2656	6750	27645	125625	4.54	4.52

Genotype	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod (2015)	Mean pod yield (3 years)	Haulm				
JVB-2336	3382	3382	6658	27645	157835	5.71	5.76
ICGV-05155	2689	2689	7333	27645	130025	4.70	4.58
GJG-20 (c)	3247	1653	6933	27645	153135	5.54	5.53
GJG-22(c)	3115	1442	7633	27645	150695	5.45	5.30
Kadiri-3(c)	3030	1468	8267	27645	150040	5.43	5.16
CD @ 5%	452.6		1040				

Performance of groundnut genotype JSP-50

Check GJG-20

3.4.1.6 Integrated farming system

In an experiment on integrated farming system at Rajkot, higher net returns of Rs.32173/ha was recorded for crops along with milch animal (cow) compared to sole cotton cultivation. The employment generation under IFS module was 365 man-days/ha/yr compared to 175 man-days/ ha/yr under farmer's practice of cotton cultivation (Table 3.231).

Table 3.231 : Economics of integrated farming system under rainfed condition - Rajkot

Farming system	Productivity (kg/ha)		System productivity (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ ha)	B:C ratio	Employ-ment generation (man-days/ ha/yr)
	Crop	Animal component					
IFS	Cotton, pigeonpea, sorghum, maize and cowpea	Cow-1	3747	145825	32173	1.2	365
Sole cotton	Cotton	--	1525	47465	24973	1.5	175

3.4.2 Soybean Based Production System

3.4.2.1 Rainwater management

At Indore, in a study on effect of rainfall on resource losses and crop productivity, July was the most erosive month and recorded highest erosion index of 27.54 followed August and June (18.02 and 7.77) for vertisols. In July, an average of 8 out of 19 storms occurred as erosive storms. The amount of erosive rainfall from February to May, and October and November months was negligible. The monthly distribution of kinetic energy (KE) is presented in Table. Monthly normal values showed that KE of the rainfall was highest in July (300.37 m t/ha-cm) followed by August and September (283.77 and 258.49 m t/ha-cm) (Table 3.232, 3.233 & 3.234).

Table 3.232 : Monthly rainfall, number of rainy days and number of erosive storms (2015) - Indore

Month	Rainfall (mm)	No. of rainy days	No. of erosive storms	Rainfall intensity/hr	Rainfall intensity/30 min
January	60.6	2	2	2.52	1.26
February	0.0	0	0	0.0	0.0
March	8.8	0	0	0.36	0.18
April	4.4	0	0	0.18	0.09
May	0.0	0	0	0.00	0.0
June	231.3	9	5	9.64	4.82
July	567.5	11	8	23.62	11.81
August	317.3	6	3	13.22	6.61
September	61.8	4	1	2.58	1.29
October	4.5	0	0	0.19	0.09
November	0.0	0	0	0.00	0.00
December	0.0	1	0	0.0	0.0

Table 3.233 : Average monthly erosion index during 2008-2015 – Indore

Month	Erosion Index								Average
	2008	2009	2010	2011	2012	2013	2014	2015	
January	0.00	1.29	0.21	0.00	0.00	0.00	2.44	3.10	0.88
February	0.00	0.00	0.09	0.00	0.00	0.58	1.82	0.00	0.31
March	0.00	4.08	0.00	0.00	0.00	0.19	0.00	0.31	0.56
April	0.00	0.00	0.00	0.00	0.00	0.96	0.11	0.13	0.15
May	0.00	6.01	0.45	0.29	1.55	0.04	1.05	0.00	1.16
June	6.31	6.19	9.97	5.88	1.41	17.61	0.48	14.36	7.77
July	8.52	46.87	8.86	32.57	19.04	37.90	27.33	39.27	27.54
August	10.97	7.25	9.85	55.30	9.23	22.54	8.51	20.50	18.02
September	5.82	8.35	5.18	12.34	6.45	7.84	6.24	3.18	6.92
October	0.99	3,38	0.02	0.64	0.00	5.88	1.45	0.13	1.56
November	0.38	5.58	3.31	0.00	0.00	0.00	0.00	0.00	1.16
December	0.05	1.13	0.00	0.00	0.00	0.05	0.25	0.00	0.18
Total	33.10	89.76	37.95	107.02	37.38	15.59	49.92	80.98	

Table 3.234 : Average monthly kinetic energy during 2008-2015 – Indore

Month	Kinetic energy (mt/ha/cm)								
	2008	2009	2010	2011	2012	2013	2014	2015	Average
January	0.00	296.54	136.67	0.00	0.00	0.00	229.31	246.02	113.57
February	0.00	0.00	112.37	0.00	0.00	191.84	235.94	0.00	67.52
March	0.00	261.80	0.00	0.00	0.00	156.41	0.00	170.81	73.62
April	0.00	0.00	0.00	0.00	0.00	206.99	211.19	144.02	52.27
May	0.00	268.26	160.80	169.42	210.47	112.36	210.30	0.00	141.31
June	246.63	269.26	261.70	267.27	210.44	304.61	208.415	297.88	258.28
July	256.68	338.65	257.75	325.79	211.55	331.04	349.50	332.52	300.37
August	288.69	274.61	261.30	344.13	211.24	313.06	266.85	310.01	283.77
September	267.21	279.49	239.77	292.49	211.08	277.02	253.92	246.93	258.49
October	281.85	248.38	74.46	194.52	0.00	267.23	221.64	146.11	179.27
November	275.38	265.77	224.89	0.00	0.00	0.00	0.00	0.0	95.76
December	267.34	212.55	0.00	0.00	0.00	117.77	206.60	0.0	100.53
Total	1893.83	2534.69	1729.71	1593.62	1055.38	2278.33	2493.66	1894.30	

Among the three crops *viz.,* soybean, chickpea and safflower evaluated at Indore, over the eight years mean, soybean recorded highest erosivity 54.46 and the lowest was chickpea (3.77). In case of mean seed yield (8 years), safflower recorded highest seed yield (1651 kg/ha), and the lowest was recorded in chickpea (1160 kg/ha) (Table 3.235).

Table 3.235 : Crop productivity based on rainfall pattern and erosivity index (EI) during 2008-2015 – Indore

E.I.	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	Mean (8 years)
Soybean	25.3	62.5	24.9	100.2	34.7	68.3	42.55	77.21	54.46
Chickpea	2.7	6.9	3.3	0	0	5.93	7.93	3.43	03.77
Safflower	6.8	6.9	3.3	0	0	5.93	7.93	3.43	04.29
Yield (kg/ha)									
Soybean	1853	2515	598	2149	1930	390	967	397	1350
Chickpea	1614	1536	1433	692	911	1395	767	930	1160
Safflower	1250	1200	950	950	450	450	7560	398	1651

In a study on evaluation of land configuration and seed rates of varieties of soybean at Indore, the plant height was marginally higher with sowing of crop under raised bed at 60 cm spacing and raised bed at 90 cm spacing over flat bed sowing at 45 cm row spacing; with 60 kg/ha seed rate over 40 kg/ha; and RVS 2001-4 variety over JS 335. The lowest number of branches/plant was recorded in case of flat bed sowing (4.48) as compared to raised bed at 60 cm (46.3) and raised bed at 90 cm (45.3). Significantly more number of branches/plant was recorded with 60 kg/ha seed rate over 40 kg/ha. Maximum number of branches/plant was recorded by RVS 2001-4. The maximum number of pods (20.5/plant) was recorded with the planting on raised bed of 60 cm width with 2 rows/bed, which was significantly higher over planting methods of FS-45 cm and RB-90 cm. The maximum number of pods (20.7/plant) was recorded with variety RVS 2001-4 which was significantly higher than JS 335. The highest grain weight/plant was recorded with RB-60 cm (4.93 g). Variety RVS 2001-4 gave significantly higher grain weight/plant (4.05 g) as compared to JS-335 (3.42 g). Interactive effect of land configuration, varieties and seed rate did not influence the grain weight/plant significantly (Table 3.236).

Table 3.236 : Effect of configuration, seed rates and varieties on growth and yield attributes of soybean – Indore

Treatment	Plant height	Branches / plant	Pods /plant	Nodules/plant at flowering	Dry weight /plant (g)	Seed weight /plant (g)
Land configuration						
Flat bed sowing at 45 cm	43.1	4	14	22	26.9	2.86
Raised bed furrow system at 90 cm bed (3 rows/bed)	45.3	6	20	25	28.2	3.42
Raised bed furrow system at 60 cm bed (2 rows/bed)	46.3	6	21	27	32.4	4.93
CD at 5 %	1.7	1	4	1	2.5	0.88
Seed rate						
75 % of normal Seed rate	45.7	6	19	25	29.3	3.78
50 % of normal Seed rate	44.0	5	18	24	29.1	3.69
CD at 5 %	1.0	1	NS	NS	NS	NS
Vateity						
RVS 2001-4	46.4	6	21	26	31.7	4.05
JS- 335	43.3	5	16	23	26.6	3.42
CD at 5%	1.0	0.7	14.49	3.3	1.7	2.86

Among different land configuration treatments, 90 cm raised bed width with 3-rows per bad recorded significantly higher seed yield (542 kg/ha) compared to sowing on flat bed and 60 cm raised bed with 2-rows per bed. Similarly, higher yield was recorded under higher seed rate (60 kg/ha) than lower seed rate (40 kg/ha). Variety RVS 2001-04 performed better than JS 335. The interaction showed that RB- 90 cm (3 rows 30cm) with 60 kg/ha seed rate (75% of the recommended) gave the maximum seed yield (Table 3.237).

Table 3.237 : Effect of different treatments on seed yield of soybean - Indore

Treatment	Seed yield (kg/ha)		Land configuration v/s Variety (L x V)					
Land configuration	2015	Mean (2 years)	Treatment	2001- 04	Mean (2 years)	JS-335	Mean (2 years)	Mean
Flat bed sowing at 45 cm	418	1491	Flat sowing 45 cm	612	2148	224	833	1491
Raised bed furrow system at 90 cm bed (3 rows/bed)	542	1898	RB- 90 cm	692	2320	392	1477	1898
Raised bed furrow system at 60 cm bed (2 rows/bed)	315	1180	RB- 60 cm	364	1350	265	1008	1180
Variety x seed rate (S x V)								
CD at 5%	66.2	141	-	-	-	CD at 5%	-	76.7
75 % of normal seed rate (S_1)	470	1678	Treatment	S1		S2		Mean
50 % of normal seed rate (S_2)	380	1368	Flat sowing 45 cm	463	1651	373	1330	1491
CD at 5%	54.4	130	RB- 60 cm	364	1330	265	1029	1180
RVS 2001-4	556	1939	-	-	-	-	-	-
JS- 335	294	1106	-	-	-	CD at 5%	-	NS
CD at 5%	54.4	130	Treatment	S1		S2		Mean
			RVS 2001- 4	617	2146	496	1734	1939
			JS- 335	324	1211	264	1002	1106
						CD at 5%	-	NS

RB: Raised bed

Flat bed system

Raised bed system 90 cm (3 rows/bed)

Performance of flat bed and raised bed systems

In an experiment on catchment-storage-command relationship for enhancing water productivity in a micro-watershed at Indore, four double cropping systems were evaluated with supplemental irrigation from the harvested rainwater in farm pond. The bunds of farm pond were also utilized for growing of vegetable crops, which gave an additional income. Sweet corn-tomato system was more remunerative with net returns of Rs.119279/ha and B: C ratio 2.70. The traditional soybean-chickpea system gave net returns of Rs.15872/ha and B: C ratio 1.48, whereas, soybean-potato sequence recorded lowest net returns of Rs.3475/ha with B:C ratio 1.08. During *rabi* season, tomato gave higher yield (13098 kg/ha), followed by sponge gourd, potato and chickpea (Table 3.238). Drip irrigation at 3 liter/hour was applied to sweet corn and tomato during *rabi* and the discharge water used by tomato crop was 30 liter per plant or 83 cm/ha and sweet corn 24 liters per plant or 88 cm/ha.

Sweet corn cv. Sugar 75

Table 3.238 : Yield and economics of different cropping systems - Indore

Cropping sequence	Crop	Yield (kg/ha)	Cost ofcultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Sweet corn-tomato	Sweet corn (K)	2915	25000	33299	2.33
	Tomato (R)	13098	45000	85980	2.91
Sweet corn-vegetables	Sweet corn (R)	3200	25000	39000	2.56
	Sponge gourd / Bottle gourd	-	-	-	-
Soybean- potato	Soybean (K)	562	20000	1372	1.07
	Potato (R)	2510	25000	103	1.00
Soybean- chickpea	Soybean (K)	562	20000	1372	1.07
	Chickpea (R)	550	13000	14500	2.12

K: *kharif*, R: *rabi*

At Rewa, soybean variety JS20-29 performed well upto flowering stage but due to dry spells at reproductive stage, gave low yield of 650 kg/ha. During *rabi*, wheat performance was adversely affected due to occurrence of hailstorms along with high intensity rains at physiological maturity. Among *rabi* crops, chickpea gave higher net returns (Rs. 40200/ha) and B:C ratio (3.35) since the crop was not affected by hailstorm (Table 3.239).

Table 3.239 : Performance of different crops in a micro-watershed - Rewa

Crop	Yield (kg/ha) Seed/grain yield (2015-16)	Mean seed/grain yield (2 years)	Stover/ stalk yield	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Soybean	650	650	1462	11500	24900	2.16	1.03
Wheat	1190	1825	2670	12000	20850	1.73	-
Chickpea	983	1160	2133	12000	40200	3.35	-
Mustard	159	294	325	11000	-3700	0.34	-

Before hailstorm - Wheat

After hailstorm - Wheat

Before hailstorm - Wheat

After hailstorm - Chickpea

At Rewa in an evaluation of *in-situ* moisture conservation practices in soybean based intercropping systems, due to occurrence of three dry spells during reproductive stage of crops, the seed yield of soybean and intercrops was adversely affected. Soybean + greengram intercropping system with ridge and furrow system (M2C1) recorded higher soybean equivalent yield (SEY) (657 kg/ha), net returns (Rs. 5645/ha), B:C ratio (1.26) and RWUE (1.22 kg/ha-mm) compared to other intercrop system (Table 3.240 & 3.241).

Table 3.240 : Effect of rainwater conservation practices on yield of soybean based intercropping systems -Rewa

Treatment	Yield (kg/ha) Seed		Stalk		SEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Soybean	Intercrop	Soybean	Intercrop					
M1 Broad bed	218	30	1042	487	475	20150	108	0.99	0.55
M2 Ridge & furrow	272	44	1027	500	615	21650	3977	1.18	0.72
M3 Flat bed	136	10	603	272	209	19650	-10687	0.46	0.24
CD at 5%					34.0				
C1 Soybean + greengram	242	24	806	340	427	19650	-1764	0.91	0.50
C2 Soybean + cowpea	248	22	933	306	396	19650	-2877	0.85	0.46
C3 Soybean + pigeonpea	236	39	927	613	478	19650	-397	1.02	0.56
CD at 5%	-	-	-	-	26.0	-	-	-	-

Table 3.241 : Effect of rainwater conservation practices and intercrops on yield and economics of soybean based intercropping systems - Rewa

Treatment	Seed yield kg/ha		SEY (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Soybean	Intercrop					
M1 C1	262	26	454	20150	-1124	0.95	0.85
M1C2	298	23	439	20150	-1454	0.92	0.82
M1C3	257	42	533	20150	2291	1.11	0.86
M2C1	348	42	657	21650	5645	1.26	1.22
M2C2	312	38	566	21650	2002	1.09	1.06
M2C3	312	52	621	21650	4238	1.19	1.00
M3C1	121	5	172	19650	-12234	0.37	0.32
M3C2	139	4	172	19650	-12119	0.38	0.32
M3 C3	151	22	278	19650	-7912	0.59	0.45
CD at 5%			15.0				

3.4.2.2 Cropping systems

At Indore, significantly higher values of leaf area index (LAI) of soybean chlorophyll content (41.15), number of pods/plant (13) and 100 seeds weight ranged from 7.13 to 9.60g were recorded with foliar spray of thiourea 250 g/ha at 25-30 and 55 DAS + trizophos @ 600 ml/ha tank mix at flowering stage. (Table 3.242).

Table 3.242 : Growth and yield attributes of soybean as influenced by different treatments - Indore

Treatment	Leaf area index at flowering	Chlorophyll content (SPAD) at flowering	Number of pods/ plant	100 seeds weight (g)
T1: Absolute control	0.36	36.67	9	7.13
T2: Water spray at 25-30 and 55-60 DAS	0.51	37.65	10	7.87
T3: Foliar spray of 1% KNO_3 at 25-30 and 55-60 DAS	0.57	39.18	10	8.06
T4: Foliar spray of 2% KCl at 25-30 and 55-60 DAS	0.63	39.23	11	8.11
T5: Foliar spray of thiourea @ 250 g/ha at 25-30 and 55-60 DAS	0.64	40.73	12	8.27
T6: T3 + trizophos @ 600 ml/ha tank mix	0.65	40.55	13	8.98
T7: T4 + trizophos @ 600 ml/ha tank mix	0.60	40.11	11	8.63
T8: T5 + trizophos @ 600 ml/ha tank mix	0.66	41.15	13	9.60
T9: Interculture	0.63	40.50	11	8.50
CD at 5%	0.14	1.89	1.57	1.16

At Indore, foliar spray of thiourea, KNO_3 and KCl alone or mixed with trizophos @ 600 ml/ha in soybean were found equally effective to combat the dry spell situation. Significantly higher soybean seed yield (365 kg/ha), B:C ratio (0.64) and RWUE of 0.39 soybean recorded with foliar spray of thiourea @ 250 g/ha + trizophos @ 600 ml/ha (T8), followed by foliar spray of 1% KNO_3 + trizophos @ 600 ml/ha tank mix (T6) as compared to control. The foliar spray of 1% KNO_3, 2% KCl and thiourea @ 250g/ha alone resulted in lower seed yield of soybean as compared to spray of trizophos. During 2015-16, the seed yield of soybean was very low and uneconomical due to moisture stress at early growth and at pod filling stages. However, crop responded appreciably better to foliar sprays with 28 to 53% improvement in seed yield as compared to control (Table 3.243).

Table 3.243 : Seed yield and economics of soybean as influenced by foliar sprays – Indore

Treatment	Seed yield (kg/ha)		Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015	Mean (2 years)					
T1: Absolute control	238	673	1225	20000	-10956	0.45	0.26
T2: Water spray at 25-30 and 55-60 DAS	249	713	1306	20600	-11138	0.46	0.27
T3: Foliar spray of 1% KNO_3 at 25-30 and 55-60 DAS	327	896	1617	20740	-8314	0.60	0.35
T4: Foliar spray of 2% KCl at 25-30 and 55-60 DAS	306	898	1287	20700	-9072	0.56	0.33
T5: Foliar spray of thiourea @ 250 g/ha at 25-30 and 55-60 DAS	333	930	1519	21050	-8396	0.60	0.36
T6: T3 + trizophos @ 600 ml/ha tank mix	350	960	1501	21390	-8090	0.62	0.38
T7: T4 + trizophos @ 600 ml/ha tank mix	331	977	1650	21350	-8772	0.59	0.36
T8: T5 + trizophos @ 600 ml/ha tank mix	365	1009	1635	21700	-7830	0.64	0.39
T9: Interculture	345	173	1785	22000	-8890	0.60	0.37
CD at 5%	56	174	427				

At Indore, in a study on intercropping systems and nutrient management, the higher soybean equivalent yield (SEY) and B:C ratio (1631 kg/ha, 3.10) was recorded with soybean + maize (1:1) at 45 cm followed by sole maize at 60 cm (1406 kg/ha, 2.67). Sole crops, maize recorded higher SEY compared to soybean (Table 3.244).

Table 3.244: Seed yield and economics of soybean / maize + sunhemp intercropping system - Indore

Treatment	Yield (kg/ha)		SEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Soybean	Maize				
Soybean + sunhemp (2:1) at 30 cm	596	-	596	2636	1.13	0.64
Soybean+ sunhemp (1:1) at 45 cm	706	-	706	6844	1.34	0.76
Sole soybean at 45 cm	840	-	840	11911	1.60	0.91
Maize + sunhemp (2:1) at 30 cm		2396	1261	27912	2.40	1.36
Maize + sunhemp (1:1) at 45 cm		2049	1079	20988	2.05	1.17
Sole maize at 60 cm		2672	1406	33439	2.67	1.52
Soybean + maize (1:1) at 45 cm	613	1934	1631	41976	3.10	1.76
T8: Sole sunhemp at 30 cm	*	*	596	2636	1.13	0.64
CD at 5%	-	-	120	-	-	-

The initial organic carbon (OC) content in various treatments ranged from 0.22 to 0.30 After harvest, higher OC (%) was recorded in sole sunhemp at 30 cm (0.34%) followed by soybean + sunhemp (1:1) at 45 cm (0.32%). After harvest the available N (kg/ha) ranged from 126 to 148; available P (kg/ha) 12.17 to 14.75; available K (kg/ha) 541 to 685 and 14.37 to 23.80 in case of available S (kg/ha). The results indicate that intercropping with sunhemp incorporation through *in-situ* recorded higher available soil nutrient status in the soil as compared to other treatments (Table 3.245).

Table 3.245 : Soybean / maze + sunhemp interccropping systems: Effect on soil chemical properties - Indore

Treatment	OC (%)	Nutrient status of soil (kg/ha)				pH (1:2.5)	EC (dsm^{-1})
		N	P_2O_5	K_2O	S		
Soybean + sunhemp (2:1) at 30 cm	0.29	139	12.17	541	52.65	7.35	0.07
Soybean+ sunhemp (1:1) at 45 cm	0.32	147	12.67	562	14.37	7.34	0.19
Sole soybean at 45 cm	0.26	126	13.87	620	14.77	7.27	0.19
Maize + sunhemp (2:1) at 30 cm	0.26	126	12.85	653	20.97	7.45	0.20
Maize + sunhemp (1:1) at 45 cm	0.27	128	12.51	662	23.29	7.41	0.06
Sole maize at 60cm	0.28	130	12.99	667	25.07	7.43	0.05
Soybean + maize (1:1) at 45 cm	0.26	127	12.89	681	22.83	7.45	0.21
Sole sunhemp at 30 cm	0.34	148	14.75	685	23.80	7.44	0.05

Sole sunhemp for green manuring

Soybean + sunhemp for green manuring

At Rewa, in an evaluation of chickpea and lentil based intercropping systems after *kharif* paddy under zero till condition, the higher chickpea equivalent yield (647 kg/ha) was recorded from sole lentil with higher net returns (Rs.16350/ha) and B:C ratio (2.02) followed by chickpea + linseed (4:2) with chickpea equivalent yield of 529 kg/ha, net returns Rs.10600/ha and B:C ratio 1.66. Very low yields of *rabi* crops were recorded due to hailstorm with high intensity rains at the time of physiological maturity of crops (Table 3.246).

Table 3.246 : Yield and economics of different crops in zero till condition – Rewa

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Main crop	Inter crop	CEY			
Sole chickpea	297	-	297	19600	-4750	0.75
Sole lentil	538	-	647	16000	16350	2.02
Sole linseed	498	-	399	12100	7850	1.64
Sole mustard	55	-	109	10350	-4900	0.52
Chickpea + linseed (4:2)	387	178	529	15850	10600	1.66
Chickpea + mustard (4:2)	387	102	461	14950	8100	1.54
Lentil + linseed (4:2)	249	200	460	14050	8950	1.63
Lentil + mustard (4:2)	370	87	506	13150	12150	1.92
CD at 5%	-	-	27.0	-	-	-

CEY-Chickpea equivalent yield

Chickpea + linseed (4:2)

Chickpea + mustard (4:2)

At Rewa, in soybean, foliar spray of 1% KNO_3 alone and trizophos @ 600 ml/ha (T6) at vegetative (25-30) and reproductive stage (55-60 DAS) was found effective to mitigate dry spells. The highest seed yield and B:C ratio (1388 kg/ha; 2.63) of soybean was recorded with foliar spray of 1% KNO_3 + trizophos @ 600 ml/ha, followed by spray of 1% KNO_3 alone (1354 kg/ha; 2.63) (Table 3.247).

Table 3.247 : Performance of different chemicals on drought mitigation in soybean - Rewa

Treatment	Yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1- Control	679	20200	9348	1.46	1.08
T_2- Water spray at 25-30 and 55-60 DAS	904	20700	18319	1.88	1.43
T_3- Foliar spray of 1% KNO_3 at 25-30 and 55-60 DAS	1354	21800	35700	2.63	2.15
T_4-Foliar spray of 1% KCl at 25-30 and 55-60 DAS	1085	21800	24576	2.13	1.72
T_5- Foliar spray of thio urea @ 250 ml/ha at 25-30 and 55-60 DAS	951	21800	19234	1.88	1.51
T_6- T_3+ trizophos @ 600 ml/ha tank mix	1388	22300	36369	2.63	2.20
T_7- T_4+ trizophos @ 600 ml/ha tank mix	1047	22300	22725	2.01	1.66
T_8- T_5+ trizophos @ 600 ml/ha tank mix	1016	22300	21256	1.95	1.61
CD at 5%	0.67	-	-	-	-

3.4.2.3 Nutrient management

In the Permanent Manurial Trial (PMT) at Indore, the mean soybean seed yield (24 years) revealed that integrated nutrient management with FYM 6 t/ha + N20 P13 gave highest seed yield (1988 kg/ha). Similarly in 2015, FYM 6 t/ha+ N20 P13 gave higher seed and stalk yield (1367 and 3774kg/ha), net returns (Rs.32246/ha) and B:C ratio 2.64 (Table 3.248).

Table 3.248 : PMT - Seed yield and economics of soybean - Indore

Treatment	Yield (kg/ha)		Mean (24 yrs)	Cost of cultivation (Rs/ha)	NMR (Rs./ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk					
T_1 : N0 P0- Control	387	1068	1193	16300	(-) 1594	0.90	0.42
T_2 : N20 P13	645	1780	1521	16700	7810	1.47	0.7
T_3 : N30 P20	550	1519	1674	16900	4000	1.24	0.6

Treatment	Yield (kg/ha)		Mean (24 yrs)	Cost of cultivation (Rs/ha)	NMR (Rs./ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk					
T_4: N40 P26	903	2492	1782	17200	17114	2.00	0.98
T_5: N60 P35	628	1733	1847	18400	5464	1.30	0.68
T_6 : FYM 6 t ha^{-1}+ T2	1367	3774	1988	19700	32246	2.64	1.48
T_7: Crop residues 5 t/ha + T2	1041	2872	1726	20300	19258	1.95	1.13
T_8: FYM 6 t/ha	688	1899	1762	20000	6144	1.31	0.75
T_9: Residues 5 t/ha	783	2160	1614	20200	9554	1.47	0.85
CD at 5%	93	-	-	-	-	-	-

The maximum mean weight diameter (MWD) was obtained in the plots under FYM + N20 P13 (1.90 mm) and minimum in control (0.44 mm). In general, the FYM and crop residue addition gave higher MWD compared to inorganic fertilizer alone. Due to increased MWD and reduced bulk density, the porosity of soil also increased in organic amendments treated plots. The porosity ranged from 43.77 to 56.98% in different treatments and was highest with FYM + N20 P13 (Table 3.249).

Table 3.249 : Effect of various treatments of PMT on soil physical properties before and after harvest – Indore

Treatment	After harvesting of soybean		
	Mean wt. diameter (m)	Bulk density (Mg/m^3)	Porosity (%)
T_1: N0 P0- Control	0.44	1.49	43.77
T_2: N20 P13	0.72	1.47	44.53
T_3: N30 P20	0.8	1.43	46.04
T_4: N40 P26	0.88	1.38	47.92
T_5: N60 P35	0.9	1.39	47.55
T_6 : FYM 6 t/ha + T2	1.9	1.14	56.98
T_7: Crop residues 5 t/ha + T2	1.88	1.16	56.23
T_8: FYM 6 t/ha	1.82	1.7	35.85
T_9: Crop residues 5 t/ha	1.79	1.29	51.32

The soil organic C was highest (0.87%) in the plots under FYM 6 t/ha + N2O P13 compared to other treatments. Similarly, the available P, K and S were highest with T8 whereas available N was marginally higher in the plots under residues 5 t/ha + N2O P13 (Table 3.250).

Table 3.250 : PMT - Effect on soil chemical properties - Indore

Treatment	After harvesting of soybean (2015-16)						
	OC (%)	Available nutrients (kg/ha)				pH	EC (dS/m)
		N	P_2O_5	K_2O	S		
T_1: N0 P0- Control		182.0	9.0	471.0	6.8	7.55	0.20
T_2: N20 P13	0.37	240.0	10.8	521.0	6.1	7.66	0.20
T_3: N30 P20	0.43	214.3	12.5	543.0	7.1	7.79	0.22
T_4: N40 P26	0.52	208.0	13.3	552.0	7.7	7.60	0.22
T_5: N60 P35	0.55	217.7	14.5	584.0	8.2	7.72	0.23
T_6 : FYM 6 t/ha + T2	0.87	289.7	21.6	646.0	18.4	7.65	0.22
T_7: Residues 5 t/ha +T2	0.83	291.0	18.5	637.0	15.1	7.97	0.18
T_8: FYM 6 t/ha	0.81	288.3	16.0	608.0	16.1	7.75	0.22
T_9: Residues 5 t/ha	0.66	249.0	14.6	605.0	17.1	7.83	0.20

The uptake of N, P, K and S by soybean seed, stalk and total uptake of these nutrients in relation to different treatments was mainly governed by biomass yield. Application of FYM 6 t/ha + T2 recorded higher uptake of N, P, K and S as compared to other treatments (Table 3.251).

Table 3.251 : PMT - Effect on nutrient uptake by soybean crop - Indore

Treatment	Nutrient uptake (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	29.1	2.7	18.4	0.4	4.7	0.5	5.4	0.6	33.8	3.2	23.9	1.0
T_2: N20 P13	43.9	3.1	24.2	0.8	5.7	0.6	5.5	2.1	49.5	3.7	29.7	2.9
T_3: N30 P20	51.8	5.2	30.0	2.3	6.7	1.3	7.3	4.2	58.5	6.4	37.3	6.5
T_4: N40 P26	52.6	5.3	30.1	3.0	7.2	0.7	6.9	4.1	59.8	6.0	37.0	7.0
T_5: N60 P35	50.1	5.2	28.8	3.5	5.7	1.1	6.2	3.5	55.8	6.3	35.0	7.0
T_6 : FYM 6 t/ha + T2	78.4	11.3	45.3	6.1	8.4	2.3	7.3	5.2	86.7	13.6	52.6	11.3
T_7: Residue 5 t/ha +T2	62.0	7.8	34.6	3.5	7.3	1.1	5.8	3.2	69.3	8.9	40.3	6.8
T_8: FYM 6 t/ha	58.6	6.7	34.3	3.4	7.6	1.8	5.9	4.2	66.1	8.5	40.2	7.6
T_9: Residues 5 t/ha	63.4	8.8	35.4	3.5	5.9	1.1	5.3	4.2	69.3	9.9	40.7	7.8

Similarly, during *rabi*, application of FYM @ 6 t/ha + N20 P13 (T6) recorded significantly higher seed yield (881 kg/ha), net returns (Rs.26650/ha), RWUE (195.79 kg/ha-mm) and B:C ratio (2.53) compared to other treatments (Table 3.252).

Table 3.252 : PMT - 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	480	106.75	15000	9000	1.60
T_2: N20 P13	536	119.21	15900	10900	1.69
T_3: N30 P20	736	163.45	16200	20600	2.27
T_4: N40 P26	753	167.27	16500	21150	2.28
T_5: N60 P35	662	147.20	16800	16300	1.97
T_6 : FYM 6 t/ha + T2	881	195.79	17400	26650	2.53
T_7: Residue 5 t/ha +T2	638	141.87	17800	14100	1.79
T_8: FYM 6 t/ha	620	137.81	17200	13800	1.80
T_9: Residues 5 t/ha	830	184.44	17000	24500	2.44
CD 5%	76				

Performance soybean with N080

Performance of soybean with N20P13

Permanent Manorial Trial in soybean

In a study on integrated nutrient management in soybean at Indore, significantly highest soybean seed yield (753 kg/ha), net returns (Rs.9964/ha) and B:C ratio (1.53) was recorded due to application of 50% NPK, 20 kg Zn, 10 kg S + 10 t/ha FYM + 5 t residue with *Rhizobium* + PSB compared to other treatments (Table 3.253).

Table 3.253 : Effect of INM yield and economics of soybean - Indore

Treatment	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Control	376	16300	(-)2012	0.49	0.88
100% NPK (20:60:20 NPK kg/ha)	659	20000	5042	0.87	1.25
100% NPK + Zn (20 kg/ha)	634	20200	3892	0.83	1.19
100% NPK + Zn + S	694	20300	6072	0.91	1.30
100% NPK + S (10 kg/ha)	664	20100	5132	0.87	1.26
10 t FYM + 50% NPK	692	18150	8146	0.91	1.45
10 t FYM + (*Rhizobium* + PSB) + 50% NPK	729	18350	9352	0.96	1.51
10 t FYM + (*Rhizobium* + PSB) + 50% NPK + Zn + S	741	18650	9508	0.97	1.51
10 t FYM + (*Rhizobium* + PSB) + 50% NPK + 5 t Residues + Zn + S	753	18650	9964	0.99	1.53
CD at 5%	164	-	-	-	-

Application of FYM, crop residue and biofertilizers improved soil fertility particularly available N, P, K, S and organic carbon content in plough layer. The soil organic C after harvest of soybean was similar under all the treatments (0.26-0.28%) except under control (0.22%). The N content was 127-135 kg/ha among different nutrient management treatments. Similarly, the available P and K was similar with different treatments (Table 3.254).

Table 3.254 : Changes in soil chemical properties as affected by different treatments of INM- Indore

Treatment	OC (%)	Available nutrients (kg/ha)				pH	EC (dS/m)
		N	P_2O_5	K_2O	S		
Control	0.22	107	11.91	333	10.85	7.55	0.20
100% NPK (20:60:20 NPK kg/ha)	0.28	133	12.39	335	10.71	7.66	0.20
100% NPK + Zn (20 kg/ha)	0.27	129	12.11	334	11.51	7.79	0.22
100% NPK + Zn + S	0.26	127	11.45	332	11.14	7.60	0.22
100% NPK + S (10 kg/ha)	0.28	135	12.11	327	11.10	7.72	0.23
10 t FYM + 50% NPK	0.28	135	11.93	333	10.87	7.65	0.22
10 t FYM + (*Rhizobium* + PSB) + 50% NPK	0.28	135	12.42	339	11.33	7.97	0.18
10 t FYM + (*Rhizobium* + PSB) +50% NPK + Zn + S	0.27	134	11.83	333	11.47	7.75	0.22
10 t FYM + (*Rhizobium* + PSB) +50% NPK + 5 t residues + Zn + S	0.27	134	12.74	338	11.41	7.83	0.20

The uptake of N, P, K and S by soybean seed, stalk and total uptake different treatments was mainly governed by biomass yield. Application of 10 t FYM + (*Rhizobium* + PSB) + 50% NPK + 5 t residues + Zn + S recorded higher uptake of N, P, K and S as compared to other treatments (Table 3.255).

Table 3.255: INM in soybean : Effect on nutrient uptake by soybean – Indore

Treatment	Nutrient uptake (kg/ha)								Total nutrient uptake (kg/ha)			
	Seed				Stalk							
	N	P	K	S	N	P	K	S	N	P	K	S
Control	29.08	2.65	18.44	0.41	4.7	0.54	5.44	0.61	33.78	3.19	23.88	1.02
100% NPK (20:60:20 NPK kg/ha)	43.86	3.12	24.24	0.77	5.67	0.57	5.46	2.13	49.53	3.69	29.70	2.90
100% NPK + Zn (20 kg/ha)	51.80	5.18	29.97	2.33	6.72	1.26	7.31	4.20	58.52	6.44	37.28	6.53
100% NPK + Zn + S	52.62	5.26	30.07	2.95	7.2	0.72	6.93	4.05	59.82	5.98	37.00	7.00
100% NPK + S (10 kg/ha)	50.11	5.18	28.8	3.46	5.66	1.06	6.16	3.54	55.77	6.24	34.96	7.00
10 t FYM + 50% NPK	63.38	8.84	35.38	3.54	5.91	1.1	5.32	4.22	69.29	9.94	40.70	7.76
10 t FYM + (*Rhizobium* + PSB) + 50% NPK	62.04	7.75	34.55	3.53	7.28	1.13	5.75	3.24	69.32	8.88	40.30	6.77
10 t FYM + (*Rhizobium* + PSB) + 50% NPK + Zn + S	58.55	6.73	34.32	3.43	7.55	1.76	5.88	4.2	66.1	8.49	40.20	7.63
10 t FYM + (*Rhizobium* + PSB) + 50% NPK + 5 t residues + Zn + S	78.39	11.32	45.29	6.1	8.35	2.3	7.31	5.22	86.74	13.62	52.60	11.32

In a study at Rewa, involving different combinations of N sources for rice-wheat; blackgram-chickpea and rice + blackgram - wheat + chickpea system in separate blocks, application of 100% N through compost was superior in all the blocks (Table). Rice and blackgram during *kharif* failed due to dry spells at vegetative and reproductive stage. During *rabi*, chickpea and wheat crops were affected by hailstorm accompanied with high intensity of rains at physiological maturity. However, application of 100% N through compost gave higher wheat yield (912 kg/ha) compared to other treatments (Table 3.256).

Table 3.256 : Effect of source and levels of N on the yield rice-wheat system - Rewa

Treatment	Yield (kg/ha)		
	Rice	Wheat	
Block B-1 Rice –Wheat	Mean grain yield (17 years)	Grain yield in 2015-16	Mean grain yield (17 years)
Control (no nitrogen)	1149	588	658
100% N (inorganic) (60 kg/ha)	1799	743	973
100% N through compost	2105	912	1032
50% N (inorganic) + 50% N (compost)	1809	776	930
50% N (inorganic) + 25% N (compost)	1508	754	844
25% N (inorganic) + 50% N (compost)	1404	800	892
50% N (inorganic) + 25% N (compost)+ *Azotobacter*	1523	776	930
25% N (inorganic) + 50% N (compost) + *Azotobacter*	1729	830	917
50% N (inorganic) + 50% N (compost) + *Azotobacter*	2007	838	930
Mean	-	780	-

*Rice crop failed due to drought during 2015

3.4.2.4 Energy management

In the longterm study on tillage and nutrient management in soybean at Indore, low tillage (LT) + 4 t/ha compost + herbicide recorded significantly highest seed yield of 882 kg/ha with higher net returns (Rs. 38187/ha), B:C ratio (2.98) and RWUE (1.75 kg/ha-mm) (Table 3.257). However, averaged 16 years indicated that highest soybean yield (1505 kg/ha) was recorded with conventional tillage (CT) + RF (+OT) + hand weeding, compared to other treatments.

Table 3.257 : Tilage and nutirent management: Effect on soybean yield and economics - Indore

Treatment	Seed yield (kg/ha) 2015-16	Mean seed yield (kg/ha) (16 years)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
CT + RF (-OT) + HW	281	1375	0.89	11100	11210	1.01
CT + RF (+OT) + HW	453	1505	1.13	12600	14241	1.13
LT + 4 t/ha straw + HW	506	1493	1.76	12900	25720	1.99
LT + 4 t/ha straw + Hb	440	1129	0.96	13700	14264	1.04
LT + 4 t/ha compost + HW	415	1418	1.00	13900	12288	0.88
LT + 4 t/ha compost + Hb	882	1229	1.75	12800	38187	2.98
LT + 2 t/ha *Glyricidia green leaves* + Hb	333	1021	0.79	12400	8281.8	0.67
LT + 2 t/ha *Glyricidia green leaves* + HW	478	1324	0.88	12800	18095	1.41
CD at 5%	97	-	-	-	-	-

CT-Conventional tillage; LT-Low tillage; OT - Off season tillage; Hb - herbicide application; Hw - hand weeding

The highest energy balance was recorded with LT + 4 t/ha compost + Hb closely followed by LT + 4 t/ha straw + HW. Input energy was lower under low till treatments than that of CT + RF (-OT) + HW and LT + 2 t/ha *Glyricidia green leaves* + Hb. The highest output energy was recorded with LT + 4 t/ha compost + chemical weed control (Fig 3.5).

After harvest of soybean, the highest soil organic carbon content (0.71%) was recorded in plots under LT + 4 t/ha compost + Hb, and minimum (0.46%) with CT + RF (-OT) + HW. Available N was higher in T6. It could be noted that irrespective of treatments, available P percent increased ranged from 16.3 to 39.3; available K 11.4 to 26.3 and 2.77 to 12.2 percent in case of available S (Table 3.258).

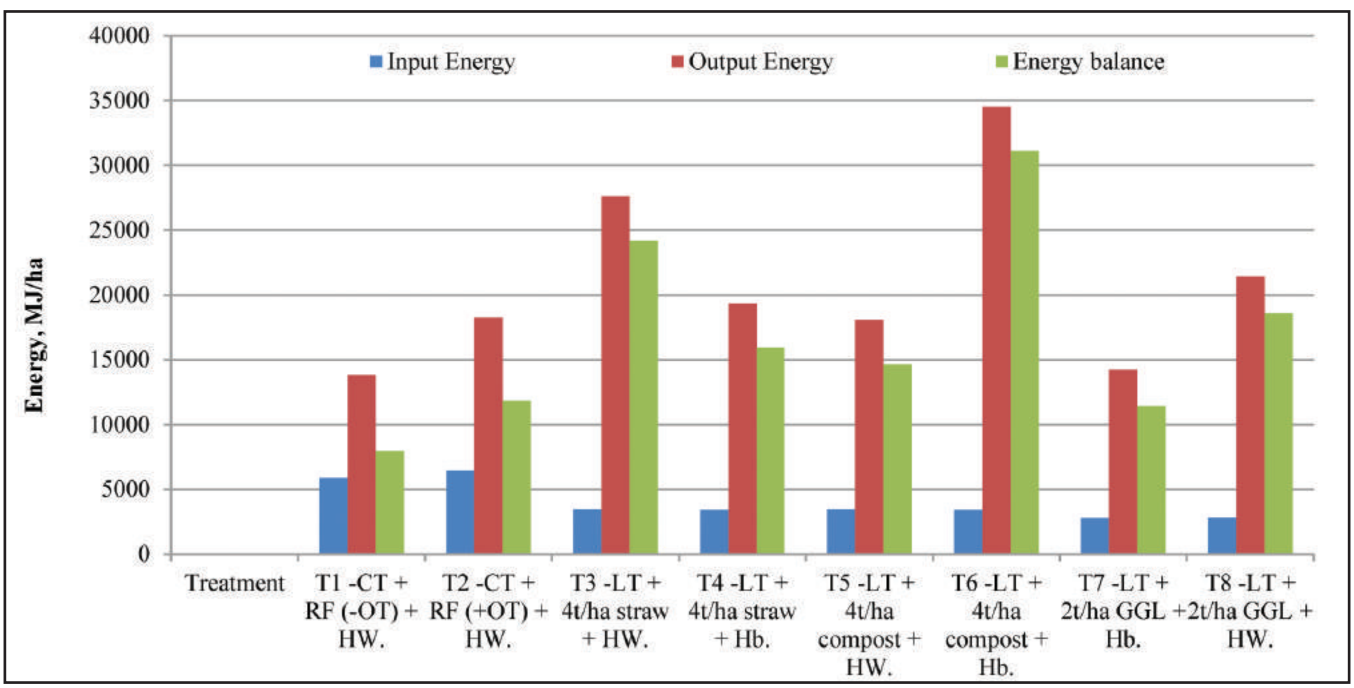


Fig. 3.5 Input, output and energy balance as influenced by different tillage and nutrient management in soybean - Indore

Table 3.258 : Tillage and nutrient management : Effect on soil chemical properties - Indore

Treatment	OC (%)	Nutrient status of soil (kg/ha)				pH	EC (ds/m)
		N	P_2O_5	K_2O	S		
T1- CT + RF (-OT) + HW	0.46	235.3	15.47	633	21.80	7.7	0.24
T2- CT + RF (+OT) + HW	0.44	219.3	15.07	599	21.43	7.7	0.34
T3- LT + 4 t/ha straw + HW	0.65	266.3	18.06	678	22.58	7.7	0.37
T4- LT + 4 t/ha straw + Hb	0.53	245.5	15.92	598	20.68	7.7	0.36
T5- LT + 4 t/ha Compost + HW	0.54	265.8	15.73	649	20.83	7.6	0.37
T6- LT + 4 t/ha Compost + Hb	0.71	276.8	21.00	755	23.20	7.7	0.38
T7- LT + 2 t/ha *Glyricidia green leaves* + Hb	0.57	241.0	16.69	658	22.38	7.6	0.34
T8- LT + 2 t/ha *Glyricidia green leaves* + HW	0.58	246.3	17.96	672	22.53	7.7	0.28

CT-Conventional tillage; LT-Low tillage; Hb - herbicide application; Hw - hand weeding

The lowest bulk density (1.21 Mg/m3) was recorded in plots under LT + 4 t/ha straw + HW and the maximum bulk density of 1.32 Mg/m3 was recorded with CT + RF (-OT) + HW. The reduction in bulk density in comparison to T1 was 1.5, 10.8, 5.6, 9.0, 3.9, 4.7 and 7.3% in the treatments T2, T3, T4, T5, T6, T7 and T8, respectively. The soil porosity was highest (53.94%) in case of T3 closely followed by T5. The mean weight was the parameter which was affected most due to different treatments. The percent increase ranged between 93 to -48% over T1 and in case of T2 mean weight diameter was decreased by 49% as compared to T1(Table 3.259).

Table 3.259: Tilage and nutirent management: Effect on soil physical properties - Indore

Treatment	Bulk density (Mg/m^3)	Porosity (%)	MWD (mm)
T1- CT + RF (-OT) + HW	1.32	50.19	2.39
T2- CT + RF (+OT) + HW	1.31	50.94	1.28
T3- LT + 4 t/ha straw + HW	1.21	53.97	4.96
T4- LT + 4 t/ha straw + Hb	1.27	51.90	3.56
T5- LT + 4 t/ha Compost + HW	1.23	53.27	4.26
T6- LT + 4 t/ha Compost + Hb	1.29	52.25	2.87
T7- LT + 2 t/ha *Glyricidia green leaves* + Hb	1.25	51.34	2.65
T8- LT + 2 t/ha *Glyricidia green leaves* + HW	1.23	52.55	3.98

3.4.2.5 Evaluation of improved varieties

The 32 entries of pigeonpea were evaluated along with the checks *viz.,* JKM-189 and JA 4 (medium maturing varieties *i.e.,* 170-175 days) and ICPL 88039 and UPAS 120 (early maturing varieties *i.e.,* 130-140 days). The promising entries identified for seed yield and yield attributes (Table 3.260).

Table 3.260 : Peformance of pigeonpea entries for seed yield and earliness - Indore

Class	Frequency	Entries
Seed yield (kg/ha): Range: From 690 kg/ha (JKM 189 08-37) to 3250 kg/ha (JKE - 114E)		
500-1000	02	ICPL 88039 08-08; JKM 189 08-37
1001-1500	09	Selection Panod; Selection Badnawar; JA 4 08-14; JA 4 08-15; JA 4 08-19; JKM 189 08-24; ICP 8863 08-23; JA-4; JIA-65
1501-2000	14	ICPL 88039 08-02; ICPL 88039 08-05; ICPL 88039 08-06; ICPL 88039 08-07; JA 4 08-10; JA 4 08-11; JA 4 08-16; JA 4 08-20; JKM 189 08-30; ICP 8863 08-38; JKM 189; JKE - 115E; DT 501; MN 5

Class	Frequency	Entries
> 2000	10	ICPL 88039 08-01; ICPL 88039 08-03; ICP 8863 08-39; ICP 8863 08-40; ICP 8863 08-41; ICP 8863 08-42; JKE - 114E; JKE 116E; UPAS 120; ICPL 88039
Days to maturity: Range: From 169 days (ICPL 88039 08-02) to 191.0 days (JKM 189 08-37, ICP 8863 08-41 and JKE - 115E)		
<170	04	ICPL 88039 08-01; ICPL 88039 08-02; JA-4; JIA-65
171 - 180	03	ICPL 88039 08-03; ICPL 88039 08-05; ICPL 88039 08-06
181 – 185	07	ICPL 88039 08-08; JA 4 08-10; JA 4 08-11; JA 4 08-15; ICP 8863 08-23; ICP 8863 08-38; MN 5
186-190	18	ICPL 88039 08-07; Selection Panod; Selection Badnawar; JA 4 08-14; JA 4 08-16; JA 4 08-19; JA 4 08-20; JKM 189 08-24; JKM 189 08-30; ICP 8863 08-39; ICP 8863 08-40; ICP 8863 08-42; JKM – 189; JKE - 114E; JKE - 116E; DT – 501; UPAS-120; ICPL – 88039
>191	03	JKM 189 08-37; ICP 8863 08-41; JKE - 115E

At Indore, based on the performance of pigeonpea entries during different years the top ranking entries were JKE 114 E (1685 kg/ha); ICP 8863-08-38 (1664 kg/ha); ICP 8863-08-40 (1638 kg/ha); JA 4 08-20 (1586 kg/ha); ICP 8863 –08-41 (1585 kg/ha) and JKM 189 (check) (1541 kg/ha) over rest of the entries (Table 3.261).

Table 3.261 : Performance of pigeonpea entries - Indore

Entry	Yield (kg/ha)									NMR (Rs/ha)	RWUE (kg/ha-mm)
	2015-16	2014-15	2013-14	2012-13	2011-12	2010-11	2009-10	2008-09	Mean		
ICPL 88039 08-01	522	2240	634	1426	1260	1013	2500	1250	1356	17333	0.56
ICPL 88039 08-02	844	1830	862	1647	568	778	3750	956	1404	36667	0.91
ICPL 88039 08-03	617	2010	945	1091	1310	566	2604	867	1251	23000	0.67
ICPL 88039 08-05	389	1520	1724	1470	1161	945	2083	875	1271	9333	0.42
ICPL 88039 08-06	839	1790	1295	1718	844	856	2187	1067	1324	36333	0.91
ICPL 88039 08-07	389	1560	272	1984	1156	846	1979	994	1147	9333	0.42
JA 4 08-10	922	1810	634	2322	1302	850	2500	1051	1424	41333	1.00
JA 4 08-11	633	1660	1790	2449	682	911	2500	921	1443	24000	0.68
Sel. Panod	678	1280	1668	2042	307	747	3125	754	1325	26667	0.73
Sel. Badnawar	511	1010	464	1611	209	704	2500	390	925	16667	0.55
JA 4 08-14	789	1270	49	2513	2015	806	2083	824	1294	33333	0.85
JA 4 08-15	656	1280	382	1123	1308	664	2604	804	1103	25333	0.71
JA 4 08-16	839	1940	1195	1324	580	371	3333	1197	1347	36333	0.91
JA 4 08-19	767	1430	2085	1028	1039	667	3542	1182	1467	32000	0.83
JA 4 08-20	767	1960	1451	1454	1126	603	4167	1161	1586	32000	0.83
JKM 189 08-24	789	1330	1515	1491	1029	957	2219	1598	1366	33333	0.85
JKM 189 08-30	978	1550	884	1916	712	964	3125	1408	1442	44667	1.06
JKM 189 08-37	772	690	489	1960	621	563	2187	1565	1106	32333	0.83
ICP 8863 08-23	900	1180	1068	1960	391	549	1979	1234	1158	40000	0.97
ICP 8863 08-38	633	1670	1660	2009	1771	669	3542	1361	1664	24000	0.68
ICP 8863 08-39	489	2570	2039	1501	208	795	2083	1270	1369	15333	0.53
ICP 8863 08-40	800	2070	1902	1871	1755	875	2292	1536	1638	34000	0.86
ICP 8863 08-41	822	2820	667	1804	1263	771	3229	1301	1585	35333	0.89
ICP 8863 08-42	622	2020	1273	1416	1021	850	2083	1426	1339	23333	0.67
JKM 189 (check)	533	1950	828	1766	1510	799	3125	1820	1541	18000	0.58
JA 4	822	1440	2103	1625	1330				1464	35333	0.89
JIA 65	889	1450	1201	1460	1120				1224	39333	0.96
JKE 114 E	750	3250	1557	2165	703				1685	31000	0.81

Entry	Yield (kg/ha)									NMR (Rs/ha)	RWUE (kg/ha-mm)
	2015-16	2014-15	2013-14	2012-13	2011-12	2010-11	2009-10	2008-09	Mean		
JKE 115 E	678	1590	306	2207	945				1145	26667	0.73
JKE 116 E	344	2280	1205	1821	441				1218	6667	0.37
DT 501	356	1750	1220	2349	224				1180	7333	0.38
UPAS 120	259	2050	1421	532	286				910	1533	0.28
MN-5	267	1930	1195	932	599				985	2000	0.29
ICPL 88039	333	2030	465	2387	608				1165	6000	0.36
ICPL 88039 08-04	278								278	2667	0.30

Out of 16 blackgram varieties evaluated at Rewa, PU 35 ranked first with the highest seed yield of 843 kg/ha, NMR (Rs. 61616/ha), B:C ratio (4.85) and RWUE (1.33 kg/ha-mm). Variety PDU 1 and TU 136 ranked second and third in terms of yield (718 kg/ha and 703kg/ha, respectively). The mean data of over 5 years also followed the same trend (Table 3.262).

Table 3.262 : Yield and economics of blackgram varieties- Rewa

Variety	Seed yield in 2015 (kg/ha)	Mean seed yield (kg/ha)	Stalk yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
TU 94-2	653	593	1404	44254	3.76	1.03
PDU 1	718	702	1544	50165	4.13	1.13
PU 30	632	664	1359	42301	3.64	1.00
TU 98-4	755	680	1623	53677	4.35	1.20
JU 2	581	659	1249	37545	3.34	0.92
JU 3	317	734	682	13290	1.83	0.50
TU 10	581	626	1249	37564	3.34	0.92
TU 27	676	589	1453	46322	3.89	1.07
PU 35	843	736	1812	61616	4.85	1.33
TU 57	692	658	1488	47769	3.98	1.09
TU 136	703	554	1511	48676	4.02	1.11
DU4	477	542	1026	27937	2.75	0.75
IVU466	231	487	497	5305	1.33	0.36
IVU 486	373	393	802	18432	2.15	0.59
IVU88-10	437	506	940	24103	2.51	0.69
TU 47-4	486	438	1045	28863	2.80	0.77
CD at 5%	95					

Blackgram cv. PU35

Blackgram cv. JU2

In an assessment of 10 promising varieties of soybean at Rewa, the maximum seed yield 1216 kg/ha, net returns (Rs.32838/ha), B:C ratio (3.05) and RWUE (1.92 kg/ha-mm) was recorded by JS 20-69 followed by JS 20-34 (1200 kg/ha), JS 97-52 (1095 kg/ha) and JS 20-29 (1016 kg/ha). Out of all varieties, only five soybean varieties namely JS 20-69, JS 20-34, JS 20-34, JS 97-52 and JS 93-05 were significantly superior over check (Bragg) (Table 3.263).

Table 3.263 : Yield and economics of soybean varieties – Rewa

Variety	Seed yield in 2015-16 (kg/ha)	Mean seed yield (kg/ha)	Stalk yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
JS 335	457	818	2833	4199	1.26	0.72
JS 93-05	889	978	2578	20360	2.27	1.40
JS 95-60	346	780	930	-1920	0.87	0.54
JS 97-52	1095	1240	5475	31085	2.94	1.73
JS 20-29	1016	946	2320	24928	2.55	1.61
JS 20-34	1200	1272	2410	32010	3.00	1.90
JS 20-69	1216	1216	2630	32838	3.05	1.92
JS20-09	546	956	2021	28208	1.42	0.86
JS 90-41	286	520	944	-4181	0.73	0.45
Bragg	667	721	2570	11916	1.74	1.05
CD at 5%	131.8					

At Rewa, due to dry spell during physiological maturity the seed yield of greengram varieties was poor and ranged from 107 kg/ha to 753 kg/ha. The highest seed yield (753 kg/ha), net returns (Rs.5554/ha), B:C ratio (4.47) and RWUE (1.20 kg/ha-mm) was recorded by HUM 16 followed by TJM99-50 (675 kg/ha) and MI24-91 (625 kg/ha). The mean data of over 5 years also followed the same trend. The lowest yield was recorded by TARM 37 and SL 688 (417 kg/ha) (Table 3.264).

Table 3.264 : Yield (kg/ha) and economics of greengram varieties - Rewa

Variety	Seed yield in 2015-16	Mean seed yield (5 years)	Stalk yield	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
HUM 1	478	498	2191	30167	2.88	0.75
HUM 12	484	632	2070	30598	2.91	0.76
HUM 16	753	721	2278	55554	4.47	1.20
TARM 18	425	385	1770	24870	2.55	0.67
TARM 37	417	424	1629	23993	2.50	0.66
TJM 12	467	510	1716	28688	2.79	0.74
TJM 15	508	513	1856	32592	3.03	0.80
TJM 59	497	419	1745	31469	2.96	0.78
TJM 65	378	286	1545	20321	2.97	0.60
TJM 237	536	318	1860	35172	3.20	0.84
PDM 139	553	467	1969	36796	3.29	0.87
MI 181-1	575	458	1920	38832	3.43	0.91
MI 24-91	625	471	2145	43645	3.73	1.00
SL 688	417	375	1680	24044	2.50	0.66
Ganga 8	569	455	2020	40552	3.55	0.90
TM 99-50	675	447	2036	48139	4.01	1.07
CD at 5%	80.66		-	-	-	-

Among different mustard varieties evaluated at Rewa, the maximum seed yield (917 kg/ha), net returns (Rs.23514/ha) and B:C ratio (2.57) was recorded with Pusa Tarak followed by Pusa-Agahani (819 kg/ha), Basanti (806 kg/ha), JM3 (759 kg/ha)and Pusa-Jagannath (722kg/ha). The mean data of 5 years also followed the same trend (Table 3.265).

Table 3.265 : Yield (kg/ha) and economics of mustard varieties - Rewa

Variety	Seed yield (kg/ha)		Stalk yield	NMR (Rs/ha)	B:C ratio
	2015-16	Mean (5 years)			
Teri Uttam	519	428	2450		
Basanti	806	662	2925	18432	2.22
JM 1	532	577	2545	7386	1.49
JM 2	639	589	2680	11838	1.79
JM 3	759	649	2780	16878	2.13
JM 4	685	608	2725	13770	1.92
Pusa Jagannath	722	595	2660	15324	2.02
ACN Satabdi	639	644	2670	11838	1.79
Pusa Tarak	917	723	2890	23514	2.57
Pusa Agahani	819	657	2870	19390	2.29
Pusa Mahak	458	574	2540	4236	1.28
Pusa Bold	569	613	2780	8890	1.59
CD at 5%	87		-	-	-

In an assessment of 12 varieties of chickpea at Rewa, the maximum seed yield of 1766 kg/ha, net returns (Rs.71832/ha) and B:C ratio (4.59) was recorded by JG 16 followed by JG 14 (1753kg/ha), Jaki 9218 (1708 kg/ha) and JG 12 (1695 kg/ha) which were highly significant over check (JG 315 1164 kg/ha) (Table 3.266).

Table 3.266 : Yield (kg/ha) and economics of chickpea varieties - Rewa

Variety	Seed yield in 2015-16	Mean seed yield (5 years)	Stalk yield	NMR (Rs/ha)	B:C ratio
JG 11	1230	1157	2495	43960	3.20
JG 12	1695	1363	2865	68296	4.41
JG 14	1753	1417	3116	71156	4.56
JG 16	1766	1533	2930	71832	4.59
JG 63	1275	1234	2640	46300	3.32
JG 74	1536	1477	2850	59872	3.99
JG 130	1686	1560	3145	67672	4.38
JG 218	1442	1371	2846	54984	3.75
JG315 (check)	1164	1217	2760	40528	3.03
JG 322	1505	1386	2865	58260	3.91
Jaki 9218	1708	1564	3152	68816	4.44
JG 412	1044	997	1942	34288	2.71
CD at 5%	79.70	-	-	-	-

In an assessment of seven promising varieties of lentil at Rewa, the maximum seed yield of 1708 kg/ha, net returns of Rs.77940/ha and B:C ratio of 5.87 was recorded by IPL316 followed by IPL81 (1625 kg/ha) and DPL62 (1583 kg/ha) (Table 3.267).

Table 3.267 : Performance of lentil varieties - Rewa

Variety	Seed yield (kg/ha)	Stalk yield (kg/ha)	NMR (Rs/ha)	B:C ratio
L 4016	1144	2145	46920	3.93
DPL 62	1583	2707	71065	5.44
IPL 81	1625	2960	73375	5.58
IPL 810	1111	2035	45105	3.82
IPL 316	1708	3055	77940	5.87
JL 1	1032	1948	40760	3.55
JL 3	1315	2480	56325	4.52
CD at 5%	96.9	-	-	-

3.4.2.6 Alternate land use system

At Indore, soybean equivalent yield (SEY), in evalutaion of agri-horti systems, among the cropping systems, sole pigeonpea and soybean + pigeonpea intercropping (4.2) recorded the SEY 186 to 176 kg/ha and among fruit plants, guava recorded higher yield 2822 kg/ha with net returns of Rs.56444/ha followed by Aonla with net returns of Rs.19918/ha (996 kg/ha) (Table 3.268).

Table 3.268 : Development of suitable agri-horti system for medium deep *Vertisols* of Malwa – Indore

Treatment	Seed yield (kg/ha)							Mean
	Custard	Guava	Phalsa	Drum stick	Aonla	Ber	Total	
Sole soybean	131	145	131	167	139	144	856	143
Soybean + pigeonpea (4:2)	53	38	40	65	65	41	301	50
	102	105	83	74	76	81	522	87
Sole pigeonpea	125	129	148	120	75	111	708	118
				Soybean equivalent yield (kg/ha)				
Sole soybean	131	145	131	167	139	144	856	143
Soybean + pigeonpea (4:2)	214	203	171	182	185	169	1125	187
Sole pigeonpea	197	203	234	190	118	175	1118	186
				Net returns (Rs./ha)				
Sole soybean	-16056	-15639	-16083	-15000	-15833	-15695	-94306	-15718
Soybean + pigeonpea (4:2)	-11884	-12280	-13487	-13093	-12954	-13563	-77260	-12877
Sole pigeonpea	-12500	-12278	-11111	-12778	-15500	-13334	-77501	-12917
				B:C ratio				
Sole soybean	0.20	0.22	0.20	0.25	0.21	0.22	1.28	0.21
Soybean + pigeonpea (4:2)	0.41	0.39	0.33	0.35	0.35	0.32	2.14	0.36
Sole pigeonpea	0.37	0.39	0.44	0.36	0.22	0.33	2.12	0.35
Fruit yield	193	2822	0	0	996	367	4377	
Net return (Rs/ha)	3860	56433	0	0	19918	7334	87545	
Fruit yield eq. to soybean	102	1485	0	0	524	193	2304	

3.5 Cotton Based Produced System

3.5.1 Rainwater management

At Akola, total rainfall of 357.5 mm was received during crop growing period with four major runoff events which resulted in rainwater harvesting in the farm pond. From the stored farm pond water supplemental irrigation was given to soybean. Higher seed yield of soybean (1055 kg/ha) was obtained with two protective sprinkler irrigations from stored farm pond water at pod initiation and pod filling stage. The water use efficiency (1.72 kg/ha-mm) and B:C ratio (1.68) was also higher with two protective irrigations over one protective irrigation at pod initiation (Table 3.270).

Table 3.270 : Yield and economics of soybean as influenced by protective irrigation - Akola

Treatment	Yield (kg/ha)	Mean yield (4 years) (kg/ha)	WUE (kg/ha-mm)	NMR (Rs/ha)	B:C ratio
One protective irrigation at pod initiation	910	1173	1.48	12355	1.49
Two protective irrigations at pod initiation and pod filling	1055	1351	1.72	17285	1.68
Without irrigation	802	1122	1.30	8700	1.34

At Akola, the runoff causing rainfall in the catchment area of 4 ha of farm pond-2 was 357.5 mm which helped in accumulation of 2579.2 m^3 runoff in the farm pond. The total runoff recorded was 64.48 mm, which was 18.04% of the runoff causing rainfall. From the stored pond water (2579.2 m^3), if protective irrigation of 5 cm is given, about 4.0 ha area could be irrigated (Table 3.271).

Table 3.271 : Runoff during 2015 from catchment area of 4 ha in farm pond-2 - Akola

Date	Rainfall (mm)	Runoff	
		Accumulated in farm pond (m^3)	Recorded (mm)
04-08-2015	194.0	1961.20	49.03
12-08-2015	28.0	120.0	3.00
15-09-2015	57.0	209.6	5.24
17-09-2015	78.5	288.4	7.21
Total	**357.5**	**2579.2**	**64.48**

During the *rabi* season, the stored farm pond water was used for supplemental irrigation to vegetable crops with micro-irrigation systems (MIS) and it was observed that B:C ratio was 0.60 (okra) to 6.38 (spinach) and water use efficiency ranged from 1.05-4.5 kg/m^3. The net returns from the vegetables was Rs. 537337/ha (Table 3.272).

Table 3.272 : Effect of irrigation through micro-irrigation system from farm pond on different vegetables - Akola

Vegetable	Irrigation system	Total water applied (m^3)	Area (m^2)	Yield (kg/ plot)	Computed yield (kg/ha)	NMR (Rs/ha)	B:C ratio	WUE (kg/m^3)
Okra	Micro-sprinkler	12.0	280	20	714	-16314	0.60	1.66
Clusterbean	Micro-sprinkler	28.0	410	112	2732	59683	3.39	4.0
Brinjal	Micro-sprinkler	4.0	36	9	2500	2500	1.05	2.25
Sponge gourd	In line drip	7.0	42	10	2381	27048	1.64	1.42
Bitter gourd	In line drip	1.9	26	2	769	-18923	0.55	1.05
Fenugreek	In line drip	7.0	65	15	2308	23646	2.17	2.14
Spinach	In line drip	11.0	52	49	9423	165962	6.38	4.45
Coriander	In line drip	6.0	45	8	1778	37333	2.17	1.33
Carrot	In line drip	6.0	45	8	1778	1556	1.05	1.33
Radish	In line drip	10.0	45	45	10000	246000	5.59	4.50
Apple gourd	In line drip	2.0	26	3	1154	8846	1.25	1.50

Rainwater harvested in farm pond, Akola

Among different tillage methods evaluated in cotton at Kovilpatti, rotovator ploughing + chisel ploughing recorded the highest yield of cotton (974 kg/ha) with net returns of Rs. 11330/ha and B:C of 1.35, which was 11% higher than the conventional tillage. Rotovator ploughing + chisel ploughing recorded the highest RWUE of 2.05 kg/ha-mm. This might be due to the fine tilth of the seed bed due to rotovator ploughing (Table 3.273).

Table 3.273 : Effect of tillage methods on yield and economics of cotton - Kovilpatti

Treatment	Seed cotton yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Conventional tillage	880	32000	7600	1.24	1.85
Rotavator ploughing once + chisel ploughing once	974	32500	11330	1.35	2.05
Chisel ploughing once + tiller ploughing once	805	29500	6725	1.23	1.69
Conservation tillage	921	31250	10195	1.33	1.93

At Parbhani, during the year 2015, out of the total monsoon rainfall (407.3 mm), only 18 mm of runoff was produced in the month of September from only two storms and thus contributed less runoff water from 1 ha catchment area to farm pond. The total quantity of runoff water available from 1.8 ha field area was estimated as 125 m^3 which was diverted for well recharging (Table 3.274).

Table 3.274 : Runoff events during 2015 - Parbhani

Date	Rainfall (mm)	Runoff (mm)	Runoff from 1.8 ha field (m^3)	Runoff (lakh litre)
Sep 09	50.5	6.0	60	60000
Sep 18	57.4	6.5	65	65000
Total		**18**	**125**	**125000**

At Parbhani, in a study on catchment-storage-command relationship, due to low monsoon rainfall (207.3 mm), *kharif* season up to mid September, 2015, and protective irrigation to soybean crop was not given. In *rabi* season, the harvested water was very less and was lost due to evaporation (273.6 mm) and seepage (352.1 mm). Therefore protective irrigation was not given to *rabi* crop (Table 3.275).

Table 3.275 : Seasonal evaporation and seepage losses through farm pond - Parbhani

Date	Evaporation loss from farm pond (mm)	Seepage loss from farm pond (mm)
18 - 30 September, 2015	75.6	99.7
01-15 October, 2015	100.3	114.9
15-31 October, 2015	97.7	137.5
Total	**273.6**	**352.1**
water loss from 196 m^2 area	54 m^3 i.e 54000 lit	69 m^3 i.e. 69000 lit

At Parbhani, the *in-situ* moisture conservation practices had significant effect on seed yield of soybean. Broad bed and furrow (BBF) system recorded significantly higher seed yield (848 kg) as compared to all other treatments and found at par with the opening of furrow after every 4 rows of soybean. Among various treatments, recorded higher soybean seed yield than flat bed treatment, with higher RWUE (2.97 kg/ha-mm), net returns (Rs.13972/ha) and B:C ratio (1.78), followed by opening of furrow after every 4 rows (722 kg/ha) and dead furrow after 10 m distance (692 kg/ha) (Table 3.276).

Table 3.276 : 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)
Opening of furrow after every 4 rows	722	9220	1.52	2.53
Dead furrow after 10 m	692	8099	1.45	2.42
Tied ridging after every 4 rows	592	4340	1.24	2.07
Conservation furrow at 2.7 m distance	643	6280	1.35	2.25
BBF system	848	13972	1.78	2.97
Flat bed	524	1815	1.10	1.84
CD at 5%	145	4755		

At Parbhani, the storm-wise runoff soil loss and per cent moisture during the crop growth period and monsoon period was determined. The highest runoff of 94 mm was produced in the treatment of flat bed and minimum runoff of 49 mm was produced in the treatment of BBF which was 52% less than the flat bed treatment. All moisture conservation treatments recorded less runoff as compared to flatbed treatment to the tune of 31 to 48%. At Parbhani, during 2015, the highest soil loss of 2.41 t/ha was produced in the treatment of flat bed and minimum soil loss of 1.05 t/ha was produced in the treatment of BBF which was 66% less than the flat bed treatment (Table 3.277).

Table 3.277 : Storm-wise rainfall–runoff, soil loss and soil moisture as influenced by various treatments - Parbhani

Date	Rainfall (mm)	Runoff (mm)					
		Opening of furrow after every 4 rows (T_1)	Dead furrow after 10 m (T_2)	Tied ridging after every 4 rows (T_3)	Conservation furrow at 2.7 m distance (T_4)	BBF (T_5)	Flat bed (T_6)
Sep 09	50.5	28	32	29	30	24	46
Sep 18	57.4	29	33	30	31	25	48
Total		57	65	59	61	49	94
% less than T_6		39	31	37	35	48	-
Soil loss (t/ha)							
Sep 09	50.5	0.72	0.83	0.78	0.76	0.52	1.16
Sep 18	57.4	0.74	0.85	0.79	0.77	0.53	1.25
Total		1.46	1.68	1.47	1.43	1.05	2.41

Date	Rainfall (mm)	Runoff (mm)					
		Opening of furrow after every 4 rows (T_1)	Dead furrow after 10 m (T_2)	Tied ridging after every 4 rows (T_3)	Conservation furrow at 2.7 m distance (T_4)	BBF (T_5)	Flat bed (T_6)
% less than T_5		39	30	39	41	66	-
Soil moisture (%)							
July		26	25	26	26	28	22
August		29	27	28	27	29	22
Sept		28	26	26	27	29	22
Oct	22	21	21	22	24	19	-

At Parbhani, the reduction in evaporation rate as influenced by various evaporation control practices was evaluated during the period of 13 August 2015 to 29 February 2016. The cumulative evaporation was found to be 989 mm. Among all the treatments, the treatment T6 (application of acetyl alcohol @ 15 mg/m2) at an interval of 5 days was found to be significantly superior over all the treatments and was at par with treatment T5 i.e. application of acetyl alcohol @ 10 mg/m^2 after every 5 days. All the evaporation control practices were found to be effective in reducing evaporation rate as compared to the control. Application of neem oil and vegetable oil reduced the evaporation rate by 20-27%, however application of acetyl alcohol with various rates and duration was found to be effective in reducing evaporation rate to the tune of 54 to 66% (Table 3.278).

Table 3.278 : Reduction in evaporation rate as influenced by various treatments - Parbhani

Treatment	Evaporation (mm)	% reduction in evaporation
T_1: Neem oil @50 ml/m2 every after 15 days	719	27.3
T_2: Neem oil @50 ml/m^2 every after 30 days	785	20.6
T_3: Vegetable oil @50 ml/m^2 every after 15 days	778	21.3
T_4: Vegetable oil @50 ml/m^2 every after 30 days;	791	20.0
T_5: Cetyl alcohol @10 mg/m^2 every after 5 days	366	62.9
T_6: Cetyl alcohol @15 mg/m^2 every after 5 days	329	66.6
T_7: Cetyl alcohol @20 mg/m^2 every after 10 days	455	54.0
T_8: Cetyl alcohol @30 mg/m^2 every after 10 days	401	59.4
T_9: Control	989	-
CD at 5%	40	-

At Parbhani, cost of each evaporation agent of Acetyl alcohol was very less as compared to neem oil and vegetable oil, similarly the cost of application of control agent for a standard size of farm pond was worked out (Table 3.279).

Table 3.279 : Cost of application of evaporation control agents in farm pond for one application - Parbhani

Size of farm pond	Surface water spread area (m^2)	Cost of acetyl alcohol (Rs / application)				Neem oil	Vegetable oil
		10 mg	15 mg	20 mg	30 mg		
20 m × 20 m	400	140	208	280	416	2800	1400
25 m × 25 m	625	219	325	438	650	4375	2188
30 m × 30 m	900	315	468	630	936	6300	3150

Considering the water availability for four month period after monsoon in the farm pond, the gross rate of application of evaporation control agents revealed that the cost of application of cetyl alcohol was very less as compared to neem oil and vegetable oil (Table 3.280).

Table 3.280 : Cost of evaporation control agents for four months duration in farm pond -Parbhani

Evaporation control agent	Interval and no. of applications	Cost of application (Rs.)	
		farm pond 30 m x 30 m (900 m²)	farm pond 20 m x 20 m (400 m²)
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/m² 5 days (24 applications in 4 month)	7560	3360
	15 mg /m² 5 days (24 applications)	11232	4992
	20 mg/m² 10 days (12 applications)	7560	3360
	30 mg/m² 10 days (12 applications)	11232	4992

3.5.2 Cropping systems

At Akola, in a study on performance of cotton based intercropping system and fertilizer levels, sole cotton recorded significantly higher seed cotton yield (1445 kg/ha). However, among intercropping systems, cotton + cowpea (1:1) system recorded significantly higher seed cotton yield (1401 kg/ha). Intercropping systems of cotton + cowpea and cotton + clusterbean were at par and recorded significantly higher cotton equivalent yield (2320 and 2310 kg/ha), net returns (Rs.65865 and 66582/ha), B:C ratio (2.33 and 2.37) and RWUE (4.03 and 4.05 kg/ha/mm), respectively over rest of the treatments. Similarly, various levels of fertility had significant effect on yield of seed cotton. Seed cotton yield increased from 1196 kg/ha at 100% RDF to 1283 kg/ha at 125% RDF, which increased yield by 6.8%. The same treatment also recorded significantly higher NMR, B:C ratio and RWUE (Table 3.281).

Table 3.281 : Influence of intercropping systems on crop yield and economics - Akola

Treatment	Yield (kg/ha)				CEY (kg/ha)	CEY (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton	Stalk	Intercrop	Straw					
Intercropping system									
Sole cotton	1445	2284	-	-	1445	31232	39559	2.27	2.52
Cotton+ cowpea (1:1)	1401	2185	2881	3601	2320	49513	65865	2.33	4.05
Cotton+ cowpea (1:2)	1228	1793	2912	3757	2157	52426	54967	2.05	3.77
Cotton+ clusterbean (1:1)	1395	2162	2868	3756	2310	48435	66582	2.37	4.03
Cotton+ clusterbean (1:2)	1196	1805	2934	3843	2132	50171	56124	2.12	3.72
Cotton+ okra (1:1)	1144	1545	2051	2790	1799	43783	45484	2.04	3.14
Cotton+ okra (1:2)	869	1112	1777	2435	1436	44113	27188	1.62	2.51
CD at 5%	130.3	182.7	-	-	145.61	-	7158	-	0.25
Fertility level									
100% RDF (60:30:30 NPK kg/ha)	1196	1776	2114	2766	1871	44572	48349	2.08	3.27
125% RDF	1283	1905	2292	3001	2014	46763	53299	2.14	3.52
CD at 5%	85.29	119.6	-	-	95.32	-	4686	-	NS

CEY: Cotton equivalent yield

At Akola, the study on effect of pre-monsoon sowing of cotton under high density planting system, revealued that the sole Bt cotton registered the highest seed cotton yield (2114 kg/ha) and RWUE (3.69 mg/ha/mm). Whereas, higher net returns (Rs. 67130/ha) and B:C ratio (3.00) were recorded in sole *deshi* cotton (AKA-7) and the lowest seed cotton yield was recorded in sole American cotton genotype (AKH-081) (2070 kg/ha). Sole crops of soybean and mustard also registered higher seed yield (1139 and 624 kg/ha, respectively). Among the inter cropping systems, *deshi* cotton (AKA-7) + soybean (6:6) – mustard recorded significantly higher cotton equivalent yield (2148 kg/ha), net returns (Rs.63080/ha), B:C ratio (2.54) and RWUE (3.75 kg/ha/mm) (Table 3.282).

Table 3.282 : Influence of pre-monsoon sowing of cotton under high density planting on crop 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	Soybean	Mustard	CEY				
Sole American cotton (AKH-081) 45 cm x 15 cm	2070	0	0	2070	35430	64655	2.82	3.62
Sole Bt. Cotton (Ankur -651) 45 cm x 60 cm	2114	0	0	2114	41690	60628	2.45	3.69
Sole *Deshi* cotton (AKA-7) (45 cm x 15 cm)	2081	0	0	2081	33522	67130	3.00	3.63
Soybean - mustard (45 x 15 cm)	-	1139	624	1373	39216	27223	1.69	2.40
American cotton (AKH-081) + soybean (6:6) - mustard (45 cm x 15 cm)	1257	614	368	2018	43234	54365	2.26	3.52
Bt. cotton (Ankur-651) + soybean (6:6)-mustard (45 x 15 cm)	1325	628	365	2085	46060	54834	2.19	3.64
Deshi cotton (AKA-7) + soybean (6:6)-mustard (45 x 15 cm)	1303	636	375	2148	40834	63080	2.54	3.75
CD at 5%	128.4	-	-	-	-	-	-	0.22

At Akola, in a study on diversification in cotton based cropping systems, higher seed cotton yield (1331 kg/ha) and yield of soybean (1075 kg/ha) were recorded in sole cropping system than intercropping of cotton + soybean (4:10). Application of 100% RDF recorded higher seed cotton and soybean yield (992 and 879 kg/ha) than other treatments. Cotton + soybean (4:10) - safflower and cotton + soybean (4:10) - chickpea systems were at par in respect of cotton equivalent yield than sole soybean. Application of 100% RDF recorded higher cotton equivalent yield (1505 kg/ha) than 50% RDF + *Gliricidia* + biofertilizer (1394 kg/ha). Significantly higher net returns (Rs.41752/ha), B:C ratio (2.12) and RWUE (2.93 kg/ha/mm) were recorded with cotton + soybean (4:10) - safflower than sole cotton and soybean. 100% RDF recorded significantly higher net returns (Rs.31952/ha), B:C ratio (1.82) and RWUE (2.63 kg/ha-mm) than 50% RDF + 50% N through *Gliricidia* + biofertilizer (Table 3.283).

Table 3.283 : Influence of cropping systems and nutrient management on crop yield and economics - Akola

Treatment	Yield (kg/ha)				CEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton		Soybean					
	2015-16	Mean (3 years)	2015-16	Mean (3 years)				
Cropping pattern								
Sole cotton	1331	1268	-	-	1331	31561	1.96	2.32
Soybean-chickpea	-	-	1075	1493	1490	21265	1.41	2.60
Soybean-safflower	-	-	1075	1493	1510	27987	1.56	2.64
Soybean-linseed	-	-	1075	1493	1075	5823	1.10	1.88
Cotton + soybean (4:10)-chickpea	804	750	613	903	1653	37587	1.92	2.89
Cotton + soybean (4:10)-safflower	800	746	619	923	1677	41752	2.12	2.93
Cotton + soybean (4:10) - linseed	806	750	616	917	1410	29058	1.72	2.46
CD at 5%	-	-	-	-	139.9	6871	-	0.24

Treatment	Yield (kg/ha)				CEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton		Soybean					
	2015-16	Mean (3 years)	2015-16	Mean (3 years)				
Nutrient management								
100% RDF	992	939	879	1242	1505	31954	1.82	2.63
50% N + 100% P and K through fertilizer + 50% N through *Gliricidia*	879	845	812	1165	1394	23769	1.55	2.44
CD at 5%	-	-	-	-	72.3	4067	-	0.14

RDF 100% (NPK kg/ha): Cotton: 60:30:30; Soybean: 30:75:30;

At Kovilpatti, in the experiment on response of cotton to crop geometry, fertility levels and moisture conservation practices under high density planting system in Vertisols, among the crop geometry, 45 cm x 15 cm recorded higher yield parameters viz., number of sympodia, number of bolls/plant and boll weight.

Among the interaction effect, the geometries of 45 cm x 15 cm of cotton under BBF with 125% fertility level recorded significantly higher yield (1054 kg/ha) than other treatment combinations. Lowest yield (604 kg/ha) was recorded with compartmental bunding + 45 cm x 10 cm + 100% RDF (Table 3.284).

Table 3.284 : Interaction effect between crop geometry, fertility levels and moisture conservation practices on yield of cotton - Kovilpatti

Treatment	100% RDF (40:20:40 NPK kg/ha)	125% RDF (50:25:50 NPK kg/ha)	150% RDF (60:30:60 NPK kg/ha)
Broad bed furrow + 45 cm x 15 cm	1013	1054	941
Broad bed furrow + 45 cm x 10 cm	728	812	684
Compartmental bunding + 45 cm x 15 cm	1018	1024	914
Compartmental bunding + 45 cm x 10 cm	604	648	552
		CD at 5%	
Moisture conservation treatments at same fertility level		59.0	
Fertility levels at moisture conservation treatments		42.3	

High density planting 45 cm x 15 cm with BBF and 125% RDF ($P_1M_1F_2$) recorded significantly higher seed cotton yield (1054 kg/ha), NMR (Rs.17332/ha), B:C ratio (1.64) and RWUE (2.21kg/ha-mm) followed by 45 cm x 15 cm spacing + compartmental bunding + 125% RDF (Table 3.285).

Table 3.285 : Effect of different treatment combinations on cotton yield and economics - Kovilpatti

	Seed cotton yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
P1M1F1	1013	26269	16277	1.62	2.13
P1M1F2	1054	26936	17332	1.64	2.21
P1M1F3	941	27604	11918	1.43	1.98
P1M2F1	1018	26269	19007	1.72	2.26
P1M2F2	1024	26936	16072	1.60	2.15
P1M2F3	914	27604	10784	1.39	1.92
P2M1F1	728	25749	4827	1.19	1.53
P2M1F2	812	26416	7688	1.29	1.71
P2M1F3	684	27084	1644	1.06	1.44
P2M2F1	604	25749	-381	0.99	1.27
P2M2F2	648	26416	800	1.03	1.36
P2M2F3	552	27084	-3900	0.86	1.16

P1 - Crop geometry 45 cm x 15 cm; P2 - Crop geometry 45 x 10 cm; M1 - Broad bed furrows; M2 - Compartmental bunding; F1 - 100% RDF; F2 - 125% RDF; F3 - 150% RDF

At Kovilpatti, in a study on different crop geometry, fertility and moisture conservation practices in cotton, yield and yield parameters were significantly influenced by crop geometry. Among the crop geometry, 45 x 15 cm recorded significantly higher kapas yield (1004 kg/ha) than 45 x 10 cm. Higher NMR (Rs. 15982/ha) and BC ratio (1.61) were recorded under 45 x 15 cm than 45 x 10 cm. Among the moisture conservation practices broad bed furrow gave higher kapas yield (872 kg/ha), NMR (Rs.9198/ha), B:C ratio (1.34) and RWUE (1.83) than compartmental bunding. Among the fertility levels more kapas yield (885 kg/ha), NMR (Rs.10473/ha), B:C ratio (1.40) and RWUE (1.86) were recorded under 125% fertility level than 100 and 150%.

At Kovilpatti, an experiment on *in-situ* green manuring, intercrops such as sunhemp, dhaincha and fodder cowpea were sown under paired row intercrop system. The intercrops were incorporated at 40 days after sowing. On an average, 8 - 10 tonnes of green manure biomass was incorporated in sunhemp and dhaincha plots. Whereas fodder cowpea yielded upto 12 to 13 tonnes of biomass. All the intercropping system completely arrested monopodia branches in cotton whereas in sole crop number of monopodia were present. Among the fertility levels 100% RDF recorded more number of bolls /plant, boll weight and kapas yield. Among the intercropping system dhaincha, sunhemp and cowpea reduced the weed growth (Table 3.286).

Table 3.286 : Effect of *in-situ* green manuring on growth of cotton and weed under rainfed vertisols - Kovilpatti

Treatment	Plant height (cm)	No.of sympodia / plant	No. of bolls/ plot	Boll weight (g)	Weed density (No/m^2)	Weed dry weight (g/m^2)
Fertility level (kg NPK/ha)						
F1- control	96.3	8.5	2.6	3.3	21.2	13.5
F2 - 100% RDF (40:20:40)	111.3	9.8	4.6	4.0	34.9	19.2
F3 - 75% RDF (30:15:30)	107.9	9.4	4.2	3.9	29.6	18.4
F4 - 50% RDF 20:10:20)	103.7	9.2	3.0	3.6	21.5	14.0
CD at 5%	11.9	NS	0.9	NS	3.8	2
Intercropping system						
S1 - Sole cotton	96.4	9.0	4.2	4.0	40.4	24.3
S2 - Cotton + sunnhemp	102.6	9.4	4.8	3.5	27.9	16.4
S3 - Cotton + daincha	105.3	9.6	4.6	3.9	22.4	13.5
S4 - Cotton + cowpea	115.0	8.9	2.9	3.4	16.6	9.9
CD at 5%	10.9	NS	0.7	0.5	11.2	1.8

Interaction effect between fertility level and *in-situ* green manuring on yield of cotton revealed that higher yield was recorded in 100% RDF with cotton + dhaincha (1235 kg/ha) green manure system. The yield increased by 24% as compared to sole cotton. However sunhemp and dhaincha intercropped with cotton + 75% RDF were at par with 100% RDF (Table 3.287).

Table 3.287 : Interaction effect between fertility level and *in-situ* green manuring on yield of cotton - Kovilpatti

Treatment	Sole cotton	C + sunhemp	C + dhaincha	C + cowpea
F1 - control	703	742	782	680
F2 - 100% RDF	995	1158	1235	787
F3 - 75% RDF	925	954	988	773
F4 - 50% RDF	853	892	917	726
		CD at 5%		
F at S		172		
S at F		113		

At Parbhani, in a study on land configuration and fertilizer management, broad bed furrow (BBF) system gave maximum soybean yield (1022 kg/ha), net returns (Rs.12144/ha), B:C ratio (1.59) and RWUE (3.58 kg/

ha-mm) compared to ridge and forrow system. Among fertilizer management practices, RDF + foliar application of KNO_3, recorded maximum seed yield (987 kg/ha), net returns (Rs.11228/ha), B:C ratio (1.55) and RWUE (3.46 kg/ha-mm) compared to other treatments (Table 3.288)

Table 3.288 : Yield and economics of soybean as influenced by land configuration and nutrient / drought management - Parbhani

Treatment	Soybean yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Land configuration				
L_1 : Flat bed	837	6129	1.30	2.93
L_2 : BBF system	1022	12144	1.59	3.58
L_3 : Ridges & furrow system	930	9075	1.44	3.26
CD at 5%	84.7	1669	-	-
Nutrient / drought management				
F_1: RDF (30:60:30 NPK kg/ha)	835	8044	1.43	2.92
F_2 :RDF + foliar spray of KNO_3	987	11228	1.55	3.46
F_3: RDF + foliar spray of NPK (19:19:19)	969	10805	1.53	3.40
F_4: RDF + foliar spray of M_0P	919	9385	1.46	3.22
F_5: RDF + foliar spray of micronutrients mixture	945	9983	1.49	3.31
F_6: RDF + straw mulch	952	7931	1.35	3.34
F_7: RDF + anti-transpirant (kaolin)	839	5025	1.21	2.94
F_8: RDF + water spray (35 & 60 DAS)	936	10526	1.54	3.28
CD at 5%	96.9	2081	-	-
Interactions (L X F)				
CD at 5%	64.5	3604	-	-

At Parbhani, the interaction effect of land configurations (L) and fertilizer cum drought management practices (FS) on soybean seed yield was found to be significant. The treatment combination of BBF + RDF with foliar application of KNO_3 recorded the highest soybean seed yield (1004 kg/ha) which was found at par with treatment combinations of BBF+RDF+foliar spray of KNO_3 and other treatments, L2F3, L2F4, L2F5, L2F8, L3F2, L3F3 & L3F6 and found significantly superior over rest of the treatment combinations (Table 3.289).

Table 3.289: Interaction effect of land configuration and netruient / drought cum stress management on soybean seed yield - Parbhani

Treatment	Flat bed (L_1)	BBF (L_2)	Ridges & furrow (L_3)
F_1: RDF (30:60:30 NPK kg/ha)	836	928	881
F_2 :RDF + foliar spray of KNO_3	912	1004	958
F_3: RDF + foliar spray of NPK (19:19:19)	903	995	948
F_4: RDF + foliar spray of MoP	878	970	924
F_5: RDF + foliar spray of micronutrients mixture	891	983	937
F_6: RDF + straw mulch	894	987	941
F_7: RDF + anti-transpirant (kaolin)	838	929	884
F_8: RDF + water sprays (35 & 60 DAS)	886	978	933
CD at 5%	64.48		

3.5.3 Nutrient management

In an INM study in cotton + greengram intercropping system at Akola, long term application of 25 kg N/ha (50% RDN) through organic source (FYM) in combination with 25 kg N + 25 kg P_2O_5/ha through urea and SSP recorded significantly higher seed cotton yield (1180 kg/ha) and higher stalk yield (2207 kg/ha) which was at par with the application of 50% N fertilizers + 50% N *glyricidia* + 100% P_2O_5/ha fertilizers but significantly higher compared to other treatments. Similar results were obtained in case of greengram yield. Application of 50% N fertilizers + 50% N/ha FYM + 100% P_2O_5/ha fertilizers gave higher seed and stalk yield (448 and 264 kg/ha, respectively) which was at par with the application of 50% N fertilizers + 50% N *glyricidia* + 100% P_2O_5/ha fertilizers (Table 3.290).

Table 3.290 : Effect of INM on yield of cotton + greengram (1:1) intercropping system - Akola

Treatment	Cotton yield (kg/ha)		Greengram yield (kg/ha)	
	Seed cotton	Stalk	Seed	Stalk
Control	648	1609	245	179
100% N + 100% P_2O_5/ha (inorganic)	969	2132	345	247
50% N + 50% P_2O_5/ha (inorganic)	895	1833	326	209
50% N/ha (gliricidia)	811	1684	310	194
50% N/ha (FYM)	828	1646	321	199
50% N + 50% N (gliricidia) +100% P_2O_5/ha (inorganic)	1018	2170	413	260
50% N (inorganic)+ 50% N/ha (FYM) + 100% P_2O_5/ha (inorganic)	1180	2207	448	264
100% N/ha (gliricidia)+100% P_2O_5/ha (inorganic)	988	1796	358	231
CD at 5%	187	335	70	40

At Akola, potash management through gliricidia green leaf manuring in cotton, the seed cotton yield in different treatments ranged from 669 kg/ha to 1173 kg/ha. Significantly higher seed cotton yield (1173 kg/ha) was recorded with the application of 100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia which was at par with most of the INM treatments. Similar trend was observed with stalk yield of the cotton (Table 3.291).

Table 3.291 : Effect of potash management through gliricidia green leaf manuring on cotton yield - Akola

Treatment	Yield (kg/ha)	
	Seed cotton	Stalk
Control	669	1989
100% RDF (60:30:30 NPK kg/ha)	916	2743
100% NP + 15 kg K (inorganic) + 15 kg K through gliricidia	1169	3429
100% NP + 10 kg K (inorganic) + 20 kg K through gliricidia	1173	3224
100% NP + 30 kg K through gliricidia	1011	3155
75% N +100% P +15 kg K (inorganic) + 15 kg K through gliricidia	1061	2949
75% N +100% P + 30 kg K through gliricidia	1012	2675
50% N +100% P + 30 kg K through gliricidia	879	2401
100% K through gliricidia	689	2126
CD at 5%	199	637

In an another experiment on potash management through gliricidia green leaf manuring in soybean at Akola, the soybean seed yield ranged from 415 kg/ha to 691 kg/ha. The significantly higher seed yield (691 kg/ha) was recorded with the application of 100% RDF (30:75:30 NPK kg/ha) and it was on par with 75% N + 100% P + 15 kg K (inorganic) + 15 kg K through gliricidia. Similarly, soybean stalk yield ranged from 257 kg/ha to 382 kg/ha. Significantly higher stalk yield (382 kg/ha) was recorded with application of 100% RDF (30:75:30 NPK kg/ha) and it was on par with 75% N +100% P + 15 kg K (inorganic) + 15 kg K through gliricidia and 75% N + 100% P + 30 kg K through gliricidia (Table 3.292).

Table 3.292 : Effect of potash management through gliricidia green leaf manuring on soybean yield - Akola

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)
Control	415	257
100% RDF (30:75:30 NPK kg/ha)	691	382
75% N +100% P + 15 kg K(inorganic) + 15 kg K through gliricidia	620	359
75% N +100% P + 30 kg K through gliricidia	601	350
50% N +100% P + 30 kg K through gliricidia	547	329
100% K through gliricidia	490	302
CD at 5%	74	40

At Kovilpatti, among the different land configuration methods in sorghum, broad bed furrow (BBF) recorded higher plant height (133.7 cm), higher weight of earhead (114.5 g) and earhead length (27.8 cm) than flat bed and ridges & furrow method. Among the fertilizer levels, application of 20 kg N as a urea + 20 kg P_2O_5 through EFYM as a basal and top dressing of 20 kg N as a urea + 10 kg K_2O recorded higher plant height (130.1 cm), higher weight of ear head (104.5 g) and ear head length (26.5 cm) and it was followed by the basal application of 8 kg N as urea + 20 kg P and top dressing of 32 kg N as urea +10 kg K.

BBF recorded the highest grain and straw yield (2763 and 4604 kg/ha) with B:C ratio of 1.60 and RWUE of 5.80 kg/ha-mm, followed by ridges and furrow and flat bed. Application of 20 kg N as a urea + 20 kg P_2O_5 through EFYM as a basal and top dressing of 20 kg N as a urea + 10 kg K_2O/ha recorded the highest grain and straw yield (2952 and 4919 kg/ha), net returns (Rs.25393/ha), B:C ratio (2.42) and RWUE (6.20 kg/ha-mm) (Table 3.293).

Table 3.293 : Effect of nutrient management and moisture conservation practices on yield and economics of sorghum (K 8) in Vertisols - Kovilpatti

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWM (kg/ha-mm)
Moisture conservation (M)						
M1 - Broad bed & furrow system	2763	4604	25532	14995	1.60	5.80
M2 - Ridge & furrow system	2651	4416	24032	15053	1.61	5.57
M3 - Flat bed	2733	4554	25032	14841	1.63	5.74
CD at 5%	76.60	123.30	-	-	-	-
Nutrient managment (N)						
N_1 - FYM @12.5 t/ha	2429	4583	22833	17509	1.77	5.10
N_2 - FYM @ 5 t/ha + NPK 4 : 10 : 0 kg/ha	2830	4721	18710	22793	2.22	5.95
N_3 - NPK 40 : 20 : 0 kg/ha	2468	4112	20294	15908	1.78	5.18
N_4 - NPK 8 : 20 : 0 kg/ha	2835	4715	20486	21024	2.03	5.96
N_5 - NPK 20 : 20 10 kg/ha as FYM @ 5t/ha :	2952	4919	17906	25393	2.42	6.20
N_6 - FYM 5 t/ha + NPK 4 : 10 :0 kg/ha	2750	4581	18903	21424	2.13	5.78
N_7 - Control	2751	4047	17127	18497	2.08	5.78
CD at 5%	106	128	-	-	-	-
M × N						
CD at 5%	182.7	237.6	-	-	-	-
N × M						
CD at 5%	183.9	221.8	-	-	-	-

Basal application: Topdressing: N_1- N_2- NPK 16 : 0 : 0; N_3- N_4 - NPK 32 : 0 : 10; N_5 - NPK 20 : 0 : 10; N_6 - NPK 16 : 0 : 10 ; N_7**-0**

At Parbhani, in the Permanent Manurial Trial (PMT), the cropping system of soybean + pigeonpea produced significantly higher cotton equivalent yield (1571kg/ha) with highest net returns (Rs. 57707/ha), B:C ratio (3.30), and RWUE (5.51 kg/ha-mm) compared to cotton + pigeonpea intercropping system. Among nutrient sources, 75% RDF + 5 t/ha recorded significantly higher cotton equivalent yield (1521 kg/ha) over all other treatments except N4 (1412 kg/ha). The yield increased by 107% as compared to absolute control (N5) whereas 100% RDF for both the crops recorded significantly higher net returns (Rs.48560/ha) and B:C ratio (2.69) than rest of other treatments (Table 3.294)

Table 3.294 : Cotton equivalent yield (CEY) and economics as affected by intercropping systems in PMT – Parbhani

Treatment	CEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
C_1 Cotton + pigeonpea (6:1)	903	9587	1.31	3.17
C_2 Soybean + pigeonpea (4:2)	1571	57707	3.30	5.51
CD at 5%	95.64	2591	--	--
N_1 FYM 15 t/ha for cotton; FYM 10 t/ha for soybean	1150	20212	1.69	4.04
N_2 FYM 10 t/ha + 50% RDF for cotton FYM 7.5 t/ha + 50% RDF for soybean	1370	31716	2.04	4.81
N_3 FYM 5 t/ha + 75% RDF for cotton FYM 5 t/ha + 75% RDF for soybean	1521	44811	2.56	5.34
N_4 RDF 100% (100:50:50 NPK kg/ha) for cotton RDF 100% (30:60:30 NPK kg/ha) for soybean	1412	48560	2.69	4.95
N_5 Absolute control for cotton and soybean	732	22938	1.68	2.57
CD at 5%	138.9	4817	--	--
Interaction C x N				
CD at 5%	196.5	NS	--	--

At Parbhani, the combination of soybean + pigeonpea (4:2) intercropping system with nutrient level of FYM 5 t/ha + 75% RDF (C_2N_3) recorded higher cotton equivalent yield (1898 kg/ha) except that it was at par with C_2N_4 and significantly superior over rest of the treatments (Table 3.295).

Table 3.295 : Interaction effect of cropping systems and nutrient levels on cotton equivalent yield - Parbhani

Treatment	N_1	N_2	N_3	N_4	N_5
C_1- Cotton + pigeonpea (6:1)	841	993	1144	987	550
C_2- Soybean + pigeonpea (4:2)	1460	1748	1898	1883	914
Interaction (C x N) : CD at 5%			196.5		

The effect of various treatments on properties of the soil showed that higher organic carbon and NPK content was observed in soybean + pigeonpea (4:2) intercropping system than that of cotton + pigeonpea intercropping system. Among nutrient levels, FYM 10 t/ha + 50% RDF recorded higher NPK content at flowering stage and it was higher in 100% RDF at harvesting stage. However the organic carbon content was higher in plots under FYM 15 t/ha for cotton and FYM 10 t/ha for soybean (Table 3.296).

Table 3.296 : Effect of cropping systems and nutrient management on soil properties – Parbhani

Treatment	pH	EC (dS/m)	OC %	Available nutrients (kg/ha)			Available S (ppm)
				N	P	K	
Initial Soil properties	8.0	0.38	0.40	150.0	10.4	488.0	10.90
C_1 Cotton + pigeonpea (6:1)	7.83	0.39	0.50	219.5	18.1	554.0	15.41
C_2 Soybean+ pigeonpea (4:2)	7.81	0.29	0.54	237.1	18.3	531.2	13.78
CD at 5%	NS	0.03	NS	NS	NS	NS	NS
N_1- FYM 15 t/ha for cotton FYM 10 t/ha for soybean	7.69	0.28	0.60	243.8	14.3	505.1	12.63
N_2- FYM 10 t/ha + 50% RDF for cotton; FYM 7.5 t/ha + 50% RDF for soybean	7.76	0.32	0.56	251.0	20.1	550.1	16.0
N_3-FYM 5 t/ha + 75% RDF for cotton; FYM 5 t/ha + 75% RDF for soybean	7.75	0.33	0.53	274.0	24.3	597.1	18.59
N_4-RDF 100% (100:50:50 NPK kg/ha) for cotton; RDF 100% (30:60:30 NPK kg/ha) for soybean	7.89	0.37	0.49	229.2	19.5	576.5	15.52
N_5-Absolute control for cotton and soybean	8.0	0.40	0.43	143.7	12.9	484.3	10.25
CD at 5%	0.04	0.04	0.035	32.5	1.4	16.3	0.99

At Parbhani, in a study on land configuration and fertilizer management, BBF gave maximum seed cotton yield (916 kg/ha), net returns (Rs.7746/ha), B:C ratio (1.23) and RWUE (3.21kg/ha-mm) compared to other land configurations. Among fertilizer management practices, RDF + foliar application of KNO_3 recorded maximum seed cotton yield (881 kg/ha), net returns (Rs.5922/ha), B:C ratio (1.18) and RWUE (3.08 kg/ha-mm) compared to other treatments (Table 3.297)

Table 3.297 : Cotton yield and economics as influenced by land configuration and nutrient management - Parbhani

Treatment	Seed cotton yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
L1 :Flat bed	732	5911	1.18	2.56
L_2 : BBF	916	7746	1.23	3.21
L_3 : Ridges & furrow	853	5911	1.18	2.99
CD at 5%	27.8	898.8	--	-
F_1 :RDF (100:50:50: kg/ha NPK)	756	3042	1.10	2.65
F_2 :RDF + foliar application of KNO_3 (35 and 65 DAS)	881	5922	1.18	3.08
F_3 : RDF + foliar application micronutrient mixture (35 and 65 DAS)	838	4516	1.14	2.93
F_4 : 75% RDF + 25% NPK through FYM + KNO_3 spray (35 and 65 DAS)	867	5853	1.18	3.04
F_5 :RDF + 25% NPK through FYM + micro-nutrient mixture spray (35 and 65 DAS)	830	5141	1.16	2.91
F_6 :75% RDF + 25% NPK through green manuring + KNO_3 spray (35 and 65 DAS)	845	2731	1.08	2.96
F_7 :75% RDF + 25% NPK through green manuring + micronutrient mixture spray (35 and 65 DAS)	820	2475	1.07	2.87
CD at 5%	56.0	1316	--	-

The interaction effect of land configurations (L) and fertilizer cum stress management (FS) practices on seed cotton yield was found to be significant. The treatment combination of L_2F_2 (BBF + RDF + foliar application of KNO_3 at 35 and 65 DAS) recorded the highest seed cotton yield (898 kg/ha) which was found at par with treatment combinations of L_2F_6, L_2F_5, L_2F_4, L_2F_7, L_2F_1, L_2F_8, L_1F_2, L_1F_6 L_1F_3, L_1F_4, L_1F_5, L_1F_1 and L_1F_7 and significantly superior over rest of the treatment combinations (Table 3.298).

Table 3.298 : Interaction effect of land configurations and fertilizer cum stress management on seed cotton yield (kg/ha) - Parbhani

Treatment	L_1 : Flat bed	L_2 : BBF	L_3: Ridges & furrow
F_1 : RDF (100:50:50 kg/ha NPK)	804	836	744
F_2 : RDF + foliar application of KNO_3 (35 and 65 DAS)	867	898	806
F_3 : RDF + foliar application micro-nutrient mixture (35 and 65 DAS)	845	877	785
F_4 : 75% RDF + 25% NPK through FYM + KNO_3 spray (35 and 65 DAS)	860	892	780
F_5 : RDF + 25% NPK through FYM + micro-nutrient mixture spray (35 and 65 DAS)	841	873	781
F_6 : 75% RDF + 25% NPK through green manuring + KNO_3 spray (35 and 65 DAS)	849	881	789
F_7 : 75% RDF + 25% NPK through green manuring + micro-nutrient mixture spray (35 and 65 DAS)	837	868	776
CD at 5%	97		

At Parbhani, soil nutrient status was significantly influenced by various land management and fertility treatments. Organic carbon, available N, P_2O_5, K_2O and sulphur increased significantly due to BBF and ridges & furrow method compared to flat bed method. Significantly highest organic carbon, available P_2O_5 and sulphur content in soil was recorded by treatment 75% RDF + 25% NPK through green manuring + KNO_3 spray (35 and 65 DAS) over RDF (Table 3.299).

Table 3.299 : Effect of land and stress management on soil nutrient status after harvest of Bt-cotton - Parbhani

Treatment	pH	EC (dS/m)	OC (%)	Available nutrients (kg/ha)			Avail. S (ppm)
				N	P	K	
Land configurations							
Initial soil properties	7.75	0.40	0.38	237.5	10.4	451.0	8.82
Flat bed	7.74	0.52	0.45	261.0	12.0	500.6	11.20
BBF	7.73	0.50	0.52	281.2	14.5	543.0	11.95
Ridges & furrow	7.75	0.50	0.50	287.0	13.7	527.6	11.34
CD at 5%	NS	NS	0.014	13.5	0.2	8.8	0.33
Fertilizer cum stress management							
RDF (100:50:50 kg/ha NPK)	7.77	0.41	0.42	263.2	10.8	492.6	9.77
RDF + foliar application of KNO_3 (35 and 65 DAS)	7.79	0.53	0.46	304.2	13.9	543.4	10.84
RDF + foliar application micro-nutrient mixture (35 and 65 DAS)	7.81	0.59	0.48	263.1	12.1	516.1	10.98
75% RDF + 25% NPK through FYM + KNO_3 spray (35 and 65 DAS)	7.71	0.50	0.52	268.8	15.6	562.2	12.57
RDF + 25% NPK through YM + micro-nutrient mixture spray (35 and 65 DAS)	7.73	0.53	0.52	262.5	13.7	523.6	11.91
75% RDF + 25% NPK through green manuring + KNO_3 spray (35 and 65 DAS)	7.76	0.47	0.55	295.9	16.0	530.0	13.12
75% RDF + 25% NPK through green manuring + micro-nutrient mixture spray (35 and 65 DAS)	7.76	0.50	0.54	297.2	13.9	518.3	12.17
CD at 5%	0.041	0.059	0.010	11.5	0.8	15.3	0.33

At Parbhani, in a study on nutrient management and foliar spray, application of RDF + foliar spray of KNO_3 @ 1 and 2% (35 and 65 DAS) gave maximum seed cotton yield (898 kg/ha), net returns (Rs. 7158/ha), B:C ratio (1.21) and RWUE (3.15 kg/ha-mm) compared to other treatments (Table 3.300).

Table 3.300 : Cotton yield and economics as influenced by nutrient management- Parbhani

Treatment	Seed cotton yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
RDF (100:50:50 kg/ha NPK)	687	1218	1.04	2.41
RDF + straw mulch	869	5998	1.18	3.04
RDF + foliar application of anti-transpirant kaolin at 35 and 65 DAS	752	318	1.00	2.63
RDF + foliar application of KNO_3 at 35 and 65 DAS	898	7158	1.21	3.15
RDF + foliar application of NPK (19:19:19) at 35 and 65 DAS	853	6258	1.19	2.99
RDF + foliar application of MOP at 35 and 65 DAS	799	4397	1.13	2.80
RDF + foliar application of thiourea @ 250 g/ha at 35 and 65 DAS	740	2188	1.07	2.59
RDF + water sprays at 35 and 65 DAS	718	2062	1.06	2.51
75% RDF + 25% through FYM	659	-1347	0.95	2.31
75% RDF + foliar application of KNO_3 at 35 and 65 DAS	825	5738	1.18	2.89
CD at 5%	1778	438	--	-

3.5.4 Energy management

At Akola, in the long term study on tillage and nutrient management, the effect of tillage was significant on grain yield and was non-significant for fodder yield of sorghum. The treatment 50% of conventional tillage and hand weeding recorded significantly highest grain (3843 kg/ha) and fodder yield (10069 kg/ha) over conventional tillage (2987 and 9027 kg/ha, respectively). Application of 50% each of recommended dose through organic and inorganic sources recorded significantly high grain (3664 kg/ha) and fodder yield (10155 kg/ha) over recommended dose through inorganic source and was at par with recommended dose through organic (FYM/glyricidia) (Table 3.301).

Table 3.301 : Grain and fodder yield of sorghum as influenced by tillage and nutrient management - Akola

Treatment	Grain yield (kg/ha)		Fodder yield (kg/ha)	
	2015-16	Mean (4 years)	2015-16	Mean (4 years)
Tillage				
Ploughing (every 3 years) + intercultural opera-tions + hand weeding (CT)	2987	2711	9027	7351
50% of CT + hand weeding	3843	2925	10069	7523
50% of CT + herbicides	3501	2860	9790	7374
CD at 5%	370.8	163.7	NS	NS
Nutrient management				
100% RDF (inorganic) (50:25:30 kg/ha NPK)	3252	2937	9505	7401
50% inorganic + 50% organic (FYM/gliricidia)	3664	2954	10155	7555
RDF through organic (FYM/gliricidia)	3415	2606	9226	7291
CD at 5%	268.4	221.4	704.9	NS

At Kovilpatti, in an experiment on evaluation of different seed drills, line sowing of minor millets with air assisted seed drill resulted in 30 to 40 % saving in seed rate. Cost of sowing with air assisted seed drill was Rs. 800/hr compared to *gorru* sowing (Rs.900/ha) and broadcasting (Rs.850/ha). The time taken for sowing one hectare was 1.24, 2.81 and 3.00 hours with air assisted seed drill, tractor drawn *gorru* and broadcasting, respectively. The highest plant population/m^2 was recorded with broadcasting followed by *gorru* sowing and seed drill sowing owing to the high seed rate in all millets except little millet where the variation among the treatments was not significant. The number of tillers/plant was not significantly influenced by the method of sowing excepting kodo millet. The effect of treatments on yield were on par in barnyard millet, foxtail millet and little millet (Table 3.302).

Table 3.302 : Effect of different sowing methods on yield and economics of minor millets - Kovilpatti

Crops	Air assisted seed drill	Tractor drawn *gorru*	Broadcasting	CD at 5%
Seed rate (kg/ha)				
Barnyard millet	7.0	8.5	10	-
Foxtail millet	6.5	8.0	10	-
Little millet	5.0	8.0	10	-
Kodo millet	5.0	8.0	10	-
Plant population/m^2				
Barnyard millet	24.5	31.2	36.6	0.9
Foxtail millet	26.2	34.5	33.6	1.8
Little millet	30.3	29.1	36.3	2.0
Kodo millet	16.4	31.4	37.5	1.3

Crops	Air assisted seed drill	Tractor drawn *gorru*	Broadcasting	CD at 5%
No. of tillers/plant				
Barnyard millet	3.0	2.3	3.2	0.2
Foxtail millet	4.2	4.1	5.2	0.3
Little millet	5.0	5.2	5.5	0.2
Kodo millet	14.4	8.7	9.2	0.6
Yield (kg/ha)				
Barnyard millet	1010	1050	1170	41.5
Foxtail millet	908	950	1090	45.7
Little millet	276	290	340	15.0
Kodo millet	915	1020	1110	60.3
B:C ratio				
Barnyard millet	1.95	2.03	2.27	-
Foxtail millet	1.70	1.58	1.82	-
Little millet	0.52	0.48	0.57	-
Kodo millet	1.37	1.53	1.67	-

In the longterm study on tillage and nutrient management on biennial cropping sequence of cotton + soybean (1:1) and soybean + pigeonpea (4:2) at Parbhani, among tillage methods, conventional tillage recorded maximum soybean seed equivalent yield (2439 kg/ha), net returns (Rs. 60232/ha), B:C ratio (3.18) and RWUE (8.55 kg/ha-mm). Whereas among nutrient sources, RDF gave highest soybean seed equivalent yield (2574 kg/ha), net returns (Rs. 65084/ha), B:C ratio (3.36) and RWUE (9.03 kg/ha-mm) compared to other treatments (Table 3.303).

Table 3.303 : Crop yield and economics as affected by tillage and nutrient management - Parbhani

Treatment	Yield (kg/ha)		SEY (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/mm-ha)
	Soybean	Pigeonpea				
Tillage (T)						
Conventional tillage	658	916	2439	60232	3.18	8.55
Reduced tillage + interculture	615	842	2252	53504	2.94	7.90
Reduced tillage + herbicide	560	740	1999	44684	2.61	7.01
CD at 5%			156	3663	0.21	
Nutrient source (N)						
FYM @ 5 t/ha	600	701	1963	43094	2.56	6.88
Vermicompost @ 3 t/ha	552	542	1606	30236	2.09	5.63
RDF (50%) + FYM (2.5 t/ha)	624	820	2218	52288	2.89	7.78
RDF (50%) + vermicompost (1.5 t/ha)	617	781	2136	49306	2.79	7.49
RDF (30:60:30 kg/ha NPK)	645	992	2574	65084	3.36	9.03
CD at 5%	-	-	246	5193	0.42	-
Interaction (T X N)						
CD at 5%	-	-	267	5092	0.21	-

SEY: Soybean equivalent yield

On an average, maximum infiltration rate of 9.8 cm/hr was recorded in conventional tillage + vermicompost whereas minimum of 5.0 cm/hr was observed in reduced tillage + interculture + RDF. The lowest bulk density (1.20 g/cm^3) was recorded in the plots under reduced tillage + interculture with FYM application compared to other treatments (Table 3.304).

Table 3.304 : Infiltration rate and bulk density as affected by tillage and nutrient management – Parbhani

Treatment	FYM	Vermi-compost	RDF+ FYM	RDF + vermicompost	RDF	Mean
Infiltration rate (cm/hr)						
Conventional tillage	12.5	9.8	8.9	8.6	8.2	9.6
Reduced tillage + interculture	5.5	6.2	6.4	6.2	5.0	5.8
Reduced tillage + herbicide	6.5	7.6	8.2	8.0	6.1	7.23
Mean	8.16	7.86	7.83	7.6	6.45	
Bulk density (g/cm^3)						
Conventional tillage	1.23	1.39	1.34	1.20	1.40	1.31
Reduced tillage + interculture	1.20	1.38	1.38	1.40	1.32	1.33
Reduced tillage + herbicide	1.40	1.28	1.24	1.28	1.30	1.30
Mean	1.27	1.35	1.32	1.29	1.34	

In a study on intercropping systems and tillage practices at Parbhani, cotton + soybean intercropping system (1:1) recorded significantly higher seed cotton equivalent yield (SCEY) (2120 kg/ha), net returns (Rs.67543/ha) and B:C ratio (3.42) than other cropping systems. Soybean + pigeonpea (4:2) and sorghum + pigeonpea (4:2) systems recorded at par seed cotton equivalent yield, net returns and B:C ratio. Among tillage practices, shallow tillage with tractor drawn implements recorded significantly higher SCEY (2067 kg/ha), net returns (Rs.65455/ha) and B:C ratio (3.37) than conventional tillage with bullock drawn implement, conventional tillage with tractor drawn implements and tillage with rotary tillers and found to be at par with shallow tillage with bullock drawn implement (Table 3.305).

Table 3.305 : Crop yield and economics as affected by cropping systems and tillage practices - Parbhani

Treatment	Yield (kg/ha)		SCEY (kg/ha)	NMR (Rs/ha)	B:C ratio
	Main crop	Intercrop			
Cropping system					
Sorghum + pigeonpea (4:2)	1563	602	1700	51950	3.11
Soybean + pigeonpea (4:2)	626	903	1905	58170	3.10
Cotton + soybean (1:1)	1319	1001	2120	67543	3.42
CD at 5%			207	5781	0.27
Tillage practice					
Shallow tillage with bullock drawn implements	1149	964	2031	64811	3.43
Conventional tillage with bullock drawn implements	987	970	1880	56064	2.96
Shallow tillage with tractor drawn implements	1201	950	2067	65455	3.37
Conventional tillage with tractor drawn implements	933	813	1678	45939	2.55
Tillage with rotary tillers	1012	678	1624	45516	2.65
CD at 5%			108	1012	0.15

SCEY: Seed cotton equivalent yield

Among cropping systems, higher soil moisture use of 367 mm and RWUE of 6.97 kg/ha-mm was recorded in cotton + soybean, followed by soybean + pigeonpea and sorghum + pigeonpea systems. Among tillage practices, the highest soil moisture use (351 mm) and RWUE (6.97 kg/ha-mm) was recorded with shallow tillage with tractor drawn implements. The lowest RWUE of 6.19 was observed in tillage with rotary tillers. Similarly, highest soil moisture use efficiency of Rs.256/mm-ha was recorded in soybean + pigeonpea followed by cotton + soybean intercropping system. Similarly, among the tillage practices, highest moisture use efficiency was observed in shallow tillage with bullock drawn and tractor drawn implement than other treatments (Table 3.306).

Table 3.306 : Soil moisture use, MUE and RWUE as affected by cropping systems and tillage practices – Parbhani

Treatment	T_1	T_2	T_3	T_4	T_5	Mean
Soil moisture use (mm)						
Sorghum + pigeonpea (4:2)	319	325	340	332	327	329
Soybean + pigeonpea (4:2)	327	332	337	335	324	331
Cotton + soybean (1:1)	367	362	375	367	362	367
Mean	338	340	351	345	338	342
Moisture use efficiency (Rs/ha-mm)						
Sorghum + pigeonpea	263	248	249	229	229	243
Soybean + pigeonpea	271	256	265	240	245	256
Cotton + soybean	254	249	251	233	233	244
Mean	263	251	255	234	236	248
Rainwater use efficiency (kg/ha-mm)						
Sorghum + pigeonpea	6.55	6.28	6.61	5.93	5.83	6.23
Soybean + pigeonpea	6.90	6.64	6.97	6.28	6.18	6.59
Cotton + soybean	7.28	7.02	7.34	6.66	6.57	6.97
Mean	6.91	6.65	6.97	6.29	6.19	6.60

T_1- Shallow tillage with bullock drawn implements; T_2- Conventional tillage with bullock drawn implements ; T_3- Shallow tillage with tractor drawn implements; T_4- Conventional tillage with tractor drawn implements ; T_5 -Tillage with rotary tillers

3.5.5 Evaluation of improved varieties

At Akola, among the castor genotypes evaluated, AKCS-2 recorded highest yield (1762 kg/ha) compared to local check (AKC-1) and other varieties. AKCS-2 also produced highest no of iry spikes (3.80) and number of capsules (126.1) compared to other genotypes (Table 3.307).

Table 3.307 : Performance of castor genotypes - Akola

Genotype	Seed yield (kg/ha)	Days to maturity of iry spikes	Plant height (cm)	No. of nodes	No. of spikes	Length of iry spikes (cm)	No. of capsules
AKCS-1	1053	138	147.8	20.2	3.2	29.9	97.3
AKCS-2	1762	141	171.4	21.1	3.8	39.1	126.1
AKCS-3	1291	134	144.4	19.1	2.5	49.9	97.5
AKCS-4	708	138	149.7	18.5	1.8	36.9	100.2
AKCS-5	980	135	142.5	20.4	2.1	52.3	82.4
AKCS-6	856	135	150.6	23.5	2.1	53.5	73.0
AKCS-7	1088	146	153.8	23.9	3.2	37.2	93.0
AKCS-8	1140	143	179.9	20.5	2.5	42.0	103.3
AKCS-9	478	141	170.6	17.8	1.5	25.0	48.0
AKCS-10	485	144	129.8	21.3	3.0	23.6	47.9
AKCS-11	995	148	139.7	22.3	3.8	13.8	54.0
AKCS-12	1046	151	155.9	20.2	3.6	41.1	88.6
AKC-1 ©	1198	151	175.4	21.4	3.3	39.8	72.1
CD at 5%	299	9.61	NS	NS	NS	11.0	25.9

Among the horsegram genotypes evaluated at Akola, all the genotypes except IC 139349 recorded significantly higher seed yield over the check Sinna. The genotype IC 139546 produced highest seed yield followed by IC-139542 and IC 139416 (913, 641 and 509 kg/ha, respectively) (Table 3.308).

Table 3.308 : Performance of horsegram genotypes - Akola

Genotype	Seed yield (kg/ha)	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods/ plant	No. of seeds/ plant	100 seed weight (g)
IC-139343	400	39.3	5.0	4.0	8.0	6.0	3.7
IC-139345	388	49.0	8.0	11.0	14.0	7.0	3.5
IC-139346	320	51.0	5.0	14.0	25.0	7.7	3.4
IC-139349	242	37.3	6.0	7.0	12.0	7.0	3.4
IC-139416	509	57.0	8.0	8.0	12.0	7.0	3.4
IC-139541	490	65.0	9.0	5.0	8.0	8.0	3.4
IC-139542	641	54.3	8.0	8.0	17.0	6.0	3.8
IC-139546	913	65.0	7.0	7.0	45.0	7.0	4.5
Sinna (C)	177	50.3	10.0	7.0	16.0	4.0	3.3
CD at 5%	106	22.2	1.9	4.0	4.0	1.5	NS

3.5.6 Alternate land use systems

In an agri-horti system evaluated under CCT treated catchment at Akola, green gram was sown as an intercrop, which recorded higher seed yield of greengram in the CCT treated catchment (230 kg/ha) as against untreated catchment (156 kg/ha). Similarly, custard apple yield was more in CCT treated catchment (67 kg) as compared to untreated catchment (35 kg). The increase in groundwater recharge of CCT treated catchment over untreated catchment was more in August (4.39 m) followed by September (4.29 m). It was also observed that the groundwater levels were more in CCT treated catchment compared to non treated catchment in all the months. On an average, the ground water recharge in the CCT treated catchment was 21.2% more compared to the non treated catchment (Table 3.309).

Table 3.309 : Average monthly groundwater levels in the observation wells - Akola

Month	Average ground water levels (m)						Increase in GW levels of CCT treated catchment (%)
	CCT treated catchment		Untreated catchment		Average of CCT treated catchment	Average of untreated catchment	
	OW-1	OW-3	OW-2	OW-4			
January	2.8	3.6	2.7	3.1	3.2	2.9	10.6
February	2.3	2.9	2.2	2.3	2.6	2.3	16.0
March	1.9	2.7	1.7	2.2	2.3	1.9	18.1
April	1.3	2.1	1.2	1.6	1.7	1.4	20.4
May	0.6	1.4	0.5	1.0	1.0	0.8	29.0
June	0.6	1.5	0.5	1.1	1.0	0.8	26.5
July	0.7	1.8	0.6	1.3	1.3	0.9	36.8
August	4.0	4.8	3.5	3.6	4.4	3.5	25.1
September	3.8	4.6	3.3	3.5	4.2	3.4	23.1
October	3.5	3.7	3.2	3.0	3.6	3.1	16.9
November	2.1	3.0	2.0	2.4	2.5	2.2	16.3
December	2.0	2.5	1.9	2.0	2.3	2.0	15.8

At Parbhani, in drumstick based agri-horti system, among all the intercrops drumstick + greengram (1:6) recorded higher system yield (2246 kg/ha), net returns (Rs.10807/ha) and RWUE (7.88 kg/ha-mm) followed by drumstick + soybean (1:2), drumstick + blackgram (1:6) and drumstick + green mannuring (1:2) (Table 3.310).

Table 3.310 : Effect of alternate land use systems on crop yield and economics - Parbhani

Treatment	Yield (kg/ha)		NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Drumstick equivalent yield	System yield			
Drumstick sole (3 m x 3 m)	--	1387	6224	1.21	4.86
Drumstick + greengram (1:6)	885	2246	10807	1.25	7.88
Drumstick + blackgram (1:6)	707	2056	6077	1.15	7.21
Drumstick + soybean (1:2)	717	2147	7888	1.18	7.53
Drumstick + green mannuring (1:2)	--	1560	7652	1.26	5.47

3.5.6. Integrated farming systems

At Kovilpatti, in a study on integrated farming system with crops, livestock (1 milch animal) and goat rearing (10+1), the mean system productivity and mean system income in IFS were 10,609 kg/ha and 1,33,876 Rs/ha whereas in conventional system the values were 2713 kg/ha and Rs.35,281 /ha during 2015-16 (Table). The mean employment generation was 212 and 437 man days/year due to cropping alone and integration of crops, livestock and goat rearing. Integrated farming system recorded mean average system productivity of 12,641 kg/ha and total system income of Rs.1,26,183 besides 420 man-days of employment in the rainfed vertisols of Southern Zone by integration of animal components (goat and livestock) along with conventional cropping. The average organic manure generated from IFS was 3956 kg which could be recycled into the crop component (Table 3.311).

Table 3.311 : System productivity and economics under integrated farming system - Kovilpatti

Enterprise	System productivity (kg/ha)		NMR (Rs/ha)		Employment generation (man- days/ha/year)	
	2015-16	Mean (6 years)	2015-16	Mean (6 years)	2015-16	Mean (6 years)
CCS	2713	1391	10906	3212	212	177
IFS	10609	12641	47997	64107	437	420

CCS: Conventional cropping system (cotton + greengram – 0.6 ha; greengram – 0.4 ha); IFS: Integrated farming system (cotton + greengram – 0.6 ha; sorghum + cowpea – 0.4 ha; fodder – 0.3 ha; maize + greengram – 1.14 ha; clusterbean – 0.15 ha; goat (10 + 1) and milch animal – 1) (Table 3.312).

Table 3.312 : Total organic manure produced (kg/year on dry wt. basis) through IFS components - Kovilpatti

Livestock component	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	Mean
Cattle	1850	2165	1674	1782	1845	1942	1876
Goat	2255	2462	1864	1976	1907	2013	2080
Total	**4105**	**4627**	**3538**	**3758**	**3752**	**3955**	**3956**

4. Operational Research Project

During 2015-16, the on-farm assessment/ demonstration of technologies/practices were conducted in the adopted villages of 8 ORP centres (Table 4.1)

Table 4.1: Details of ORP villages

RP 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	Hoshiarpur	Punjab	19
Bengaluru	Baichenahalli and Iraksandra	Tumkur	Tumkur	Karnataka	228
Chianki	Gonda	Meral	Garhwa	Jharkhand	197
Hisar	Chhapar Jogiyan	Tosham	Bhiwani	Haryana	245
Indore	Piploda Dwarakdheesh	Ujjain	Ujjain	Madhya Pradesh	514
Solapur	Hingani	Man	Satara	Maharashtra	342

4.1 Ananthapur

(Yerraguntlapally, Kurnool district, Andhra Pradesh)

ORP village Kalchatla was delineated in to microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 1741 ha with an operational area of 142 ha and altitude varies from 455 – 535 m MSL (Fig. 4.1).

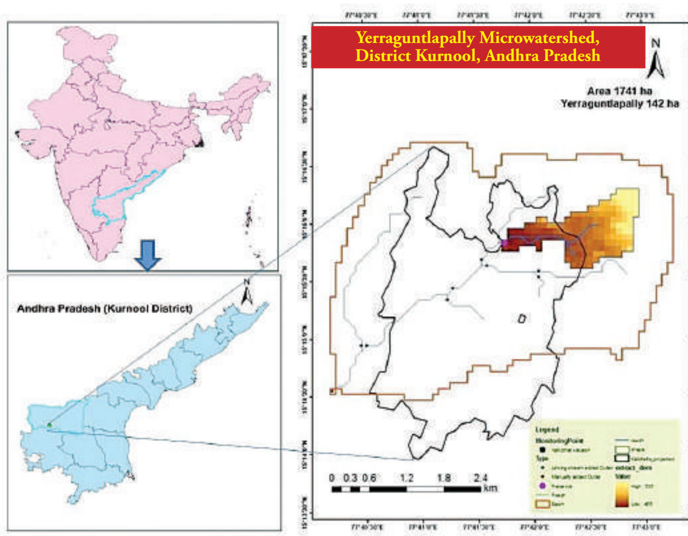


Fig. 4.1 Microwatershed with operational area, streams, village boundary and DEM

In 2015, Kurnool district received total annual rainfall of 477.5 mm against the normal rainfall of 670.5 mm which was deficit by 28.8 %. In district, during South West monsoon (June – Sept), 331.6 mm of rainfall was received against the normal (455.1 mm), which was 27%, less than the normal. During North East monsoon (Oct – Dec), 77.1 mm of rainfall was received against the normal rainfall of 149.6 mm, which was deficit by 49%.

4.1.1 Participatory Technology Development

During 2015-16, sub soiling with chisel plough in pigeonpea under rainfed conditions improved seed yield (728 kg/ha) and net returns (Rs.49000/per ha) compared to farmers' practice (676 kg/ha and Rs.35700/ha) (Table 4.2).

Table 4.2 Yield and economics of pigeonpea as influenced by sub soiling – Ananthapuramu

Treatment	Seed yield (kg/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Sub soiling with chisel plough	728	49000	4.16	3.6
Farmers' practice without sub soiling	676	35700	3.38	3.4

During February, 2016 one farm pond with dimensions of 10 x 10 x 2.5 m was constructed in the village with water storage capacity of 250 cum. Farm pond is lined with soil cement with mixing of 6:1 ratio for seepage control. An existing check dam was deepened to increase its capacity.

Mixing of red soil + cement (6:1) as lining material

Farm pond after lining

In an assessment of sowing of setaria with Ananta automatic bullock drawn seed plantar, higher grain yield (1125 Kg/ha), net returns and B:C ratio (Rs.23750/ ha and 3.3) were recorded in Ananta automatic bullock drawn sown plot compared to farmers' practice (Rs.1080 kg/ha and 3.3) (Table 4.3).

Table 4.3: Yield and economics of setaria as influenced by sowing implements – Ananthapuramu

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Improved practice (bullock drawn planter)	1125	---	6200	23750	3.3	3.94
Farmers' practice (seed drill)	1080	---	6950	22400	3.2	3.78

Setaria sowing with Ananta bullock drawn seed drill

Farmers' practice

4.1.1 Technology Upscaling

The results of on-farm assessment of soil test based fertilizer (STBF) application in groundnut during 2015-16 revealed that pod and haulm yields (530 and 1085 kg/ ha) were higher with STB fertilizer compared to farmer's practice (452 and 965 kg/ha). Net returns were also higher (Rs.4395/ha) with STB fertilizer application compared to negative returns from farmers' practice. This might be due to reduced cost on fertilizer through balanced fertilizer use and improved pod and haulm yield of groundnut. The benefit cost ratio was also higher with STB fertilizer compared to farmer's practice (Table 4.4).

Table 4.4: Yield and economics of groundnut as influenced by soil test based fertilizer application –Ananthapuramu

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Haulm				
Improved practice (Soil test based fertilizer application)	530	1085	22594	4395	1.19	1.62
Farmers' practice (50kg bag DAP/acre)	452	965	24875	-1625	0.94	1.39

Groundnut with soil test based fertilizer application

The improved varieties of groundnut K6 (480kg/ha) exhibited its superiority in out yielding TMV-2 (452 kg/ha), with higher net returns (Rs.22915/ha) and B:C Ratio (1.0) (Table 4.5).

Table 4.5: Performance of improved varities of groundnut - Anantapuramu

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod	Haulm				
Improved variety (K6)	480	1280	22915	125	1.0	1.47
Farmers' variety (TMV-2)	452	1118	23694	-1275	0.9	1.39

Groundnut Cv. Kadiri-6

Groundnut Cv. TMV-2

4.2 Arjia

(Neweriya, Chittorgarh district, Rajasthan)

ORP village Newariya was delineated in to microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 2508 ha with an operational area of 465 ha and altitude varies from 421 – 444 m MSL (Fig. 4.2).

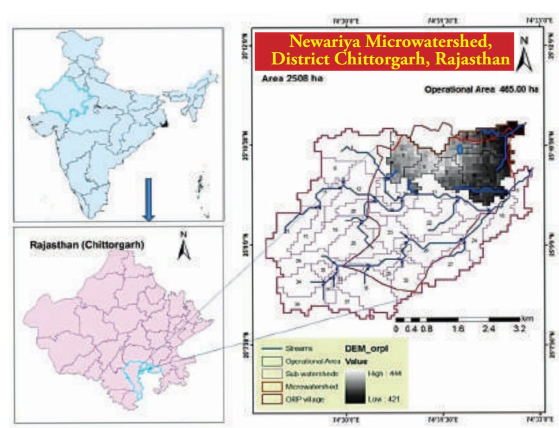


Fig. 4.2 Microwatershed with operational area, streams, village boundary and DEM

Climate of district is semi-arid, the normal onset of monsoon takes place in the third week of June and withdraws in the first week of October. The mean annual rainfall of the district is 800.2 mm of which, 93.24% is contributed by monsoon season (June - Sept), 3.13% by post-monsoon or NE monsoon (Oct.-Dec.), 1.01% by winter rains (Jan.-March) and 2.62 % by summer rains (April-May), respectively. July and August months are observed to contribute major rainfall of the region. The normal numbers of rainy days are 36. During 2015, annual rainfall of 283.2 mm was received. Onset of monsoon was late during this season (22th July) instead of last week of June as a normal date of onset of monsoon). During the month of August monsoon ceased, hence crop growth and yield suffered.

4.2.1 Participatory Technology Development

During the year, in general low maize grain yield was obtained due to delayed onset of monsoon and mid and terminal drought in the village. In-situ moisture conservation practices gave the higher maize grain yield (480 kg/ha) as compared to farmer's practice (367 kg/ha), with higher net returns (Rs.2287/ha) and B:C ratio (1.18) (Table 4.6).

Table 4.6 Yield and economics of maize under improved moisture conservation practices - Arjia

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio
	Grain	Fodder			
Improvedpractice*	480	2017	12500	2287	1.18
Farmers' practice	367	1610	11700	-127	0.99

* Improved practice includes soil & water conservation measures viz., peripheral bunding, deep ploughing, tillage and sowing across the slope, soil mulching and ridging at 30 DAS.

In an on-farm assessment for suitability of maize + blackgram (2:2) intercropping system, very low yield of maize and blackgram was obtained due to drought in the operational area. Maximum maize grain equivalent yield was obtained in maize + blackgram (2:2) inter-cropping system (572 kg/ha) as compared to mixed cropping (385 kg/ha). Both mixed cropping and sole maize recorded negative returns due to very low yields (Table 4.7).

Table 4.7: Maize equivalent yield (kg/ha) and economics under different cropping systems - Arjia

Treatment	Maize equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio
	Grain	Fodder			
Intercropping system (IC)	572	1565	12550	1720	1.14
Mixed cropping (MC)	385	1345	12050	-1280	0.89
Sole maize (SC)	308	1367	11400	-1617	0.86

IC = Sowing of two rows of maize with two rows of blackgram MC = Mixed seeding of maize + blackgram

In an on-farm assessment for suitability of groundnut + sesame (6:2) intercropping system, very low yield of both groundnut and sesame were obtained due to late onset of monsoon and terminal drought. Maximum groundnut pod equivalent yield was obtained in groundnut + sesame (6:2) intercropping system (404 kg/ha) as compared to mixed cropping (327 kg/ha) (Table 4.8).

Table 4.8: Groundnut equivalent yield (kg/ha) and economics under different cropping systems - Arjia3

Treatment	Groundnut equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Grain	Fodder			
Groundnut + sesame intercropping (6:2)	404	522	14250	1970	1.14
Mixed cropping of groundnut + sesame	327	474	14100	-755	0.95
Sole groundnut	293	453	13500	-1420	0.89

In an on-farm assessment of suitability of sorghum+ greengram (2:1) intercropping system, maximum sorghum grain equivalent yield of 659 kg/ha, net returns of Rs.2708/ha and B:C ratio of 1.21 were attained from sorghum + greengram (2:1) intercropping system. The mixed cropping of sorghum and greengram gave a sorghum equivalent yield of 531 kg/ha, net returns of Rs. 885/ha and B:C ratio of 1.07 (Table 4.9).

Table 4.9: Sorghum equivalent yield (kg/ha) and economics under different cropping systems - Arjia

Treatment	Sorghum equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Grain	Fodder			
sorghum + greengram Intercropping (2:1)	659	1888	12750	2708	1.21
Mixed cropping of sorghum + greengram	531	1645	12070	885	1.07
Sole sorghum	473	1717	11850	697	1.06

During the year, under late onset of monsoon and terminal drought all crops gave very low yield. However, sorghum crop performed better under delayed sowing and gave the highest maize equivalent yield (510 kg/ha) and net returns (Rs.1470/ha) followed by maize (302 kg/ha) (Table 4.10).

Table 4.10: Maize equivalent yield and economics of different crops under delayed onset of monsoon - Arjia

Location	Maize equivalent yield (kg/ha)					
	Maize	sorghum	Groundnut	Blackgram	Greengram	Sesame
Maize equivalent yield (kg/ha)	302	510	134	38	29	36
Mean	1380	1850	250	73	56	75
Cost of cultivation (Rs/ha)	12250	12050	13500	7700	7900	7550
NMR (Rs/ha)	-2502	1470	-9111	-4938	-5791	-4235
B:C ratio	0.80	1.12	0.33	0.36	0.27	0.44

In an assessment of the effect of zinc sulphate application (soil/foliar) on yield of maize, very low maize grain yield was obtained due the terminal drought in the operational area. However, foliar application of zinc sulphate @ 0.5% at 25 DAS gave marginally higher grain yield (363 kg/ha) as compared to basal application of zinc sulphate (327 kg/ha) and farmers' practice (Table 4.11).

Table 4.11: Yield and economics of maize in response to zinc application - Arjia

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Farmer's practice	223	1217	10700	-2707	0.75
IP + 25 kg $ZnSO_4$/ha	327	1400	11700	-1527	0.87
IP + Spray of $ZnSO_4$ @ 0.5%	363	1550	11900	-613	0.95

IP: Improved practice

In an assessment of application of sulphur @ 120 kg/ha (gypsum) in groundnut + sesame (6:2) intercropping system gave the higher net returns of Rs. 3213 ha-1, B:C ratio of 1.22 from groundnut pod equivalent yield of 438 kg/ha as compared to farmers' practices (320 kg/ha). The yield levels obtained were very low due to terminal drought (Table 4.12).

Table 4.12: Groundnut equivalent yield (kg/ha) and economics as influenced by sulphur application in groundnut + sesame (6:2) - Arjia

Treatment	Groundnut equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio
	Pod	Fodder			
Control	320	495	13500	-318	0.98
Sulphur @ 120 kg/ha (gypsum)	438	620	14600	3213	1.22

In an on-farm evaluation of maize cultivars, low maize grain yield was obtained due to drought in the operational area. However, PM-3 variety of maize gave highest grain yield (362 kg/ha) followed by PM-5 (267 kg/ha) compared to local (183 kg/ha) (Table 4.13).

Table 4.13: Yield and economics of maize varieties - Arjia

Varieties	Yield (kg/ha)		Cost of cultivation (Rs./ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
	Grain	Fodder				
PM-3	362	1683	10400	11797	1397	1.13
PM-5	267	1283	10200	8867	-1333	0.87
Local	183	917	9250	6233	-3017	0.67
Mean	203	971	7463	6724	-738	0.67

4.2.2 Technology upscaling

In an assessment of horsegram varieties, AK-42 gave maximum seed yield of 267 kg/ha, net returns of Rs. 4124/ha, B:C ratio of 1.57, while local variety gave a yield of 95 kg/ha with negative net returns of Rs.2888/ha (Table 4.14).

Table 4.14: Yield and economics of horsegram varieties - Arjia

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Grain	Fodder			
AK-21	187	377	7250	804	1.11
AK-42	267	487	7250	4124	1.57
Local	95	217	7050	-2888	0.59

In an on-farm evaluation of sorghum cultivars, sorghum grain yield was very low due terminal drought in the operational area. However, CSV-15 variety gave the highest grain yield (717 kg/ha) as compared to local cultivars (Table 4.15).

Table 4.15: Yield and economics of sorghum varieties - Arjia

Varieties	Yield (kg/ha)		Cost of cultivation (Rs./ha)	NMR (Rs/ha)	B:C ratio
	Grain	Fodder			
CSV-15	717	3100	11075	9925	1.90
CSV-17	500	2100	11075	3325	1.30
Local	307	1743	10900	-247	0.98

In an on-farm evaluation of groundnut cultivars, groundnut pod yield was very low due to terminal drought in the operational area. However, TG 37A variety of groundnut performed better at farmers' field and gave highest pod yield (403 kg/ha), compared to other varieties (Table 4.16).

Table 4.16: Yield and economics of groundnut varieties - Arjia

Varieties	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
	Pod	Fodder			
TG 37 A	403	840	14250	3227	1.23
TAG 24	337	747	14250	520	1.04
Local	233	550	13550	-3183	0.77

4.3 Ballowal Saunkhri

(Behdarya-Kothi, Hoshiarpur district, Punjab)

ORP village Behdarya was delineated in to microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 134 ha with an operational area of 18.50 ha and altitude varies from 571 – 597 m MSL (Fig. 4.3).

At Behdarya-Kothi, the onset of monsoon was at normal time (25th June) and sufficient rains occur in July and August. The annual rainfall was 738.7 mm, which was 31.6 % deficit over the mean normal rainfall (1081 mm). During kharif and rabi the rainfall was deficit by 23.4% and 71.5%, respectively to that of normal rainfall. There was no dry spell during the vegetative stage but a long dry spell of 31 days duration was recorded at silking & grain formation stages of maize which had negative effect on the maize grain yield. The rainfall was also not sufficient for sowing of rabi crops moreover, the long dry spells rigorously affected almost all the crop growth stages of rabi crops.

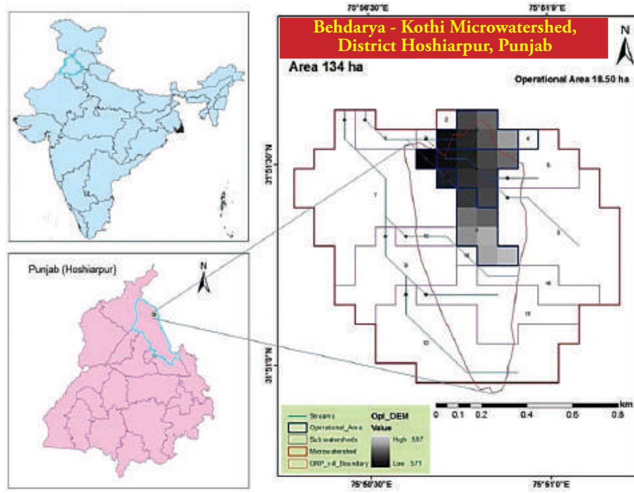


Fig. 4.3 Microwatershed with operational area, streams, village boundary and DEM

4.3.1 Participatory Technology Development

In an assessment of different stone/vegetative barriers in maize, stone pitching as mechanical barrier gave highest grain yield (3425 kg/ha) followed by Napier bajra hybrid (3342 kg/ha). However, the net returns (Rs. 28,156 /ha) and B:C ratio (1.92) were marginally higher in farmers' practice due to establishment cost of vegetative/mechanical barrier (Table 4.17).

Table 4.17: Effect of different vegetative/mechanical barriers on grain yield and economics of maize (PMH 1) –Ballowal Saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	BC ratio	RWUE (kg/ha-cm)
	Grain	Stover				
Napier bajra Hybrid	3345	7526	31,434	27,702	1.88	66.4
Stone pitching	3425	7706	32,628	27,628	1.85	68.0
No barrier	3315	7459	30,560	28,156	1.92	65.8

Rainfall: 503.8 mm

Stone pitching on bunds

Plantation of Napier bajra on bunds

In an assessment of different soil moisture conservation practices, reduced tillage (RT) + interculture (3333 kg/ha) resulted in almost similar grain yield when compared to convention tillage (CT) + interculture treatment (3393 kg/ha) with higher RWUE (66.2 kg/ha-mm). However, the net returns (Rs 32144/ha) and B:C ratio (2.21) was higher with reduced tillage + interculture over other treatments (Table 4.18).

Table 4.18: Effect of different tillage operations on yield and economics of maize -Ballowal Saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-cm)
	Grain	Stover				
CT + interculture	3393	7635	27,848	31,826	2.14	67.4
RT + interculture	3333	7499	26,581	32,144	2.21	66.2
RT + herbicide	3174	7142	26,957	29,596	2.10	63.0

Rainfall: 503.8 mm

Similarly in wheat, highest grain yield (2149 kg/ha) was recorded with conventional tillage (CT) + interculture followed by reduced tillage (RT) + interculture (1918 kg/ha) and reduced tillage (RT) + herbicide (1858 kg/ha). The highest net returns of Rs 21377/ha and B:C ratio of 1.82 was also obtained with conventional tillage + interculture (Table 4.19).

Table 4.19: Effect of different tillage operations on wheat yield and economics – Ballowal saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	BC ratio	RWUE (kg/ha-cm)
	Grain	Stover				
CT + Interculture	2149	4205	26,105	21,377	1.82	407.7
RT + Interculture	1918	3815	23,827	18,768	1.79	363.9
RT + Herbicide	1858	3655	22,660	18,460	1.81	352.5

Rainfall: 52.7 mm

In an assessment of the comparative performance of different sowing methods in maize, sowing across the slope resulted in higher grain yield (3344 kg/ha) which was 8.0% higher over the sowing of maize along slope. The net returns (Rs 31082/ha), B:C ratio (2.05) and RWUE (66.4 kg/ha-cm) was also higher with sowing of maize across the slope (Table 4.20).

Table 4.20: Effect of different sowing methods of maize – Ballowal Saunkhri

Sowing method	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C	RWUE (Kg/ha- cm)
Across slope	3344	29,617	31,082	2.05	66.4
Along slope	3106	29,444	23,444	1.80	61.6

Rainfall 503.8 mm

In an on- farm assessment of nutrient management in maize, maximum grain yield of 3608 kg/ha with RWUE of 71.6 kg/ha-cm was recorded with application of 100 % N through inorganic source which was almost similar to application of N through combination of 50% inorganic + 50% organic but 10.9% higher over application of N through 100% organic source with maximum net returns of Rs. 32372/ha and B:C ratio of 2.08. The B:C ratio was considerably lower with organic source of N due to more application cost of FYM (Table 4.21).

Table 4.21: Effect of different nitrogen sources on the yield and economics of maize –Ballowal Saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-cm)
	Grain	Stover				
100% inorganic N	3608	7912	30,008	32,372	2.08	71.6
50% inorganic + 50% organic N	3567	7852	33,617	28,095	1.84	70.8
100% organic N	3253	7736	36,929	20,222	1.55	64.6

Rainfall: 503.8 mm

The effects of mechanized and traditional sowing methods were demonstrated in wheat. Sowing of wheat with seed cum fertilizer drill gave net returns of Rs 20145/ha with B:C ratio of 1.81, and grain yield of 2073 kg/ha which was 22.4% higher over tractor ploughing followed by seed broadcasting (1693 kg/ha) (Table 4.22).

Table 4.22: Effect of sowing method on productivity and economics of wheat under rainfed conditions – Ballowal saunkhri

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	BC ratio	RWUE (kg/ha-cm)
	Grain	Stover				
Seed cum fertilizer drill sowing	2073	3847	24,924	20,145	1.81	393.3
Tractor ploughing + seed broadcasting (FP)	1693	3363	23,864	13,717	1.57	321.2

Sowing of wheat with seed cum fertilizer drill and crop stand in the field

In an assessment of performance of maize in kharif and raya during rabi season under two year old eucalyptus plantation, maize crop gave grain yield of 2600 kg/ha with net returns of Rs.17493/ha and B:C ratio of 1.63. Similarly in rabi season, the same field gave raya yield of 560 kg/ha with net returns of Rs. 8559/ha and B:C ratio of 1.62. With the introduction of these crops under eucalyptus plantation, farmers could get additional income of about Rs 25000/ha/year (Table 4.23).

Table 4.23: Performance of maize during kharif season and raya during rabi season under eucalyptus plantation – Ballowal Saunkhri

Treatment	Grain /Seed yield (kg/ha)	Straw yield (kg/ha)	*Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
***Kharif* season**					
Maize crop	2600	5625	27682	17,493	1.63
***Rabi* season**					
Raya	560	850	13851	8,559	1.62

Rainfall (mm): Maize: 503.2; Raya: 52.7 * Cost of cultivation is taken only for maize & raya

Raya crop in eucalyptus plantation

4.3.2 Technology upscaling

In an assessment of different cropping sequences, economic analysis showed that maize - wheat cropping system gave highest net returns of Rs 54524/ha from maize equivalent yield (MEY) of 5875 kg/ha followed by maize - raya (Rs 45612/ha). The minimum net returns (Rs.22049/ha) was recorded with pearl millet - gobhi sarson cropping system. However the B:C ratio was highest in maize based cropping system with maximum under maize-raya system (2.08) (Table 4.24).

Table 4.24: Productivity and economics of double cropping sequences – Ballowal Saunkhri

Cropping system	MEY (kg/ha)	Cost cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Maize-wheat	5875	53344	54524	2.02
Maize- raya	5381	42276	45612	2.08
Maize - gobhi sarson	5236	42276	43421	2.03
Sesame- wheat	4788	42758	38315	1.90
Sesame-raya	4295	31690	29403	1.93
Sesame-gobhi sarson	4149	31690	27212	1.86
Pearl millet -wheat	4513	39851	33152	1.83
Pearl millet -raya	4020	28783	24240	1.84
Pearl millet -gobhi sarson	3874	28783	22049	1.77

Field assessment of raya intercropping at row distance of 3 meters in wheat and sowing of raya on boundary of wheat field was conducted in farmers' fields. The highest wheat equivalent yield (WEY) of 2318 kg/ha was recorded with sowing of raya crop on the boundary of wheat field followed by wheat + raya intercropping (12:1) which recorded 13 and 8% higher yield compared to sole wheat. The net returns and B:C ratio of wheat + raya on boundary was Rs.23028/ha with B:C ratio of 1.90 which was Rs.3888 higher than sole wheat (Table 4.25).

Table 4.25: Productivity and economics of wheat and raya intercropping – Ballowal Saunkhri

Intercropping system	WEY (kg/ha)	RWUE (kg/ha-cm)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio
Sole wheat	2054	389.7	24,907	19,140	1.77
Wheat + raya (cv. RLM 619)	2218	420.9	25,729	21,841	1.85
Wheat (PBW 660) + raya (Boundary)	2318	439.8	25,713	23,028	1.90

Rainfall: 52.7 mm

Sole wheat

Wheat: raya (12:1)

4.4 Bengaluru

(Baichenahalli and Iraksandra, Tumkur district, Karnataka)

ORP villages Baichenahalli and Iraksandra were delineated in to microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 1202 ha with an operational area of 101.8 and 125.8 ha respectively and altitude varies from 789 – 825 m MSL (Fig. 4.4).

At Baichenahalli, during the year the normal onset of monsoon was timely (1st June) and an annual rainfall of 1061.2 mm was received against the mean annual rainfall of 1061 mm. In kharif 488.6 mm and in rabi 264.2 mm rainfall was received against the normal rainfall (507.8 and 237.8 mm, respectively). There was one dry spell (8th October on wards) coinciding with flowering of most of the crops resulted in reduced yield attributes.

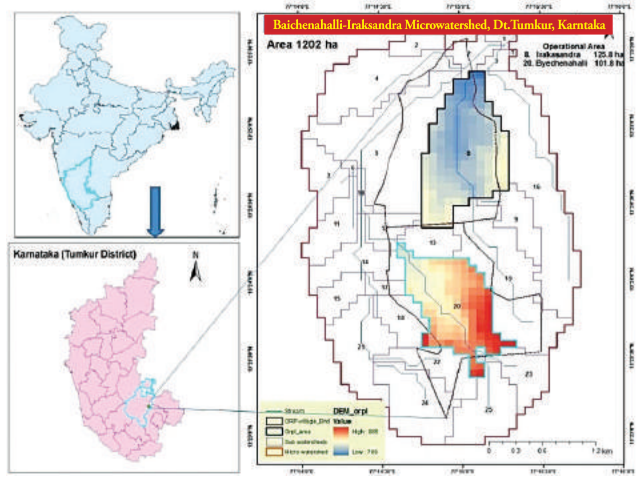


Fig. 4.4 Microwatershed with operational area, streams, village boundary and DEM

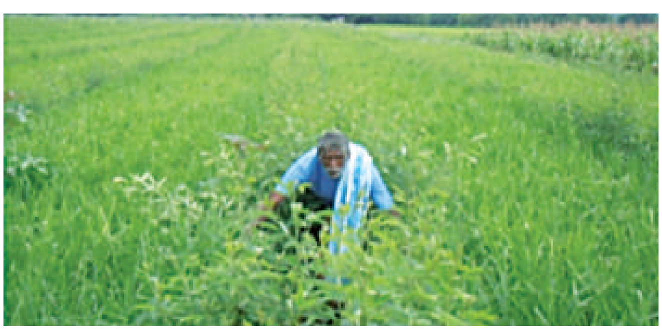
4.4.1 Participatory Technology Development

In an assessment of in-situ moisture conservation practices, opening of moisture conservation furrow between paired rows of pigeonpea in finger millet + pigeonpea (8:2) intercropping system recorded higher finger millet grain equivalent yield (4076 kg/ha), RWUE (5.89 kg/ha-mm), net returns (Rs. 66880/ha) and B:C ratio (3.44). The finger millet grain equivalent yield increased by 50% as compared to farmers' practice (2719 kg/ha) (Table 4.26).

Table 4.26: Yield and economics of finger millet + pigeonpea (8:2) cropping system as influenced by in-situ moisture conservation practice – Bengaluru

Treatment	Finger millet yield (kg/ha)		Pigeon pea yield (kg /ha)	FMEY (kg/ha)	Cost of cultivation (Rs /ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw						
Finger millet (MR-1) + pigeonpea (BRG-2) (8:2) with moisture conservation furrow	2295	6108	392	4076	25206	66,880	3.44	5.89
Farmers' Practice (finger millet + Akkadi)	1919	5515	PP: 82 Castor: 73 Sorghum: 47 FB: 37 Sesame: 12 Cowpea: 43	2719	28106	35,863	2.28	3.93

PP: Pigeonpea; FB: Field bean



Finger millet + pigeonpea (8:2)

Akkadi (Farmers' practice)

Introduction of pigeonpea + field bean cropping system (1:1) resulted in higher pigeonpea equivalent yield (832 kg/ha) with RWUE of 2.23 kg/ha-mm, net returns (Rs.53,020/ha) and B:C ratio (2.75) compared to sole crop of pigeonpea (721 kg/ha) and field bean (207 kg/ha). The yield was 15% higher with pigeonpea + field bean cropping system (1:1) than pigeonpea sole (Table 4.27).

Table 4.27: Yield and economics of pulse based intercropping system - Bengaluru

Treatment	Yield (kg/ha)		PEY	LER	MAI	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop							
Pigeonpea + field bean {BRG-1 + HA-4 (1:1) }	710	191	832	1.53	18376	30264	53,020	2.75	2.23
Pigeonpea sole (BRG-1)	707	-	721	-	-	27574	44,566	2.61	1.94
Field bean (HA-4) sole	363-	-	207	-	-	24486	-3729	0.85	0.56

PEY: Pigeonpea equivalent yield

Pigeonpea + field bean (1:1)

Sole pigeonpea (Farmers' practice)

Pigeonpea + maize (1:1) intercropping recorded higher net returns (Rs.1, 40,055/ha) and B:C ratio (6.39) as compared to sole maize (Table 4.28).

Table 4.28 Yield and economics of maize+ pigeonpea (1:1) intercropping system – Bengaluru

Treatment	Yield (kg/ha)		MCEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop					
Maize+ Pigeonpea (1:1)	2267	1343	11860	25983	1,40,055	6.39	22.52
Sole maize	3789	-	3789	25983	27,063	2.04	7.19

MEY: Maize equivalent yield

Maize+ pigeonpea (1:1)

Sole maize

In an assessment of INM in fingermillet + pigeonpea (8:2) system, 50% N through organic source + 50% N & 100% PK through inorganic + 12.5 kg zinc sulphate +10 kg borax per ha recorded maximum finger millet grain equivalent yield (4580 kg/ha) and B:C ratio (3.85) followed by RDF alone (4263 kg/ha and 3.59, respectively) compared to farmers' practice of finger millet + akkadi (2576 kg/ha and 2.18, respectively). (Table 4.29)

Table 4.29: Yield and economics of finger millet + pigeonpea intercropping under integrated nutrient management – Bengaluru

Treatment	FM yield (kg/ha)		Yield (kg/ha)			COC (Rs/ha)	NMR (Rs /ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw	PP	*Akkadi* crop	FMEY				
T_1	2436	5946	402	-	4263	27,391	70,861	3.59	6.16
T_2	2512	6122	455	-	4580	27,391	77,965	3.85	6.62
			PP	61					
			Cas	25					
T_3	2025	4168	Sor	54	2576	27,391	32,400	2.18	3.72
			FB	29					
				24					

T1: RDF (50:40:37.5 kg N, P2O5 and K2O ha-1), T2: 50% N through FYM +50% N and 100% P K through inorganic source + micronutrients based on soil test+ bio-fertilizer treatment, T3: Farmers' practice (Finger millet +akkadi crops), COC: cost of cultivation, PP: pigeonpea; FB; Field bean

Crops under INM

Farmers' practice

In an assessment of fingermillet varieties, medium duration variety GPU-28 (2458 kg/ha) gave higher yield followed by long duration variety MR-1 (2295 kg/ha) due to late sowing, and local variety recorded the lowest yield (1975 kg/ha) (Table 4.30). Similarly, Samruddhi chilli recorded higher green chilli yield (4626 kg/ha) and B:C ratio (2.39) as compared to Chikaballapura local variety (2510 kg/ha and 1.30, respectively) (Table 4.31).

Table 4.30: Yield and economics of different finger millet varieties – Bengaluru

Variety	Yield (kg /ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed/grain yield in 2015	Straw yield				
MR-1	2295	5987	25206	29,774	2.18	3.32
GPU-28	2458	6115	25206	33,456	2.33	3.55
GPU-48	2369	5162	25206	30,784	2.22	3.42
Local	1975	4023	25206	21,261	1.84	2.85

GPU-28

Local

Table 4.31: Yield and economics of green Chilli varieties – Bengaluru

Variety	Fruit yield (kg/ha) 2015	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Samruddhi	4626	29031	40359	2.39	8.78
Chikaballapura local	2510	29031	8619	1.30	4.78

Chilli Cv. Samruddhi

Chilli Cv. Chikkaballapura local

Among the 4 varieties of groundnut assessed, GKVK-5 recorded higher pod yield (1270 kg/ha) and B:C ratio (2.13) followed by KCG-6 (1140 kg/ha and 1.91, respectively) and ICGV-91114 (1000 kg/ha and 1.68, respectively). (Table 4.32)

Table 4.32: Yield and economics of different groundnut varieties – Bengaluru

Variety	Pod yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain yield in 2015	Haulm yield				
GKVK-5	1270	1612	33206	37,450	2.13	2.31
ICGV 91114	1000	1484	33206	22,536	1.68	1.82
KCG-6	1140	1598	33206	30,293	1.91	2.07
TMV-2	774	1213	33206	9,971	1.30	1.41

4.4.2 Technology upscaling

Groundnut + pigeonpea intercropping (8:2) row proportion with moisture conservation furrow between paired rows of pigeonpea recorded higher groundnut pod equivalent yield (2168 kg/ha) with RWUE of 3.95 kg/ha-mm, net returns (Rs. 86707/ha) and B:C ratio (3.61) compared to farmers' practice (869 kg/ha) (Table 4.33)

Table 4.33: Yield and economics of groundnut + pigeonpea (8:2) intercropping system - Bengaluru

Treatment	Yield (kg/ha)			GNEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg /ha-mm)
	Main crop	Intercrop						
GN+PP (8:2)	864	717		2168	35,676	86,707	3.61	3.95
		Pigeonpea	42					
		Castor	17					
GN +*Akkadi*	729	Sorghum	24	869	33,206	15,225	1.46	1.58
		Field bean	19					
		Sesame	14					

GNEY: Groundnut equivalent yield; GN: Groundnut; PP: Pigeonpea

Groundnut + pigeonpea (8:2)

Groundnut + Akkadi (Farmers' practice)

In an assessment of castor + fingermillet intercropping system, higher castor bean equivalent yield (2318 kg/ha) was obtained in nipped castor + field bean intercropping (1:2) with B:C ratio of 4.32 as compared to sole nipped castor (1082 kg/ha) with B:C ratio of 2.48 (Table 4.34).

Table 4.34: Yield and economics of nipped castor + fingermillet intercropping - Bengaluru

Treatment	Yield (kg/ha)		CEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop					
Nipped castor + Finger millet (1:2)	2188	1001	2318	21455	71,259	4.32	3.57
Nipped castor (Sole)	-	1082	1082	17480	25,800	2.48	1.67

CEY: Castor equivalent yield

Nipped castor + finger millet (1:2)

Nipped castor (sole)

In an assessment of fingermillet based intercropping system, finger millet + field bean cropping system (4:1) resulted in higher finger millet equivalent yield (2414 kg/ha) and B:C ratio (1.93) compared to sole crop of finger millet (2138 kg/ha and 1.89, respectively) (Table 4.35)

Table 4.35: Yield and economics of finger millet + field bean (4:1) intercropping system - Bengaluru

Treatment	Yield (kg/ha)		FMEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop					
Finger millet + field bean (4:1)	1864	150	2414	27391	25,712	1.93	3.49
Sole finger millet	2138	-	2138	25206	24,470	1.89	3.08

Finger millet + field bean (4:1)

Sole finger millet

Hand weeders were demonstrated for weed control in finger millet + pigeonpea (8:2) intercropping system. Farmers are convinced with the technology as it reduces the time and drudgery (Table 4.36).

Table 4.36: Comparative performance of hand weeder as compared to traditional hand weeding

Particulars	Hand weeder	Hand weeding
Width coverage (cm)	20	-
Field capacity (ha/day)	0.27	0.03
Labour requirement (Man days/ha)	4	30
Labour saving (%)	85	-
Operational cost (Rs/ha)	760	5400
Net returns (Rs/ha)	57960	47816
B:C ratio	3.29	2.58

PP: pigeonpea, FM: finger millet, FB: field bean

In an on-farm assessment, application of alachlor followed by one hand weeding resulted in effective suppression of weeds and recorded higher groundnut pod equivalent yield (2247 kg/ha) and B:C ratio (3.83) compared to farmers' practice (2101 kg/ha and 3.52 respectively) (Table 4.37).

Table 4.37: Yield and economics of groundnut + pigeonpea intercropping system (8:2) under weed management practice - Bangalore

Treatment	Yield (kg/ha)		GEY	Cost of cultivation (Rs/ha)	NMR (Rs /ha)	B:C ratio	RWUE (kg/ha-mm)
	Groundnut	Pigeonpea					
Herbicide application (Alachlor) + 1 hand weeding	839	756	2247	32641	92,310	3.83	4.09
Farmers' practice	321	712	2101	33206	83,656	3.52	3.82

GEY: Groundnut equivalent yield

4.5 Chianki

(Gonda & Meral, Block: Garhwa, District: Jharkhand)

ORP village Gonda was delineated in to microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 1242 ha with an operational area of 197 ha and altitude varies from 240 – 257 m MSL (Fig. 4.5). At Gonda, the onset of monsoon was delayed by 13 days (23rd June). The annual rainfall was 823.3 mm, which was 20.2% deficit over the mean normal rainfall (1032 mm; 768 mm during kharif and 40.2 mm during rabi).

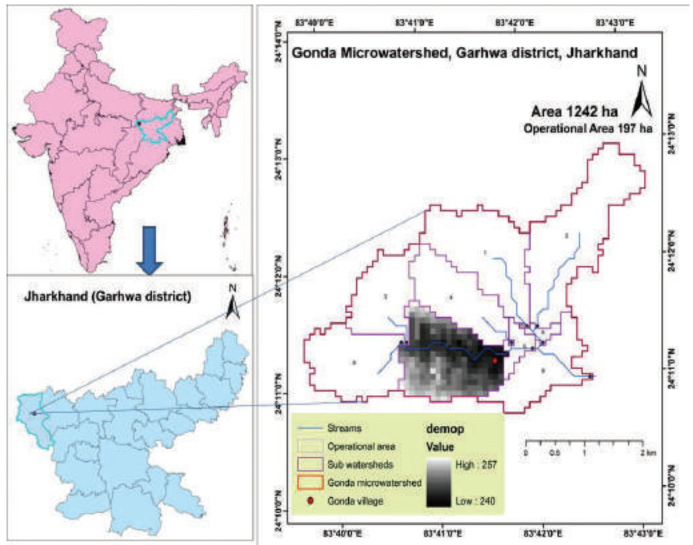


Fig. 4.5 Microwatershed with operational area, streams, village boundary and DEM

4.5.1 Participatory Technology Development

In an on-farm assessment of upland rice cultivation in bunded and unbunded plots at farmers' fields, bunded condition gave higher yield (2289 kg/ha) and the yield increased by 78% in comparison to unbunded condition (1285 kg/ha), with higher net returns, B:C ratio and RWUE of Rs. 18739/ha, 2.35 and 2.98 kg/ha-mm, respectively as compared to unbunded condition (Table 4.38).

Table 4.38: Yield and economics of upland rice var. Vandana in bunded and unbunded plots - Chianki

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw				
Bunded field	2289	3231	13850	18739	2.35	2.98
Unbunded field	1285	1850	10850	7550	1.70	1.67

Upland rice variety vandana in bunded field

Upland rice variety vandana in unbunded field

In an on-farm assessment of maize + pigeonpea intercropping (1:1), intercropping of maize with improved variety of pigeonpea (Bahar) produced higher pigeonpea equivalent yield (2489 kg/ha) whereas pigeonpea equivalent yield with intercropping of local varieties of maize and pigeonpea yielded 1581 kg/ha. With improved varieties, net returns, B:C ratio and RWUE were Rs. 55195/ha, 3.83 and 3.24, respectively (Table 4.39).

Table 4.39: Yield and economics of maize + pigeonpea intercropping (1:1) - Chianki

Treatment	Yield (kg/ha)		PEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop					
Maize (Kanchan) + pigeonpea (Bahar)	1822	2427	2489	19500	55195	3.83	3.24
Maize + pigeonpea with local varieties	1127	1652	1581	19500	45321	3.32	2.05

PEY: Pigeonpea equivalent yield

Maize (Kanchan) + pigeonpea (Bahar)

Maize + pigeonpea with local varieties

4.5.2 Technology Upscaling

In an on farm assessment of pigeonpea + okra intercropping (1:1) intercropping with improved varieties of pigeonpea (Bahar) and okra (SG-597) produced higher pigeonpea equivalent yield (3306 kg/ha) with net returns, B:C ratio and RWUE of Rs.89205/ha, 3.20 and 4.12 kg/ha-mm, respectively compared to intercropping with local varieties of maize + pigeonpea (2066 kg/ha) (Table 4.40).

Table 4.40: Yield and economics of pigeonpea + okra intercropping system - Chianki

Treatment	Yield (kg/ha)		PEY	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop					
Pigeonpea (Bahar) + okra (SG-597)	1936	3653	3306	40500	89205	3.20	4.12
Pigeonpea + okra with local varieties	1125	2510	2066	35500	49206	2.38	2.69

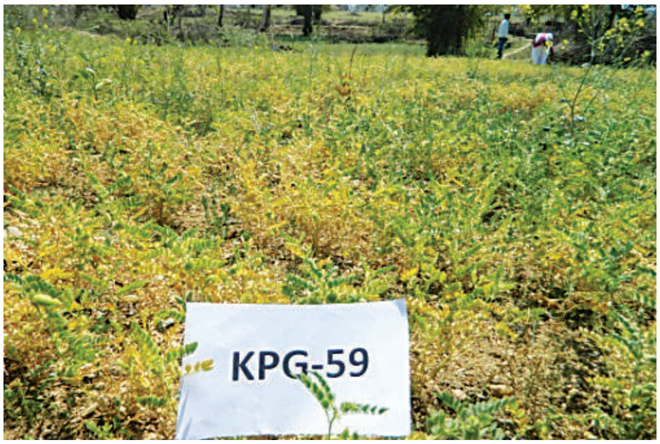
PEY: Pigeonpea equivalent yield

Pigeonpea (Bahar) + okra (SG-597)

In an assessment of chickpea cultivation as second crop after harvest of rice on residual moisture under minimum tillage conditions, the improved variety of chickpea KPG-59 gave higher seed and stover yield (1138 and 815 kg/ha) with net returns, B:C ratio and RWUE of Rs.34951/ha, 3.69 and 28.30 kg/ha-mm, respectively. The seed yield increased by 57.6% as compared to farmers' practice (722 kg/ha) (Table 4.41).

Table 4.41: Yield and economics of chickpea cultivation as second crop after harvest of rice - Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
KPG-59	1138	815	13000	34951	3.69	28.30
Local variety	722	516	11500	18928	2.64	17.96



Chickpea var. KPG-59

Farmers' practice (Local variety)

In an on-farm assessment of nutrient management in hybrid rice variety Arize Tej, maximum grain (5047 kg/ha) and straw yield (6020 kg/ha) was recorded with RDF (150:70:90) in medium land condition as compared to farmers' input level (110 N: 45 P2O5) (2207 kg/ha). Application of RDF also recorded higher net returns (Rs.63157 kg/ha), B:C ratio (4.38) and RWUE (6.49 kg/ha-mm). The yield increased by 128.6% as compared to farmers' practice (Table 4.42).

Table 4.42: Yield and economic analysis of medium land hybrid rice at farmer's input and RDF – Chianki

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw				
RDF (150:70:90)	5047	6020	18700	63157	4.38	6.49
Farmers input level (110 N: 45 P_2O_5)	2207	3418	16000	21734	2.63	2.35

Hybrid rice (Arize-Tej) under RDF

In an on-farm demonstration of sowing with implement in wheat, the maximum grain yield was recorded with the sowing by dutch hoe (3496 kg/ha), and the yield increased by 23% as compared to sowing by behind plough (2840 kg/ha) due to proper maintenance of depth and spacing of the seed. Similarly, net returns (Rs.37291 kg/ha) and B:C ratio (2.70) was higher with sowing using dutch hoe as compared with sowing by behind plough (Table 4.43).

Table 4.43: Comparison of sowing methods in Wheat (K-9107) – Chianki

Particulars	Behind plough	Dutch hoe
Grain yield (kg/ha)	2840	3496
Straw yield (kg/ha)	2785	3429
Cost of cultivation (Rs/ha)	19,000	22000
Net returns (Rs/ha)	29168	37291
B:C ratio	2.54	2.70


Sowing with dutch hoe plough


Sowing with behind

In an assessment of medium land improved and drought tolerant variety of rice (Sahabhagi Dhan) in farmers' fields, the variety gave higher yield (4076 kg/ha), net returns (Rs 49970/ha), B:C ratio (3.84) and RWUE (5.31 kg/ha-mm) in drought like situation as compared to local cultivar of farmers (2532 kg/ha) with net returns (Rs.28580/ha), B:C ratio (3.0) and RWUE (3.30 kg/ha-mm). The yield increased by 60.9% as compared to farmer's cultivar of rice (Table4.44).

Table 4.44: Yield and economics of medium land improved variety of rice (Sahabhagi Dhan) –Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw				
Sahabhagi Dhan	4076	5255	17600	49970	3.84	5.31
Local cultivar	2532	3716	14300	28580	3.0	3.30


Improved variety of rice (Sahabhagi Dhan)

In a participatory evaluation of hybrid rice, Arize Tej variety gave higher grain and straw yield (4836 kg/ha and 5471 kg/ha), net returns (Rs. 59952/ha), B:C ratio (4.21) and RWUE (6.30 kg/ha-mm) in drought like situation as compared to local cultivar of farmers (2368 kg/ha) with lower net returns (Rs 23066/ha), B:C ratio (2.44) and RWUE (3.08) kg/ha-mm (Table 4.45).

Table 4.45: Yield and economics of hybrid rice (Arije-Tej) - Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Straw				
Arize Tej	4836	5471	18700	59952	4.21	6.30
Local cultivar	2368	2957	16000	23066	2.44	3.08

Hybrid rice var. Arije-Tej

In an on-farm assessment of improved varieties/ hybrids of different kharif field crops, hybrid maize (Kanchan) gave maximum grain (3478 kg/ha) and stover (5267 kg/ha) yield, net returns (Rs.23912/ha), B:C ratio (2.55) and RWUE (4.53 kg/ha-mm), while local variety gave a seed yield of 1856 kg/ha with net returns of Rs. 7541/ha, B:C ratio of 1.56 and RWUE of 2.42 kg/ha-mm. The yield increased by 87 % as compared to farmers practice (Table 4.46).

Table 4.46: Performance of improved varieties/hybrids of kharif crops - Chianki

Crop	Variety/hybrid	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain/ seed	Straw/ stover				
Maize	Kanchan	3478	5267	15400	23912	2.55	4.53
	Local cultivar	1856	3124	13500	7541	1.56	2.42
Pigeonpea	Birsa Arhar-1	1768	4941	12500	68461	6.48	2.19
	Local variety	1054	2647	11500	36469	4.17	1.30

Hybrid maize (Kanchan)

Farmers's variety

Pigeonpea cultivar, Birsa Arhar-1 gave higher seed yield of 1768 kg/ha and stover yield of 4941 kg/ha, net returns of Rs. 68461/ha, B:C ratio of 6.48 and RWUE of 2.19 kg/ha-mm as compared to local variety. The yield increased by 68% as compared to local variety (1054 kg/ha).

Improved variety of pigeonpea (Birsa Arhar-1)

In an on-farm evaluation of sesame variety, shekhar gave higher seed yield (595 kg/ha) and stalk yield (2832 kg/ha), net returns (Rs. 12789/ha), B:C ratio (2.16) and RWUE (0.77 kg/ha-mm) and yield increased by 158.6% as compared to local variety (230 kg/ha) (Table 4.47).

Table 4.47: Yield and economics of improved variety of sesame - Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
Sesame (Shekhar)	595	2832	11000	12789	2.16	0.77
Local variety	230	1068	9000	200	1.02	0.29

Improved variety of sesame (Shekhar)

Improved variety of fingermillet (A-404) gave maximum mean grain yield of 1688 kg/ha with net returns of Rs. 13255/ha, B:C ratio of 2.20 and RWUE of 2.20 kg/ha-mm, while local variety gave lowest grain yield of 891 kg/ha with lower B:C ratio (1.44) and RWUE (1.16 kg/ha-mm) (Table 4.48).

Table 4.48: Yield and economic of improved variety of fingermillet (A-404) in farmer's field – Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
A-404	1688	3132	11000	13255	2.20	2.20
Local variety	891	2615	9000	3997	1.44	1.16

In sorghum, CSV-20 gave higher grain yield (2034 kg/ha), net returns (Rs.11174/ha), B:C ratio (1.89) and RWUE (2.65 kg/ha-mm) as compared to local variety (1177 kg/ha) (Table 4.49).

Improved variety of fingermillet (A-404)

Table 4.49: Yield and economic of sorghum (var. CSV-20) in farmers field – Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
CSV-20	2034	6525	12500	11174	1.89	2.65
Local variety	1177	3179	11000	1947	1.17	1.53

In blackgram, shekhar variety gave higher seed yield of 1393 kg/ha, with net returns of Rs. 54624 kg/ha, B:C ratio of 5.97 and RWUE of 1.81 kg/ha-mm and also the percent yield increased by 119% as compared to local variety (635 kg/ha) (Table 4.50).

Table 4.50: Yield and economic of improved variety of blackgram (Shekhar) at farmer's field – Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
Shekhar	1393	2937	11000	54624	5.97	1.81
Local variety	635	1479	9000	21054	3.33	0.82

In an evaluation of wheat cultivar, K-9107 gave higher grain yield (3267 kg/ha), net returns (Rs. 33697/ha) and B:C ratio (81.27 kg/ha-mm) and the yield increased by 47% compared to local variety (2230 kg/ha) (Table 4.51).

Table 4.51: Yield and economics of improved variety of wheat (K-9107) at farmer's field - Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:Cratio	RWUE (kg/ha-mm)
	Grain	straw				
K-9107	3267	3345	22000	33697	2.53	81.27
Local variety	2230	2513	20000	18476	1.92	55.47

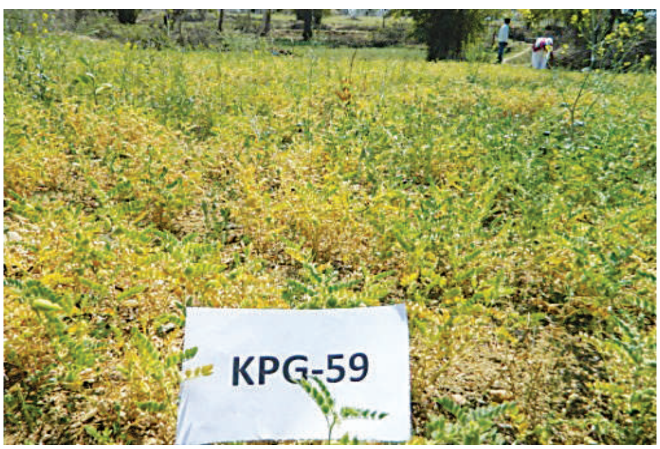
Improved variety of wheat (K-9107)

Local variety

Improved variety of chickpea (KPG-59) gave higher seed yield of 1141 kg/ha and the yield increased by 68% compared with local variety (680 kg/ha) with net returns of Rs. 34779/ha, B:C ratio of 3.68 and RWUE of 28.39 kg/ha-mm (Table 4.52).

Table 4.52: Yield and economics of improved variety of chickpea (KPG-59) at farmer's field - Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
KPG-59	1141	710	13000	34779	3.68	28.39
Local variety	680	523	11500	17269	2.50	16.91



Improved variety of gram (KPG-59)

Local variety

In an assessment of improved variety of lentil, KLS-218 gave higher seed yield (991 kg/ha) than local variety (523 kg/ha) with higher B:C ratio (2.35) and RWUE (24.66 kg/ha-mm) respectively (Table 4.53).

Table 4.53: Yield and economics of improved variety of lentil (KLS-218) at farmers filed - Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
Lentil (KLS-218)	991	619	13000	17608	2.35	24.66
Local variety	523	373	11000	5286	1.48	13.0

In an on-farm evaluation of mustard cultivar, Pusa bold gave higher seed yield (1110 kg/ha), net returns (Rs.27408/ha), B:C ratio (2.28) and RWUE (27.61 kg/ha-mm) than local variety (627 kg/ha) (Table 4.54).

Table 4.54: Yield and economics of improved variety of mustard (Pusa bold) at farmer's field -Chianki

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
Pusa bold	1110	2784	12000	27408	2.28	27.61
Local variety	627	1484	10000	12175	2.21	15.59

4.6 Hisar

(Chappar jogiyan, Bhiwani district, Haryana)

ORP village Chappar jogiyan was delineated in to microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 1690 ha with an operational area of 245 ha and altitude varies from 211 – 231 m MSL (Fig. 4.6). During 2015, in Budhshelly village, onset of monsoon was normal. A rainfall of 505.5 mm was received which was excess by 205.5 mm (68.5%) compared to normal of 300 mm. During kharif, 254 mm rainfall was received which was deficit by 43.3 mm (20.6%) than the normal rainfall of 210.7 mm; there was no rainfall during rabi season and in summer rainfall received was 232 mm which was excess by 188.9 mm than normal of 43.1 mm.

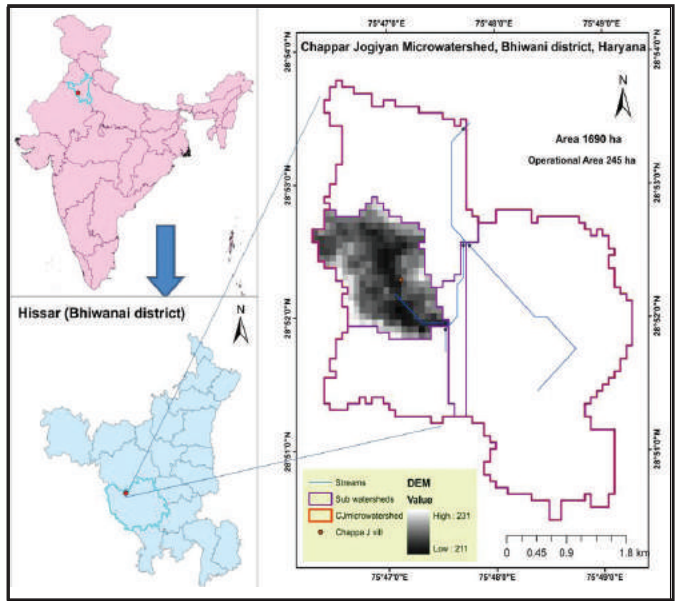


Fig. 4.6 Microwatershed with operational area, streams, village boundary and DEM

4.6.1 Participatory Technology Development

In an assessment of *in-situ* moisture conservation with disc harrow and country plough in mustard (RH 30), higher mean seed yield of mustard (1522 kg/ha) was recorded when soil moisture was conserved with disc harrow as compared to country plough (1338 kg/ha). The B:C ratio with disc harrow was also higher (2.92) as against country plough (2.50) (Table 4.55).

Mustard with disc harrow

Mustard with country plough

Table 4.55: Yield and economics of mustard (RH-30) as influenced by in-situ rainwater management -Hisar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed 2015	Mean (2 yrs)	stalk				
Disc harrow	1684	1522	4760	18950	36416	2.92	29.6*
Farmers' practice	1502	1338	4179	18950	28379	2.50	26.0*

*Includes one protective irrigation

In an on-farm assessment of pond silt application @ 40 t/ha in mustard 10.6% higher seed yield (1700 kg/ha) was recorded with pond silt application, as compared to untreated plot (1551kg/ha) with higher B:C ratio (2.78) and RWUE (30.7 kg/ha-mm) (Table 4.56).

Pond silt applied plot

Untreated plot

Table 4.56: Yield and economics of mustard (RH-30) as influenced by pond silt application-Hisar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed 2015	Mean (2 yrs)	stalk				
Pond silt @ 40 t/ha	1700	1576	4935	20050	35711	2.78	30.7*
Farmers' practice	1551	1425	4455	18950	31461	2.66	27.7*

*Includes one protective irrigation

The adoption of improved package of practices in clusterbean (HG 563) resulted in 25.1% increase in seed yield (598 kg/ha) over farmers' practices (478 kg/ha) with RWUE of 6.2 kg/ha-mm. Further, net returns and B:C ratio were also higher with recommended package of practices (Rs.8805/ha and 1.47) as compared to farmers' practices (Rs.5649/ha and 1.34, respectively). Similarly, in mungbean 102 kg/ha increase in seed yield was recorded due to adoption of full package of practices (462 kg/ha) with higher B:C ratio (1.37), net returns (Rs. 6144/ha) and RWUE (6.2 kg/ha-mm) as compared to farmers' practices (360 kg/ha) (Table 4.57).

Clusterbean with full package of practices

Clusterbean under farmers' practice

Mustard with package of practices

Mustard under farmers' practices

Table 4.57: Demonstration of improved practices of different crops - Hisar

Crop	Treatment	Seed yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		(2015)	Mean (2 yrs)	Stover/stalk				
Clusterbean	Improved practices	630	598	1471	18840	8805	1.47	6.2
	Farmers' practice	514	478	1179	16450	5649	1.34	4.9
Mungbean	Improved practices	464	462	1849	16610	6144	1.37	6.2
	Farmers' practice	361	360	1426	15480	2243	1.14	4.8
Chickpea	Improved practices	478	456	578	18120	-1916	0.89	14.59
	Farmers' practice	417	394	499	16870	-2870	0.83	12.61
Mustard	Improved practices	1667	1525	4652	18950	34883	2.84	29.7*
	Farmers' practice	1506	1364	4154	17690	30453	2.72	26.6*
Barley	Improved practices	1926	2059	5739	22440	16347	1.73	16.31*
	Farmers' practice	1508	1650	4589	20940	10117	1.48	13.07*

*Includes two protective irrigations

In chickpea, 15.7% increase in seed yield was recorded under recommended package of practices (456 kg/ha) over farmers' practices (394 kg/ha). About 11.7% increase in seed yield of mustard was recorded with full package of practices (1525 kg/ha) over farmers' practices (1364 kg/ha). Higher net returns (Rs.34883 kg/ha), B:C ratio (2.84) was also recorded with full package of practices as compared to farmers' practices. In barley, 24.8% increase in grain yield was recorded with full package of practices (2059 kg/ha) over farmers' practices (1650 kg/ha). Further, adoption of package of practices also recorded higher net returns (Rs.16347/ha) and B:C ratio of 1.73 as against Rs.10117/ha and 1.48 under farmers' practices.

4.6.2 Technology Upscaling

In a demonstration on seed inoculation with Azotobacter compared with and without fertilizer N in pearl millet and mustard, only 4.0% increase in grain yield of pearl millet while 2.1 % in seed yield of mustard was observed when 20 kg N/ ha + Azotobacter was applied over 20 kg N /ha and there was a very little difference in B:C ratio and RWUE. However, cost of bio-fertilizer was compensated in terms of higher net returns by Rs.976 in mustard (Table 4.58).

Table 4.58: Effect of nutrient management on yield and economics of pearl millet and mustard - Hisar

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain/ seed (2015)	Mean grain/ seed (2 yrs)	Stover/ stalk				
Pearl millet							
20 kg N/ha+*Azotobacter*	582	748	1914	18025	-5715	0.68	10.0
20 kg N/ha	555	719	1840	17975	-6142	0.66	9.6
Mustard							
20 kg N/ha+*Azotobacter*	1498	1394	4341	18900	30397	2.61	27.1*
20 kg N/ha	1471	1365	4250	18850	29421	2.56	26.6*

*Includes one protective irrigation

In an assessment of improved clusterbean variety, variety HG 563 (bold seed) recorded slightly higher seed yield (621 kg/ha) and B:C ratio (1.56) and RWUE (6.4 kg/ha-mm) as compared to HG 365 (593 kg/ha) (Table 4.59).

Table 4.59: performance of improved varieties/ hybrids of kharif crops-Hisar

Variety	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2015)	Mean (2 yrs)	Stalk				
HG-563	693	621	1525	18440	10267	1.56	6.4
Farmers' variety (HG-365)	662	593	1455	18440	8972	1.49	6.1

Among different varieties of rabi crops assessed, mustard variety RH 119 recorded highest seed yield (1523 kg/ha) and B:C ratio (2.84) followed by RH 406 (1493 kg/ha) with B:C ratio of 2.78, whereas RH 30 recorded the lowest seed yield (1449 kg/ha) and B:C ratio (2.70). Among chickpea varieties C-235 (drought tolerant) recorded higher mean seed yield (432 kg /ha) and B:C ratio (0.85) as compared to variety HC 1 (400 kg/ha) (Table 4.60).

Mustard var. RH-406

Mustard var. RH-119

Table 4.60: performance of improved varieties of *rabi* crops-Hisar

Variety	Yield (kg/ha)			Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2015)	Mean (2 yrs)	Stover/ stalk				
Mustard							
RH-406	1608	1493	4596	18950	33795	2.78	29.1*
RH-119	1636	1523	4641	18950	34807	2.84	29.6*
Farmers' variety (RH-30)	1566	1449	4530	18950	32310	2.70	28.2*
Chickpea							
C-235	439	432	545	18120	-2774	0.85	13.8
HC-1	402	400	503	18120	-3914	0.78	12.8

*Includes one protective irrigation

4.7 Indore

(Piploda Dwarakdheesh, Tehsil & District: Ujjain, MP)

ORP village Piploda Dwarakdheesh was delineated in to microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 2638 ha with an operational area of 513.5 ha respectively and altitude varies from 511 – 539 m MSL (Fig. 4.7).

At Piploda Dwarakdheesh, the onset of monsoon was at normal time (June). The annual rainfall was 1372 mm, which was 28.5 % excess over the mean normal rainfall (1067 mm). During the month of July, rainfall received 843 mm against normal of 374 mm in excesses of 125.4% with intensive runoff producing events. In spite of good rainfall, there was 3 dry spells (20, 10, 20 days in July, Aug and Sep) coinciding with flowering and grain setting stage of the crops resulted in slight reduction in yield.

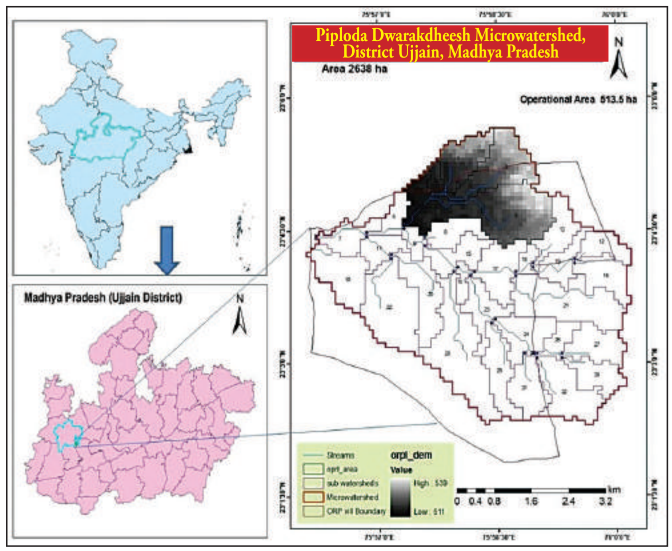


Fig. 4.7 Microwatershed with operational area, streams, village boundary and DEM

4.7.1 Participatory Technology Development

In an assessment of two systems of soybean planting with ridge – furrow system and broad bed – furrow system, for ridge and furrow system, regular seed drill available with the farmers was used by fixing V blade type sweeps in between the furrow openers which not only removes the weeds while sowing but also forms a shallow furrow in between two plant rows and put soils on the seed row from both sides to give it a sort of raised ridge shape. However, for broad bed – furrow system, a BBF planter was used. Ridge and furrow system was found superior (535 kg/ha) to BBF (Table 4.61).

Table 4.61: Effect of ridge and furrow system and BBF on crop yield in farmers field - Indore

Treatment	Seed/ yield (kg/ha)	Stover yield (kg/ha)
Ridge – furrow system	535	380
Broad bed – furrow system	399	299

BBF

Ridge and furrow

NRCS seed drill was assessed for sowing of soybean and power weeder for intercultural operation in soybean. The results of performance of NRCS seed drill as compared to local drill having fluted roller-seeding mechanism revealed that plant population/m row length was consistent with NRCS seed drill compared to local seed drill (Table 4.62).

Table 4.62: Comparison of NRCS seed drill with locally available seed drill - Indore

Particulars	NRCS drill	Local drill
Area Coverage (ha/hr)	0.45	0.30
Row spacing (cm)	30	30
Sowing depth (cm)	3	5
Labour requirement	1	1
Plant population/m row length	14 (consistent)	23 (non-consistent)
Seeding mechanism	Adjustable orifice	Fluted roller

NRCS seed drill for soybean

NRCS seed drill for Kabuli Channa

The implements like weeding hoes like cycle hoe, and hand hoes were adopted for interculturing operations on farmers' field and the benefits and the results of field trials indicated that cycle was more comfortable to use and involves less cost than other implements (Table 4.63).

Table 4.63: Performance of weeding implements in soybean - Indore

Particulars	Cycle hoe	Manual method	Hand hoe
Width of operation, cm	30	-	12
Area covered ha/ hr.	0.4	0.4	0.14
Cost of operation Rs/ha	250	1500	714
Operators comfort	More comfortable	-	Less comfortable
Drudgery	Less	Medium	More

In an evaluation of promising varieties of soybean, local variety despite abnormal monsoon, the seed yield recorded by all varieties were similar but superior to local. However, the farmers liked a new variety JS 2029 due to its four seeded pods (more than 50% pods having four seeds), higher yield, net returns and B:C ratio (Table 4.64). JS 9560 also possess four seeded pods, high yielding and matures 7 to 8 days earlier than local varieties and thus it suitable for the farmers willing to grow potato after soybean. In general, the yield of soybean was affected very badly due to adverse monsoon and prolonged dry spell during crop season.

Table 4.64: Performance of soybean varieties - Indore.

Variety	Seed yield	Stover yield	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
JS 2029	535	380	17000	20583	3583	1.21	0.39
JS 9560	409	299	17000	15892	-1108	0.93	0.30
JS 335	448	318	17000	17629	629	1.02	0.33
Local (farmers' variety)	399	297	16000	15763	-328	0.96	0.29

Soybean JS 2029

Soybean JS 335

4.8 Solapur

(Hingani, Satara district, Maharashtra)

ORP village Hingani was delineated into microwatershed for enhancing the resources use efficiency at cadastral level. The total microwatershed area is 2741.4 ha with an operational area of 1287.7 ha respectively and altitude varies from 589 – 705 m MSL (Fig. 4.8).

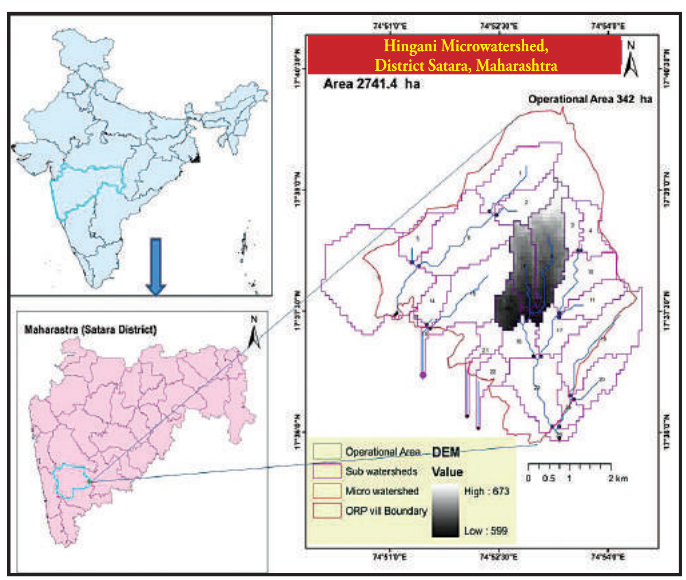


Fig. 4.8 Microwatershed with operational area, streams, village boundary and DEM

In Hingani in the year 2015, the onset of monsoon was normal (9th June) and 152 mm of rainfall was received which was deficit by 66% than average rainfall (450 mm). The total rainfall received in kharif was 123 mm and 29 mm in rabi. The yield of cowpea, blackgram, greengram, pearlmillet, sunflower, pigeonpea could not be harvested due to deficit rainfall. The sowing of the rabi crops was done on the deficit soil moisture and yield of rabi crop viz; sorghum, chickpea resulted in very poor growth.

4.8.1 Participatory Technology Development

In an assessment of in-situ moisture conservation measures on the yield of rabi sorghum, higher mean grain yield of 111 kg/ha was attained with compartmental bund treatment compared to farmers practice with a gain yield 45 kg/ha and fodder yield of 110 kg/ha and B:C ratio of 1.12 (Table 4.65). There was terminal drought at grand growth stage of rabi sorghum during 30 to 35 days after sowing which affected the yield.

Table 4.65: Effect of in-situ moisture conservation practices on yield of sorghum -Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Compartment bund in *kharif* season	111	271	6050	1571	1.25	0.97
Farmers' practice (Two harrowings)	45	110	4990	637	1.12	0.29

Compartmental bunding

In-situ moisture conservation in sorghum

In an assessment of rainwater harvesting in farm pond and efficient recycling on the yield of rabi sorghum, higher mean grain yield of 295 kg/ha, fodder yield of 826 kg/ha and B:C ratio of 1.58 were recorded with two protective irrigations at 30 and 65 DAS followed by one protective irrigation at 30 DAS compared to no irrigation (60 kg/ha) (Table 4.66).

Table 4.66: Performance of rabi sorghum under protective irrigation - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed/grain yield in 2015-16	Stover/ stalk yield				
One protective irrigation at 30 DAS	240	672	6980	3398	1.48	2.10
Two protective irrigation at 30 & 65 DAS	295	826	7110	4177	1.58	2.57
Farmers' practice (no irrigation)	60	168	4850	849	1.17	0.52

Rain water harvesting in farm pond and efficient recycling in rabi sorghum

In an assessment of application of tank silt on yield of rabi sorghum, tank silt application with ridges and furrows treatment gave higher grain yield of 210 kg/ha, stover yield of 588 kg/ha and B:C ratio of 1.36 compared to tank silt application without ridges and furrows (85 kg/ha) and farmers' practice (58 kg/ha) (Table 4.67).

Table 4.67: Effect of tank silt application on performance of sorghum - Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Application of tank silt	185	518	7890	2619	1.33	1.62
Application of tank silt + ridges and furrows	210	588	8750	3210	1.36	1.84
Farmers' practice (No tank silt and ridges & furrows)	58	190	4700	962	1.20	0.59


Sorghum in plots under tank silt


Sorghum in plots without tank silt

In an assessment of effect of crop residue on performance of rabi sorghum on farmers' fields, application of 50% N through FYM and 50% N through inorganics gave a maximum grain yield of 118 kg/ha and fodder yield 330 kg/ha followed by 100% N through inorganic fertilizer and no fertilizer treatment (Table 4.68).

Table 4.68: Response of rabi sorghum to application of crop residue – Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
50% N through FYM + 50% N through inorganic fertilizer	118	330	6680	1670	1.25	1.03
100% N through inorganic fertilizer	95	266	5900	1345	1.22	0.83
Farmers' practice (No fertilizer)	64	180	4420	906	1.20	0.56

In an assessment of the effect of foliar application of different chemicals on yield of chickpea on farmers' fields, application of 1% potassium nitrate at 30 and 45 days after sowing gave higher mean chickpea yield of 90 kg/ha as compared to farmers' practice with yield of 65 kg/ha (Table 4.69)

Table 4.69: Response of chickpea to foliar application of potassium nitrate -Solapur

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
1% potassium nitrate foliar spry at 30 & 45 DAS	90	207	5270	1800	1.34	0.78
Farmers' practice (no foliar spry)	65	150	4910	1223	1.24	0.57

4.8.2 Technology Upscaling

In an assessment of production potential of improved sorghum cultivars for medium and medium deep soils, variety phule suchitra gave higher mean grain yield 92 kg/ha than M-35-1 (65 kg/ha). On medium deep soil cultivar Phule revati recorded higher mean grain yield of 125 kg/ha than M-35-1 70 kg/ha (Table 4.70).

Table 4.70: Production potential of improved sorghum cultivars on medium and deep soils - Solapur

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed/grain yield in 2015-16	Stover/ stalk yield				
Medium soil						
Phule Suchitra	92	257	5780	1242	1.21	0.80
Farmers' variety (M 35-1)	62	174	4900	888	1.18	0.54
Deep soil						
Phule Revati	125	350	6250	1780	1.28	1.09
Farmers' variety (M 35-1)	70	200	4780	990	1.20	0.61

Evaluation of different implements for seeding and fertilization of rabi sorghum revealed that sowing with Solapur sheti yantra gave highest grain yield (95 kg/ha) and fodder yield (266 kg/ha) followed by sowing with two bowl ferti seed drill and sowing with single bowl ferti seed drill (Table 4.71).

Table 4.71: Performance of different ferti seed drill on yield 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				
Sowing with Solapur sheti yantra	95	266	6320	1345	1.21	0.83
Sowing with two bowl ferti seed drill	86	240	6000	1217	1.20	0.75
Farmers' practice (sowing with single bowl seed drill)	58	162	5120	821	1.16	0.50

Sowing with Solapur Sheti Yantra

Sowing with tTwo bowl ferti seed dril

5.1 National Innovations in Climate Resilient Agriculture (NICRA)

The AICRPDA-NICRA program, both on-station and on-farm is being implemented at 23 centers (Fig. 5.1.1) since 2011. The emphasis was continued on real time contingency crop plan implementation and preparedness to cope with weather aberrations with interventions such as rainwater harvesting (*in-situ* and *ex-situ*) and efficient use, drought tolerant crops/varieties, resilient crop management practices, and efficient energy management. The interventions to cope with delayed onset of monsoon and seasonal drought (early, mid season and terminal) were demonstrated in 1050 farmers' fields covering about 400 ha in 33 villages in 24 districts across 15 states.

Experienced weather at AICRPDA- NICRA villages during 2015-16

The onset of monsoon was delayed by more than two weeks in NICRA villages of Rajasamand and Solapur districts. Further, there were 4 to 6 dry spells at different stages of crops in NICRA villages of Lakhimpur (Assam), Garhwa (Jharkhand), Kandhamal (Odisha), Vijayapura (Karnataka) and Solapur (Maharashtra) districts (Table 5.1).

Fig. 5.1.1 Map showing locations of AICRPDA-NICRA villages

Table 5.1: Details of onset of monsoon in AICRPDA-NICRA villages (2015)

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

In general, the total rainfall during kharif season (June-September), 2015 was below normal in all NICRA villages except in Balawas & Budhshelly (Bhiwani), Kalimati (Banaskantha), Nignoti (Indore), Pata Meghpar (Jamnagar), Chikkamaranahalli (Bengaluru Rural) and Tahkapal (Bastar) (Fig 5.1.2). Similarly, during rabi season (October-December) 2015, the rainfall was less than normal seasonal rainfall in all NICRA villages except Vannedoddipally (Ananthapuramu), Muthukrishnapuram & Thoppureddipatti (Toothukkudi) and Chikkamaranahalli (Bengaluru Rural). During the period, no rainfall was received in 10 NICRA villages viz. Budhshelly (Bhiwani), Kochariya (Bhilwara), Lapsiya (Rajasmand), Nagla Dulhe Khan (Agra), Kalimati (Banaskantha), Narotewadi (Solapur), Nignoti (Indore), Pata Meghpar (Jamnagar), Kadesara Kalan (Lalitpur) and Hardoiya (Faizabad) (Fig 5.1.3).

The rainfall was deficit by 50-100% during June 2015 in NICRA-villages of Agra, Garhwa, Indore, Lalitpur, Toothukkudi, Samba, Rewa and Solapur districts. In July, the deficit in rainfall was more than 60% in villages of Agra, Akola, Vijayapur, Lalitpur, Toothukkudi, Parbhani and Solapur districts. Similarly, in August, villages in Bhilwara, Rajasmand, Faizabad, Bhiwani, Indore, Toothukkudi, Parbhani, Jamnagar, Banaskantha, Solapur and Mirzapur districts recorded more than 50% deficit rainfall. In September, NICRA villages in Bhilwara, Rajasmand, Lalitpur, Jamnagar and Solapur districts did not receive any rainfall while the villages in Faizabad, Rewa and Mirzapur received scanty (more than 90% deficit) rainfall. Similarly, in October, 11 villages in Agra, Akola, Bhilwara, Rajasmand, Faizabad, Bhiwani, Kandhamal, Jamnagar and Banaskantha districts did not receive any rainfall (Table 5.2).

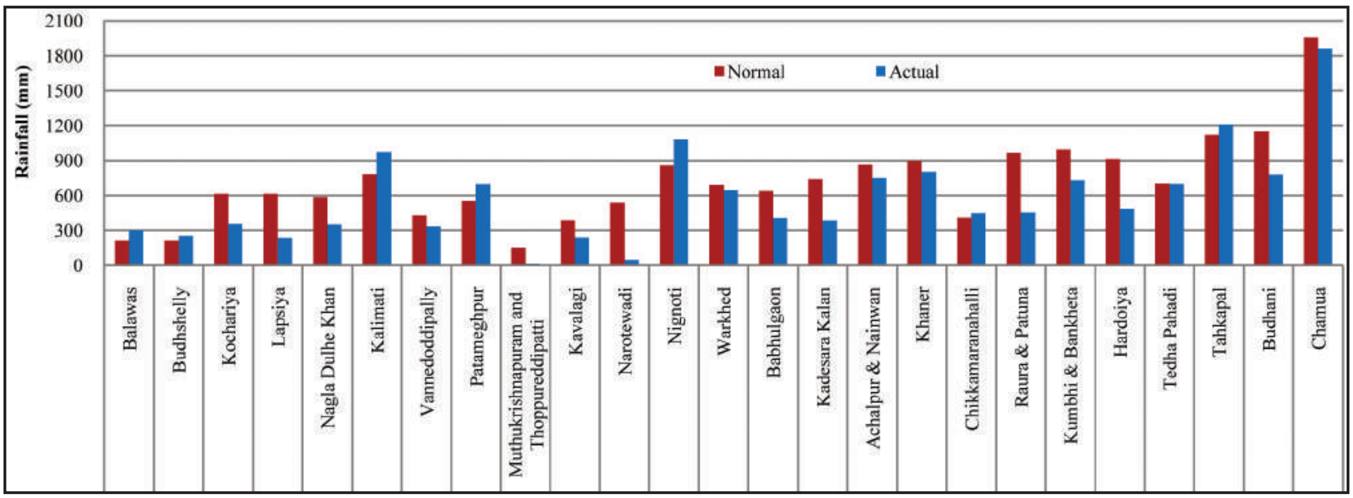


Fig 5.1.2: Normal and actual (2015) rainfall in AICRPDA-NICRA villages (June – September)

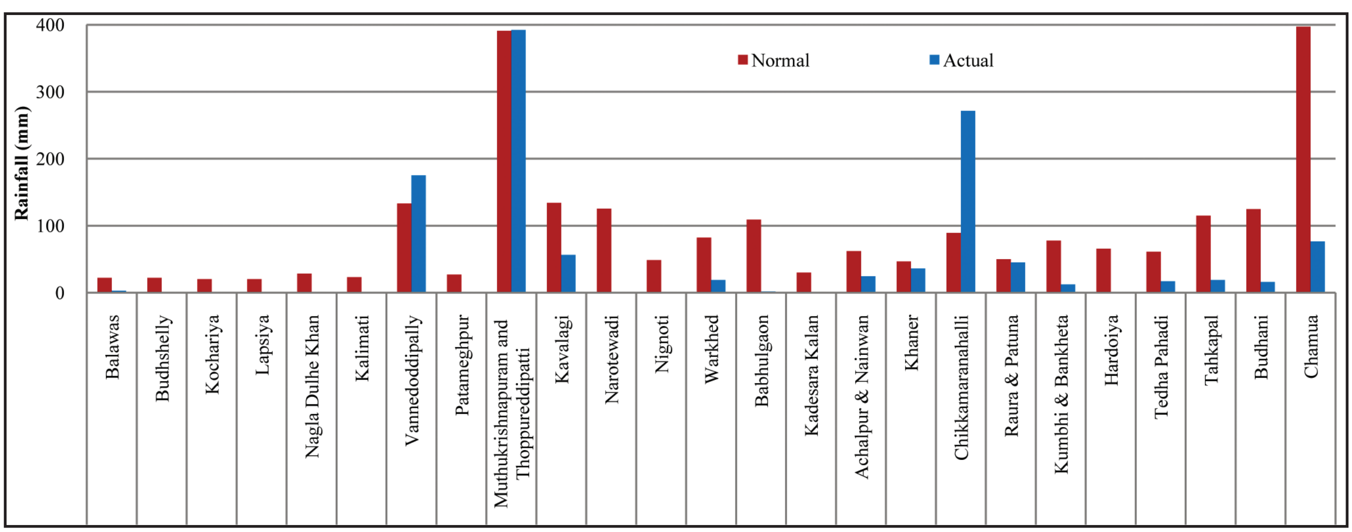


Fig 5.1.3: Normal and actual (2015) rainfall in AICRPDA-NICRA villages (October – December)

Table 5.2: Rainfall during June-December, 2015 in AICRPDA-NICRA villages

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

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

Salient achievements during 2015-16 under AICRPDA-NICRA are briefly presented below.

On-station research/demonstrations

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

At Varanasi, to cope with mid season drought in rice, foliar spray of 2% thiourea with micronutrients (Zn + Bo) @ 0.5% recorded higher yield (2400 kg/ha), net returns (Rs.18600/ha), B:C ratio (1.16) and RWUE (4.70 kg/ha) with yield increase of 11.6% over control (2150 kg/ha). Similarly, maize gave higher grain yield (2400 kg/ha) and the increase in yield was 45% over without foliar spray. At Ballowal Saunkhri, maximum maize seed yield (2979 kg/ha), straw yield (7438 kg/ha), RWUE (5.32 kg/ha-mm) and net returns (Rs.18603/ha) were recorded with crop residue mulching along with foliar spray of 1% KNO3 as compared to other contingency measures to cope with mid season drought.

At SK Nagar, to cope with terminal drought, supplemental irrigation of 50 mm with drip irrigation system at flowering to capsule development stage in castor recorded higher seed and stalk yields of 1055 and 1785 kg/ha, respectively with The higher net returns (Rs.23713/ha), B:C ratio (1.82) and RWUE (1.02 kg/ha-mm) over no supplemental irrigation (456 kg/ha).

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

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

Mango based agri-horti systems - Jagalpur, Chhattisgarh

On-farm demonstrations

I. Real-time contingency plan implementaion

a. Delayed onset of monsoon

At Kumbhi and Bankheta villages (Garhwa district, Jharkhand), under delayed onset of monsoon by 13 days, drought tolerant and short duration varieties gave higher yield and net returns as compared to local checks viz. rice cv. Arize Tej (3067 kg/ha, Rs 35071/ha); maize cv. Kanchan (3194 kg/ha, Rs 19954/ha); fingermillet cv. A-404 (1621 kg/ha, Rs 11687/ha); sesame cv. Shekhar (487 kg/ha, Rs 11867/ha) and blackgram cv. Birsa Urd-1 (1235 kg/ha, Rs 44578/ha). At Kalimati and Dholia villages (Banaskanta district, Gujarat), under delayed onset of monsoon by 31 days, pearlmillet hybrid GHB 558 recorded higher grain (445 kg/ha) and fodder (1215 kg/ha) yield with higher net returns (Rs.2070/ha) and B:C ratio (0.25) than GHB 538 (395 kg/ha). Similarly, greengram var. GM-4 recorded though low but higher seed and stover yield of 405 and 1030 kg/ha, respectively compared to GM-3 (325 kg/ha).

Rice (Arize Tej)- Kumbhi and Bankheta villages, Garhwa district, Jharkhand

Sesame cv. Shekhar- Kumbhi village, Garhwa district, Jharkhand

Pearlmillet- Kalimati, Banskanta district, Gujrat

b. Early season drought

At Tahkapal, Tandpal and Gumiyapal villages (Bastar district, Chhattisgarh), furrow opening in rice with country plough gave higher grain yield of 2230 kg/ha with net returns of Rs.10763/ha, B:C ratio of 1.67 and RWUE of 3.26 kg/ha-mm compared to without furrow opening (1202 kg/ha). At Ningnoti village (Indore district, Madhya Pradesh), seed yield of soybean cv. JS 93-05 increased by 8% (1060 kg/ha) with net returns of Rs 17920/ha and B:C ratio of 2.12 due to weeding/intercultural operation over without weeding (980 kg/ha). At Vannedoddipally village (Ananthapuramu district, Andhra Pradesh), in-situ moisture conservation with opening of conservation furrows 20 DAS improved yield in groundnut (5%), castor (11%), pigeonpea (9%) and cotton (6%) compared to without conservation furrows (1510, 460, 676 and 470 kg/ha, respectively). At Pata Meghapar (Jamnagar district), Gujarat the seed cotton yield (1850 kg/ha) was increased by 17% due to furrow opening (45 cm wide) 20 DAS for in-situ moisture conservation as compared to without furrow, with higher net returns (Rs.58575/ha), B:C ratio (2.00) and RWUE (3.15 kg/ha-mm).

Furrow opening in cotton at Pata Meghapar, Jamnagar district, Gujarat

Conservation furrow at Vannedoddipally, Kurnool district, Andhra Pradesh

In-situ moisture conservation with scooping in between rows at Tahkapal village, Bastar district, Chhattisgarh

c. Midseason drought

At Kavalagi village (Vijayapur district, Karnataka), foliar spray of KNO3 @ 0.5% during dry spell and urea @ 2% immediately after receipt of rains gave 19 and 27% higher yield of greengram (328 kg/ha) and pigeonpea (1000 kg/ha), respectively compared to without foliar spray with greengram and pigeonpea yield of 275 and 788 kg/ha, respectively. At Chamua village (Lakhimpur district, Assam), one supplemental irrigation from harvested rainwater in rapeseed gave 10% higher seed yield (1000 kg/ha) with net returns of Rs 13373/ha, B:C ratio of 1.82 and RWUE of 4.08 kg/ha-mm compared to rainfed crop (909 kg/ha). At Hardoiya village (Faizabad district, Uttar Pradesh), mulching with green leaves of subabool @ 10 t/ha in maize recorded 28% higher grain yield (1450 kg/ha) with net returns of Rs. 987/ha and B:C ratio of 1.05 compared to farmers' practice of no mulching (1140 kg/ha). At Tahkapal, Tandpal and Gumiyapal villages (Bastar district, Chhattisgarh), supplemental irrigation from harvested rainwater at flower initiation in rice with 2 cm depth of water gave higher grain yield of 1530 kg/ha, with net returns of Rs.42208/ha, B:C ratio of 3.22 and RWUE of 2.24 kg/ha-mm compared to without irrigation (1023 kg/ ha). At Budhadani village (Kandhamal district, Odisha), supplemental irrigation in rice from nearby water stream gave higher yield (2600 kg/ha), net returns (Rs.10000/ ha), B:C ratio (1.63) and RWUE (4.36 kg/ ha-mm) compared to rainfed rice (2200 kg/ha). At Terha Saraya Village (Mirzapur District, Uttar Pradesh), foliar spray of 2% thiourea with micronutrients 0.5% (Zn + Bo) in rice recorded higher yield (2400 kg/ha), net returns (Rs.18600/ha), B:C ratio (1.16) and RWUE (4.70 kg/ha) with yield increase of 11.6% over control (2150 kg/ha).

At Kochariya village (Bhilwara district, Rajasthan), foliar application of 2% KNO3 in maize gave 25% higher seed yield (878 kg/ha) over farmers' practice (704 kg/ ha) with higher net returns (Rs.14600/ha) and B:C ratio (1.21). At Nignoti village (Indore district, Madhya Pradesh), foliar spray of chlormequet chloride (VAM-C) 50 SL @ 375 ml/ha and thiourea @ 250 g/ha using 400 lit water/ha increased seed yield of soybean by 6-8% and 3-50% respectively over without foliar spray. At Pata Meghpar village (Jamnagar district, Gujarat), life saving irrigation of 30 mm applied in cotton increased seed cotton yield (2280 kg/ha), net returns (Rs.43300/ha), B:C ratio (1.36) and RWUE (2.21 kg/ ha-mm) compared to rainfed crop (1330 kg/ha).

Foliar spray of KNO3 @ 2% during midseason dry spell at Kochariya village (Bhilwara district, Rajasthan)

Furrow opening in cotton for in-situ moisture conservation - Babhulgaon village, Parbhani district, Maharashtra

Supplemental irrigation to groundnut from harvested rainwater in farm pond - Tahkapal (Bastar, Chhattisgarh)

d. Terminal drought

At Budhadani village (Kandhamal district, Odisha), maize (NMH -51) with supplemental irrigation gave the highest yield of 3000 kg/ha, net returns of Rs. 11000 / ha, B:C ratio of 1.58 compared to rainfed maize (2500 kg/ha). At Kalimati/Dholiya village (Banaskantha district, Gujarat), two supplemental irrigations given at flowering and capsule formation in castor recorded higher seed and stalk yields of 1170 and 2315 kg/ha, respectively over no irrigation. At Babulgaon village (Parbhani district, Maharashtra), supplemental irrigation (5 cm) from harvested rainwater with sprinklers increased pigeonpea seed yield by 78% (494 kg/ha) with net returns of Rs. 17016/ha, B:C ratio of 1.97 and RWUE of 1.73 kg/ha-mm over no irrigation (290 kg/ha).

Supplemental irrigation (drip) in castor (left) to cope with terminal drought at Kalimati/ Dholiya village, Banaskantha District (right: crop without irrigation)

II. Preparedness

The risk resilient rainfed technologies/practices were implemented as preparedness to cope with weather aberrations and the highlights are presented below.

a. Rainwater Management

At Kalimati/Dholiya village (Banaskantha district, Gujarat), even under delayed onset of monsoon for 31 days, *in-situ* moisture conservation with compartmental bunding in pearlmillet recorded significantly highest grain (1348 kg/ha) and fodder (3640 kg/ha) yields with higher net returns of (Rs.18222/ha), B:C ratio (1.87) and RWUE (1.39 kg/ ha-mm) compared to no compartmental bunding (870 kg/ha). At Ningnoti village (Indore district, Madhya Pradesh), sowing of soybean with broad bed furrow (BBF) planting system gave maximum yield (600 kg/ha) with net returns and B:C ratio of Rs. 3200/ha and 0.20 respectively compared to flat method of sowing (560 kg/ha). At Muthukrishnapuram village (Thoothukudi district, Tamil Nadu), adoption of BBF method for *in- situ* moisture conservation resulted in 12, 13 and 17% higher yield in maize (4360 kg/ha), greengram (710 kg/ha) and sorghum (2640 kg/ha), respectively compared to sowing on flat beds. At Babulgaon village (Parbhani district, Maharashtra), *in-situ* rainwater management with BBF in soybean (MAUS-71) gave higher seed yield (632 kg/ha), net returns (Rs.9024/ha), B:C ratio (1.61) and RWUE (2.21 kg/ha-mm) compared to flat bed method (487 kg/ ha).

Ridge furrow planting of castor (Kalimati/Dholia, Banaskanta district) and ridge planting of pearlmillet, Nagladulehkhan village, Agra district

b. Cropping systems

At Chamua village (Lakhimpur district, Assam), intercropping system of sesame + greengram (2:2) produced higher rice equivalent yield of 7902 kg/ha with net returns of Rs 67610/ha and B:C ratio of 6.9 compared to rice cultivation (1200 kg/ha). At Chikkamaranahalli village (Bengaluru rural district, Karnataka), pigeonpea (BRG-1) + field bean (HA-4) recorded higher pigeonpea seed equivalent yield (1030 kg/ha), RWUE (1.48 kg/ha-mm), net returns (Rs. 72773/ha) and B:C ratio (3.40) compared to farmers' practice of pigeonpea sole crop (795 kg/ha). At Nagla Dulhe Khan village (Agra District, Uttar Pradesh), pearlmillet + clusterbean (4:4) grown in strip cropping system recorded highest pearlmillet equivalent yield of 1163 kg/ha, net returns of Rs.3511/ha and B:C ratio of 1.23 compared to net returns of Rs. 464/ha and B:C ratio of 1.03 recorded with sole pearlmillet. At Kalimati/Dholiya village (Banaskantha district, Gujarat), cotton + greengram intercropping system (1:1) recorded significantly higher castor equivalent yield (1394 kg/ha) with higher RWUE (1.43 kg/ha), net returns (Rs.31872/ ha) and B:C ratio (2.05) over sole castor with yield of 911 kg/ha. At Muthukrishnapuram village (Thoothukudi district, Tamil Nadu), cotton + clusterbean intercropping system (2:2) recorded higher seed cotton equivalent yield (1563 kg/ha) with higher net returns (Rs.22730/ha) and B:C ratio of 1.53 .

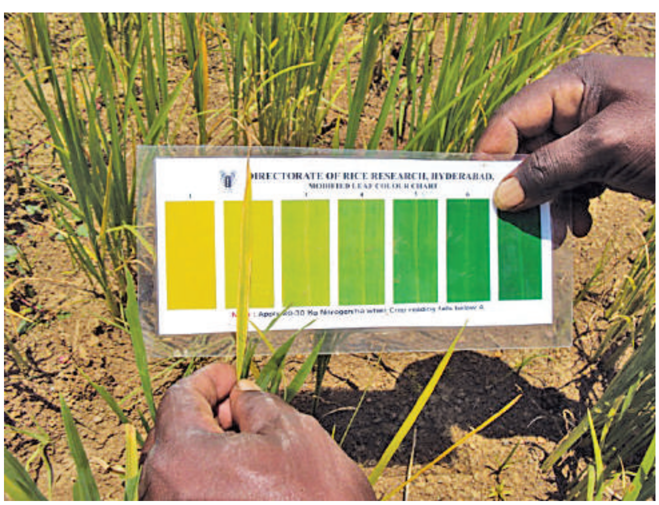
Pigeonpea (BRG 2) + field bean (1:1) – Chikkamaranahalli, Bengalure district, Karnataka

Cotton + greengram (1:1) - Kalimati/Dholiya, Banaskanta district, Gujarat

c. Nutrient management

At Chamua village (Lakhimpur district, Assam), application of N:P:K @ 20:20:10 kg/ha as basal dose followed by top dressing of 20 kg N in two equal splits at maximum tillering and panicle initiation stages and top dressing of 10 kg K at maximum tillering stage produced 38-43% higher grain yield of rice compared to farmers' practice of no fertilizer application, with higher net returns (Rs 35295/ha) and B:C ratio (2.7). At Kochariya village (Bhilwara district, Rajasthan), application of zinc sulphate @ 25 kg/ha gave 18% higher maize grain yield (888 kg/ha) over farmers' practice (760 kg/ha) with higher net returns (Rs.3827/ ha) and B:C ratio (1.26). At Achalpur and Nainwan villages (Hoshiarpur district, Punjab), application of N through combination of 75% inorganic + 25% organic source gave maximum yield (3580 and 3410 kg/ha), RWUE (52 and 49.5 kg/ha-mm) and net returns (Rs.34291 and Rs.31315/ha), respectively at Achalpur and Nainwan over farmers' practice of fertilizer application alone (2925 and 2825 kg/ha). At Babulgaon village (Parbhani district, Maharashtra), foliar spray of 19:19:19 (0.5%) in pigeonpea recorded higher seed yield (484 kg/ha), net returns (Rs.16422/ha), B:C ratio (1.94) and RWUE (1.70 kg/ha-mm) compared to farmers' practice of no foliar spray (436 kg/ha).

At Tahkapal, Tandpal and Gumiyapal villages, Bastar district, Chhattisgarh, among nutrient management in rice, Leaf Colour Chart (LCC = 2) based N application (N20 in 3 splits) recorded higher yield (3544 kg/ha), net returns (Rs.20028/ha), B:C ratio (1.89) and RWUE (4.22 kg/ha-mm).



Leaf Colour Chart as a decision tool for N application (Tahkapal village, Bastar district)

d. **Energy management**

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), sowing fingermillet with modified bullock drawn seed drill recorded higher grain yield (2500 kg/ha), net returns (Rs. 33072/ha) and B:C ratio (2.31) compared to farmer's practice (2356 kg/ha). At Kalimati/ Dholiya village (Banaskantha district, Gujarat), greengram sowing with roto till drill recorded significantly higher seed (665 kg/ha) and stover yield (1560 kg/ha) with higher net returns (Rs.43402/ha), B:C ratio (5.53) and RWUE (0.68 kg/ha-mm).

Sowing of greengram with zero till drill (Kalimati/Dholia, Banaskantha district)

e. **Alternate land use**

At Khaner village (Samba district, Jammu and Kashmir), the yield of mixed fodder on farmers' fields under aonla + mixed fodder system ranged from 21800 to 29000 kg/ha with mean yield of 24825 kg/ha and the net returns ranged from Rs.10409/ha to Rs.17609/ha with B:C ratio of 1.91 to 2.55. the soil moisture content was 0.35-0.5% higher in the plots under organic management during the crop season compared to integrated and inorganic treatments. Similarly, the soil temperature was lower under organic management by 0.7oC compared to other treatments. At Tahkapal village (Bastar district, Chhattisgarh), among mango (8-year old) based agri-horti systems, mango + colocasia intercrop recorded higher net returns (Rs.38506/ha), B:C ratio (2.94) and RWUE (2.68 kg/ha), compared to other systems.

Village Climate Risk Management Committee (VCRMC)

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

VCRMRC meeting at Kavalagi, Vijayapura, Karnataka

Custom Hiring Centres (CHCs)

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

Demonstration of operation of potato planter at Jinjia village, Biswanath Chariali (left), custom hiring centre at Narotewadi, Solapur district

Village Seed Bank

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

Collection of traditional rice varieties in Tahkapal village , Bastar district, Chhattisgarh

Fodder Bank

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

Setaria

Hydrid Napier (Var CO-2)

Congosignal

Oats

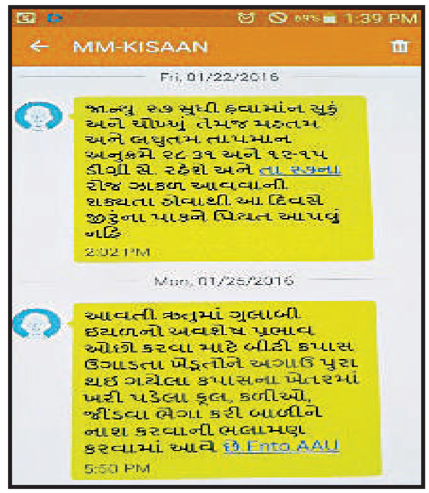
Hydrid Napier (Var CO -4)

Maize

Fodder species cultivated in Chamua village, Lakhimpur district

Agro-advisories

Real time contingency measures were advised for implementation in all the villages through display of weather information and agro-advisories on black boards, SMS service through mobiles and All India Radio. During 2015-16, Ananthapuramu, Agra, Faizabad, Bengaluru, Kovilpatti, Rajkot, Biswanath Chariali and Indore issued timely agro-advisories to farmers.



AAS disseminated in local vernacular language through cell phones

Soil Health Cards

Soil health cards were given to farmers in NICRA villages are to be used for site-specific nutrient management, nutritional sprays, and for maintaining soil health. Soil health cards issued by different centres during 2015- 16 include Anantapuramu (49 farmers), Arjia (40 farmers), SK Nagar (93 farmers), Faizabad (15 farmers), Kovilpatti (23 farmers), Jhansi (60 farmers), Vijayapura (46 farmers), Phulbani (40 farmers), Jagdalpur (86 farmers), Agra (40 farmers), Varanasi (30 farmers), Rewa (65 farmers) and Biswanath Chariali (14 farmers).

Sample soil health card issued by AICRPDA centres

Distribution of soil health cards in Vannedoddipalli, Anantapuramu district

5.2 Tribal Sub-Plan (TSP)

The TSP program is being implemented at 7 centres (Fig. 5.2.1)of AICRPDA *viz.* Arjia, Biswanath Chariali, Chianki, Indore, Jagdalpur, Phulbani and SK Nagar covering 20 tribal dominated villages across 8 districts in Rajasthan, Gujarat, Chattisgarh, Odisha, Madhya Pradesh, Assam and Jharkhand (Table 5.3). The main objective of the program is to directly benefit either individuals or community of tribal farmers through demonstration of improved natural resource management, crop based and livelihood interventions for higher productivity, income and employment generation, creation of physical assets and capacity building.

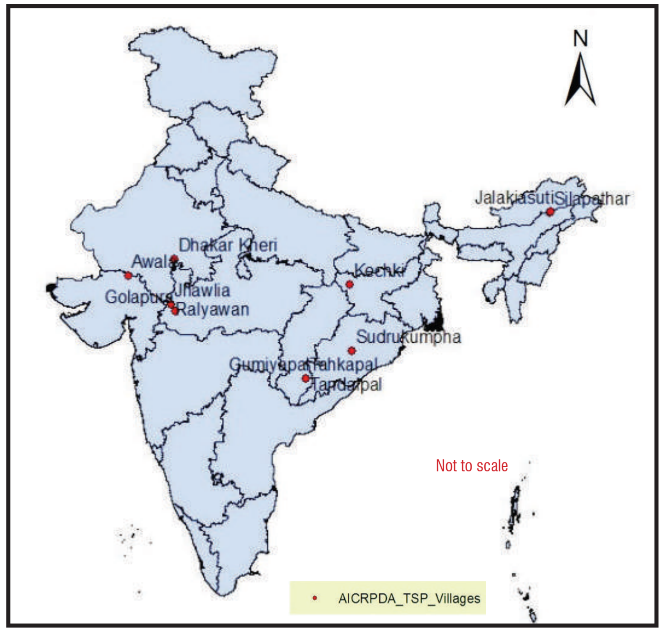


Fig. 5.2.1 Map showing locations of AICRPDA-TSP villages

Table 5.3 : Details of villages under AICRPDA-TSP programme

AICRPDA Centre	TSP villages	Block/ District/ State
Arjia	Dhakar Kheri,Barundani (Nalaka kuva &Nayaka) Beeramata & MalhiJhodia, Gutata rani NalakaJhoda	Syampura, Mohanpura blocks, Bhilwara, Rajasthan
Chianki	Kechki	Barwadih, Latehar, Jharkhand
Indore	Ralyawan	Petlawad, Jhabua, Madhya Pradesh
	Jhawlia , Golpura	Sardapur, Dhar, Madhya Pradesh
Phulbani	Dadaki, Sudrukumpha, Kumbhariguda	Phulbani, Kandhamal, Odisha
Biswanath Chariali	Jalakiasuti	Sissibor-gaon, Dhemaji, Assam
Jagdalpur	Tahkapal, Tandapal and Gumiyapal	Tokapal Bastar, Chattisgarh
SK Nagar	Juni Sarotri	Nandod, Narmada , Gujarat
	Awala and Arnivala	Amirgadh, Banaskantha, Gujarat

Interventions implemented in TSP adopted villages

The details of interventions during 2015-16 are given below:

a. NRM based interventions:

AICRPDA centre	TSP village	Name of the intervention	Crop	Area in ha	No. of tribal farmers benefitted
Arjia	Dhakar Kheri, Barundani	Ridge and furrow system	Maize	2	10
		Compartmental bunding	Maize	2	10
	Beeramata & MalhiJhodia, Gutata rani	Supplemental irrigation	Groundnut	4	50
			Maize	2	20
			Wheat	2.5	25
Biswanath Chariali	Jalakisutia	Mulching with paddy straw	Ginger	4.0	21
Indore	Jhawlia, Golpura	Sulphur application along with RDF	Soyabean	6.0	70
Jagdalpur	Tahkapal, Tandapal and Gumiyapal,	Bunding in fields	Onion	9.0	12
Phulbani	Dadaki, Sudrukumpha, Kumbhariguda	Summer ploughing and bund height raising in fields	Rice (Lalat and Sahabhagi)	7.5	15
SK Nagar	Awala and Arnivala	Drip irrigation system	Cotton	2	4

Compartmental bunding in Maize at Beeramata village, Bhilwara district, Rajasthan

Drip irrigation system for cotton in Awala and Arnivala villages, Banakanta district, Gujrat

b. Crop based interventions:

TSP centre	TSP village	Improved varieties/hybrids	Area (ha)	No. of tribal farmers benefitted
Arjia	Dhakar Kheri,Barundani	Maize (Bioseed-9881, Hybrid-937, PM-3)	2	10
		Blackgram (T-9, TAU-1, PU-31)	2	10
	Beeramata & MalhiJhodia, Gutata rani	Clusterbean (RGC-936,RGC 936, RGC-1003), sesame (RT-46,RT- 46), groundnut (TAG-24, TG37 A), soybean (JS-335), horsegram (AK-42)	10	50
Biswanath Chariali	Jalakisutia	Sali rice, maize, blackgram, toria, sesame, turmeric, ginger, tomato, potato and cabbage	4.0	25
Chianki	Kechki	Rice, maize, pigeonpea, wheat, chickpea, lentil and toria	10	260
Jagdalpur	Tahkapal, Tandapal and Gumiyapal,	Rice (MTU1010) and onion	17	23
SK Nagar	Awala and Arnivala	Hybrids of maize and cotton	6.5	26

Blackgram cv. PU31 at Barundani village, Bhilwara district, Rajasthan

Maize hybrid Kanchan at Kechki village, Latehar district, Jharkhand

c. Livelihood interventions:

TSP centre	TSP village	Livelihood intervention	No. of farmers benefitted
Biswanath Chariali	Jalakisutia	Mushroom cultivation, traditional handlooms and apiary	80
Chianki	Kechki	Vermi compost units, pisciculture, lac production and mushroom cultivation	50
Indore	Jhawlia, Golpura	Improved poultry birds	7
Jagdalpur	Tahkapal, Tandapal and Gumiyapal	Improved breeds of goats, cows, chicks and pigs	50

Mushrooms and silk worm rearing at Jalakisutia village, Dhemaji district, Assam

Sewing as livelihood activity, Kechki village, Latehar district, Jharkhand

d. Physical assets created:

Village/district	Details of the physical assets created	Number	No. of Beneficiaries
Jallamke Jhopdiya, Bhilwara	Vermicompost units	4	4
Nala ka kua, Bhilwara	Biogas plant	4	4
Jalakiasuti, Dhemaji	Bore wells	4	4
	Vermicompost units	32	32
	Renovation of community pond	1	All farmers
	Recharging of bore wells	3	3
	Power tiller	5	All farmers
	Pump sets	5	All farmers
Kechki, Latehar	Sprinkler system	1	1
	Vermicompost units (10 ft x 3 ft x 2.5 ft)	23	23
	Repairing the gate of Damdaha Dam	1	150
	Honeybee production units	5	5
	Mushroom production units	15	15
Ralyawan, Jhabua	Farm pond	1	1
	Recharging of wells	23	23
Tahkapal, Gumiyapal & Tandpal, Bastar	Farm ponds (12 m x 3 m x 3 m)	6	6
	Open ring tube wells	6	6
	Contour trenches	360 m	12
	Vermicompost units	7	7
	Stop dam	4	17
	Stone pitched well	1	3
	Zing terraces	2	2
	Gabion structures	15	Entire village
	Sunken ponds	16	Entire village
Dadaki, Kandhamal	Poultry breed (Vanaraja)	-	835

Impact of TSP programme:

The combined impact of implementation of TSP programme in 20 tribal villages with the participation of more than 20000 tribal farmers/women either resulted in improved seed replacement in large areas, creation of water assets for efficient utilization and crop diversification, sensitization and adoption of integrated crop management practices in filed and vegetable crops, awareness and operationalization of improved farm implements for small farm mechanization, promotion of integrated farming systems viz. crop-animal-other livelihood activities, improved animal health, creation of infrastructure facilities, enhanced skills and knowledge, environmental benefits through resource conservation etc. leading to higher productivity, profitability, employment generation and, ultimately the enhanced livelihoods of tribal families.

6. Publications

I. Research Papers Published in Journals

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V. Papers presented in seminars, symposium, conferences, workshops/meetings etc

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Agra		
Javed Ali, Singh SP and Singh PK. 2015. Studies on impact of improved dry land technology on rain fed pearl millet. An on –farm approach in south –western part of Agra district.	National Conference on Reinvigorating Agricultural Innovation for Farmers Empowerment and Development	3-4 May 2015, PJTSAU, Hyderabad
Rahul Pundir, Singh SB, Javed Ali and Singh SP. 2015. Studies on effect of inorganic fertilizer with and without organic sources on pearlmillet in pearl millet-wheat crop sequence in south-western part of U.P.	National Conference on Reinvigorating Agricultural Innovation for Farmers Empowerment and Development	3-4 May 2015, PJTSAU, Hyderabad
Singh PK, Javed Ali, Arvind Singh, Rajesh Kumar and Singh SP. 2015. Integrated production technologies for enhancing productivity of pearl millet under rainfed condition through farmers participated approach.	National Conference on Reinvigorating Agricultural Innovation for Farmers Empowerment and Development	3-4 May 2015, PJTSAU, Hyderabad
Singh SP, Singh PK, Arvind Singh, Javed Ali and Rahul Singh. 2015. Effect of moisture conservation practices and mode of nitrogen application on productivity and profitability of pearlmillet under semi-arid condition.	National Conference on Reinvigorating Agricultural Innovation for Farmers Empowerment and Development	3-4 May 2015, PJTSAU, Hyderabad
Singh SP, Singh PK, Arvind Singh, Javed Ali and Rahul Singh. 2015. Effect of potassium fertilization with different fertility levels on mustard (*Brassica juncea* L.) in light textured soil of south-western zone of Uttar Pradesh.	National Conference on Reinvigorating Agricultural Innovation for Farmers Empowerment and Development	3-4 May 2015, PJTSAU, Hyderabad
Akola		
Gabhane VV and Nagdeve MB. 2015. Soil related constraints and their management in dryland agriculture.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Gabhane VV, Ganvir MM, Nagdeve MB and Usha Satpute. 2015. Effect of conjoint use of glyricidia green leaf manure and chemical fertilizers on soybean yield and nutrient balance in vertisols of semi-arid conditions in Maharashtra.	National Seminar on Organic Ameliorants for Soil Resilience and Environmental Securities	19-21 August 2015, RVSKVV, Gwalior
Gabhane VV, Nagdeve MB, Ganvir MM and Turkhede AB. 2015. Soil fertility and crop productivity as influenced by integrated nutrient management in cotton-soybean rotation under Vertisols in semi arid agroecosystem of Maharashtra.	National Seminar on Issues, Challenges and Strategies in Sustaining Soil Health	10-11 December 2015, Kerla Forest Research Institute, Thrissur
Ganvir MM, Nagdeve MB, Karunakar AP, Patode RS, Sakhare SB and Vandana Mohod. 2015. Productivity of crops and intercropping systems in custard apple based agro horticulture system under dryland condition in Vidarbha.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola

Centre/ Authors/ Title of the paper	Symposium/Seminar Conference	Date and Venue
Megha Khambalkar, Gabhane VV, Nagdeve MB, Ghare AS, Chandel AC and Turkhede AB. 2015. Effect of integrated nutrient management on soil fertility and productivity of rainfed cotton in Vertisols.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Nilam Kanase, Gabhane VV, Konde NM and Paslawar AN. 2015. Effect of IPNS on productivity, residual soil fertility and nutrient use efficiency of soybean grown on Inceptisols under semi arid agroecosystem in Vidarbha.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Patode RS, Nagdeve MB and Ramanmohan Reddy K. 2015. Assessing water balance of a CCT treated micro-catchment.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Patode RS, Nagdeve MB and Ramanmohan Reddy K. 2015. Continuous contour trenches for enhancing soil moisture and growth of perennial plantation in micro-catchment.	National Conference on Water Environment and Society	30-31 July 2015, JNTU, Hyderabad
Pushpa Yadav, Konde NM, Gabhane VV, Nilam Konde, Goud VV and Age AB. 2015. Contribution of IPNS in sequestration of carbon under soybean-chickpea cropping system in Inceptisols.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Ranee Wankhade, Patode RS, Nagdeve MB and Gabhane VV. 2015. Monitoring of runoff and nutrient status of a CCT treated micro-catchment.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Sakhare SB, Nagdeve MB and Ganvir MM. 2015. Studies on moisture stress tolerance in cotton.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Shingne SD, Gabhane VV, Ashwini Chandel, Nagdeve MB and Ganvir MM. 2015. Long term effect of IPNS on soil fertility and productivity of cotton + greengram intercropping system in Vertisols.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Sonune BA, Gabhane VV, Kharche VK, Tamgadge DB and Mohod PV. 2015. Soil quality and rainfed cotton productivity under long term tillage and nutrient management on Vertisols in semi arid climatic conditions of Maharashtra.	National Seminar on Organic Ameliorants for Soil Resilience and Environmental Securities	19-21 August 2015, RVSKVV, Gwalior
Sonune BA, Gabhane VV, Mali DV, Jadhao SM, Mohod PV and Jadhao SD. 2015. Effect of nutrient management on yield sustainability of rainfed cotton and nutrient balance under minimum and conventional tillage on Vertisols of Maharashtra.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Sonune BA, Gabhane VV, Mali DV, Jadhao SM, Mohod PV and Tamgadge DB. 2015. Effect of nutrient management on soil quality and rainfed cotton productivity under tillage practices on Vertisols in semi arid climatic conditions of Maharashtra.	National Seminar on Issues, Challenges and Strategies in Sustaining Soil Health	10-11 December 2015, Kerla Forest Research Institute, Thrissur
Srinivasarao Ch, Sharma KL, Sumanta Kundu, Srinivas K and Gabhane VV. 2015. Nutrient management strategies in dryland agriculture.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola
Turkhede AB, Nagdeve MB, Karunakar AP, Gabhane VV, Mali RS and Palaspagar NR. 2015. Performance of intercrops in American cotton under dryland condition.	State Level Seminar on Soil and Water Quality: A Concern	2-3 November 2015, Dr PDKV, Akola

Centre/ Authors/ Title of the paper	Symposium/Seminar Conference	Date and Venue
Ballowal Saunkhri		
Anil Khokhar. 2015. Research achievement of NICRA on station and on-farm	National Workshop on Natural Resource Management for Climate Resilient Agriculture in Lower Himalayas	22 -23 December 2015, Regional Research Station, Ballowal Saunkhri
Manmohanjit Singh. 2015. Impact of improved production technologies on productivity enhancement of maize under rainfed conditions in *Kandi* region of Punjab.	4th Regional Co-ordination meeting of ICARDA-South Asia and China Regional Programme	Kathmandu, Nepal
Singh MJ, Kukal SS and Anil Khokhar. 2015. Soil and water conservation research in Shiwaliks of Punjab.	National Workshop on Natural Resource Management for Climate Resilient Agriculture in Lower Himalayas	22 -23 December 2015, Regional Research Station, Ballowal Saunkhri
Vijay Kumar, Singh MJ, Vivek Sharma, Anil Khokhar, Amit Salaria and Yogesh Khokhar. 2015. Problems and prospectus of farming in *kandi* region of Punjab.	National Workshop on Natural Resource Management for Climate Resilient Agriculture in Lower Himalayas	22 -23 December 2015, Regional Research Station, Ballowal Saunkhri
Vijay Kumar. 2015. Mitigation of drought stress effect on growth and productivity of rainfed maize by foliar application of different agrochemicals.	National Workshop on Natural Resource Management for Climate Resilient Agriculture in Lower Himalayas	22 -23 December 2015, Regional Research Station, Ballowal Saunkhri
Bengaluru		
Bhavitha NC, Sathish A, Shashidhara GC, Thimmegowda MN and Ashok EG. Soil fertility status under sustainable finger millet and pigeon pea mixed cropping system in *Alfisols*.	80th Annual Convention of Indian Society of Soil Science	5-8 December 2015
Ramachandrappa BK, Thimmegowda MN, Sathish A, Ravi Kumar HS, Dinesh Kumar SP, Savitha MS and Prashanth KM.2015.Effect of polymer hydrogels on growth, yield and economics of finger millet under rainfed condition.	National Conference on Reinvigorating Agricultural Innovations for Farmers' Empowerment and Development: Rainfed-2015	3-4 May 2015, PJTSAU, Hyderabad
Sathish A, Ramachandrappa BK, Thimmegowda MN, Savitha MS. And Prashanth KM. 2015. Levels of potassium and magnesium on soil properties, nutrient uptake and productivity of finger millet in *Alfisols*.	80th Annual Convention of Indian Society of Soil Science	5-8 December, 2015
Thimmegowda MN, Ramachandrappa BK, Devaraja K, Ravi Kumar HS, Anitha M and Savitha MS.2015. Catchment-storage-command relationship for enhancing water productivity through farm ponds in dry land conditions.	National Conference on Reinvigorating Agricultural Innovations for Farmers' Empowerment and Development: Rainfed-2015	3-4 May 2015, PJTSAU, Hyderabad

Centre/ Authors/ Title of the paper	Symposium/Seminar Conference	Date and Venue
Chianki		
Ahmad Ekhlaque, Ansari Abdul Majid, Paul A, Singh Munish Kumar and Singh DN. 2016). Combining ability and heterosis analysis for yield traits in linseed (*Linum usitatissimum* L.).	Innovative Breeding Approaches for Agricultural Security	13-14 March 2016, BAU, Ranchi
Ahmad Ekhlaque, Paul A, Singh Munish Kumar, Mahto Jaylal and Singh DN. 2016. Evaluation of ricebean genotypes under rainfed condition of Sub- Zone V of Jharkhand	National Conference on Agriculture and Rural Innovations for sustainable Empowerment	21-22 May 2016, Warangal
Ansari Abdul Majid, Kumar Anil, Ahmad Ekhlaque, Singh DN and Yadava MS. 2015. Guava based intercropping system as alternate land use of upland under Jharkhand	National Conference on Reinvigorating Agriculture Innovations for farmers Empowerment	3-4 May 2015, PJTSAU, Hyderabad
Ansari Abdul Majid, Singh DN, Ahmad Ekhlaque and Singh Munish Kumar. 2016. Pigeonpea and sorghum based intercropping system with vegetable crops under late sown condition	National Conference on Agriculture and Rural Innovations for Sustainable Empowerment	21-22 May 2016, Warangal
Paul A, Ahmad Ekhlaque, Singh DN and Singh, Munish Kumar. 2016. Genetic variability for grain yield and character association studies in Mustard (*Brassica juncea* L.)	National Seminar on Innovative Breeding Approaches for Agricultural Security organized by ISGBP Ranchi Chapter	13-14 March 2016, BAU, Ranchi
Singh DN, Ahmad Ekhlaque, Paul A and Singh Munish Kumar. 2016. Evaluation of sorghum genotypes suitable under dryland condition of Palamau region	Innovative Breeding Approaches for Agricultural Security	13-14 March 2016, BAU, Ranchi
Singh DN, Singh Munish Kumar, Ahmad Ekhlaque and Paul A. 2016. Evaluation of Safflower (*Carthamus tinctorius*) genotypes suitable for dry land condition of Jharkhand.	Innovative Breeding Approaches for Agricultural Security.	13-14 March 2016, BAU, Ranchi
Singh DN, Singh Munish Kumar, Ahmad Ekhlaque and Paul A. 2016. Genetic variability and yield component analysis of Niger (*Guizotia abyssinica* L.).	Innovative Breeding Approaches for Agricultural Security.	13-14 March 2016, BAU, Ranchi
Singh DN. 2015. Genotype X Environment interaction for yield and its components in upland rice (*Oryza sativa* L.)”	Ist International Conference on Agriculture and Horticulture Sciences	6-7 June 2015, New Delhi
Singh, Singh DN, Munish Kumar, Prasad Yogendra, Ahmad Ekhlaque, Paul A and Sah, A. 2015. Evaluation of drought tolerant safflower (*Carthamus tinctorius* L.) genotypes under dryland condition of Sub Zone - V of Jharkhand.	National Seminar on Dryland Agriculture in Vidarbha. Priorities and Development Issues	3-4 March 2015, Dr. PDKV, Akola
Singh, Singh DN, Munish Kumar, Prasad Yogendra, Ahmad Ekhlaque, Paul A and Sah, A. 2015. Evaluation of drought tolerant lentil (*Lens culinaris Medik*) genotypes under dryland condition of Sub Zone – V of Jharkhand.	National Seminar on Dryland Agriculture in Vidarbha. Priorities and Development Issues	3-4 March 2015, Dr. PDKV, Akola
Hisar		
Neelam, Sidhpuria MS, Hooda RS and Duhan Darshna. 2015. Identification of potential water harvesting sites using geo-informatics in Raitan sub watershed in Haryana, India	National Workshop on Space Technology and Archaeology	29-30 April 2015, Haryana Space Application Centre (HARSAC), Hisar

Centre/ Authors/ Title of the paper	Symposium/Seminar Conference	Date and Venue
Neelam, Sidhpuria MS, Hooda RS, Tamanna Garima and Arvind. 2015. Land use/land cover classification and identification of WHS using geo-informatics in Panchkula district, Haryana.	Geomatics 2015, National Conference	8-9 October 2015, M.D.S. University, Ajmer
Indore		
Argal SK and Jain MP. 2015. Effect of mulching on growth of fruit crops in dryland conditions of shallow and medium vertisols of western M.P.	National Seminar on Organic Ameliorants for Soil and Environmental Securities	19-21 August 2015, RVSKVV, Gwalior
Bharat Singh and Jain MP. 2015. Temperature trends and their impact on *rabi* crops in changing climatic scenario of Madhya Pradesh	Global Ravine Conference on Managing Ravines for food and Livelihood Security in India	7-10 March 2016, RVSKVV, Gwalior
Jain MP. 2015. Adaptation and mitigation strategies for climate change in drylands	National seminar on Climate Change and Smart Agriculture Technologies	13-14 June 2015, RVSKVV, Gwalior
Jain MP. 2015. Contingency planning for enhancing crop production and productivity in variable weather aberration conditions in MP	State Level Training Workshop on Mainstreaming Climate change in sectorial planning	22 April 2015, Bhopal
Singh Bharat, Paliwal Kiran, S Chauhan, Smriti and Upadhyay Ashish. 2015. Assessment of nutrient availability in different fertilization practices in Vertisol soil of soybean cropping system.	National Seminar on Organic Ameliorants for Soil Resilience and Environmental Securities	19-21 July 2015, RVSKVV, Gwalior
Singh Bharat, Paliwal Kiran, Upadhyay Ashish, Sharma SK, Jain MP and Chauhan Smiriti. 2015. Yield, available nutrient status, economics of soybean influenced by long term low till farming strategies.	80th Annual Convention of the Indian Society of Soil Science	5-8 December 2015, UAS, Bangalore
Thakur HS and Girothia OP. 2016. Effects of integrated nutrient management on sweet corn-chickpea cropping sequence under dryland Vertisol of Malawa plateau.	Global Revine conference on Manageing Ravines for Food and Livelihood Securities in India	07-10 March 2016, RVSKVV, Gwalior
Upadhyay Ashish, Paliwal Kiran, Sharma SK, Jain MP, Singh Vijay, KA and Chouhan Samriti. 2015. Effect of Integrated Nutrient Management on yield attributes nutrient status of Vertisols in soybean.	80th Annual Convention of the Indian Society of Soil Science	5-8 December 2015, UAS, Bangalore
Rajkot		
Sutaria GS, Vora VD and Akbari KN. 2015. Sulphur fractionation in medium black soils of Rajkot district, Gujarat	International Conference on Natural Resource Management for Food Security and Rural Livelihoods	10–13 February 2015, New Delhi
Vaghela TD and Vekariya PD. 2015. Weed management in summer cluster bean	25th Asian-Pacific Weed Science Society Conference	13-16 October 2015, Hyderabad

Centre/ Authors/ Title of the paper	Symposium/Seminar Conference	Date and Venue
Rewa		
Dubey R, Dubey DP and Chandawat RS. 2015. Organic farming – A ladder of sustainability of Indian agriculture.	National Seminar on Organic Ameliorants for Soil Resilience And Environment Securities	19-21 August 2015, RVSKVV, Gwalior
Solapur		
Amrutsagar VM and More NB. 2015. Dryland technology for Vidarbha region	National Seminar on Dryland Agriculture in Vidarbha: Priorities and Development Issues	3-4 march 2015, Solapur
Amrutsagar VM, Takate AS, Tamboli BD and Pawar AB. 2015. Effect of integrated phosphorus management on yield of pigeonpea under dryland conditions.	80th Annual Convention of Indian Society of Soil Science	5-8 December, 2015, UAS, Bangalore
Dhadge SM, Amrutsagar VM, Satpute NR, patil SV and Chary GR. 2015. Sutability of pigeonpea (*cajanus cajan* L.) based different intercropping systems under dryland condition of scarcity zone of Maharashtra	National Seminar on Dryland Agricluture in Vidarbha: Priorities & Development,	3-4 March 2015, Solapur
More NB, Archana Pawar and Amrutsagar VM. 2015. Tillage and residue retention for resource conservation for improving soil fertility and productivity of blackgram-*rabi* sorghum sequence in Inceptisol under dryland conditions	National Seminar on Dryland Agriculture in vidarbha: Priorities and Development Issues	3-4 march 2015, Solapur
Takate AS, Sheetal R. Tatpurkar, Rajguru AB and Amrutsagar VM. 2015. *In-situ* rainwater conservation techniques with integrated phosphorus management on moisture use efficiency and productivity of pigeonpea under dryland conditions	National Seminar on Organic Ameliorants for Soil Resilience & Environmental Securities	19-21 August, 2015, RVSKVV, Gwalior
Solapur ORP		
Bhanvase DB, Takate AS, Rajguru AB and Amrutsagar VM. 2015. *In -situ* rainwater management with integrated phosphorus management on yield of pigeonpea under rainfed conditions	State Level Seminar on Soil Health Awareness: A Prerequisite to Yield Sustainability" organized by Rahuri Chapter of ISSS	21-22 December 2015, MPKV, Rahuri
Thorve SB, Bhanavase DB,Upadhye SK, Amrutsagar VM, Ravindra Chary G. 2015. Enhancement in the productivity of *rabi* sorghum under dryland condition by adopting *in-situ* moisture conservation practices – A case study of Maniknal watershed	Two day National Conference on Water, Environment of Society	30-31 July 2015, Hyderabad

7. Technologies for assessment/upscaling

Bengaluru (for Southern dry zone of Karnataka)

- Nipped castor + fingermillet (1:2) intercropping system
- Tractor drawn rotovator for in-situ green manure incorporation for southern dry region of Karnataka
- Modified bullock drawn seed drill for sowing of fingermillet
- Model for Artificial recharging of borewells
- Site specific nutrient management and *in-situ* moisture conservation practices (conservation furrow) in rainfed fingermillet + pigeonpea intercropping system (8:2)
- Balanced nutrient management (recommended dose of nitrogen (50 kg/ha) and potassium (25 kg/ha) along with agriculture grade lime @ 300 kg/ha, magnesium carbonate @ 150 kg/ha and borax @ 10 kg/ha) in fingermillet

Ballowal Saunkhri (for Kandi region of Punjab)

- Vegetative barriers (Napier-Bajra hybrid) on field bunds for soil and water conservation under slopy land conditions
- Toria + gobhi sarson (1:1) intercropping system
- Seed priming and foliar spray of thiourea for rainfed wheat
- Reduced tillage for maize-wheat cropping system
- Sesame (*Sesamum indicum* L.) as an alternate crop during *kharif* season in wild/stray cattle menace prone areas
- Improved varieties of oilseed crops (sesame – Punjab Til No.2, RT 346; linseed- LC2063; raya RLM619, PBR 97 and taramira-TMLC2)
- Improved varieties of pulsecrops *viz.,* Greengram-PAU 911, ML 818; blackgram-Mash 114 and lentil-LL931, LL699
- Improved varieties of rainfed wheat *viz.,*PBW 644 & PBW 660

Biswanath Chariali (for North bank plain zone of Assam)

- Intercropping of greengram and blackgram with sesame (2:2)
- Seed priming (1% KH_2PO_4) for higher productivity of toria
- Foliar spray of potassium (2% KCl) for higher drought tolerance and nutrient use efficiency in toria

Kovilpatti (for Southern zone of Tamil Nadu)

- Broad bed and furrow technique for *in-situ* moisture conservation in rainfed maize
- Foliar spray of Mg and Zn for enhancing productivity of rainfed Bt cotton
- Pearlmillet as a contingent crop to cop with late onset of monsoon

Phulbani (for Eastern ghat zone of Odisha)

- Fertilizer scheduling in maize + cowpea (2:2) intercropping system
- Nutrient management (100% RDF (20:40:20 kg/ha)::N:$_p2O_5$:K_2O + Ca (PMS @ 5q/ha) + S (gypsum @ 30 kg S/ha) + B (Borax @ 12.5kg/ha) in groundnut

Parbhani (for Marathwada region of Maharashtra)

- Model for Artificial well recharge of open wells
- BBF planting of soybean with application of KNO_3 (1%) as stress management practice

Solapur (for Scarcity zone of Maharashtra)

- New horsegram variety *viz.,* Phule Sakas (SHG0628-4)
- Identified sorghum varieties for shallow, medium deep and deep black soils

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	√	√	√	√	-	√	√
Ballowal 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. Sahadeva Reddy	1
	M. Vijay Sankar Babu	5
	C. Radha Kumari	1
Ballowal Saunkhri	Manmohanjit Singh	1
Bengaluru	B.K. Ramachandrappa	2
Chianki	D.N. Singh	2
	Munish Kumar Singh	1
Indore	M.P. Jain	2
	H.S. Thakur	2
	B. Singh	1
Parbhani	B.V. Asewar	1
	A.K. Gore	1
	M.S. Pendke	1
	G.K. Gaikwad	1
Rajkot	V.N. Patel	1
Rakh Dhiansar	Vikas Abrol	2
	Jai Kumar	2
Rewa	D.P. Dubey	1
Solapur	S.M. Dhadge	1
	D. B. Bhanavase	3
	S. B. Thorve	4
Vijayapura	S.T. Hundekar	4
	V.S. Surakod	1
	B.C. Kolhar	1
	S.B. Devaranavadagi	1

c) TV talks

Centre	Resource person	No. of TV talks
Arjia	S.K. Dadhich	2
Anantapuramu	B. Sahadeva Reddy	1
	C. Radha Kumari	2
Bengaluru	B.K. Ramachandrappa	4
	M.N. Thimmegowda	4
	A. Sathish	3
Chianki	D.N. Singh	4
	Munish Kr. Singh	3
Indore	M.P. Jain	5
	H.S. Thakur	6
Parbhani	B.V. Asewar	1
Rajkot	V.D. Vora	1
Rakh Dhiansar	Jai Kumar	1

9. Workshops and Trainings

A. Workshop/Group Meetings/Brainstorming etc., organized

PC Unit

AICRPDA-NICRA Third Annual Review Workshop

The Third Annual Review Workshop of AICRP for Dryland Agriculture (AICRPDA) - National Innovations on Climate Resilient Agriculture (NICRA) network programme was held at AICRPDA Centre, Ananthapuramu, A.N.G.R. Agricultural University (ANGRAU) during 01-03 September, 2015 to review the progress achieved during 2014-15, both on-station and on-farm situations. The workshop was inaugurated by Dr. A. Padma Raju, Hon'ble Vice Chancellor, ANGRAU and presided over by Dr. K. Raja Reddy, Director of Research and Director of Extension I/c, ANGRAU. Dr. T. Ramesh Babu, Dean of PG Studies & Dean of Agriculture, ANGRAU, Dr. G. Ravindra Chary, Project Coordinator, AICRPDA , Dr. T. Yellamanda Reddy, Dean of Agriculture (Retd.), ANGRAU, and Dr. Y. Padmalatha, Associate Director of Research, Regional Agricultural Research Station, Nandyal, Scientists from 23 AICRPDA centres, scientists from ARS, Anantapuramu and PC Unit, AICRPDA, Hyderabad participated. The progress achieved under both on-station and on-farm conditions during 2014-15 was reviewed and the technical programme for 2015-16 was developed during the three-day workshop.

Dr A. Padma Raju addressing the participants

Felicitation of best dryland farmer

Visit of participants to on-station experiments

Two-day Vetting Workshop on Doable Rainfed Technologies in Maharashtra

A Two Day Vetting Workshop on Doable Rainfed Technologies in Maharashtra State was organized during 15-16 October, 2015 at ICAR-CRIDA. Sixteen scientists from three AICRPDA centres (Akola, Parbhani and Solapur) located in Maharastra participated.

One-day District Level Stakeholder Consultation Workshop

A one-day district level stakeholder consultation workshop was held at AICRPDA Centre, Ballowal Saunkhri (PAU) on 19th November 2015. Dr Ashok Kumar, Additional Director of Research, PAU, Dr. P.S. Aulakh, Additional Director of Extension, PAU, Dr G Ravindra Chary, Project Coordinator, AICRPDA, Hyderabad, Sh. Jagjit Singh, SDM, Balachaur, scientists from Regional Research Station, Ballowal Saunkhri, officials from line departments, Project Coordinators of KVKs, and farmers from the domain districts participated in the workshop. An action plan was developed for upscaling of rainfed technologies developed by AICRPDA centre, Ballowal Saunkhri for the domain districts of Hoshiarpur, Gurdaspur, Nawanshahr and Rupnagar located in Kandi region of Punjab.

Release of publications

Felicitation of best dryland farmer

XV Working Group Meeting of AICRPDA

The XV Working Group Meeting of All India Coordinated Research Project for Dryland Agriculture (AICRPDA), CRIDA, was held at AICRPDA centre, Biswanath Chariali, Assam Agriculture University during 24-27 December 2015. Dr. K. M. Bujarbaruah, Hon'ble Vice Chancellor, AAU, Dr. Ch. Srinivasa Rao, Director, CRIDA, Dr. G.N. Hazarika, Director of Research, AAU, Dr. D.K. Borah, Dean, Faculty of Agriculture, AAU, Dr. S.K. Sharma, Director, Central Research Institute for Arid Horticulture, Dr.J.J.R. Narware, Director, FMTTI, NEH Region, Dr. G. Ravindra Chary, Project Coordinator (Dryland Research), Dr. Basant Kandpal, Principal Scientist, NRM Division, ICAR, Dr. T.C. Baruah, Associate Dean, BN College of Agriculture, scientists from Tezpur University, AAU, AICPRs, CRIDA and 30 main/sub/ORP centres of AICRPDA network participated. The progress of research achieved during 2014-15 across 22 AICRPDA Centres and 8 ORP Centres was reviewed and developed technical programme for 2016-17.

Felicitation of Best Dryland Farmers during the workshop

Visit of participants to on-station experiments

AICRPDA-TSP Second National Review Workshop

A Two day AICRPDA-Tribal sub-plan (TSP) National Review Workshop was organized at AICRPDA centre, Arjia, MPUAT, Rajasthan during 1-2 March, 2016. Dr. Ch. Srinivasa Rao, Director, ICAR-CRIDA, Dr. G.S. Ameta, Director of Research, MPUAT, Dr. G. Ravindra Chary, Project Coordinator (Dryland Research), Dr. A.S Tiwari, Director of Extension, MPUAT, Dr. P.S. Dhakar, Director of Research, Agricultural University, Kota, JDA, Bhilwara, Deans and scientists from MPUAT and CRIDA, scientists from AICRPDA-TSP centres, PCs of 3 KVKs viz. Bhilwara, Chittorgarh and Rajasamand, officials of ATMA and state line departments and tribal farmers from Bhilwara district participated. The progress of work done during 2015-16 across 8 AICRPDA centres was reviewed during the two-day workshop.

Dr Ch. Srinivasa Rao, Director, CRIDA addressing the participants

Felicitation of best dryland farmer

Feedback by farmer from Naya Kua TSP village, Bhilwara District

Title	Date	Venue	Participants
Anantapuramuamu			
Seminar on Natural Resource Management for Climate Resilient Agriculture in Lower Himalayas	22-23 December, 2015	AICRPDA centre, Ballowal Saunkhri	110 participants from SAUs, KVKs and line departments
Bengaluru			
Hobli Level Contingency Plan Preparation for the State of Karnataka	20 June, 2015	UAS, Bengaluru	Officials of line departments and scientists of UAS, Bengaluru /Raichur/ Dharwad and Shivamogga

B. Workshops/Conferences/Seminars participated

Title	Date	Venue	Participants
Agra			
National Seminar on "Reinvigorating Agricultural Innovation For Farmers Empowerment and Development"	3-4 May, 2015	PJTSAU, Hyderabad	S.P. Singh
Anantapuramu			
National Seminar on Developments in Soil Science	6-8 December, 2015	GKVK, UAS, Bengaluru	M. Vijay Sankar Babu
25th Asian-Pacific Weed Science Society Conference	13-16 October 2015	Hyderabad, Telangana	K. Madhusudhan Reddy and B. Sahadeva Reddy
International Conference on Natural Resources Management – Ecological Perspectives	18-20 February, 2016	SKUAST, Jammu	M. Vijay Sankar Babu
Ballowal Saunkhri			
DST on Revival of Village Ponds	27-28 May, 2015	PAU, Ludhiana	Manmohanjit Singh
Bengaluru			
State Level Workshop on Agroforestry in Karnataka	10-11 September, 2015	Bengaluru, Karnataka	A. Satish
Biswanath Chariali			
Contingency Plan Vetting Workshop	21- 22 April, 2015	ICAR Research Complex for NEH Region, Umiam	P.K. Sarma, P. Neog, and P. Borah
Workshop on Updating of District level Agriculture Contingency Plans in Arunachal Pradesh	3-4 June, 2015	ICAR Research Complex for NEH Region, Basar, Arunachal Pradesh	P.K. Sarma and P. Neog
Annual Review Workshop on CRP Natural Fiber, Bhopal	08-11 March, 2016	CIAE, Bhopal	M.K. Sarma
Parbhani			
Workshop on Doable Rainfed Technologies for Marathwada Region	15-16 October, 2015	CRIDA, Hyderabad	B.V. Asewar and A.K. Gore
Rakh Dhiansar			
Brain Storming Session on Climate Change	19-20 May, 2015	Indian Institute of Integrative Medicines (IIIM), Jammu	Vikas Abrol

Title	Date	Venue	Participants
4th J&K Agricultural Science Congress	28-30 October, 2015	SKUAST-J, Jammu	Vikas Abrol, Brinder Singh and Jai Kumar
India International Science Festival and Young Scientists' Meet	4-8 December, 2015	IIT, New Delhi	Vikas Abrol
25th Asian-Pacific Weed Science Society Conference	13-16 October, 2015	PJTSAU, Hyderabad	Jai Kumar, and A.P Singh
International Conference on Natural Resource Management: Ecological Perspective	18 -20 February, 2016	SKUAST-Jammu	Vikas Abrol, A.K. Sharma, Brinder Singh, and Jai Kumar
Solapur			
Fruit cracking and Soil Health Management in Pomegranate	3 October, 2015	NRCP, Solapur	V.M. Amrutsagar and B. Najan
Drought mitigation practices to be adopted for *rabi* crops and how to maintain the milk production under less fodder production	8 October, 2015	Ekhatpur Tal. Sangola, Dist. Solapur	V. M. Amrutsagar
Vijayapura			
Planning and Implementation Workshop on CRP on Climate Change, Agriculture and Food Security (CCAFS)	4 April, 2015	ICRISAT, Hyderabad	M.S. Shirahatti
Grape and Pomegranate Workshop	5 June, 2015	Vijayapura	S.T.Hundekar

C. Trainings attended

Title	Date	Venue	Participants
Arjia			
Summer School on "Advances in pest forecast models and decision support systems for crop production in changing climate scenario"	03-24 August, 2015	MPUAT, Udaipur	R.K. Sharma
Winter School on "Entrepreneurship among Rural Community for Sustainable Development"	2- 22 December, 2015	MPUAT, Udaipur	J.K. Balyan
Ballowal Saunkhri			
Tillage and nutrient dynamics for better crop production	10-30 October, 2015	GBPUAT, Pantnagar	Anil Khokhar
Advances and accomplishments of innovative resistance breeding techniques in crop improvement	28 January to 17 February, 2016	TNAU, Coimbatore	Vijay Kumar
Parbhani			
ICAR Short course on Micro-irrigation and fertigation technology for enhancing input use efficiency	23 November to 2 December, 2015	VNMKV, Parbhani	A.K. Gore

D. Trainings organized

Title	Date	Venue	Participants
Anantapuramu			
Pre season training on improved dryland technologies	15 June, 2015	ARS, Anantapuramu	85 farmers
Soil health management through STBF	05 February, 2016	ARS, Anantapuramu	124 farmers

Title	Date	Venue	Participants
Arjia			
Improved dryland technologies	22 May, 2015	DFRS, Arjia	30 farmers
Improved seed production of *kharif* crops	23 May, 2015	DFRS, Arjia	30 farmers
Pre-seasonal training on Arid Legume crops (*kharif*)	27 May, 2015	Bhesalkunda, Suwana	50 farmers
Pre-seasonal training on *kharif* crops	09 June, 2015	Nevria, Rashmi, Chittorgarh	85 farmers
Improved seed production technologies for *kharif* crops	25 June, 2015	DFRS, Arjia	82 farmers
kharif crops production technologies	25 June, 2015	Nevria, Rashmi, Chittorgarh	105 farmers
Pre-seasonal training for *kharif* crops	26 June, 2015	Amargarh, Jhajpur	95 farmers
Pre-seasonal training on *Kharif* crops and production technology	27 June, 2015	Barundni, Mandalgarh	86 farmers
Training on Biogas	15 September, 2015	Naya Kua, Mandalgarh	104 farmers
Soil health	04 September, 2015	Mahua Khurd, Banera	115 farmers
Improved production technology of Tulsi	19 November, 2015	Nevria, Rasmi	45 farmers
Water management in dryland agriculture to enhance crop production	26-27 November, 2015	DFRS, Arjia	30 farmers
Pulse and oilseed crop production	11-12 December, 2015	DFRS, Arjia	31 farmers
Soil Health	28-29 December, 2015	DFRS,Arjia	19 farmers
Pulse crop production	11-12 January, 2016	DFRS, Arjia	30 farmers
Dryland technology	12 January, 2016	DFRS, Arjia	70 farmers
Integrated nutrient management in pulse crops	19-20 March, 2016	Surendrpura, Suwana	81 farmers
Ballowal Saunkhri			
Medicinal and Aromatic plant plantation Techniques programme and its uses	29-30 March, 2016	ZARS, Solapur	50 farmers
Bengaluru			
One day *Kharif* planning meeting cum training and launching of new ORP Site	29 May, 2015	Baichenahalli, Koratagare, Tumkur	49 farmers
One day training programme on Operational Research Project	16 June, 2015	Baichanahalli, Kortagere,Tumkur	48 farmers
Biswanath Chariali			
Improved cultivation practices of paddy	20 August, 2015	Chamua, Lakhimpur	28 farmers
Improved cultivation of potato	23 August, 2015	Chamua, Lakhimpur	25 farmers
Care and management of pigs	24 August, 2015	Chamua, Lakhimpur	23 farmers

Title	Date	Venue	Participants
Improved cultivation practices of banana	25 August, 2015	Chamua, Lakhimpur	21 farmers
Integrated farming system of livestock and fishery	26 August, 2015	Chamua, Lakhimpur	23 farmers
Preservation of seasonal vegetables by pickling	27 August, 2015	Chamua, Lakhimpur	25 farmers
Improved cultivation practices of blackgram	29 August, 2015	Chamua, Lakhimpur	22 farmers
Improved cultivation of oilseeds	31 August, 2015	Chamua, Lakhimpur	25 farmers
Chianki			
Training cum *kharif* seed distribution	15 July, 2015	Gonda, Meral, Garhwa	322 farmers
Management of *kharif* crops	24 September, 2015	Gonda, Meral, Garhwa	60 farmers
Training cum *rabi* seed distribution	28 October, 2015	Gonda, Meral, Garhwa	329 farmers
Scientific management of *rabi* crops	22 November, 2015	Gonda, Meral, Garhwa	91 farmers
Indore			
Integrated farming systems in irrigated and rainfed situations	10 April, 2015	Piploda dwarkad-heesh, Ujjain	45 farmers
Improved crop production technologies	23 July, 2015	Piploda dwarkad-heesh, Ujjain	30 farmers
Rainwater harvesting and its utilization	16 September, 2015	Piploda dwarkad-heesh, Ujjain	30 farmers
Soil testing	19 October, 2015	Golpura Village, Dhar	50 farmers
IFS and organic farming	01 December, 2015	Piploda dwarkad-heesh, Ujjain	35 farmers
Efficient management of Irrigation water in *rabi* crops	19 January, 2016	Golpura Village, Dhar	40 farmers
Nutrient management in pulse crops in *rabi* crops	17 February, 2016	Golpura Village, Dhar district	50 farmers
Precautions and storage of *rabi* crops after harvest	16 March, 2016	Golpura Village, Dhar district	50 farmers
Solapur			
Soil testing and *rabi* crop production	5 December, 2015	ZARS, Solapur	240 farmers

E. Meetings attended

Title	Date	Venue	Participants
Akola			
State Level Interface Meeting on "Operationalization of Agricultural Contingency Plans".	13 May, 2015	Pune	A. B. Turkhude and R. S. Patode
Documentation of work done under Jalyukt Shiver Abhiyan	23 June, 2015	Pune	M.B. Nagdeve

Title	Date	Venue	Participants
Arjia			
Interface Meeting on Enhancing the Preparedness of Agricultural Contingencies in *Kharif* 2015 for Rajasthan	5 June, 2015	Jaipur	A.K. Kothari, R.K. Sharma and J. K. Balyan
Bengaluru			
Interface meeting on "Enhancing the preparedness for Agricultural Contingencies in *Kharif* 2015 for Karnataka"	19 May, 2015	UAS, GKVK, Bengaluru	Scientists of AICRP-DA centre, Bengaluru
Zilla-panchayath farmers-scientists interaction on farmers' suicides	10 July, 2015	Mysore	B.K Ramachandrappa
Chianki			
Meeting of National Food Security Mission (NFSM)	14 April, 2015	ATMA, Latehar	D.N. Singh
Review Meeting of Krishak Rath	15 June, 2015	ATMA, Palamau	D.N. Singh
Interface Meeting on "Enhancing the Preparedness of Agricultural Contingencies" in *Kharif* -2015	22 June, 2015	Ranchi	D.N. Singh
Meeting of ATMA Management Committee (AMC)	17 August, 2015	ATMA, Palamau	D.N. Singh
Parbhani			
Contingency planning meeting	14 May, 2015	Pune	B.V. Asewar and M.S. Pendke
Contingency crop planning	16 July, 2015	Mumbai	B.V. Asewar
RKVY meeting	6 November, 2015	Directorate of Soil Conservation, Pune	M.S. Pendke
Phulbani			
Contingent plan meeting	09 June, 2015	Kandhamal	K. Bastia and S.K. Behera
Scientific Advisory Committee (SAC) meeting	16 July, 2015	KVK, Kandhamal	S. K. Behera
Rabi strategy meeting	07 November, 2015	Phulbani	D.K. Bastia & S. K. Behera
Solapur			
Meeting on enhancing the preparedness of Agriculture Contingencies in *Kharif*-2015	14 May, 2015	Pune	V.M. Amrutsagar, B.R. Najan and S.M. Dhadge
Vijayapura			
Consultation meeting on enhancing the preparedness for agricultural contingencies in *Kharif*- 2015	24 April, 2015	CRIDA, Hyderabad	M.S. Shirahatti

F. Field Days/Kisan Melas/Field Visits

Title	Date	Venue	Participants
Anantapuramu			
World Soil Day celebrations and distribution of soil health cards	5 December, 2015	Vannedoddi (ORP village)	90 farmers

Arjia			
Field day on potassium nitrate treatment in maize	10 October, 2015	Kochariya	67 farmers
Field day cum farmers training for *rabi* crop cultivation, importance of crop rotation, and Integrated pest management	13 October, 2015	Rerwas, Kotri, Bhilwara	96 farmers
Field day on intercropping	23 October, 2015	Naya Kua, Mandalgarh, Bhilwara	105 farmers
Bengaluru			
Field day in ORP village	21 October, 2015	Baichenahalli, Kortagarere, Tumkur district	80 farmers
Krishimela-2015	19 to 22 November, 2015	UAS, GKVK, Bengaluru	2 lakh farmers
Finger millet field day	19 December, 2015	Bidarahalli village, Bengaluru	50 farmers
Soil health management and sustainable finger millet production	31 December, 2015	Byalakere village, Bengaluru	60 farmers
Biswanath Chariali			
Farmers' fair	1 April, 2015	Jalakiasuti	347 Farmers
Farmers Field School on Scientific rearing of broiler	30 September, 2015	Chamua, Lakhimpur	20 Farmers
Techniques for preservation of fruits and vegetables	28-29 December, 2015	Chamua, Lakhimpur	31 Farmers
Cultivation practices for *rabi* vegetables	09 February, 2016	Chamua, Lakhimpur	27 Farmers
Indore			
Field day	12 May, 2015	Nignoti	22 farmers
Interaction of progressive farmers and scientists	19 May, 2015	Bisa Kheda	24 farmers
Care of *kharif* crops in moisture stress situations	02 July, 2015	TSP villages	22 farmers
Vermicomposting	07August, 2015	TSP villages	15 farmers
Vijayapura			
Krishimela	27-30 September, 2015	UAS, Dharwad	5 lakhs farmers/ extension functionaries
Krishimela	3-4 January, 2016	UAS campus, Vijayapura	20000 farmers/ extension functionaries
Rabi crops field day	17 December, 2015	Honwad	100 farmers/ extension functionaries
Kharif campaign	14 July, 2015	KVK, VIjayapura	500 farmers
Pigeonpea crop field day	1 January, 2016	Balaganur	45 farmers
Pigeonpea crop field day	12 January, 2016	Nandihal	50 farmers
Rabi campaign	11 March, 2016	KVK, VIjayapura	400 farmers

G. Trainings/Field Visits/Field Days organized under AICRPDA-NICRA Programme

The AICPDA-NICRA centres organized regular farmer- scientists-stakeholder meetings, sensitization of farmers about climate variability and its impact on agriculture and allied sectors and agro-advisories, pre and in-season trainings on improved rainfed technologies/best bet practices, field visits/field days for exposing the farmers and other stakeholders on performance of thematic interventions during weather aberrations. During the year, 67 trainings and field days/visits were organized by the centres which benefitted 3789 stakeholders including farmers.

Field day at Kochariya village, Bhilwara district

Farmers training at Pata Maghpar village, Jamnagar district

H. Trainings/Field Visits/Field Days organized under AICRPDA-TSP Programme

Name of TSP centre	TSP villages	Name of the training programme	Date	No. of tribal farmers benefitted
Arjia	Barundani	Improved production technologies	19/10/2015	575
	Beeramata	Exposure visit to NICRA and ORP villages	07//07/2015	250
Biswanath Chariali	Jalakisukia	Improved cultivation practices of paddy	20/08/2015	28
		Improved cultivation practices of potato	23/08/2015	25
		Care and management of pigs	24/08/2015	23
		Improved cultivation practices of banana	25/08/2015	21
	Silapathar	Integrated farming system of livestock and fishery	26/08/2015	23
		Preservation of seasonal vegetables by pickling	27/08/2015	25
		Improved cultivation practices of blackgram	29/082015	22
		Water management in vegetables	20/01/2015	70
		Care and maintenance of diesel engines	24/01/2015	50
Chianki	Kechki	Post harvest management of crops	26/03/2015	114
		Water management in cereal crops	14/05/2015	50
		Kharif crops management	06/07/2015	70
		Orchid management	04/08/2015	24
		Goatry and piggery	01/10/2015	23

Name of TSP centre	TSP villages	Name of the training programme	Date	No. of tribal farmers benefitted
Jagdalpur	Tahkapal	*Kharif* crop production	05/07/2015	34
		Rainwater utilization for crops	15/08/2015	32
		Water harvesting techniques	12/09/2015	45
		Rabi crop production	12/10/2015	43
		Vegetable production in *Badi* conditions	15/11/2015	23
		Post-harvest technology	11/12/2015	46
	Gumiyapal	Integrated pest management	31/08/2015	30
Indore	Golpura	Farmers sangoshthi	5/12/2015	35
		Farming system	01/1/ 2016	42
		Training on nutrient management in pulses	19 /1/2016	30
		Farmers sangosthi	07/01/2016	40
Phulbhani	Dadaki	Soil testing and soil health management	05/02/2015	50
		Value addition and post harvest technology	06/02/2015	50
SK Nagar	Kodata	Dryland technologies	02/01/2015	79
	Avala	Improved production technologies	20/01/2015	125

Farmers-Scientists interaction at Bhilwara – Arjia Centre

10. Success Stories

Agra

a *In-situ* moisture conservation (ridge planting) in pearlmillet

1.	Name of the farmer	:	Ashok Kumar, S/o. Sh. Hari Singh
2.	Address : Village - Jaupura; Post - Jaupura ; Tehsil - Agra Sadar ; District - Agra ; State -Uttar Pradesh		
3.	Contact details	:	9627375544
4.	Details of the farm (size, location, water availability etc.)	:	0.8 ha
5.	Membership in Self-Help Group, Producers Cooperative / Company, Cooperative Society, etc.,	:	Cooperative society. Farmer's school club of State Agril. Dept., Agra
6.	Names of the central sector / State Schemes utilized by the farmers and the period	:	State Dept. of Agriculture / ATMA
7.	Technologies / Good Agricultural Practices / facilities / Benefits obtained with details	:	Planting of pearlmillet on the shoulder of ridge, with ridger seeder in kharif season. Use of improved variety Pro-agro-9330, Fertilizer: 60:40 kg N & P/ha.

8. Details of results obtained due to the adoption of technologies			**Improved/present production technologies**	**Traditional / past production practices**
i) Productivity (kg/ha)	Grain	:	3266	2311
	Fodder		8374	7787
ii) Cost of production (Rs/ha)		:	12853	12477
iii) Net income (Rs/ha)		:	19097	12664
iv) Price realized (Rs/q.)	Grain	:	670	670
	Fodder		125	125
v) Natural resources saved / conserved like soil, water etc.		:	More rainwater conserved in furrows	

9.	Marketing Strategy-Access to market (through private, cooperative, contract farming etc.)	:	Private
10.	Factors contributing to success	:	Less labor required, easy for operation

b. *In-situ* moisture conservation (deep tillage + compartmental bunding) in pearlmillet

1.	Name of the farmer	Pooran Singh
2.	Address : Village-Nagla Emli ; Post -Nagla Emli; Tehsil-Kheragarh ; District-Agra; State - Uttar Pradesh	
3.	Details of the farm (size, location, water availability etc.)	0.4 ha : Community check dam
4.	Membership in Self-Help Group, Producers Cooperative / Company, Cooperative Society, etc.,	Cooperative society
5.	Names of the central sector / State Schemes utilized by the farmer and the period	AICRPDA Centre, Agra
6.	Technologies / Good Agricultural Practices / facilities / Benefits obtained with details	Improved variety of pearlmillet (Pro-agro-9330) with compartmental bunding (6.0 m x 4.5 m) prepared with bund maker at the time of sowing

7. Details of results obtained due to the adoption of technologies	**Improved /present production technologies**	**Traditional/past production practices**
i) Productivity (kg/ha)	1810	1120
ii) Cost of production (Rs/ha)	7010	6502
iii) Net income (Rs/ha)	8664	4578
iv) Price realized (Rs/q)	600	600
v) BC ratio	2.23	1.70
v) Natural resources saved / conserved like soil, water etc.	Soil and rainwater conservation with compartmental bunding	

8.	Marketing Strategy-Access to market (through private, cooperative, contract farming etc.)	Private
9.	Factors contributing to success	Compartmental bunding helps in in-situ moisture conservation and minimizes risk under aberrant weather conditions

c. *In-situ* moisture conservation for mustard

1.	Name of the farmer	:	Sh. Chetanya Singh
2.	Address : Village - Nagla Emli ; Post - Nagla Emli; Tehsil - Kheragarh ; District - Agra ; State - Uttar Pradesh		
3.	Details of the farm (size, location, water availability etc.)	:	0.4 ha, Community check dam
4.	Membership in Self-Help Group, Producers Cooperative / Company, Cooperative Society, etc.,	:	Cooperative society, Mewali
5.	Names of the central sector / State Schemes utilized by the farmer and the period	:	AICRPDA Centre, Agra
6.	Technologies / Good Agricultural Practices / facilities / Benefits obtained with details		In-situ rainwater conservation practices, i.e. tillage (10-12 cm depth) with disc harrow after each effective rainfall. Mustard sown on 45cm row spacing with recommended package of practices (60:40 kg NP/ha).

			Improved/present production technologies	Traditional/past production practices
7.	Details of results obtained due to the adoption of technologies			
i)	Productivity (kg/ha)	:	1710	1405
ii)	Cost of production (Rs/ha)	:	7368	6338
iii)	Net income (Rs/ha)	:	27000	22510
iv)	B:C ratio	:	4.72	4.55
v)	Natural resources saved / conserved like soil, water etc.		Soil & rainwater conservation	
8	Marketing Strategy-Access to market (through private, cooperative, contract farming etc.)		Private	
9.	Factors contributing to success		Ploughing (10-12cm depth) after each effective rainfall conserved more moisture in soil for rabi season.	

d. Balanced nutrition in pearlmillet

1.	Name of the farmer	:	Sh. Niranjan
2.	Address : Village - Nagla Emli ; Post - Nagla Emli; Tehsil - Kheragarh ; District - Agra ; State - Uttar Pradesh		
3.	Details of the farm (size, location, water availability etc.)	:	0.4 ha
4.	Membership in Self-Help Group, Producers Cooperative/Company, Cooperative Society, etc.,		Cooperative society, Ghusiyana
5.	Names of the central sector/State Schemes utilized by the farmer and the period		State Soil & Water conservation dept. made a check dam for collection of rainwater
6.	Technologies/Good Agricultural Practices/facilities/Benefits obtained with details		* Pearlmillet sown in 45 cm row spacing * Fertilizer (NPK kg/ha) 75:50:50 * Improved variety – Pro-agro 9330

			Improved/present production technologies	Traditional/past production practices
7.	Details of results obtained due to the adoption of technologies			
i)	Productivity (kg/ha)	:	3485	2320
ii)	Cost of production (Rs/ha)	:	10233	7299
iii)	Net income (Rs/ha)	:	17505	4908
iv)	B:C ratio	:	1.71	0.67
v)	Natural resources saved / conserved like soil, water etc.)	:	-	
8.	Marketing Strategy-Access to market (through private, cooperative, contract farming etc.)	:	Private	
9.	Factors contributing to success	:	-	

Anantapuramu

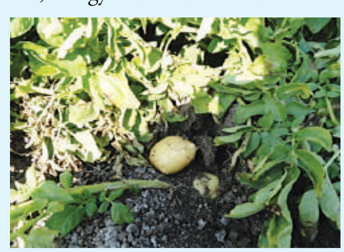
Sowing of castor with Anantha Planter

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 (size, location, water availability etc.)		10.0 ha	
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		Utilised services of custom hiring center of AICRPDA, ARS, Ananthapuramu	
7.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained with details		Sowing of castor with Ananta planter	
8.	Details of results obtained due to the adoption of technologies		**Improved / present production technologies**	**Traditional / past production practices**
	i) Productivity (kg/ha)	:	1006	768
	ii) Cost of production (Rs/ha)	:	9250	11600
	iii) Net income (Rs/ha)	:	28978	17584
	iv) Price realized (Rs. per ton)	:	38000	38000
	v) Natural Resources saved /conserved like soil, water etc.	:	Seed	-
9.	Marketing Strategy – Access to market (through private, cooperative, contract farming etc.)		Private	
10.	Factors contributing to success		Recommended seed rate (5 kg per ha) sown through Anantha planter which enabled to maintain optimum plant population, less cost of cultivation and drudgery reduction	

Indore

Modified ridge planter for potato sowing

1.	Name of the farmer	:	Shri. Prakash Singh Solanki	
2.	Address : Village - Nignoti ; Post - Nignoti ; Tehsil - Indore ; District - Indore ; State - Madhya Pradesh			
4.	Details of the farm (size, location, water availability etc.)	:	7 ha : Water harvesting tank and tube well for irrigation	
6.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	AICRPDA, College of Agriculture, Indore	
7.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained with details		Use of harvested rain and runoff water Modified ridge planter for sowing of potato	
8.	Details of results obtained due to the adoption of technologies (Season-wise crops grown techniques adopted, results achieved etc.)		**Improved / present production technologies**	**Traditional / past production practices**
	i) Productivity (kg/ha)	:	27500	17000
	ii) Cost of production (Rs/ha)	:	58630	58630
	iii) Net income (Rs/ha)	:	51370	9370
	iv) Price realized (Rs/ton)	:	4000	4000
	v) Natural Resources saved /conserved like soil, water etc.	:	Saved energy by using modified ridge planter, and water by using drip system of irrigation	-
	vi) Product quality improvement	:	Shining and big sized tubers fetch premium in market	
9.	Marketing Strategy – Access to market (through private, cooperative, contract farming etc.)	:	Private	
10.	Factors contributing to success	:	The use of modified ridger former helps for planting potatoes on ridges Saving in water, energy and natural resources	



Kovilpatti

Ferti-cum-seed drill for greengram sowing

1.	Name of the Farmer	:	Mr. P.Marisamy	
2.	Address : Village -Thoppureddiapatti ; Tehsil - Kovilpatti ; District - Thoothukudi ; State - Tamil Nadu			
4.	Details of the farm (size, location, water availability etc.)	:	2 ha	
6.	Names of the Central Sector / State Schemes utilized by the farmer and the period		AICRPDA Centre, Kovilpatti	
7.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained with details		Sowing of CO8 greengram using ferti-cum-seed drill with simultaneous formation of broad bed & furrows	
8.	Details of results obtained due to the adoption of technologies (Season-wise crops grown techniques adopted, results achieved etc.)		**Improved / present production technologies**	**Traditional / past production practices**
	i) Yield (kg/ha)	:	710	615
	ii) Net returns (Rs/ha)	:	12100	9500
	iii) B:C ratio	:	1.52	1.10
9.	Marketing Strategy – Access to market (through private, cooperative, contract farming etc.)	:	Private	
10.	Factors contributing to success	:	Rainwater conservation in the furrows with uniform spacing of seeds	
11.	Any other revelant information	:	Nearly 60 to 70% of the village farmers have adopted the technology	

Parbhani

Improved agronomic practices for cotton + soybean (1:1) intecropping system

1.	Name of the farmer	:	Shri. Babasaheb Dagduba Paradhe	
2.	Address : Village - Babhulgaon; Post - Babhulgaon; Tehsil - Parbhani; District-Parbhani; State - Maharashtra			
3.	Contact details	:	9763554321	
4.	Details of the farm (size, location, water availability etc.)			
	Farm size	:	02 ha	
	Water availability	:	One open well	
8.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained with details	:	Cotton+ soybean (1:1) intercropping system with opening of furow Opening of furrow after every four rows of soybean. Foliar application of KNO3 @ 1.0% 35 DAS and @ 2.0 at 65-70 DAS due to the mid season drought situation	
9.	Details of results obtained due to the adoption of technologies (Season-wise crops grown techniques adopted, results achieved etc.)	:	**Improved / present production technologies**	**Traditional / past production practices**
	i) Productivity (kg/ha)	:	1356	1121
	iii) Net income (Rs/ha)	:	21312	18235
	v) Natural Resources saved /conserved like soil, water	:	In-situ moisture conservation	-
10.	Marketing Strategy	:	Private	
11.	Factors contributing to success	:	Availability of furrow opener through custom hiring centre	

Phulbani

Improved dryland technologies

1.	Name of the farmer	:	Dinadar Kanhar	
2.	Address : Village - Budhadani ; Post - Phulbani ; Tehsil -Phulbani ; District - Kandhamal ; State - Odisha			
4.	Details of the farm (size, location, water availability etc.)	:	7 acres	
6.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	NICRA programme of AICRPDA, Phulbani	
7.	Technologies / Good Agricultural Practices / Facilities / Benefits obtained with details	:	Recommended intercropping systems	
8.	Details of results obtained due to the adoption of technologies (Season-wise crops grown techniques adopted, results achieved etc.)	:	**Improved / present production technologies**	**Traditional / past production practices**
	i) Productivity (kg/ha)	:	Paddy: 3000	Paddy: 2100
			Maize + cowpea (2:2) : 5100 (MEY)	Maize: 3200
			Mango + turmeric: 8500 (TEY)	Mango: 1000
			Greengram: 750	Greengram: 510
	ii) Cost of production (Rs/ha)	:	Paddy: 22000	Paddy: 22000
			Maize + cowpea: 28000	Maize: 22000
			Mango + turmeric: 60000	
			Green gram: 22000	Green gram:22000
	iii) Net income (Rs/ha)	:	Paddy: 20000	Paddy: 7600
		:	Maize + cowpea: 32000	Maize: 10000
		:	Mango + turmeric: 60000	Mango: 10000
		:	Greengram: 33000	Greengram: 18000
	v) Natural Resources saved /conserved like soil, water etc.	:	*In-situ* moisture conservation	-
9.	Marketing Strategy – Access to market (through private, cooperative, contract farming etc.)	:	Private	
10.	Factors contributing to success	:	Resilient intercropping systems with higher productivity and profitability particularly during years of weather aberrations	

Solapur

Improved cultivation practices in rabi sorghum

1.	Name of the farmer	:	Shri. Daji Chandu Kale
2.	Address: Village - Narotewadi ; Post - Narotewadi ; Tehasil - North Solapur ; District - Solapur ; State - Maharashtra		
3.	Contact details	:	09890808284
4.	Details of the farm (size, location, water availability, etc.)	:	6.0 ha - Source of irrigation: Well
5.	Membership in Self Help Group, producers co-operative/company, co-operative society, etc.	:	Shivratna Farmers' Club
6.	Names of the central sector / state scheme utilized by the farmer and period	:	State Department of Agriculture, NICRA project
7.	Technologies / good agricultural practices / facilities / benefits obtained with details	:	• In-situ rainwater conservation i.e., opening of ridges and furrows in kharif season. • Use of improved cultivar – Phule Vasudha • Fertilizer (N:P2O5:K2O kg/ha) – 50:25:00 • Seed treatment: Azotobactor, PSB, Trichoderma

8	Details of results obtained due to adoption of technologies		:	**Improved / present production technologies**	**Traditional / past production technologies**
i)	Productivity (kg/ha)	Grain	:	1750	719
		Fodder	:	3503	2289
ii)	Cost of production (Rs/ha)		:	15000	13000
iii)	Net income (Rs/ha)		:	39259	11842
iv)	Price realized (Rs./ton)	Grain	:	2500	2500
		Fodder	:	300	300
v)	Natural Resources saved /conserved like soil, water		:	30% more moisture conserved due to ridges and furrows	-

9.	Marketing strategy – Access to market	:	Private
10.	Factors contributing to success	:	Access to improved varieties of sorghum and farm implements

Varanasi

Ridge-furrow planting of rice + pigeonpea (1:1) intercropping system

1.	Name of the farmer	:	Rakesh Singh
2.	Address : Village - R C Nagar ; Post - Padari ; Tehsil - Mirzapur; District - Mirzapur ; State - Uttar Pradesh		
3.	Contact details	:	9936525591
4.	Details of the farm (size, location, water availability etc.)	:	8.0 ha, one well
5.	Membership in Self-Help Group, Producers Cooperative/ Company, Cooperative Society etc., (give details)	:	Bharpura Sadhan Sahkari Samiti
6.	Names of the Central Sector / State Schemes utilized by the farmer and the period	:	AICRPDA-NICRA program
7.	Technologies/Good Agricultural Practices/Facilities /Benefits obtained with details	:	• Ridge forming machine for rice + pigeonpea sowing • Incorporation of greengram in alternate strips with rice saves 30 kg N/ha in cereal component

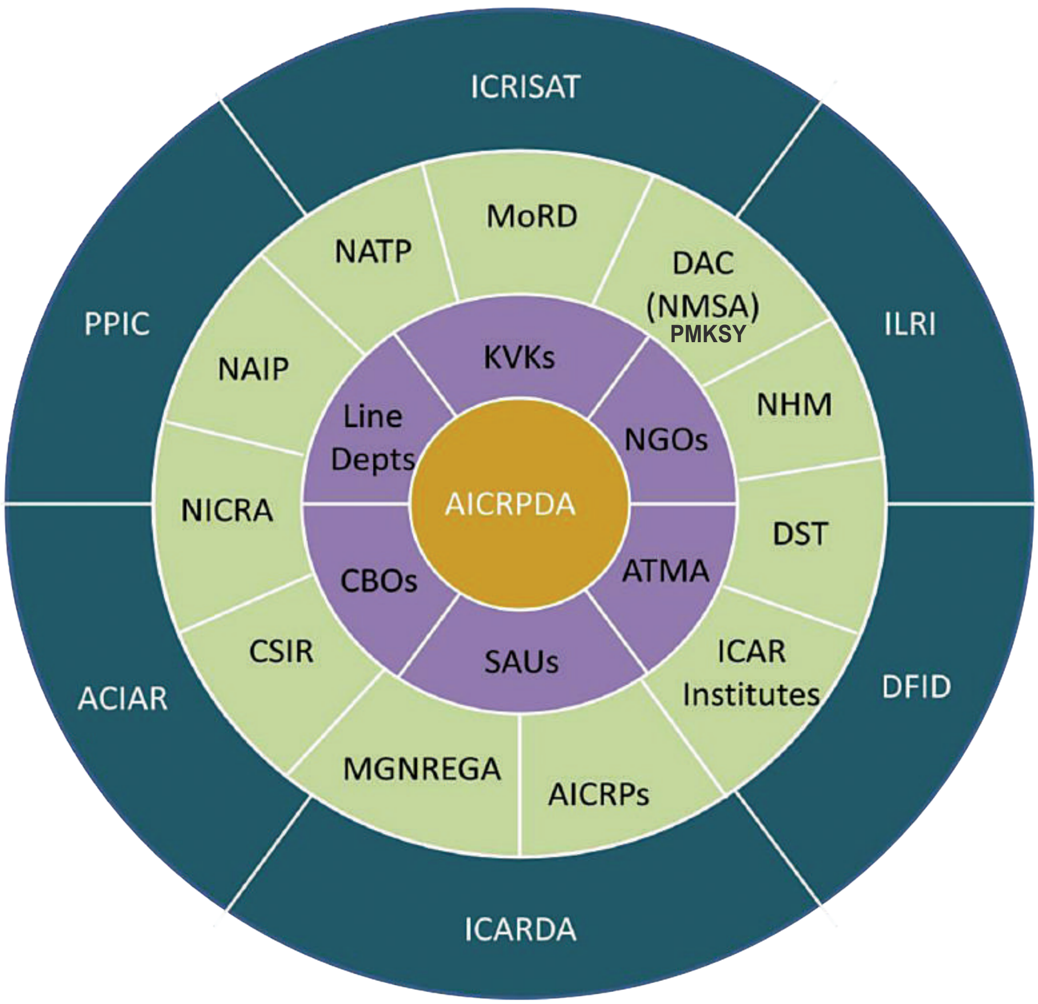
8.	Details of results obtained due to the adoption of technology		**Improved / technology adopted**	**Traditional / past production practices**
i)	Productivity (kg/ha)	:	3125	1800
ii)	Cost of production (Rs/ha)	:	11000	11000
iii)	Net income (Rs/ha)	:	35000	10875
iv)	Price realized (Rs./ton)	:	33000	7000
v)	Natural Resources saved /conserved like soil, water etc.	:	Soil and water conservation	-

9.	Factors contributing to success	:	• Assured pulse production with ridge-furrow system in rice growing areas. • Efficient management of soil and rainwater
10.	Details on the spread (area and or no. of farmers / villages) of the technology adopted by the successful farmer	:	Sixty famers covered 40 ha area of R.C. Nagar, Shivgarh and Pathraha villages of Pahari block, (Mirzapur)

11. Collaboration/Linkages

AICRPDA network centres are persistently in collaborations linkages with various stakeholders for i) research, ii) technology assessment and refinement, iii) upscaling of doable rainfed technologies, iv) operationalization of contingency plans on real-time basis, and v) capacity building of primary and secondary stakeholders, both on-station and on-farm. The network has strong linkage/collaboration with national and international institutes, state/central government programmes, district level institutions and local PRIs.

- Research: ICAR institutes, Crop AICRPs, AICRP on Integrated Farming Systems, AICRP on Agroforestry, NICRA, DST, CSIR, DAC, ICRISAT, DFID, ICARDA, ACIAR
- Technology assessment and refinement: KVKs, SAUs, State Line Departments
- Technology upscaling: KVKs, ATMA, State Line Departments, NGOs
- Preparation, updation and operationalization of district agriculture contingency plans: CRIDA, SAUs, State Line Departments, DAC



AICRPDA Collaboration/Linkages for Rainfed Agriculture Research, Education & Development

12. Honors/Awards

Akola

- **Best Poster Presentation Award** to V.V. Gabhane in National Seminar on "Organic Ameliorants for Soil Resilience and Environmental Securities" at RVSKVV, Gwalior during 19-21 August, 2015.
- **Best Poster Presentation Award** to M.B. Nagdeve, in "First International Conference on New Challenges in Plant Protection and Awareness for Crop Health" at Dr. PDKV, Akola during 20-22 January, 2016.

Bengaluru

- **Best Field Demonstration Award** for the Dryland Technology Park during *Krishimela* at UAS, GKVK, Bengaluru during 19-22 November, 2015.
- **ICAR Vasanth Rao Naik Award for Research Application in Agriculture** during ICAR Foundation Day held at Patna on 24th July, 2015.

- **Best Poster Presentation Award** to B.K. Ramachandrappa and M.N. Thimmegowda in 25th APWSS Conference at PJTSAU, Hyderabad during 13-16 October, 2015.
- Fellow **of National Environmental Science Academy Award 2015** to B.K. Ramachandrappa at New Delhi on 21st December 2015.
- **Indian Association of Soil and Water Conservation Gold Medal 2015** (Field Functionary) to B.K. Ramachandrappa in Global Ravine Conference held at Gwalior, Madhya Pradesh during 7-9 March, 2016.
- **Certificate of Merit** award to M.N. Thimmegowda and A. Sathish for the DBT sponsored Indo-Swiss Project on Biofi during the Foundation day of UAS, Bangalore on 9th October, 2015.

Biswanath Chariali

Following 5 famers (including one woman farmer) from NICRA and NICRA upscaling villages (Chamua, Ganakdoloni, Bornadi and Jinjia) under AICRPDA, BNCA located in different districts of Assam were honored and awarded with the **Best Dryland Farmer Award** during XV Working Group Meeting of AICRPDA held at BN College of Agriculture, Biswanath Chariali during 24-27 December, 2016.

Name of the farmer	For adaptation and popularization of dryland technology
Sri Chakradhar Goswami, Chamua Village, Lakhimpur District	Climate resilient agricultural technologies
Sri Harendra Neog, Chamua Village, Lakhimpur District	Crop diversification in rainfed upland and protected cultivation
Sri Jadab Dutta, Ganakdoloni Village, Lakhimpur District	Flash flood resilient rice based agro technologies
Sri Devi Prasad Sharma, Jinjia Village, Sonitpur District	Potato cultivation as contingent crop and adoption and popularization of agromet advisories
Sri Dinesh Chandra Baishya, Dowkushi Village, Nalbari District	Polyhouse nursery and integrated farming system as climate resilient technology
Sri Luhit Sonowal, Jalakia Suti Village, Dhemaji District	Integrated farming system as climate resilient technology
Srimoti Bhabani Kachari, Jalakia Suti Village, Dhemaji District	Mechanization of eri spinning technology

Hisar

- **Appreciation Letter** to Dr. M.S. Sidhpuria by CCSHAU, Hisar for Excellence and Devotion to Work in Dryland Agriculture presented on 8th July, 2016.

Indore

- **Member of Institute Management Committee (IMC),** ICAR-Directorate of Soybean Research (DSR), Indore to Bharat Singh for the period 2015 to 2018.
- **Distinguished Scientist Award (2016)** to Bharat Singh by Society of Biotechnology, SHIATS, Allahabad.
- **Distinguished Scientist Award (2015)** to Bharat Singh by SSDAT, Meerut.
- **Outstanding Achievement Award (2015)** to Bharat Singh by SSDAT, Meerut.

Rakh Dhiansar

- **Best Research Paper Award-2015** to Vikas Abrol in category of Soil Science and Agronomy in *Indian Journal of Soil Conservation.*

Solapur

- **Best Poster Presentation Award** to V.M. Amrutsagar, J.D. Jadhav, S.B. Thorve, V.A. Shinde, S.H. Pathan and D.B. Bhanawase, under the theme "Agro Advisories a Boon for Crop Planning on Real Weather Basis in Scarcity Zone of Maharashtra"

13. Visitors

Visitors to AICRPDA centres

Name of the Visitor with Designation	Date of visit
Akola	
R. G. Dani, Hon'ble Vice-Chancellor, PDKV Akola	19 August, 2015
K. Shrikant, District Magistraten & District Collector, Akola District	20 October, 2015
4836 farmers	19-21 Oct and 8, 27- 29 Dec, 2015
Scientists and officials from Kenya, UK, Congo, France, Uzbekistan, South Africa, Zimbabwe,	6 February, 2016
Solapur	
Prakash Patil, Member, Executive Council, MPKV, Rahuri	16 October, 2015
Patricia Imas, Coordinator IPI, South Asia (India, Shrilanka and Bagladesh)	21 August, 2015
Bengaluru	
N.N. Acharya, Nepal	06 January, 2015
Dr. Ernst August, Professor, University Giessen	08 January, 2015
Lally Jacob, FSI, India	18 February, 2015
Officials of Department of Agriculture, Karnataka	17 June, 2015
M.P. Viwcent, MLA, I.C. Balakrishnan, MLA, P.A. Salam, A.J. Francis and B. Ajith Kumar, KAG, Executive committee members, UAS, Bengaluru	18 November, 2015
Krishimela-2015, Farmers from different districts of Karnataka	19 November, 2015 to 22 November, 2015
Deepa N, Research Officer, Abdul Nazir Sab Institute Rural Development Bengaluru	06 December, 2015
A.V.K. Iyengar, Director, Kothai Agricultural Management Centre Coonoor, The Nilgiris, Tamil Nadu	31 December, 2015

Visit of scientists and progressive farmers from different countries to AICRPDA centre, Akola on 6th February, 2016

14. Project Team

April 2015 to March 2016

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Name/Designation/Address	Name/Designation/Address	Name/Designation/Address
Main centres		
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Operational Research Projects

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Statement showing the remittance, expenditure and closing balances for AICRPDA centres for the year 2015-16

S. No.	Centre	RE for 2015-16	Opening balance as on 1.4.2015	Remit-tance	Revenue receipts	Expenditure up to 31.03.2016 (as per AUCs for 2015-16)									Closing balance as on 31.3.2016
						Other than NEH & TSP				NEH		TSP		Grand Total	
						Pay & Allow	TA	RC	NRC	RC	NRC	RC	NRC		
1	Akola (MC)	8165000	-3918089	8165000	0	9800000	83000	650000	193000	0	0	0	0	10726000	-6102136
2	Anathapur (MC)	7950000	-3783371	7950000	0	8041303	161921	650000	199079	0	0	0	0	9052303	-4085675
3	Arjia (MC)	12035000	-3432820	12035000	0	8798326	94019	740249	200000	0	0	941524	0	10774118	-795073
4	Bal.Saunkhri (MC)	8940000	-3520609	8940000	0	9602459	44917	540000	197414	0	0	0	0	10384790	-3755399
5	Bengaluru (MC)	8452000	-4495433	8452000	0	8693217	148413	582004	170668	0	0	0	0	9594302	-5517735
6	Vijayapura (MC)	8187000	-5474139	8187000	0	9696330	89065	600000	134214	0	0	0	0	10519609	-6781748
7	S.K.Nagar (MC)	9730000	-1404461	9730000	205777	8254598	47310	599402	196391	0	0	194532	147100	9439333	216983
8	Hisar (MC)	8450000	-6327560	8450000	0	6377421	53630	495044	196081	0	0	0	0	7122176	-2999736
9	Indore (MC)	13335000	-4886541	13335000	0	10817547	106483	633960	194122	0	0	651492	30324	12433928	458422
10	Jagdalpur (MC)	9993000	-788662	9993000	0	4446326	233000	710000	103940	0	0	2620081	122963	8236310	1423818
11	B. Chariali (MC)	32089000	-5569316	32089000	0	6323035	217931	0	197952	15786971	1499679	2708984	399712	27134264	4289986
12	Kovilpatti (MC)	7740000	-2575266	7740000	0	7958335	148735	650000	0	0	0	0	0	8757070	-3092336
13	Parbhani (MC)	7075000	-1873091	7075000	0	5074566	50819	459026	148768	0	0	0	0	5733179	-206270
14	Phulbani (MC)	6400000	685705	5714295	0	3639319	47387	169003	0	0	0	95785	0	3951494	3928989
15	Chianki (MC)	5595000	298954	5296046	0	2426843	76275	216697	0	0	0	1641501	149302	4510618	3471070
16	Rewa (MC)	7628000	-2264530	7628000	0	9025700	7970	561930	137912	0	0	0	0	9733512	-2445042
17	Solapur (MC)	8627000	-6028531	8627000	0	8896041	157460	649987	139728	0	0	0	0	9843216	-5921747
18	Targhadia (MC)	6780000	-1700235	6780000	30569	4559105	104000	586000	0	0	0	0	0	5249105	147229
19	Varanasi (MC)	10610000	-6228104	10610000	0	8833022	202566	600000	199300	0	0	0	0	9834888	-4552992
20	Agra (SC)	5360000	-243292	5360000	22700	7614827	24738	199555	93697	0	0	0	0	7932817	-1245409
21	Faizabad (SC)	6900000	-53341	6900000	0	6661971	104404	122961	0	0	0	0	0	6889336	382323
22	R.Dhiansar (SC)	7830000	-74500	7830000	0	6999000	138750	407250	108000	0	0	0	0	7653000	107000
23	Anantapur (ORP)	4470000	-2695391	4470000	0	3739841	70097	419887	99225	0	0	0	0	4329050	-2354441
24	Arjia (ORP)	4950000	-5569336	4950000	0	3686927	68913	420000	100000	0	0	0	0	4275840	-4900176
25	Bal.Saunkhri(ORP)	3860000	-1174020	3860000	0	3377173	44610	434897	94875	0	0	0	0	3951555	-1016958
26	Bengaluru (ORP)	2620000	-876567	2620000	0	1275350	39111	430000	99988	0	0	0	0	1844449	-1016
27	Hisar (ORP)	3555000	-3719294	3555000	0	2947884	28740	224844	82117	0	0	0	0	3283585	-3447879
28	Indore (ORP)	4130000	-4687756	4130000	0	3626197	66620	420754	92760	0	0	0	0	4206331	-4766281
29	Chianki (ORP)	133000	3444826	33000	0	887146	0	164348	0	0	0	0	0	1051494	2426332
30	Solapur (ORP)	4890000	-2621310	4890000	0	3555601	89062	446747	96145	0	0	0	0	4187555	-1851465
31	PC Unit	1230000		1230000	0	0	226338	709064	0	0	0	0	0	935402	315160
	Total	**237709000**	**-81556080**	**236624341**	**259046**	**185635410**	**2976284**	**14493609**	**3475376**	**15786971**	**1499679**	**8853899**	**849401**	**233570629**	**-48672202**

Proceedings of XXIV Biennial Workshop of AICRP for Dryland Agriculture, ICAR-CRIDA 26-29 December 2014, AICRPDA Centre, Indore, RVSKVV, Madhya Pradesh

The XXIV Biennial Workshop of AICRP for Dryland Agriculture (AICRPDA) was held during 26-29 December, 2014 at AICRPDA Centre, College of Agriculture, Indore, RVSKVV, Madhya Pradesh. The objective of the workshop was to review the progress of research achieved during 2012-14 across 22 AICRPDA centres and 8 ORP centres and further, for finalization of technical programme for 2015-16. The scientists from RVSKVV, ICAR- CAZRI, ACRIPDA centres and ICAR-CRIDA participated.

Action Points

a. Technical

Main / Sub-centres

- Each centre should present on how many experiments were conducted during the reporting period, how many were successful, how many experiments failed (crop yields below state average yields) and the reasons for failure.
- The crop yields in some experiments are very poor (below state average yields). Justification and solutions for poor crop yields need to be given. Further, the data of such experiments should not be presented in the workshop.
- Since the results of two years (2012 and 2013) are presented, year-wise data and the mean data should also be presented in future.
- Data on soil and plant analysis to be recorded and reported particularly for the experiments on nutrient management and permanent manurial trials.
- In the experiments on foliar sprays, it should be clearly mentioned how much fertilizers were applied to soil in all treatments.
- In experiments on contingency crop planning, intercropping systems involving short duration varieties should be evaluated instead of evaluation of sole crops.
- Data on energy use, energy output and energy use efficiency should be presented for all the experiments under the theme – Energy Management.
- For the experiments on rainwater management, different terminologies are being used including rainwater use efficiency, moisture use efficiency etc. Further, the unit of RWUE is not uniform across different centres (kg/ha-mm). It was suggested to clarify on these points and circulate the same to all centres for uniform reporting of data.
- More scientific data should be generated for the experiments on catchment-command-storage area relationship.
- Whenever locally available organic manures (FYM, vermicompost, green manure, crop residues etc) are used in experiments, the nutrient composition of manures and their application rates should also be given.
- There should be clarity on participatory varietal selection (PVS) and evaluation of improved varieties (EIV). If it is PVS, in consultation with plant breeders, we need to develop some common guidelines/methodology for conducting such trials. Further, in these trials, farmers also look for other parameters, other than yield, including cooking quality, appearance of seed etc. These things should be kept in mind while evaluating the varieties/new genotypes.
- In evaluation of improved varieties, the approved varieties need to be evaluated. In trials on PVS, data on relative water content, DSI etc are being recorded; however, more emphasis may be given to duration of varieties and yields while selecting the varieties.
- The criteria for defining dry spells should be clarified and circulated to all centres.

- In the PMT trials, the comprehensive data on soil physical, chemical and biological properties and micronutrient status to be given.
- The centres should submit a note on the non-implementation of certain on-station experiments during 2013-14 and 2014-15. A note with justification may be submitted to the PC unit.
- In INM trials, the treatment 100% RDF should include all deficient micronutrients in addition to NPK as a standard check.
- In experiments on cropping systems, the yields of component crops should also be presented. The names of crop varieties should be mentioned for experiments on intercropping systems. Further, land equivalent ratio (LER) should also be considered in addition to crop equivalent yields while evaluating intercropping systems.
- Crop management experiments should be concluded after 3 years, if the experiment does not fail during three years.
- The linkages with AICRPs on Agroforestry, integrated farming systems, agrometeorology, weed management and other crop science AICRPs should be further strengthened.
- A comprehensive RPF III has to be submitted by centers for all the concluded experiments with all the relevant data, scope for upscaling, on-arm evaluation, scope for recommendation by SAU as package of practices (Action: All Main/sub centres). For economics gross and net returns and BCR, cost of farm pond to be taken over a period of time.

Guidelines for proposal of New Experiments during 2015-16

Technical programme of the centres to be rationalized based on the resources (agro-ecological settings, staff, and facilities) and work load. While rationalizing/ initiating new experiments during 2015-16. The new experiments proposed are to be proposed again after consultation with the scientists at the centre.

Theme: Rainwater management

- Need of development of matrix containing runoff-pond-crop-pump-details of the sprinkler system. A simple 10 page document should be published district wise/rainfall dependent.

Programme1: Catchment-storage- command area relationship and rainwater harvesting and efficient utilization is a Network Project at all centres: To be initiated at Chianki, Faizabad, Rakh Dhiansar and to be strengthened at ongoing centres based on the following principles:

- Design of farm pond- site specific, consider soil type, rainfall-run off relationsship
- Lining – needed /not needed, if needed – what material?
- Water lifting with energy efficient pump
- Efficient utilization - pressurized irrigation systems for supplemental/life saving/pre-sowing irrigation
- Crop diversification and or increasing the area of rainfed crops

Programme 2: Study on minimizing evaporation losses from the farm pond

- At two to three sites (can be both on-station and or on-farm)

Treatments:

- Control
- Neem oil spray
- Solar panel
- Other techniques/material
- Consider technical feasibility, cost, environmental safety, durability etc.

Programme 3: Coping with Midseason Drought

- Foliar spray of nutrients/chemicals: KNO_3, KCl, Thiourea, water spray etc – Network Project at all Centres, both On-station and On-farm (NICRA village).

Treatments: Dominant rainfed crop

- RDF + No spray
- RDF + Water spray
- RDF + KNO_3 (1% spray) (one or two sprays)
- RDF + KCl (1% spray) (one or two sprays)
- RDF + Thiourea @ 250 g/ha

Programme 4: Use of hydrogel, aquagel, zeolite, polymers etc.

- At 5 centres *viz.*, Biswanath Chariali, Indore, SK Nagar, Anantapur, Bangalore

Treatments:

- Control
- RDF + Use of hydrogel/ aquagel/zeolite/ polymers – at specific centres

Theme: Crops/Cropping Systems

Programme 1:

- Intercropping systems with in-situ moisture conservation practices and with a suitable implement - to be initiated in the on-going experiments

Theme: Farm Machinery and Energy

Programme 1:

- Versatile, multi crop, multipurpose equipment's for small holders need immediate attention of researchers.

Theme: IFS Systems

- Generation of scientific data base related to IFS under rain-fed situation to promote across the country and particular rain-fed areas.
- Tailoring the rainfed IFS models based availability of rainwater
- Logical planning and baseline while designing the on station research
- Relationship between economic stability and climatic variability with successful implementation of IFS.

Programme 1. AICRPDA - AICRP-IFS collaborative research

S. No.	Common centre of AICRPDA-AICRP on IFS	On-station	On-farm
1	Indore	√	√
2	Varanasi	√	√
3	SK Nagar	√	√
4	Hyderabad (CRIDA and ANGRAU)	√	√

Technical backstopping:

Biswanath Chariali centre – AICRP-IFS, Jorhat centre and Jagdalpur centre – AICRP-IFS, Raipur centre

Theme: Agroforestry and Alternate Land Use

- Network Project at all Centres: AICRPDA-AICRP-AF Collaborative Research

Programme.1. AICRPDA - AICRP-AF collaborative research

S. No	Common centre of AICRPDA-AICRPAF	On-station	On-farm
1	Bangalore	√	√
2	Hisar	√	√
3	SK Nagar	√	√

Technical back stopping: AICRP-AF centre Ludhiana to AICRPDA centre at Ballowal Saunkhri. Studies on GHG emissions, carbon sequestration to be taken up.

b. ORPs

- The basic mandate of ORPs i.e. the on-farm assessment of the findings of the main centres to be strengthened and the feedback of farmers if any need to be given to the main centres for refinement.
- The best treatment and farmer's practice only to be assessed.
- The on-farm trials to be carefully laid out and appropriate data to be recorded so that when recommendations go from ORPs, no contradictions arise.
- The list of varieties selected by ORP centres may be sent to respective crop science institutes/ AICRPs for their inputs, before finalizing the technical program.
- Impact assessment studies of all ORP villages to be done.
- Demonstrate only best performing treatments in farmers' fields and in more area.
- More emphasis to be given for demonstration of NRM technologies.

c. Reporting and Publications

- It is mandatory to submit the progress of research in RPF-I for new experiments, RPF- II for on-going experiments and RP- III for completed experiments.
- The 40 years of Dryland Research to be submitted by remaining centres by 15th February 2015.
- The Annual Reports of AICRPDA, NICRA and TSP to be submitted in revised/new proformae.

- The Impacts of ORPs to be submitted as per the format by 15th March 2015
- Weekly Weather Report to be submitted every week by Tuesday.
- Crop contingency plans documented at the centre to be updated periodically and if possible to be translated into local language.

d. Administrative and Financial aspects

- To submit monthly expenditure statements, utilization certificates, audit utilization certificates, as per the schedules already given to process the budget releases effectively.
- The negative budget under pay and allowance, if any, will be regularized during the next two years of the XII Plan.
- The head-wise details of Monthly Expenditure Statement along with Staff Position may be furnished on or before 15th of next month.
- Discrepancies, if any, in respect of the funds will be dealt on priority basis before end of the current financial year.
- The salaries of the contractual staff (RAs/SRFs/JRFs etc.) recruited by the centers, may be booked under Recurring Contingent (RC) but NOT UNDER Pay and Allowances.
- Not to fill up the vacant positions temporarily. However, the approval of Competent Authority is a must. Without prior approval even the temporary /outsourced positions will not be approved.
- Audit Utilization Certificate (AUC) may be furnished on or before 10th June, 2015 duly signed by the Auditor together with head-wise details, remittance received during the year and actual expenditure incurred in the prescribed format.
- Each centre is requested to kindly intimate the head wise unspent balance available with them in the month of March, so that the same can be allocated to other centres where needed.
- Excess expenditure incurred on each head-wise on the basis of BE allocation 2014-15 will be communicated accordingly on or before 31st March, so that efforts can be made to regularize the excess amount by finding out the unspent balance available within the same head from other centres.

Acronyms

AESR	Agroecological Subregion
AEY	Anola equivalent yield
AICRPAM	All India Coordinated Research Project on Agrometeorology
AICRPDA	All India Coordinated Research Project for Dryland Agriculture
ANGRAU	Acharya NG Ranga Agricultural University
ARS	Agriculture research station
ASM	Available soil moisture
ATMA	Agricultural Technology Management Agency
AWC	Available water capacity
BBF	Broad bed furrow
BC ratio	Benefit cost ratio
B	Boron
CAEY	Custard Apple equivalent yield
CCSHAU	Chaudhury Charan Singh Haryana Agricultural University
CCT	Continuous contour trench
CD	Critical difference
CEC	Cation exchange capacity
CEY	Castor equivalent yield
CEY	Cotton equivalent yield
CEY	Chickpea equivalent yield
CGIAR	Consultative Groups on International Agricultural Research
CR	Crop residue
CRIDA	Central Research Institute for Dryland Agriculture
CSIR	Council of Scientific and Industrial Research
CT	Conventional tillage
CUM	Cubic meter
DAP	Days after planting
DAS	Days after sowing
DBHR	Days before harvesting of rice
DFRS	Dryland Farming Research Station
DSI	Drought susceptibility index
DTPA	Diphenyl triamine penta acetic acid
EC	Electrical conductivity

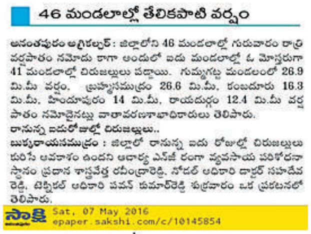
ER	Effective rainfall
FC	Field capacity
FLD	Front line demonstration
FP	Farmers' practice
FYM	Farmyard manure
FYT	Final yield trial
GEY	Ginger equivalent yield
GIS	Geological Information System
GLM	Greenleaf manure
ha	Hectare
HC	Hydraulic conductivity
HP	Horse power
HW	Hand weeding
HYV	High yielding variety
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IF	Inorganic fertilizer
IFS	Integrated farming system
IGAU	Indira Gandhi Agricultural University
IGFRI	Indian Grassland and Fodder Research Institute
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
LPA	Long period average
LR	Lime requirement
LST	Large scale varietal trial
LT	Low tillage
MAD	Maximum allowable depletion

MCEY	Main crop equivalent yield
MEY	Maize equivalent yield
Mg	Magnesium
$MgSO_4$	Magnesium sulphate
MJ	Mega joule
MLT	Multi location trial
mm	Mille meter
MoRD	Ministry of rural development
MoWR	Ministry of water resources
MPKV	Mahatma Phule Krishi Vidyapeeth
MPUA&T	Maha Rana Pratap University of Agriculture & Technology
MSL	Mean sea level
MUSLE	Modified universal soil loss equation
NDUAT	Narendra Dev University of Agriculture & Technology
NHM	National horticulture mission
NICRA	National Innovations on Climate Resilient Agriculture
NMR	Net monetary returns
NRM	Natural resource management
OC	Organic carbon
ORP	Operational Research Project
OT	Off-season tillage
OUAT	Orissa University of Agriculture & Technology
PAU	Punjab Agricultural University
PDKV	Dr. Panjabrao Deshmukh Krishi Vidyapeeth
PET	Potential evapotranspiration
PEY	Pigeonpea equivalent yield
PMT	Permanent manurial trail
POP	Package of practices
PSB	Phosphate solubilizing bacteria
PWP	Permanent wilting point

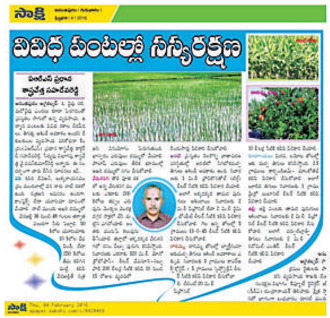
RDF	Recommended dose of fertilizer
RDN	Recommended dose of nitrogen
REY	Rice equivalent yield
REY	Radish equivalent yield
RF	Ridge furrow
RSR	Recommended seed rate
RT	Reduced tillage
RWUE	Rainwater water use efficiency
SAU	State Agricultural University
SCMR	SPAD Chlorophyll Meter Reading
SEY	Sesame equivalent yield
SI	Supplemental irrigation
SK Nagar	Sardarkrushi nagar
SKDAU	Sardar Krushinagar Dantiwada Agricultural University
SKUAS&T	Sher-e-Kashmir University of Agricultural Science & Technology
SMW	Standard meteorological week
SOC	Soil organic carbon
SSNM	Site specific nutrient management
STBF	Soil test based fertilizer
SW	South-west
SWC	Soil & water conservation
SYI	Sustainable yield index
TNAU	Tamil Nadu Agricultural University
TSP	Tribal Sub-Plan
UAS	University of Agricultural Sciences
VC	Vermicompost
WEY	Wheat equivalent yield
WHH	Wheel hand hoe
WUE	Water use efficiency
Zn	Zinc
ZT	Zero tillage

Print media

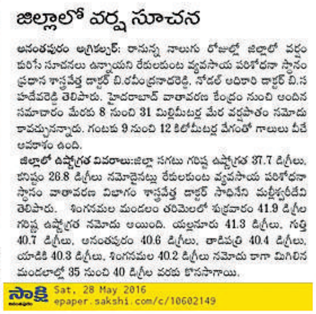
Ananthapuramu



46 మండలాల్లో తేలికపాటి వర్షం



వివిధ పంటల్లో సస్యరక్షణ



జిల్లాలో వర్ష సూచన

భూసార పరీక్షలతో అధిక దిగుబడులు

B.Saunkhri

ਕੰਢੀ ਇਲਾਕੇ ਦੀਆਂ ਖੇਤੀ ਸਬੰਧੀ ਸਮੱਸਿਆਵਾਂ ਅਤੇ ਉਨ੍ਹਾਂ ਦੇ ਹੱਲ ਬਾਰੇ ਵਿਚਾਰ ਵਟਾਂਦਰਾ ਕੀਤਾ ਗਿਆ

ਕੰਢੀ ਖੋਜ ਕੇਂਦਰ ਬੱਲੋਵਾਲ ਸੌਂਖੜੀ ਵਿਖੇ ਖੇਤੀ ਸਬੰਧੀ ਵਰਕਸ਼ਾਪ

Chianki

03 हिन्दुस्तान
रांची • शुक्रवार • 17 जुलाई 2015

गोंदा गांव का चयन

मेदिनीनगर। क्षेत्रीय अनुसंधान केन्द्र चियांकी ने शुष्क भूमि कृषि परियोजना के अंतर्गत गढ़वा जिला के मेराल प्रखंड के गोंदा गांव का चयन किया है। इस परियोजना के मुख्य वैज्ञानिक डॉ दीपन सिंह हैं। इस गांव में तीन सालों तक कृषि को बढ़ावा देने का काम किया जाएगा।

04 प्रभात खबर पलामू

रबी फसलों का उचित प्रबंधन जरूरी

गढ़वा/पलामू जागरण

उन्नत प्रभेद के बीज लगाएं किसान

मॉडल बनेगा चियांकी क्षेत्रीय अनुसंधान केंद्र

Indore

झाबुआ-आलीराजपुर

कृषि वैज्ञानिकों ने खेती करने के बताए गुर

बारानी खेती टिकाऊ लेकिन जल संरक्षण भी जरूरी : डॉ. पंजाब सिंह

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'We need to look at reducing technology cost for farmers'

नईदुनिया 07

कम वर्षा होने पर मूंग-उड़द की खेती पर दें जोर

पीपुल्स समाचार

राष्ट्रीय कार्यशाला

Print media

Parbhani


प्रादेशिक

सेंद्रिय शेती प्रकल्पाचा संशोधनासाठी उपयोग व्हावा : डॉ. व्यंकटेश्वरलू


अॅग्रोवन

नागरीकरण शेतीसाठी घातक


पुण्यनगरी

'निक्रा'च्या यशस्वी शेतकऱ्यांशी तज्ज्ञांनी साधला संवाद

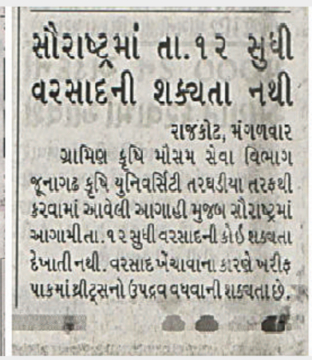

फेरभरणातून टंचाईवर मात

Rajkot


અષાઢી બીજ આવી ૧લા વરસાદના અભાવે

સૌરાષ્ટ્રમાં ત્રણ દિવસમાં ત્રીજા ખેડૂતની આત્મહત્યા


વિપરિત હવામાન પરિસ્થિતિમાં ખરીફ પાકોનું આયોજન-૨૦૧૫


સૌરાષ્ટ્રમાં તા.૧૨ સુધી વરસાદની શક્યતા નથી

રાજકોટ, મંગળવાર

ગ્રામિણ કૃષિ મૌસમ સેવા વિભાગ જૂનાગઢ કૃષિ યુનિવર્સિટી તરફથી કરવામાં આવેલી આગાહી મુજબ સૌરાષ્ટ્રમાં આગામી તા.૧૨ સુધી વરસાદની કોઈ શક્યતા દેખાતી નથી. વરસાદ ખેંચાવાના કારણે ખરીફ પાકમાં થ્રીપ્સનો ઉપદ્રવ વધવાની શક્યતા છે.


ખેડૂત પ્રભાત

ચોમાસું મોડું બેસે, તો ક્યાં પાકનું વાવેતર કરવું લાભકારક ?

Solapur


संचार

दुष्काळी परिस्थितीतही 'कृषक'ने फुलवली शेती


अॅग्रोवन

फळबागांमध्ये ओलावा टिकविणे आवश्यक


रब्बी विशेष

ज्वारीमध्ये कोळपणी करा, संरक्षित पाणी द्या


दुष्काळातही पिके हिरवीगार अन् तजेलदार!


सोलापूर दिनांक

अल्पपाऊस, ना पाणी, ना संरक्षित पाणी ! तरीही रब्बी पिके जोमात


संचार

शाश्वत पीक उत्पादनासाठी माती परीक्षण आवश्यक


पुण्यनगरी

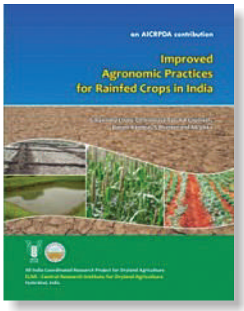
आता कमी पावसातही समाधानकारक उत्पादन शक्य

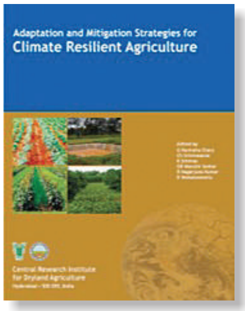

लोकमत

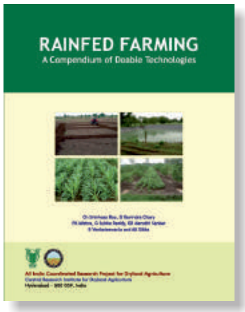
अॅग्रो व्हिजन

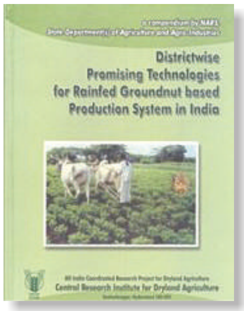
कोरडवाहू शेतीतही उत्पन्नाची

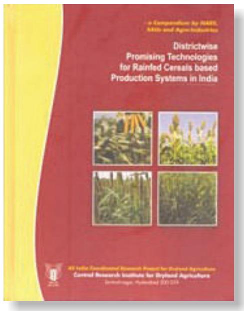
AICRPDA Publications

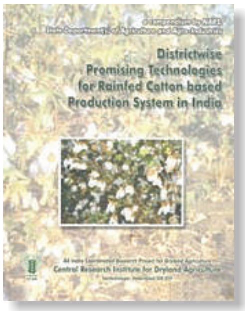


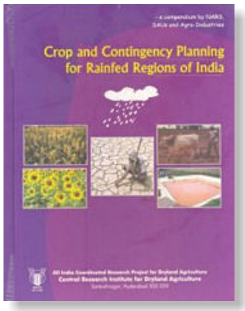


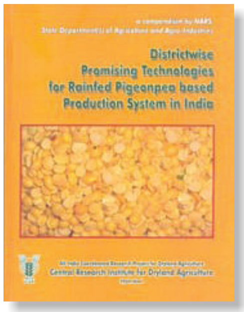


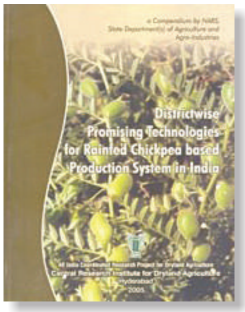


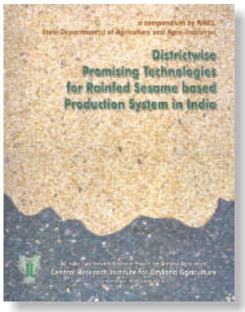


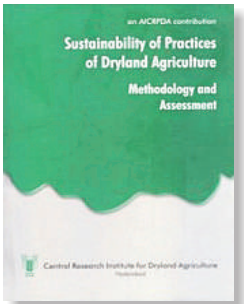


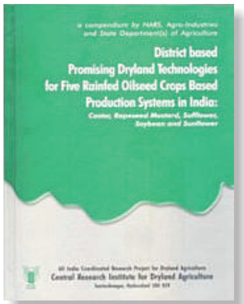


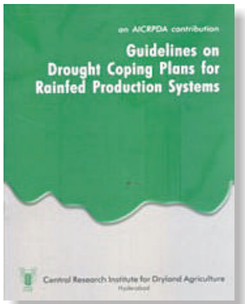


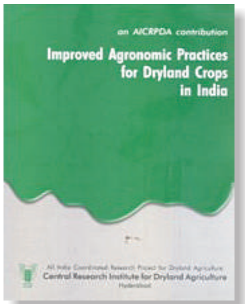


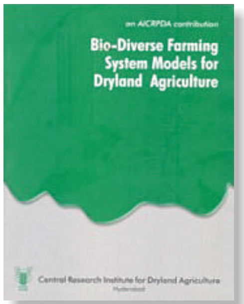


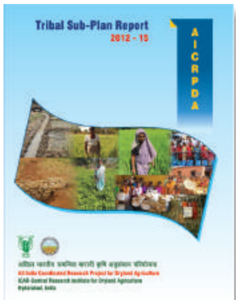












अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

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