भाकृअनुप
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वार्षिक प्रतिवेदन
Annual Report
2011-12

कृषि प्रणाली अनुसंधान परियोजना निदेशालय
मोदीपुरम, मेरठ–250 110 (उ.प्र.), भारत

Project Directorate for Farming Systems Research
Modipuram, Meerut - 250 110 (U.P.), India

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Project Directorate for Farming Systems Research
(Indian Council of Agricultural Research)
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Citation: **ANNUAL REPORT 2011-12**
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Printed at: Yugantar Prakashan Pvt. Ltd.
WH-23, Mayapuri Industrial Area Phase-I, New Delhi-64
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PREFACE

Project Directorate for Farming Systems Research was established as Project Directorate for Cropping Systems Research by Indian Council of Agricultural Research, New Delhi in April 1989 at Modipuram, Meerut (Uttar Pradesh). Earlier, the project was operating as All India Coordinated Agronomic Research Project (AICARP) since 1968-69 to coordinate agronomic research at national level. During mid-eighties it was realized that component approach of crop research is not sufficient to boost and sustain high yield levels, attained during green revolution period. Consequently, AICARP was upgraded to the level of Project Directorate with a vision to strengthen all aspects of system based crop research at national level. Further, during the year 2009-10 the PDCSR was re-named as **"Project Directorate for Farming Systems Research (PDFSR)".** It took one year for transformation and research work in farming system perspective could start during 2010-11. At present, in addition to campus based research at Modipuram, Project Directorate for Farming Systems Research is operating through All India Coordinated Research Project on Integrated Farming Systems with 37 on-station, 32 on-farm and 5 voluntary research centers spread throughout the country in five major ecosystems, i.e., arid, semi-arid, sub-humid, humid and coastal representing 15 agro-climatic zones to develop location specific system based technologies. The Network Project on Organic Farming remained operational since 2004-05 with its 13 cooperating centers spread over 12 states of the country. During the year under report, major emphasis was given for reorientation of on-going programme in to farming system mode. The major research programmes identified were Cropping Systems and Resource Management, Organic Agricultural Systems, Integrated Farming Systems, Resource Characterization and Systems Diagnosis, and Technology Transfer and Refinement.

I take this opportunity to express my sincere thanks to Dr. S. Ayyappan, Director General, ICAR and Secretary (DARE), Govt. of India; Dr. A.K. Singh, Deputy Director General (Natural Resource Management) and Dr. J. C. Dagar, Assistant Director General (Agronomy), Indian Council of Agricultural Research for their keen interest in growth and development of this Directorate.

Scientific inputs received from Research Advisory Committee and Institute Management Committee provided an immense help in taking new initiatives and improvement of the ongoing research programmes. Therefore, their contribution is thankfully acknowledged. Scientific, technical and administrative staff of Project Directorate for Farming Systems Research, Modipuram, who have contributed at different levels in preparing this annual report, deserve appreciation for their hard and sincere work.

(B. Gangwar)
Project Director

Modipuram
26 May, 2012

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फसल प्रणाली एवं संसाधन प्रबंधन

जैव–सघन प्रणाली से खरीफ में विस्तृत क्यारी पर 1:1 के अनुपात में मक्का (भुट्टा) + लोबिया (सब्जी) एवं कूंड़ में ढ़ैंचा और रबी में कूंड़ में सरसों एवं विस्तृत क्यारी पर मसूर की तीन पंक्तियां जबकि जायद में क्यारी पर मूंग की तीन पंक्तियां उगाया जाना, अन्य फसल प्रणालियों की अपेक्षा उल्लेखनीय रूप से बेहतर पाया गया। इसमें अधिकतम धान समतुल्य उपज (18.32 टन/हैक्टेयर) के साथ 50.2 कि.ग्रा. अनाज/हैक्टेयर/दिन उत्पादकता एवं रूपये 363/हैक्टेयर/दिन लाभ प्राप्त हुआ।

एक सिंचाई के तहत ज्वार–मसूर फसल प्रणाली में अधिकतम गेहूं समतुल्य उपज 4.09 टन/हैक्टेयर एवं शुद्ध लाभ रूपये 23700/हैक्टेयर प्राप्त हुआ जबकि दो सिंचाइयों के तहत मक्का–सरसों फसल प्रणाली से अधिकतम गेहूं समतुल्य उपज 5.39 टन/हैक्टेयर एवं शुद्ध लाभ रूपये 37900/हैक्टेयर प्राप्त हुआ। तीन सिंचाइयों पर सर्वाधिक गेहूं समतुल्य उपज और शुद्ध लाभ अरहर–जौ फसल प्रणाली में क्रमशः 9.76 टन/हैक्टेयर और रूपये 92000/हैक्टेयर एवं बाजरा–गेहूं में क्रमशः 6.42 टन/हैक्टेयर और रूपये 59000/हैक्टेयर प्राप्त हुआ। खरीफ में अरहर + ढ़ैंचा (6.38 टन/हैक्टेयर) एवं अरहर–उड़द–ढ़ैंचा प्रणाली (5.88 टन/हैक्टेयर) में अधिकतम तथा मूंग+धान में न्यूनतम (1.05 टन/हैक्टेयर) धान समतुल्य उपज प्राप्त हुई। रबी में अधिकतम गेहूं समतुल्य उपज मटर+गेहूं प्रणाली (12.12 टन/हैक्टेयर), सरसों (6.98 टन/हैक्टेयर) एवं गेहूं (6.18 टन/हैक्टेयर) जबकि मसूर+सरसों में न्यूनतम (1.73 टन/हैक्टेयर) गेहूं समतुल्य उपज प्राप्त हुई। जायद में मटर के बाद मूंग में 0.85 टन/हैक्टेयर प्राप्त हुई।

धान (साकेत–4) की उपज परम्परागत रोपाई, एच.टी. (4.63 टन/हैक्टेयर) की तुलना में मशीन से रोपाई, शून्यकृषण, एम.टी. (9.9 प्रतिशत) हाथ की मशीन से रोपाई, एम.ए.टी. (8.0 प्रतिशत), उच्च क्यारी बुवाई, जैड.टी. (6.9 प्रतिशत), क्यारीकृषण, एस.टी. (2.4 प्रतिशत) एवं ड्रमसीडर, बी.पी. (0.4 प्रतिशत) में अधिक जबकि छिड़काव बुवाई, डी.एस. (3.4 प्रतिशत), पराम्परागत बुवाई, सी.एस. (8.0 प्रतिशत) एवं बी.एस. (11.2 प्रतिशत) में कम दर्ज की गई। धान की रोपाई के लिए विभिन्न संसाधन संरक्षण तकनीकों के मूल्यांकन में शून्य कर्षण एवं क्यारी रोपण की तुलना से ज्ञात हुआ की मृदा स्थूलता घनत्व शून्य कृषण में अधिकतम सतह पर एवं परम्परागत बुवाई में 15–30 सेमी. तह पर दर्ज किया गया। पट्टी कृषण एवं क्यारी रोपण के पश्चात् अधिकतम मृदा जैविक कार्बन (7.5 ग्राम/कि.ग्रा.) शून्य कर्षण में एवं न्यूतनम (4.45 ग्राम/कि.ग्रा. मृदा) परम्परागत बुवाई में पाया गया। सभी कृषण उपचारों में 30 से.मी. मृदा से नीचे मृदा जैविक कार्बन की सान्द्रता गहराई बढ़ने के साथ कमतर दर्ज की गई। नर्सरी के लिए सबसे अच्छा संयोजन 5.0 X 1.2 मीटर नर्सरी, 30 किग्रा./हैक्टेयर बीज दर (साकेत–4),

16–20 दिनों की पौध (105–115 मि.मि. ऊंचाई) का प्रत्यारोपण, 40–45 मि.मि. जड़ लम्बाई, 3.2–4.2 मि.मि. तना व्यास, 3.6–4.2 मि.मि. तने के आधार पर मोटाई, 3–4 पत्तियां आने पर एवं लगभग 20 पौधे/वर्ग मीटर पाया गया। धान रोपण यंत्र के लिए इष्टतम पडलिंग आवश्यकता एक पडलिंग जिसका 42.3 प्रतिशत पडलिंग सूचकांक, 55.4 मि.मि. पडलिंग गहराई, 1.52 टन/घनमीटर स्थूल घनत्व, 48.7 प्रतिशत पानी की मात्रा एवं 1650 किलो पॉस्कल पैठ प्रतिरोध पाई गई। प्रति वर्ग मीटर में औसतन 44 पौधे पाये गए। प्रति हैक्टेयर 0.44 मिलियन पौधे, 18–20 सक्रिय कल्लों के साथ होने से वृद्धि एवं तत्पश्चात् विकास तीव्र गति से हुआ। परिणामों से संकेत मिलता है कि पडलिंग से उपज में वृद्धि हुई। हाथ से रोपाई की तुलना में यांत्रिक रोपण से उपज में औसतन 6.5 प्रतिशत की वृद्धि दर्ज की गई।

पारम्परिक बुवाई की तुलना में शून्य कर्षण बुवाई से उपज (16 प्रतिशत), शुद्ध लाभ (49 प्रतिशत), लाभ : लागत अनुपात (25 प्रतिशत), ऊर्जा उत्पादन : लागत अनुपात (39 प्रतिशत) में इजाफा जबकि कम विशिष्ट लागत (20 प्रतिशत) एवं विशिष्ट ऊर्जा (28 प्रतिशत) व्यय पाया गया। कतार ड्रम सीडर का प्रदर्शन (प्रक्षेत्र क्षमता = 0.065 हैक्टेयर/घण्टा, प्रक्षेत्र दक्षता = 45 प्रतिशत, लागत = रूपये 610/हैक्टेयर एवं ऊर्जा आवश्यकता = 78 मेगाजूल/हैक्टेयर) संतोषजनक पाया गया। अंकुरित धान की छिड़काव बुवाई की तुलना में ड्रम विधि से बुवाई करने से अधिक उपज (8.8 प्रतिशत), शुद्ध बचत (33 प्रतिशत), लाभ : लागत अनुपात (8 प्रतिशत), ऊर्जा उत्पादन : लागत अनुपात (9 प्रतिशत) जबकि कम विशिष्ट ऊर्जा (8 प्रतिशत) एवं पारम्परक बुवाई की तुलना में रोटरी, पट्टी, शून्य कृषण एवं क्यारी विधियों से बुवाई से समय बचत (70, 78, 83 एवं 75 प्रतिशत), श्रम बचत (76, 73, 78 एवं 70 प्रतिशत), डीजल बचत (65, 85, 83 एवं 87 प्रतिशत), लागत बचत (71, 78, 82 एवं 77 प्रतिशत), ऊर्जा बचत (65, 84, 87 एवं 86 प्रतिशत) एवं सिंचाई जल की बचत (10.6, 10.2, 11.0 एवं 35 प्रतिशत) हुई। यह भी देखा गया कि धान (6 से 7 टन/हैक्टेयर) एवं गेहूं (8.9 टन/हैक्टेयर) के भूसे/पुआल की रीसाइक्लिंग में रीसाइक्लिंग की डिग्री 80–85 प्रतिशत तथा लागत एवं ऊर्जा क्रमशः रूपये 2970/हैक्टेयर एवं 2630 मेगाजूल/हैक्टेयर पायी गई।

लवणीय–क्षारीय मृदा में मृदा सुधारकों जैसे–जिप्सम, गोबर की खाद, प्रेस मड़ एवं हरी खाद के एकल या संयोजित प्रयोग से मृदा नत्रजन में सुधार हुआ। लवणीय–क्षारीय मृदा में सामान्य मृदा के बजाय 34–45 प्रतिशत तक नत्रजन की कमी दर्ज की गई जिसमें विभिन्न मृदा सुधारकों के प्रयोग से वृद्धि की जा सकती है। इस प्रकार इन मृदाओं में 55 प्रतिशत अतिरिक्त नत्रजन प्रयोग कर सभी मृदा सुधारकों से 17–22 प्रतिशत तक अधिक धान समतुल्य उपज प्राप्त की जा सकती है। समतल क्यारी रोपाई में गन्ने की लम्बाई, व्यास, वजन, पैराई योग्य गन्नों की संख्या एवं गन्ने की उपज इत्यादि 50 प्रतिशत अपशिष्ट के साथ काफी अधिक थे एवं इसके बाद कमतर दर्ज

किए गए। औद्योगिक अपशिष्ट सिंचाई के उपयोग से दोनों रोपण विधियों के तहत डी.टी.पी.ए. निष्कर्षण लौह, मैंगनीज, कॉपर, जिंक में महत्वपूर्ण वृद्धि हुई। मिट्टी में गन्ना अवशेषों का आगे अपघटन 50 प्रतिशत अवशिष्ट आवेदन तक बढ़ा पाया गया। धान की उत्पादकता (6.03 टन/हैक्टेयर), शून्य सिंचाई जल तनाव पर अधिकतम दर्ज की गई जो 20 किलो पास्कल नमी तनाव के समतुल्य एवं 40 किलो पास्कल नमी तनाव से सांख्यिकीयतः अधिक पाई गई। धान की एरोबिक खेती के तहत अधिकतम फसल सूचकांक (40.62 प्रतिशत), पुष्पगुच्छी लम्बाई (17.8 मि.मि.), परीक्षण वजन (16.78 ग्राम) और प्रभावी कल्ले (378/वर्ग मीटर) शून्य किलो पास्कल के तहत प्राप्त किया गया।

बासमती धान की तुलना में प्रकाश संश्लेषण (> 21 μ mol CO_2 m^{-2} S^{-1}), वाष्पोत्सर्जन (> 11 μ mol H_2O m^{-2} S^{-1}) एवं कार्यिकीय विकिरण उपयोग दक्षता (> 15 μ mol CO_2 फोटोन$^{-1}$) की उच्च दर गैर–बासमती धान में पायी गई। गैर–बासमती धान में अनाज की उपज (4.19–6.85 टन/हैक्टेयर) बासमती की अपेक्षा (2.07–4.68 टन/हैक्टेयर) अधिक पायी गई। अनाज की उपज अत्यधिक रूप से उपज सूचकांक, पुष्पगुच्छी की लम्बाई, परीक्षण वजन एवं ऊष्मा उपयोग दक्षता से जुड़ी होती है। पी.बी.डब्ल्यू.–343, पी.बी.डब्ल्यू. –550, एच.डी.–2687, यू.पी.–2338 एवं एच.डी. –2894 की उपज अधिक (5500–6000 किग्रा. /हैक्टेयर) एवं पी.बी.डब्ल्यू.–373, डब्ल्यू.एच.–711, पी.बी.डब्ल्यू.–226, एच.डी.–2733, एच.आई.–1544, राज–3765, डब्ल्यू.एच.–1021, पी.बी.डब्ल्यू.–502 एवं यू.पी.–2425 की उपज (4500–5000 किग्रा. /हैक्टेयर) अपेक्षाकृत कम दर्ज की गई। अनाज उपज अत्यधिक रूप से कील की लम्बाई, दाना/कील, कुल बायोमास, उपज गुणांक, ऊष्मा उपयोग दक्षता एवं कील निकलने के लिए ऊष्मा की आवश्यकता पर निर्भर करता है। एच.डी. –2733, राज–3765, पी.बी.डब्ल्यू.–226, डब्ल्यू. एच.–711, एच.आई.–1544 एवं यू.पी.–2425 में ऊष्मा उपयोग दक्षता (<3.0 कि.ग्रा./केण्डिल) पायी गई जबकि अन्य किस्मों में ऊष्मा उपयोग दक्षता 3.0 से अधिक तथा पी.बी.डब्ल्यू–550 में सर्वाधिक (3.9), दर्ज की गई। पी.बी.डब्ल्यू.–226 जिसमें 60 किग्रा. नत्रजन/हैक्टेयर डालकर बुवाई डी$_3$ (बुवाई के 32 दिन बाद) की गई में पुष्पगुच्छी बनना जल्दी प्रारम्भ हुआ। सभी उपचारों में शीर्षन बुवाई से 64.3 से 48.3 दिन पश्चात दर्ज किया गया। पी.बी.डब्ल्यू.–226 जो डी$_3$ पर 60 किग्रा. नत्रजन डालकर रोपित किया गया में पुष्पगुच्छी एवं शीर्षन में सबसे कम दिन दर्ज किये गए। रोपाई की तारीख और नत्रजन स्तरों के बावजूद पर्णक्षेत्र सूचकांक पी.बी.डब्ल्यू.–343 में पी.बी.डब्ल्यू. –226 से अधिक था। सभी उपचारों में गेहूं के दोनों जीनोटाइप में 150 किग्रा./नत्रजन/हैक्टेयर के साथ डी$_1$ बुवाई पर अनाज उत्पादन अधिक पाया गया। सभी उपचारों में पी.बी.डब्ल्यू.–343 जो 150 किग्रा. नत्रजन/हैक्टेयर देकर डी$_1$ पर बोया गया में अनाज उपज (6.6 टन/हैक्टेयर) ज्यादा थी जबकि पी.बी.डब्ल्यू.–343 जो 60 किग्रा. नत्रजन देकर डी$_3$ पर बोया गया में कम अनाज उपज दर्ज की गई। विभिन्न उपचारों के बावजूद पी.बी.डब्ल्यू.–343 में पी.बी.डब्ल्यू.–226 की बजाय ज्यादा ऊष्मा उपयोग दक्षता पायी गई।

दीर्घकालिक धान–गेहूं प्रणाली में अलग–अलग गहराई पर माइक्रोबियल बायोमास कार्बन में अंतर पाया गया। सभी चार स्थानों पर एन.पी.के. के साथ गोबर की खाद के निरन्तर प्रयोग से सिर्फ एन.पी.के. के बजाय काफी ज्यादा माइक्रोबियल बायोमास कार्बन दर्ज किया गया। सभी स्थानों में से सतही मृदा में माइक्रोबियल बायोमास कार्बन अधिकतम कल्याणी में तथा न्यूनतम लुधियाना में पाया गया। सभी उपचारों में मृदा कण जैविक कार्बन (0–15 सेमी. मृदा में 625 से 1243.4 माइक्रो ग्राम/ग्राम) अन्य स्थानों की बजाय कल्याणी में सर्वाधिक पाया गया।

जैविक कृषि प्रणाली

मुख्य भू–खण्ड में रबी 2011 के दौरान गेहूं की पारम्परिक विधि की तुलना में उच्चतम अनाज और पुआल उपज (क्रमशः 5.8 और 7.23 टन/हैक्टेयर) 'श्री' विधि के अन्तर्गत दर्ज की गई। पारम्परिक विधि की तुलना में 'श्री' विधि में अनाज उत्पादन 26.3 प्रतिशत अधिक पाया गया। इसके विपरीत उप–भूखण्डों में अधिकतम अनाज व पुआल उपज क्रमशः 6.7 एवं 7.3 टन/हैक्टेयर, एफ.आई.आर.बी. प्रणाली में पायी गई जो पारम्परिक विधि की तुलना में क्रमशः 35.3 एवं 16.9 प्रतिशत अधिक थी। मुख्य एवं उप–भूखण्ड दोनों में गेहूं के उपज गुणों की प्रवृत्ति उपज के समान रही।

खरीफ में पारम्परिक विधि (6.25 टन/हैक्टेयर) की तुलना में 'श्री' पद्वति के अन्तर्गत (7.0 टन/हैक्टेयर) धान की 12 प्रतिशत अधिक अनाज उपज प्राप्त हुई। 'श्री' पद्वति में पुआल उपज 10.5 टन/हैक्टेयर हुई। 'श्री' पद्वति में धान की उपज एवं उपज गुण सर्वाधिक प्राप्त हुए।

ग्रीष्म 2010 में प्याज की सर्वाधिक उपज (24.49 टन/हैक्टेयर) टी$_6$ उपचार में प्राप्त हुई जिसमें गोबर की खाद, वर्मी कम्पोस्ट एवं नीम की खली + एन.पी. जैव–उर्वरक प्रत्येक 1/3 नत्रजन के समतुलय डाले गए। टी$_7$ उपचार की तुलना में इसमें 19.7 प्रतिशत उपज बढ़ी। अन्य जैविक पोषक तत्व प्रबंधन पैकेजों के तहत 2.41 से 11.01 प्रतिशत तक अनाज उपज बढ़ी। अगले खरीफ के दौरान भी उच्चतम मक्का उपज (6.35 टन/हैक्टेयर) टी$_6$ के तहत हुई। यहां पर ध्यान देना दिलचस्प होगा कि जैविक पोषक तत्व प्रबंधन प्रथाओं से मक्का समतुल्य उपज (21.35 से 30.7) में सुधार हुआ। उपज प्रति प्रणाली के संबंध में वर्ष 2010–11 के दौरान उच्चतम मक्का समतुल्य उपज (31.3 टन/हैक्टेयर) टी$_3$ में प्राप्त हुई जिसमें मक्का के साथ लोबिया अन्तरशस्य में जैविक स्रोतों का प्रयोग किया गया। मक्का समतुल्य उपज 29.9 टन/हैक्टेयर के साथ टी$_3$ के औसत प्रदर्शन का गत तीन सालों में यही प्रवृत्ति देखी गई।

बायोडाइनेमिक + गोबर की खाद + पंचगव्य उपचार में नियंत्रण की अपेक्षा क्रमशः 20.9, 15.2 एवं 17.3 प्रतिशत अधिक अनाज, पुआल एवं जैविक उपज के साथ लोबिया की उच्चतम फली उपज (19.6 क्विंटल/हैक्टेयर) दर्ज की गई। सर्वाधिक मृदा कार्बनिक पदार्थ, मैंगनीज एवं लोह इत्यादि तत्व गोबर की खाद + वर्मी कम्पोस्ट उपचार में जबकि उपलब्ध एन.पी.के. एवं जिंक इत्यादि तत्व

गोबर की खाद + वर्मी कम्पोस्ट + पंचगव्य उपचार में दर्ज किये गए। बासमती धान की अनाज, पुआल एवं जैविक उपज ग्रीष्मकालीन जुताई की अपेक्षा हरी खाद के तहत क्रमशः 8.0, 11.0 एवं 9.4 प्रतिशत अधिक पायी गई। इसी प्रकार, उपचारित भू–खण्ड़ों में अनुपचारित भू–खण्डों की अपेक्षा अनाज, पुआल एवं जैविक उपज क्रमशः 2.8, 2.3 एवं 2.4 प्रतिशत अधिक हुई। चना एवं सरसों में ग्रीष्मकालीन जुताई + अनुपचारित भू–खण्डों के अपेक्षाकृत हरी खाद + उपचारित भूखण्डों में शुष्कभार संचयन अधिक देखा गया। मृदा जैविक कार्बन एवं उपलब्ध एन.पी.के. ग्रीष्मकालीन जुताई की तुलना में हरी खाद में क्रमशः 27.8, 26.3, 45.5 एवं 7.5 प्रतिशत अधिक पाए गए। हरी खाद आवेदित भू–खण्डों में सूक्ष्म पोषक तत्व जैसे कॉपर, जिंक, लौह, मैंगनीज इत्यादि अधिक दर्ज किए गए। पूर्वोक्त पोषक तत्व उपचारित भूखण्डों में अनुपचारित भू–खण्डों की अपेक्षा थोड़ा अधिक थे।

एकीकृत कृषि प्रणाली (आई.एफ.एस.)

अध्ययन के प्रथम चरण और वर्ष 2011–12 के तुलनात्मक परिणाम बताते हैं कि छोटे किसानों की आजीविका सुनिश्चित करने के लिए आई.एफ. एस. दृष्टिकोण एक व्यवहारिक विधा है। इसके अलावा बारहमासी उद्यमों जैसे– बागवानी, सीमावृक्षारोपण इत्यादि से अतिरिक्त आय होकर उत्पादन एवं लाभप्रदता अधिक होने से आई.एफ. एस. दृष्टिकोण दीर्घ काल में प्रभावी है। पिछले साल की तुलना में इस वर्ष सकल लाभ, शुद्ध लाभ एवं वार्षिक बचत क्रमशः 14.6, 22.5 एवं 48. 4 प्रतिशत अधिक प्राप्त हुए। दिलचस्प रूप से इस वर्ष कुल लागत में वृद्धि नगण्य (8.03 प्रतिशत) थी, जो संभवतयः मशरूम और बायोगैस जैसे नये उद्यमों की वजह से हुआ।

मीठे पानी में मछली उत्पादन 0.1 हैक्टेयर भूमि में वर्ष 2005 में वर्षा ऋतु में शुरू किया गया। मछलियों की रोहू, कतला, मृगाल, कॉमन कार्प, सिल्वर कार्प और ग्रास कार्न प्रजातियों का मिश्रण 20:20:20:10:10 के अनुपात में 10,000 अंगुलिकाएं/हैक्टेयर रखा गया। वर्ष 2011 में 241.5 किग्रा. मछली उत्पादन कर रूपये 12075 का राजस्व सृजित किया गया। इस अवधि के दौरान मधुमक्खी पालन से 84 कि.ग्रा. शहद उत्पादित कर रूपये 10080 का राजस्व अर्जित किया गया।

वर्मी कम्पोस्ट इकाई में 18 टन समृद्ध खाद का उत्पादन कर इकाई की विभिन्न फसलों में इस्तेमाल किया गया। पिछले 3 साल से फल बाग के सीमा वृक्षारोपण (करोंदा) से काफी अच्दा उत्पादन (6.0 क्विंटल फल/वर्ष) लिया गया। शुरू में 'ढ़िंगरी' प्रजाति से मशरूम इकाई का प्रारम्भ कर भविष्य में अन्य प्रजातियां उगाई जाएगी। पिछले तीन महीनों में 50.0 कि.ग्रा. मशरूम उत्पादन किया गया।

संसाधन अभिलक्षणन व प्रणाली निदान

धान + पशुधन + सब्जी/फल/दालें/तिलहन आधारित कृषि प्रणाली 44 प्रतिशत कृषकों द्वारा अपनाए जाने से उच्च उत्पादक क्षेत्रों में एवं सुपारी + पशुधन + सब्जी/फल + धान (24

प्रतिशत) आधारित कृषि प्रणाली तमिलनाडु के उत्तर–पश्चिमी कम उत्पादक क्षेत्र में प्रमुख थे। परिणाम बताते हैं कि उच्च उत्पादक क्षेत्र में खेत के आकार के बढ़ने के साथ–साथ पशुधन आय कमतर पायी गई और अन्य किसानों की अपेक्षा बागवानी गतिविधियां मध्यम और बड़े किसानों के पास अधिक देखी गई। सीमांत किसानों की आय में पशुपालन (34.46 प्रतिशत) के बाद धान्य फसलें (23.05 प्रतिशत) व पशुपालन (16.05 प्रतिशत) प्रमुख स्रोत थे। मध्यम और बड़े कृषक श्रेणियों में भी कृषि आय की यही प्रवृत्ति देखी गई। धान आधारित कृषि प्रणाली जो 24 प्रतिशत कृषकों द्वारा अपनाये जाने से प्रमुख कृषि प्रणाली पायी गई। कावेरी डेल्टा के कम उत्पादन क्षेत्रों में विभिन्न श्रेणियों जैसे– सीमांन्त, छोटे, मध्यम एवं बड़े किसानों की औसत जोत क्रमशः 0.83, 1.89, 3.14 एवं 6.75 हैक्टेयर थी। आय पैटर्न से संकेत मिलता है कि कम उत्पादक तन्जौर जिले में कृषक आय में धान फसलों (53 प्रतिशत) के बाद गन्ने (36 प्रतिशत) का योगदान है। अध्ययन क्षेत्र में धान्य फसलों (77.08 प्रतिशत) के बाद पशुधन (10.42 प्रतिशत) आधारित कृषि प्रणालियां प्रमुख हैं। उच्च उत्पादक क्षेत्र में सीमान्त, लघु, मध्यम एवं बड़े किसानों का जोत आकार क्रमशः 0.73, 0. 88, 1.94 एवं 2.31 हैक्टेयर था। आय में धान्य फसलों का 40 प्रतिशत, सब्जियों का 18 प्रतिशत एवं पशुधन का 14 प्रतिशत योगदान था।

जोवाई, री–भोई, पूर्वी खासी पहाड़ियां एवं पश्चिमी खासी पहाड़ियों में 61.4 प्रतिशत कृषक जैविक कृषि एवं शेष 38.6 प्रतिशत किसान रासायनिक कृषि अपनाते हैं। उपलब्ध आंकड़ों से संकेत मिलता है कि उत्पादन के संदर्भ में अजैविक (रासायनिक) कृषि जैविक कृषि से बढ़कर है। धान एवं मक्का उत्पादन से क्रमशः रूपये 14749 / हैक्टेयर एवं रूपये 2150 / हैक्टेयर दर्ज किये गये। धान की उत्पादकता अजैविक उत्पादन 21.9 टन / हैक्टेयर के विपरीत जैविक उत्पादन में 15.2 टन / हैक्टेयर ही दर्ज की गई। जैविक उत्पादों द्वारा धान उत्पादकता में गिरावट एवं रासायनिक उत्पादकों द्वारा वृद्धि का रूख देखा गया। प्रत्येक नमूना कृषक द्वारा औसतन 8.9 पशु जिसमें गाय, बकरी, मुर्गी एवं सुअर शामिल हैं, रखा जाना उल्लेख किया गया। अकार्बनिक उत्पादकों द्वारा उर्वरक प्रयोग औसतन 30 किग्रा. / हैक्टेयर दर्ज किया गया है। हालांकि धान, मक्का, सब्जियां एवं बागवानी फसलें यहां मुख्य रूप से उगायी जाती है तथा निर्णायक रूप से मेघालय में जैविक कृषि के लिए पर्याप्त अवसर हैं।

तकनीकी हस्तान्तरण एवं परिष्करण

साबित तकनीकों को पच्चीस फसल प्रणालियों जैसे उच्च उत्पादक किस्में, धान सघनता प्रणाली, धान की मशीनीकृत बुवाई, पोषक तत्व प्रबंधन, हरी खाद, उच्च क्यारी रोपण, व्यापक क्यारी कूंड प्रणाली, शून्य कृषण तकनीक, फसल अवशेष प्रबंधन एवं कृषक विधि का प्रदर्शन किया गया।

धान–फूलगोभी–लौकी, धान–मटर–भिण्डी, धान (श्री)–सरसों–मूंग, धान–आलू (कुफरी बहार)–मूंग एवं धान–आलू (कुफरी पुखराज)–मूंग फसल प्रणालियों की गेहूं समतुल्य उपज क्रमशः

26, 17, 14, 19 एवं 17 टन/हैक्टेयर दर्ज की गई जिनके बाद कृषक विधि धान–गेहूं–मूंग (9 टन/है.) की उत्पादकता पाई गई।

सब्जी आधारित फसल प्रणालियों में से धान–फूलगोभी–तोरई, धान–आलू (कुफरी बहार)–मूंग एवं धान–आलू (कुफरी सूर्या)–मूंग अधिक शुद्ध लाभ क्रमशः रूपये 430, 288 एवं 271/दिन/हैक्टेयर दर्ज किया गया।

पट्टी भू–खण्ड डिजाइन में गेहूं की पांच किस्मों यथा एच.आई.–1544, पी.बी.डब्ल्यू.–550, एच.डी.–2781, राज–4037 एवं लोक–1 को गोबर की खाद के पांच विभिन्न स्तरों (नियंत्रण एवं 10 से 40 टन/हैक्टेयर) पर मूल्यांकित किया गया। अधिकतम पादप ऊंचाई (105.10 सेमी.) एच.डी.–2781 में दर्ज की गई। गोबर की खाद के लिए विभिन्न स्तरों में 20 टन/हैक्टेयर तक महत्वपूर्ण अन्तर (90.6 सेमी.) दर्ज किया गया।

इसी तरह कल्ले/वर्ग मीटर में भी महत्वपूर्ण अन्तर 20 टन/हैक्टेयर तक जिसमें 300 कल्ले/वर्ग मीटर दर्ज किये गए। विभिनन किस्मों में राज–4037 में अधिकतम कल्ले (324/वर्ग मीटर) दर्ज किये गये। कील लम्बाई, दाने/कील एवं परीक्षण वजन पर विभिन्न किस्मों एवं गोबर की खाद के स्तरों का कोई महत्वपूर्ण प्रभाव नहीं पाया गया। गेहूं की अधिकतम अनाज (4.0 टन/हैक्टेयर) एवं पुआल (4.87 टन/हैक्टेयर) उपज 30 टन गोबर की खाद/हैक्टेयर के तहत दर्ज की गई। हालांकि उपज में महत्वपूर्ण अन्तर मात्र 20 टन गोबर की खाद/हैक्टेयर के तहत जिसमें 3.9 टन/हैक्टेयर अनाज एवं 4.6 टन/हैक्टेयर पुआल उपज दर्ज की गई। पैराग्राफ पंजाब के होशियारपुर जिले के किसानों द्वारा विभिन्न फसलों के प्रति हैक्टेयर शुद्ध लाभ की रिपोर्ट से पता चला है कि मटर (रू. 79040) सबसे लाभदायक फसल एवं इसके बाद धान (रू. 22675), सूरजमुखी (रू. 21316), गेहूं (रू. 19908), मक्का (रू. 14425) एवं मूंगफली (रू. 7514) फसलें रही। पांच वर्षों में पोपलर के पेड़ों से औसतन लाभ रूपये 2365 प्राप्त हुए जबकि यूकेलिप्ट्स से आठ वर्षों में रूपये 3022 प्राप्त हुए।

कृषक विधि की बजाय 'पूसा बोल्ड' उन्नत किस्म के उगाए जाने से उपज में 30.6 प्रतिशत की वृद्धि हुई। उर्वरक एवं उन्नत बीज के लिए रूपये 1345 का अतिरिक्त खर्च करने से कृषक विधि की बजाय रूपये 11475/हैक्टेयर शुद्ध लाभ बढ़ा। वर्ष के दौरान कुल 10 प्रशिक्षण/क्षेत्र/प्रयोगशाला/संस्थान दौरे एवं दूरदर्शन कार्यक्रमों का आयोजन किया गया। कुल 317 किसानों, कृषक महिलाओं और राज्यों/जिले के अधिकारियों ने कार्यक्रमों में भाग लिया। खरीफ फसल उत्पादन प्रौद्योगिकी पर 3 दिनों के कृषक प्रशिक्षण के मूल्यांकन से पता चला है कि किसानों को दिये गए प्रशिक्षण से उनके समग्र ज्ञान में 30 प्रतिशत का इजाफा हुआ। इसी तरह, नाबार्ड कोलकाता द्वारा प्रायोजित सितम्बर, 2011 में आयोजित प्रशिक्षण कार्यक्रम में भाग लेने वाले किसानों के समग्र ज्ञान में भी 20 प्रतिशत इजाफा दर्ज किया गया।

SUMMARY

Cropping Systems and Resource Management

Bio-intensive system of raising maize for cobs + vegetable cowpea in 1:1 ratio on broad beds (BB) and *sesbania* in furrows during *kharif* and mustard in furrows and 3 rows of lentil on broad beds in *rabi* while 3 rows of green gram on beds in summer was found remarkably better than others which produced highest yield of 18.3 t ha^{-1} as rice equivalent with productively of 50.2 kg grain $ha^{-1}day^{-1}$ and profitability of ₹ 363 $ha^{-1}day^{-1}$.

Sorghum – Lentil cropping system provided maximum wheat equivalent yield (WEY) of 4.0 t ha^{-1} and net returns of about ₹ 23700 ha^{-1} under one irrigation whereas, under two irrigations, Maize – Mustard cropping system provided maximum WEY of 5.4 t ha^{-1} and net returns of about 37900 ₹ ha^{-1}.Under three irrigations regimes, Pigeon pea – Barley cropping system provided maximum WEY of 9.6 t ha^{-1} and net returns of about 92000 ₹ ha^{-1}, followed by Pearl millet –Wheat (6.4 t ha^{-1}) and about 59000 ₹ ha^{-1}. During *kharif*, Pigeon pea (RB) + sesbania (F) system produced maximum rice equivalent yield, REY (6.38 t ha^{-1}) followed by [Pigeon pea + Black gram] (BB) + sesbania (F) system (5.9 t ha^{-1}) and Pigeon pea (FB) system (5.1 t ha^{-1}) while Green gram (BB) + Rice (F) produced lowest REY (1.05 t ha^{-1}). During *rabi*, Vegetable pea (RB) + Wheat (F) system produced maximum wheat equivalent yield, WEY (12.1 t ha^{-1}) followed by Mustard (FB) (7.0 t ha^{-1}) and wheat (FB) (6.2 t ha^{-1}) while Lentil (RB) + Mustard (F) produced lowest WEY (1.8 t ha^{-1}). During summer, Green gram after Veg. pea (FB) produced 0.85 t ha^{-1}.

Higher rice (Saket 4) yield was reported in MT (9.9%), MaT (8.0%), ZT (6.9%), ST (2.4%), RT (0.8%) and BP (0.4%); but lower in DS (3.4%), CS (8.0%) and BS (11.2%), respectively, compared to traditional HT (4.63 t ha^{-1}) under evaluation of different resource conservation technologies for planting of rice. In ZT, the soil bulk density was greatest near the soil surface, whereas it was higher under conventional sowing in 15-30 cm layers compared with zero tillage and bed planting. SOC content was highest under ZT (7.5 g kg^{-1}), followed by strip tillage and bed planting and lowest under conventional sowing, i.e., 4.45g kg^{-1}. Beneath 30 cm, the SOC concentrations decreased with increasing depth for all tillage treatments. The best combination reported for nursery raising was a size of 5.0 m x 1.2 m nursery bed, sown at 30 kg ha^{-1} seed (Saket 4) rate and transplanting 16 to 20 days old seedlings at height of seedling (105–115 mm), root length (40-45 mm), trunk diameter (3.2-4.2 mm), thickness of seedling at the base of root (3.6-4.3 mm), leaf stage (3-4) and about 20 thousand seedlings m^{-2}. The optimum puddling requirement reported for rice transplanter was one operation of puddler with corresponding puddling index of 42.3 percent, depth of puddle profile of 55.4 mm, bulk density of 1.52 t m^{-3}, water content of 48.7 percent and penetration resistance of 1650 k Pa. Average number of hills m^{-2} was found to be 44. The growth and subsequent establishment of the transplanted seedlings were faster having 0.44 million hills ha^{-1} with 18-20 active tillers $hill^{-1}$. The results indicated that, the yield increased with puddling operations. The average increase in mechanical transplanting was 6.5 percent compared to manual transplanting. The performance parameters of different rice seeding machines showed that ZT, ST, RT and BP of rice saved time (89 to 86%), labour (87 to 83%), diesel (88 to 60%), cost (82 to 65%), energy (88 to 61%) and also irrigation water (8 to 38%) as compared to conventional sowing. The zero till drilling produced higher rice (16 %), net returns (49%), B: C ratio

(25 %) and energy output: input ratio (39 %) while requiring lesser specific cost (20 %) and specific energy (28%), compared to conventional sowing. The performance of 8- row drum seeder was satisfactory (field capacity = 0.07 ha hr^{-1}, field efficiency = 45%, Cost of operation = ₹ 610 ha^{-1} and energy requirement = 78 MJ ha^{-1}). Drum seeding provided higher rice yield (8.8%), net returns (33%), B: C ratio (8%), energy output: input ratio (9%) while requiring lower specific energy (8%) and specific cost (7%) compared to broadcasting method of sprouted seeding of rice. The rotary, strip and zero till drilling and bed planting were reported as time saving (70, 78, 83 and 75%), labour saving (76, 73, 78 and 70%), diesel saving (65, 85, 87 and 87%), cost saving (71, 78, 82 and 77%), energy saving (65, 84, 87 and 86%) and also irrigation water saving (10.6, 10.2, 11.0 and 35%) tools compared to conventional sowing of wheat. It was observed that for recycling of rice (6 to 7 t ha^{-1}), as well as wheat straw (8 to 9 t ha^{-1}), the degree of recycling was 80-85% and cost and energy of recycling of ₹ 2970 ha^{-1} and 2630 MJ ha^{-1}, respectively.

Use of amendments such as gypsum, FYM, press mud and green manure either in isolation or in combination led to increase in potentially mineralizable nitrogen over the saline-sodic control plots. Reduction in the potentially mineralizable nitrogen under saline-sodic soil by 34-45 percent over the normal soil was reported, which could be increased with the application of different soil amendments. Thus, 25% excess N application in such soils gave 17-22 percent higher system productivity (REY) in all amendments. Cane length, cane girth, weight per cane, mileable cane number and cane yield were significantly higher with 50% effluents and declined thereafter under flat bed planting however, this parameter were improved with the raised bed planting over the flat bed planting. There was significant increase in the DTPA extractable Fe, Mn, Cu and Zn under both the planting methods with the use of industrial effluents irrigation. Further decomposition of sugarcane trash residue in the soil was increased up to 50% effluent application. Rice productivity was maximum (6.03 t ha^{-1}) at zero irrigation water tension, which is at par with 20 k Pa and statistically significant with 40 kPa. Maximum harvest index (40.6 %), panicle length (17.8 mm), test weight (16.8 g) and effective tillers/ m2 (378) were obtained under 0 k Pa moisture tension under aerobic cultivation of rice.

Higher rate of photosynthesis (>21µ mole CO_2 m^{-2} s^{-1}), transpiration (>11 m mole H_2O m^{-2} s^{-1}) and physiological radiation use efficiency (>15 m mole CO_2 $photon^{-1}$) was observed in non basmati type in comparison to basmati type of rice. The range of grain yield (t ha^{-1}) was 2.0-4.7 in basmati type and it was in higher side in non basmati type (4.2-6.9). The grain yield was highly associated with HI, panicle length, test weight and heat use efficiency. Higher yield (5500-6000 Kg ha^{-1}) performance was reported in PBW 343, PBW 550, HD 2687, UP 2338 and HD 2894, while it was lower (4500-5000 Kg ha^{-1}) in PBW 373, WH 711, PBW 226, HD 2733, HI 1544, RAJ 3765, WH-1021, PBW 502 and UP 2425. Grain yield was highly associated with spike length, spikelet $spike^{-1}$, grains $spike^{-1}$, total biomass, HI and Heat Use efficiency and Heat unit required for spike initiation. Lower Heat Use efficiency (Kg/^{0}Cd) was reported in HD-2733, RAJ-3765, PBW-226, WH-711, HI-1544 and UP-2425 (<3.0) while in rest others cultivars HUE was higher than 3.0 and it was highest in PBW 550 (3.9). Panicle initiation was significantly early in PBW 226 fertilized with 60 Kg N ha^{-1} and sown on D_3 (32.0 DAS). Days taken to heading were 64.3 to 48.3 DAS across the treatments. Significantly lower days was taken by PBW 226 fertilized with 60 Kg N ha^{-1} and transplanted on D_3. LAI was higher in PBW 343 than PBW 226 genotypes irrespective of date of transplanting and nitrogen level. Grain yield was higher in D_1 sowing fertilized with 150 Kg N ha^{-1} in both wheat genotypes across the treatments. Higher grain yield (6.6 t ha^{-1}) was recorded in PBW 343 fertilized with 150 Kg N ha^{-1} and sown on D_1 whereas, lower grain yield (2.4 t ha^{-1}) was observed in PBW 343 fertilized with 60 Kg N ha^{-1} and sown on D_3 among all the treatments. In general, Heat Use Efficiency (HUE, Kg/ ^oCd) was reported relatively higher in PBW 343 than PBW 226 irrespective of treatments.

Distinct difference of microbial biomass carbon (MBC) content was observed among different treatments and at different depths in a long term rice-wheat system. Continuous application of FYM along with NPK (NPK+FYM) resulted in significantly higher soil MBC over NPK at all four locations. Across the locations highest MBC contents in surface soil was recorded in Kalyani and lowest in Ludhiana. The particulate organic carbon (POC) content of the soil in all the treatments at Kalyani was significantly higher (625 to 1243.4 µg g^{-1} in 0-15 cm) over the soils under the same treatment at all other locations.

Organic Agriculture Systems

Highest grain and straw yield of 5.8 and 7.2 t ha^{-1} of wheat during *rabi*, 2010-11 was recorded under main plot which was designated for SRI method of rice cultivation compared to 4.6 and 6.2 t ha^{-1} respectively under conventional method of wheat cultivation. But the grain yield increase compared to conventional method of wheat cultivation was to the tune of 26.4%. On the contrary, the highest grain and straw yields among sub-plots were 6.7 and 7.3 t ha^{-1} under FIRB systems which were 35.3 and 16.9% higher than the conventional method of sowing wheat and the effect was significant. The yield attributing characters of wheat followed the same trend as with yield under both main and sub-plot treatments.

Highest grain yield of rice (7.0 t ha^{-1}) during *Kharif* was recorded under SRI method compared to 6.25 t ha^{-1} under conventional method. The percent yield increase under SRI was 12.0%. The straw yield under SRI was 10.5 t ha^{-1}. The yield and yield attributing characters of rice were also highest under SRI method.

Highest grain yield of onion during summer, 2010 was recorded under T_6 (24.5 t ha^{-1}) which received organic nutrient sources each equivalent to 1/3 N as FYM, vermi compost and neem oil cake plus biofertilizers containing N and P carriers. Percent yield increase under this treatment was 19.72% compared to T_7. The yield increase under other organic nutrient management packages varied from 2.41 to 11.01%. Highest maize crop during next *Kharif* was also observed under T_6 at 6.35 t ha^{-1}. It is also interesting to note that organic nutrient management practices helped in improving MEY varied from 21.35 to 30.74. As per system yield is concerned, the maize equivalent yield during 2010-11 was highest (31.38 t ha^{-1}) under T_3 which received organic sources of nutrients and intercropping of cowpea with maize. The same trend was also recorded in relation to last three years average performance of T_3 with MEY 29.97 t ha^{-1}

BD + FYM + Vermicompost + Panchgavya treatment recorded 20.9, 15.2 and 17.3% higher grain, straw and biological yield of rice; 32.8, 25.9 and 28.5 % higher grain, straw and biological yield of maize, respectively over control and also recorded highest (19.6 q ha^{-1}) pod yield of cowpea.Highest soil organic carbon, Mn, and Fe were recorded under FYM + vermicmpost application while, available N, P, K and Zn was higher under FYM+ vermicompost + *Panchgavya* application. Grain, straw and biological yield of basmati rice under green manure was 8.0, 11.0 and 9.4 %, respectively higher over summer ploughing. Similarly, treated crop yielded 2.8, 2.3 and 2.4 % higher grain, straw and biological yield, respectively over untreated plots.Chickpea and mustard shows higher dry matter accumulation under green manured + treated plots than summer ploughed + untreated plots.Organic carbon, available N, P and K under green manure was 27.8, 26.3, 45.5 and 7.5 % higher over summer ploughing. Micronutrients *viz*, Cu, Zn, Fe, Zn etc. were also recorded higher under green manured plots. The aforesaid nutrients were slightly higher under treated plots over untreated.

Integrated Farming Systems

The comparative results of first phase (2004-10) of the study and of successive year 2011-12, inferred that IFS approach is a viable way of ensuring livelihood of small categories of farmers. Further, the impact of IFS approach in long run is also visible as the production and profitability is on higher side with additional income/ returns achieved from perennial type of enterprises such as horticulture, boundary plantations etc. The percent increase in gross return, net return and annual saving was higher (14.6%, 22.6%, and 48.5%, respectively) as compared to previous years. Interestingly, increase in total cost of production was insignificant (8.0%), which probably was because of addition of new enterprises mushroom and biogas.

Freshwater fish production was started during rainy season of 2005 at 0.1 ha land. A mix of fish species including rohu, katla, mrigal, common carp, silver carps and grass carp were stocked @ 10000 fingerlings per hectare in ratio of 20:20:20:10:20:10. A production of 241.5 kg fish was achieved in the year of 2011 generating revenue of ₹ 12075. During this period a low yield of 84 kg honey was recorded from apiary section and total revenue of Rs.10080 was generated. Vermicompost unit produced 18 tons of enriched compost which was recycled / used in production of different field and plantation crops of the unit. Considerably high (4.5-6.0 q year^{-1}) fruit yield was harvested from boundary plantation (karonda) of the orchard from last three years or so. Mushroom unit was started with production of "Dhingary" species initially and later on other species will be grown in coming years. During last three months about 50 kg of mushroom was produced.

Resource Characterization and System Diagnosis

Rice +Livestock+ Veg/ Fruits+ Pulses/ Oilseed based farming system were found predominant being adopted by about 44 percent in high productive and Arecanut+ Livestock+ Veg/Fruits + Rice (24 Percent based farming system were predominant in North western low productive zone of T.N. The results indicated that as farm size increases the share of livestock income decreases and horticulture activities was more with medium and large farmers in comparison to others in high productive zone. The income pattern of marginal farmers comprised of animal husbandry activity with 34.5% followed by cereals 23.0% and small farmers of this district have 44.0% of income from the vegetables followed by animal husbandry 16.0%. The category of medium and large farmers also has the same trend. Rice based farming system was found predominant farming system being adopted by about 24 percent sample households followed by rice blackgram and rice- rice system. As regards to Cauvery delta zone, the average size of land holdings of different categories was 0.8, 1.9, 3.1 and 6.6 ha for marginal, small, medium and large farmers respectively in low productive zone. The income pattern indicated that cereals contributed more than 53 percent followed by sugarcane 36 percent income in low productive Thanjavurdistrict. Cereal based (77.0%) followed by livestock based farming system (10.4%) were predominating farming systems in the study area. The size of land holdings of different categories was 0.7, 0.9, 1.9 and 2.3 ha in high productive zone for marginal, small, medium and large farmers respectively. The income contribution patterns from cereals are about 40%, vegetable about 18 %, and 14 percent from livestock.

The 61.4% farmers of Jowai, Rebhoi, East Khasi Hills and West Khasi Hills practice organic agriculture, while rest 38.6% farmers found practing chemical agriculture practices. Available data indicate that inorganic agriculture had edge over organic agriculture in terms for production. The benefit from rice & maize reported to be ₹ 14749/- /ha and 2150/ha, respectively. The productivity of rice was recorded 15.5 t ha-1 for organic cultivators as against 21.9 t ha^{-1} for inorganic producers. Declining trend in rice productivity was noted in case of organic growers while increasing yield trend was observed for inorganic farmers. On an average 8.9 animal which includes cow, goat, poultry and pigs was noted to be kept by each sample household. The average use of fertilizer was recorded 30 kg/ha by inorganic producers. In Meghalaya, the climate is very good for all types of crops. However rice, maize, vegetables and horticulture crops are mainly grown here conclusively, there is ample opportunities in Meghalaya for organic agriculture.

Technology Transfer and Refinement

Proven technologies were super imposed on twenty five cropping systems viz., improved cultivars, system for rice intensification, mechanical transplanting of rice, nutrient management, green manuring, raise bed planting, broad bed furrow system, zero tillage technology, crop residue management, and farmers practice were demonstrated.

The wheat equivalent yield (WEY, t ha^{-1}) of rice-cauliflower-bottle gourd, rice- vegetable pea-ladyfinger, rice (SRI)–mustard-summer moong, rice–potato (K. Surya)-summer moong, rice-potato (K. Bad.)- Summer moong, rice –potato (K. Bahar)-summer moong and rice–potato (K. Pukhraj)-summer moong were 26, 17, 14, 19 & 17 t ha^{-1} receptively and it was followed by farmers practice rice (FP)-wheat (FP)-summar moong (9 t ha^{-1}). Amongst vegetable based cropping systems, the higher net return were recorded in rice-cauliflower-bottle guard, rice–potato (K. Bahar) -summer moong and rice –potato (K.Surya)-summer moong ₹ 430, 288, and 271 day^{-1} ha^{-1} respectively.

Five wheat varieties viz. HI 1544, PBW 550, HD 2781, RAJ 4037 and LOK 1 were evaluated at five different levels of FYM (Control and 10 to 40 t ha^{-1}) in strip plot design. Maximum plant height (105.1 cm) was recorded in wheat varieties HD-2781 followed by HI-1544 (89.0 cm). Among the FYM levels significant differences were observed up to 20 t ha^{-1} (90.6 cm). Likewise significant differences in tillers m^{-2} were noted up to 20 t ha^{-1} which attained the tillers up to 300 tillers m^{-2}. Among the varieties RAJ 4037 recorded, the maximum number of tillers (324 tillers m^{-2}). Non significant differences due to varieties and FYM levels were noted in spike length, grains/ear and test weight. Maximum grain (3998 kg ha^{-1}) and straw (4865 kg ha^{-1}) yields were recorded at 30 t FYM/ha, however yield differences were significant only up to 20 t ha^{-1} which recorded 3934 kg ha^{-1} grain and 4613 kg ha^{-1} straw yields of wheat.

The net return per hectare from different crops as reported by the farmers of Hoshiarpur district of Punjab, revealed that peas (₹ 79040/-) was the most profitable crop followed by rice (₹ 22675/-), sunflower (₹ 21316/-), wheat (₹ 19908/-), maize (₹ 14425/-) and groundnut (₹ 7514/-). The average net return per tree from poplar was reported to be ₹ 2365/- in 5 years, whereas that of eucalyptus was ₹ 3022/- in 8 years.

Study revealed that on mean data basis 62.0% farmer are practicing organic agriculture while 38.0%

are following inorganic agriculture in Meghalaya. The productivity of rice was recorded 15.5 t ha^{-1} for organic cultivators as against 21.9 t ha^{-1} for inorganic producers. Declining trend in rice productivity was noted in case of organic growers while increasing yield trend was observed for inorganic farmers. On an average 8.9 animal which includes cow, goat, poultry and pigs was noted to be kept by each sample household. The average use of fertilizer was recorded 30 kg ha^{-1} by inorganic producers. The organic materials namely FYM, compost and vermi compost was recorded to use by organic growers. Non availability of sufficient organic manure and non awareness of organic farming was observed among major constraints. The study concluded bright prospect of organic agriculture in the state if the sufficient organic manure is produce by farming community. The improved practice with the use of recommended variety Pusa Bold resulted in increase in yield by 30.6 percent over the farmers' practice. By making an additional expenditure of ₹ 1345/- in the form of fertilizer and quality seed of high yielding variety, the increase in net return under improved practice was ₹ 11475/- per hectare over farmers' practice. A total of 10 training programme/ field/ laboratory/ institute visits and Doordarshan programmes were organized. A total of 317 farmers/ farm women and officers from different states/ district attended the programmes. The assessment of 3 days duration Farmers' Training on *Kharif* Crop Production Technology, revealed that there was about 30 percent gain in overall knowledge of the participant farmers as a result of training imparted to them. Similarly, 20 per cent gain in overall knowledge of participating farmers was recorded in the collaborative training programme organized during September, 2011 which was sponsored by NABARD, Kolkata.

2. INTRODUCTION

The genesis of the Cropping Systems Research Project may be traced back to the visit of Dr. A.B. Stewart of Macaulay Institute of Soil Research, Aberdeen, U.K., somewhere in mid- nineteen forties. He was invited by the then 'Imperial Council of Agricultural Research' to review the status in respect of soil fertility investigations, in general, and manuring in particular, and to suggest necessary steps which might be taken to obtain adequate information under different conditions of soil and climate within a very short time so that the agricultural departments could provide relevant instructions to the farmers for increasing the crop yields. His review report, published in 1947, significantly influenced the philosophy and practice of fertilizer experimentation in the county. The importance of conducting simple fertilizer trials on cultivators fields and complex experiments at selected centers was emphasized in the report which promoted the initiation of "Simple Fertilizer Trials on Cultivators Fields" in 1953 under Indo-American Technology Cooperation Agreement through Soil Fertility and Fertilizer Use Project" with the following objectives:

OBJECTIVES

- To study crop responses to NPK, when applied separately and in different combinations under the cultivator's field conditions

- To investigate the relative response of different fertilizers in various broad soil groups and to work out the optimum fertilizer combinations for different agro-climatic regions

- To study the relative performance of different nitrogen and phosphatic fertilizers for indigenous production

- To demonstrate the role of fertilizer use on crop production before the farmers

Later, in 1956, Model Agronomic Experiments, i.e. complex experiments on carefully selected centers, were also brought under the purview of the project and it was renamed as "ll India Coordinated Agronomic Experiments Scheme (AICAES)". With the passage of time the scheme went through various stages of evolution to keep pace with the development in science and technology and to meet the increasing demands. The research arena was expanded to include agronomic research encompassing cultural practices, irrigation, nutrition, chemical weed control and multiple cropping. But the emphasis continued to remain on soil fertility and fertilizer use efficiency. In 1968-69 the scheme was sanctioned as 'All India Coordinated Agronomic Research Project (AICARP) with two components viz; 'Model Agronomic Experiments' and 'Simple Fertilizer Trials'.

Nevertheless, even after green revolution, agricultural research centered on only individual crops in isolation. But for a sustainable development the system approach is a must. This realization might have given an impetus to start cropping systems oriented research and the project was upgraded into a Directorate during 7th five year plan and was established as the '**Project Directorate for Cropping Systems Research (PDCSR)**', which became functional in March, 1989 with its headquarters at Modipuram, Meerut, U.P. Further, during 11th five year plan PDCSR has been re-designated as '**Project Directorate for Farming Systems Research (PDFSR)**' with revised mandate as given in the next section. Practically this has come into effect during 2009- 2010.

Since its inception, the Directorate has made significant contributions to the development and refinement of crop production technologies for diverse eco-edaphic and resource-base situations. These technologies have been aimed at efficient resource utilization and yield maximization through new technologies. Some of the major areas of research are:

* Development of need-based efficient and profitable cropping/farming systems.
* Optimum varietal combinations for various crop sequences
* Optimum crop combinations and planting geometry for intercropping systems
* Tillage requirements and crop establishment practices under different cropping systems
* Agricultural resource characterization and constraint analysis under different agro-ecological regions/ farming situations
* Farming/ cropping systems analysis
* Efficient sources of fertilizers for different crops and soil types
* INM in different farming/cropping systems
* Effect of long term INM and chemical fertilizer use on crop yields and soil fertility
* Options for introducing legumes in cereal-cereal cropping systems
* Resource conservation technologies
* Farm mechanization and crop residue management
* Climate resilient agriculture
* Organic farming
* Precision farming
* Integrated farming systems
* On-farm evaluation and refinement of cropping systems technologies
* Cropping/ farming systems related database management
* Human Resource Development related to Cropping/Farming Systems Research

During 2011-12, PDFSR was operating through following three plan schemes:

1. **PDFSR –** Strengthening and continuation of PDFSR headquarters at Modipuram.

2. **AICRP on Integrated Farming Systems (IFS):**

(a) *IFS Research Centres***:** On-station research is initiated at 31 main centres and 11 sub centres. These centres are engaged in basic and applied research at research stations and are necessarily located at SAUs or their Regional Research Stations or agriculture colleges of those general universities, where strong agricultural research base is available.

(b) *On-Farm Research:* On-farm research is going on at 32 centres. These centres are engaged in farmers' participatory research. On-farm research (earlier known as Experiments on Cultivators' Fields) centres are located in different agro climatic zones and cover the entire zone.

3. **Network Project on Organic Farming (NPOF) -** The project is presently under progress at 13 cooperating centres, located at SAUs/ ICAR Institutes in 12 states.

3. MANDATE

The revised mandate of the PDFSR is given as below:

- To characterize existing farming systems to know the productivity, viability and constraints.
- To develop resource efficient, economically viable and sustainable integrated farming system modules and models for different farming situations
- To undertake basic and strategic research on production technologies for improving agricultural resource use efficiencies in farming system mode
- To develop and standardize package of production practices for emerging cropping/ farming concepts and evaluate their long-term sustainability
- To act as repository of information on all aspects of farming systems by creating appropriate databases
- To develop on-farm agro-processing and value addition techniques to enhance farm income and quality of finished products
- To undertake on-farm testing, verification and refinement of system-based farm production technologies
- To develop capacity building of stakeholders in Integrated Farming Systems through training

4. LOCATION

The PDFSR and its research farms are located in the Modipuram suburb of Meerut City, situated on Delhi-Haridwar National Highway no. 58, near Sardar Vallabbhai Patel University of Agriculture and Technology. The distance from Meerut city (Begum Bridge) is about 10 km. Modipuram is situated at an elevation of 230 meters above mean sea level, 29° 4' N latitude and 77° 46' E longitude.

5. SOILS AND CLIMATE

As per Planning Commission of India this region where PDFSR falls is classified as 'Western Plains Sub-Zone' of 'Upper Gangetic Plains'. However, as per National Bureau of Soil Survey and Land Use Planning, Nagpur, the area falls under Agro-ecological Region number 4, i.e., 'Northern Plain and Central Highland's Hot Semi-Arid Eco-region' with Alluvium derived soils. Soils of PDFSR research farm are representative of the region and are neutral to slightly alkaline in nature and belong to Typic Ustochrept group. The climate of Modipuram is broadly classified as semi-arid sub-tropical characterized by very hot summers and cold winters. The hottest months are May-June, when maximum temperatures may, sometimes, shoot up as high as 45-46°C, whereas during December-January, coldest months of the year, the minimum temperatures may often go below 5 °C. The average annual rainfall is 862.7 mm, 75-80 percent of which is received through southwest monsoon during July to September.

The important weather parameters during 2011-12 are depicted in Figs. 1-4. Rainfall recorded at Modipuram during the year under report was almost 3/4th (638.0 mm) of the normal rain. This was

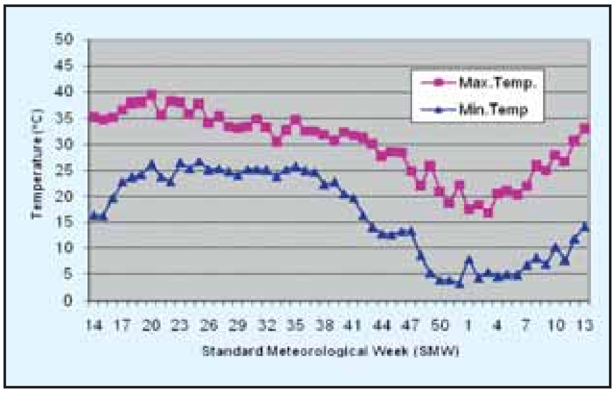


Fig 5/1: Weekly maximum and minimum temperature during crop season (2011-12)

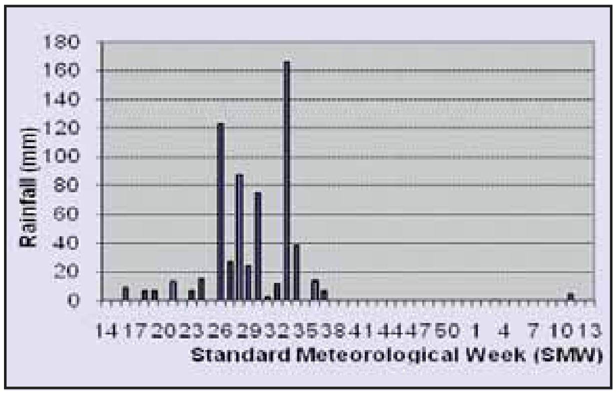


Fig 5/2: Weekly rainfall during crop season (2011-12)

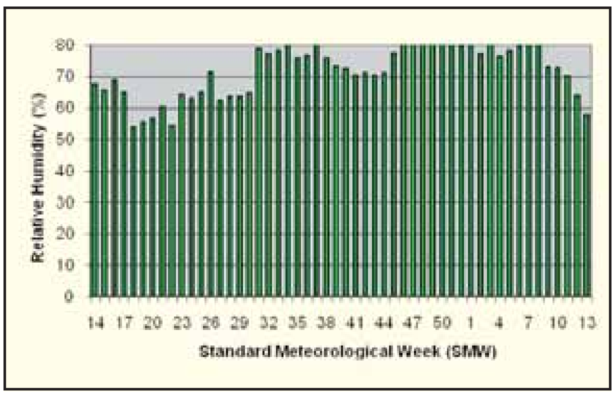


Fig 5/3: Weekly average relative humidity during crop season (2011-12)

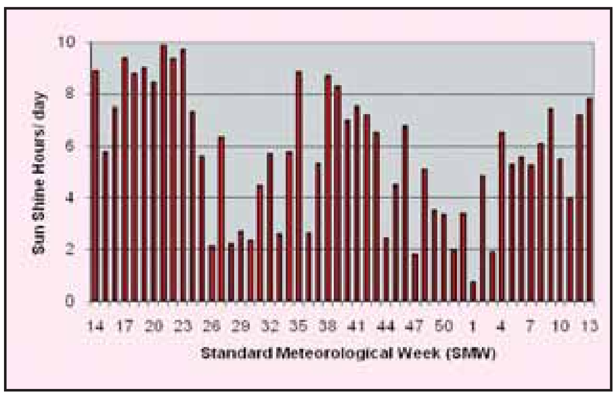


Fig 5/4: Weekly average bright sunshine hours during crop season (2011-12) primarily due to early withdrawal of the monsoon as there was no rain after 2nd week of the September and also due to lack of rainfall in winter months. The onset of monsoon occurred in the 26th standard meteorological weeks (SMW) which are the normal week of onset of monsoon at this center. The amount was good and brought about sufficient rain to the rice and sugarcane crops. The highest rainfall (166.3 mm) occurred during the 33rd SMW. Albeit the rainfall was well distributed in the months of July and August, but no rainfall occurred after 37th SMW (Mid September) to 11th SMW (Mid March). Summer season was moderate and weekly average maximum temperature remained below 39.2 °C in 20th SMW whereas, minimum temperature was highest (26.8 °C) in 25th SMW. The lowest minimum temperature (3.2°C) was recorded during 52nd SMW. A very high weekly average of RH (92%) was recorded during 50th and 52nd SMW whereas; lowest average relative humidity of 54 percent was recorded in 22nd SMW. Weekly average of daily bright sunshine hours was highest (9.9 hrs) in 23rd SMW and lowest (0.7 hrs) in 1st SMW. Due to regular cloudy weather most of the weeks in the *Kharif* season received less than 6 hours of bright sunshine.

6. PERSONNEL

6.1 STRENGTH

Table 6.1 : Staff position as on 31-03-2012

Category	Sanctioned	Filled
RMP	01	01
Scientific	38	30
Technical	25	25
Administrative	16	18**
Supportive	10	10
Total	**90**	**83**

**As per new cadre strength after re-struturing of administrative strength, one post of P.A. and one post of Jr. Steneo are in excess.

6.2 NEW APPOINTMENTS/JOININGS

Dr. V. K. Singh, joined as Principal Scientist (Agronomy), on 25.05.2011.

Dr. R.S. Yadav from National Research Centre for Agroforestry (NRCAF), Jhansi has joined as Principal Scientist (Soil Science) on 27.8.11

Dr. N. Ravisankar, from Central Agricultural Research Institute, Portblaire has joined as Principal Scientist (Agronomy) on 30-5-11.

Dr. Harbir Singh from National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi has joined as Principal Scientist (Agricultural Economics) on 27-5-2011.

Dr. Poonam Kashyap, Scientist (Horticulture) transferred from IARI Regional centre- Amartara (Shimla) and joined Directorate on 16.5.11.

Dr. A.K.Prusty, Scientist (Aquaculture) transferred from Central Institute of Fisheries Education (CIFE**)**, Varoda and joined Directorate on 16.5.11.

Dr. Sudhir Kumar, Scientist (Plant Physiology) has joined on 5.9.2011.

Ms Monalisha, Scientist (SWCE) has joined on 23.12.2011.

Mr. Rajkumar Meena, Driver transferred from NBAIM, Mau and joined on 1-10-11.

6.3 PROMOTIONS

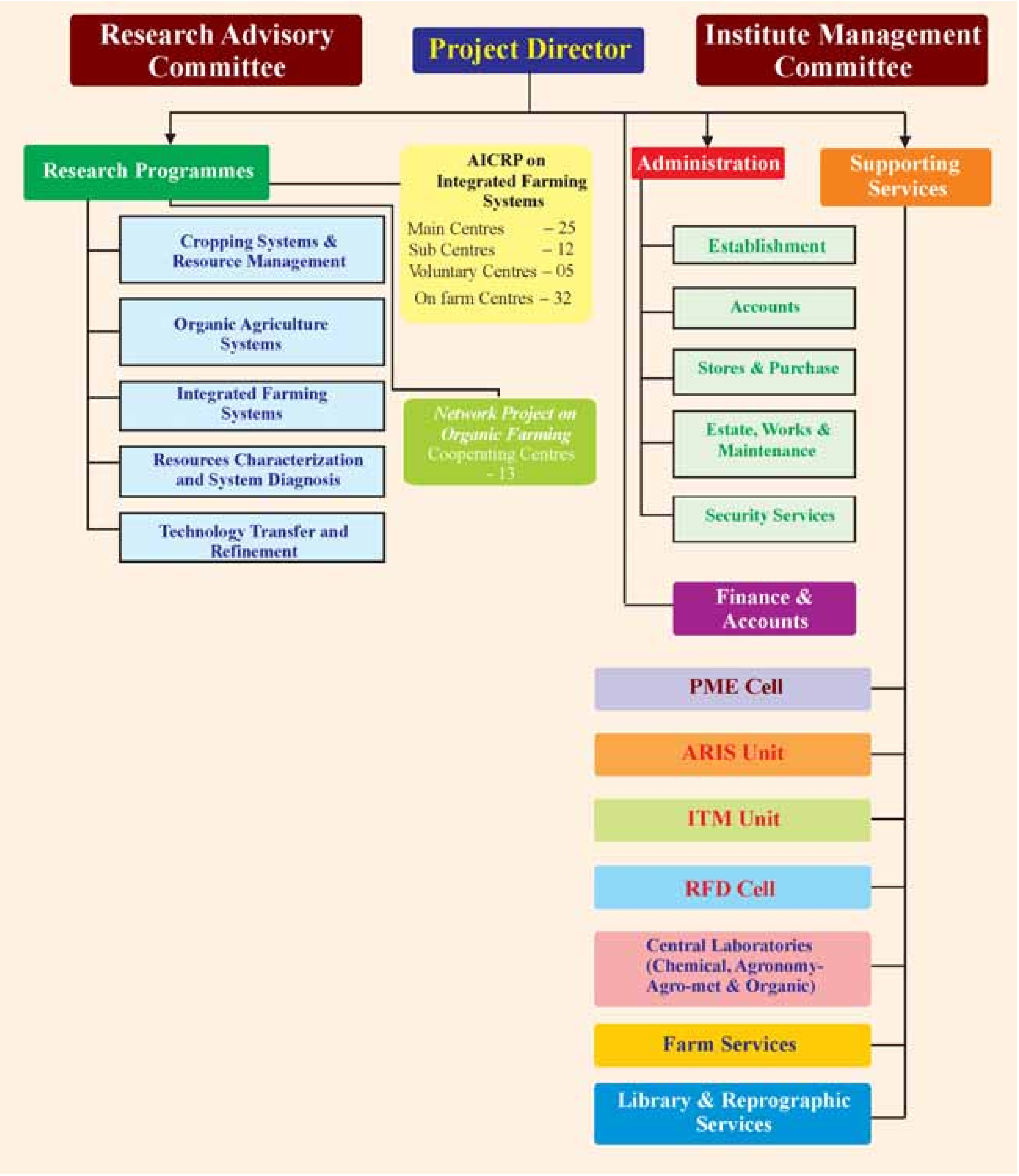
Dr. S.P. Singh promoted to the post of Principal Scientist retrospectively from Nov.2011

6.4 RETIREMENTS

Dr. N.D.Shukla, Sr. Scientist (Agril.Econ) retired on 31-12-2011

Shri Jaipal Singh, Driver retired on 31-7-2011.

7. ORGANIZATIONAL STRUCTURE



8. BUDGET

Statement for Review of Expenditure for the period ending 31-Mar-12

	Non Plan							Plan		
	Govt.			Resource		Total				
	Allocation	Remittance	Utilizaton	Allocation	Utilisation	Allocation	Utilization	Allocation	Remittance	Utilizaton
Grants for creation of Capital Assets (CAPITAL)										
Works										
A.1 Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.1 Office buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00	24.00
B.2 Residential buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.3 Minor Works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total: Works	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**24.00**	**24.00**	**24.00**
Other Capital Expenditure										
C. Equipments	10.00	10.00	10.00	0.00	0.00	10.00	10.00	44.75	49.00	44.71
D, Information Technology	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25	2.00	6.23
E. Library Books and Journals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	15.00	14.94
F. Vehicles and Vessels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Livestock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H. Furniture & fixtures	5.00	5.00	4.99	0.00	0.00	5.00	4.99	0.00	0.00	0.00
I. Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total: Other Capital Expenditure	**15.00**	**15.00**	**14.98**	**0.00**	**0.00**	**15.00**	**14.98**	**66.00**	**66.00**	**65.89**
Total Grants for creation of Capital Assets (CAPITAL)	**15.00**	**15.00**	**14.98**	**0.00**	**0.00**	**15.00**	**14.98**	**90.00**	**90.00**	**89.89**
Grants in Aid - Salaries (REVENUE)										

	Non Plan							Plan		
	Govt.			Resource		Total				
	Allocation	Remittance	Utilizaton	Allocation	Utilisation	Allocation	Utilization	Allocation	Remittance	Utilizaton
Establishment Expenses										
A.1 Establishment Charges	525.00	525.00	526.47	0.00	0.00	525.00	526.47	0.00	0.00	0.00
A.2 Wages	30.00	30.00	28.53	0.00	0.00	30.00	28.53	0.00	0.00	0.00
A.3 Overtime Allowance	0.15	0.15	0.15	0.00	0.00	0.15	0.15	0.00	0.00	0.00
B. Loans and Advances	0.00	0.00	0.00	0.80	0.80	0.80	0.80	0.00	0.00	0.00
Total: Establishment Expenses	**555.15**	**555.15**	**555.15**	**0.80**	**0.80**	**555.95**	**555.95**	**0.00**	**0.00**	**0.00**
Total Grants in Aid - Salaries (REVENUE)	**555.15**	**555.15**	**555.15**	**0.80**	**0.80**	**555.95**	**555.95**	**0.00**	**0.00**	**0.00**
Grants in Aid - General (REVENUE)										
Pension and Retirement Benefits										
A. Pension & Other Retirement Benefits	48.00	48.00	48.01	0.00	0.00	48.00	48.01	0.00	0.00	0.00
Total: Pension and Retirement Benefits	**48.00**	**48.00**	**48.01**	**0.00**	**0.00**	**48.00**	**48.01**	**0.00**	**0.00**	**0.00**
Travelling Allowances										
A. Domestic TA / Transfer TA	4.00	4.00	4.00	0.00	0.00	4.00	4.00	7.00	7.00	7.00
B. Foreign TA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total: Travelling Allowances	**4.00**	**4.00**	**4.00**	**0.00**	**0.00**	**4.00**	**4.00**	**7.00**	**7.00**	**7.00**
Research and Operational Expenses										
A. Research Expenses	1.00	1.00	1.00	3.50	3.55	4.50	4.55	18.00	18.00	17.44
B. Operational Expenses	0.50	0.50	0.50	2.00	2.00	2.50	2.50	10.00	10.00	10.60
Total: Research and Operational Expenses	**1.50**	**1.50**	**1.50**	**5.50**	**5.55**	**7.00**	**7.05**	**28.00**	**28.00**	**28.04**

	Non Plan							Plan		
	Govt.			Resource		Total				
	Allocation	Remittance	Utilizaton	Allocation	Utilisation	Allocation	Utilization	Allocation	Remittance	Utilizaton
Administrative Expenses										
A. Infrastructure	10.74	10.74	10.74	18.46	18.46	29.20	29.20	19.75	20.00	19.73
B. Communication	0.01	0.20	0.01	0.50	0.50	0.51	0.51	0.20	1.00	0.19
C.1 Repairs/ Maintenance - Equipments, Vehicles & Others	1.55	6.00	1.55	2.00	2.00	3.55	3.55	3.65	3.00	3.64
C.2 Repairs/ Maintenance - Office building	15.09	17.00	15.09	1.00	1.00	16.09	16.09	4.75	5.00	4.73
C.3 Repairs/ Maintenance - Residential building	4.58	15.00	4.58	1.00	1.00	5.58	5.58	1.00	1.00	0.98
C.4 Repairs/ Maintenance - Minor Works	0.80	5.00	0.80	2.00	2.00	2.80	2.80	0.00	0.00	0.00
D. Others (excluding TA)	22.17	1.00	22.20	2.00	2.02	24.17	24.22	20.65	20.00	20.74
Total: Administrative Expenses	**54.94**	**54.94**	**54.95**	**26.96**	**26.98**	**81.90**	**81.93**	**50.00**	**50.00**	**50.03**
Miscellaneous Expenses										
A. HRD	0.00	0.00	0.00	0.10	0.08	0.10	0.08	5.00	5.00	5.00
B. Other Items (Fellowships, Scholarships etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. Publicity & Exhibitions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Guest House – Maintenance	0.00	0.00	0.00	1.00	1.02	1.00	1.02	0.00	0.00	0.00
E. Other Miscellaneous	0.00	0.00	0.00	1.00	0.93	1.00	0.93	0.00	0.00	0.00
Total: Miscellaneous Expenses	**0.00**	**0.00**	**0.00**	**2.10**	**2.03**	**2.10**	**2.03**	**5.00**	**5.00**	**5.00**
Total Grants in Aid-General (REVENUE)	**108.44**	**108.44**	**108.46**	**34.56**	**34.56**	**143.00**	**143.02**	**90.00**	**90.00**	**90.07**
Grand Total : Capital + Revenue (Salaries)	**678.59**	**678.59**	**678.59**	**35.36**	**35.36**	**713.95**	**713.95**	**180.00**	**180.00**	**179.95**

9. Research Achievements

- Cropping Systems and Resource Management (CSRM)
- Organic Agriculture Systems (OAS)
- Integrated Farming Systems (IFS)
- Resource Characterization and Systems Diagnosis (RCSD)
- Technology Transfer and Refinement (TTR)
- Externally Funded Projects

9.1 CROPPING SYSTEMS AND RESOURCE MANAGEMENT (CSRM)

Alternative Cropping Systems

Bio-intensive complementary cropping systems for high productivity and profitability

Ten bio-intensive complimentary cropping systems were evaluated for higher productivity and profitability. The effect of these systems on rice equivalent productivity, net returns, per day productivity and per day profitability are presented in Figs. 9.1.1 to 9.1.3. Bio-intensive System of raising maize for cobs + vegetable cowpea in 1:1 ratio on broad beds (BB) and *sesbania* in furrows during *kharif* and mustard in furrows and 3 rows of lentil on broad beds in *rabi* while 3 rows of green gram on beds in summer was found remarkably better than others which produced highest yield of 18.3 t ha^{-1} as rice equivalent with productively of 50.2 kg grain $ha^{-1}day^{-1}$ and profitability of ₹ 363 $ha^{-1}day^{-1}$. The complimentary effects could be reflected in the system as in broad bed and furrow (BBF) system, the furrows served as drainage channels during heavy rains in *kharif* which were utilized for in-*situ* green manuring with 35 t ha^{-1} green foliage incorporated after 45 days of sowing and timely sown mustard crop in these furrows resulted a good harvest 1.9 t ha^{-1} and a bonus yield of lentil (1.4 t ha^{-1}) could be harvested on one hand and 30% of irrigation water could be saved as applied only in furrows. In the summer season green gram could yield 1.0 t ha^{-1} as grain while incorporation of green foliage of about 4 t ha^{-1} in the soil further helped the system favourably.

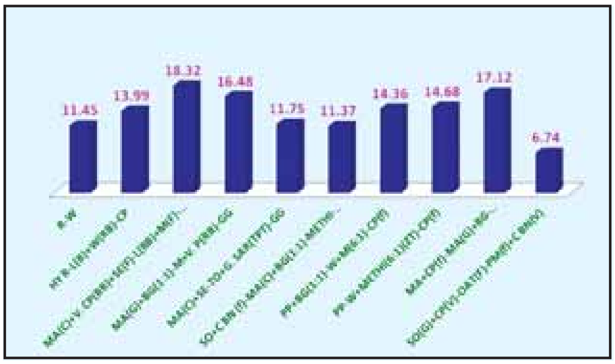


Fig. 9.1.1. Effect of bio-intensive cropping systems on rice equivalent yield (t ha^{-1})

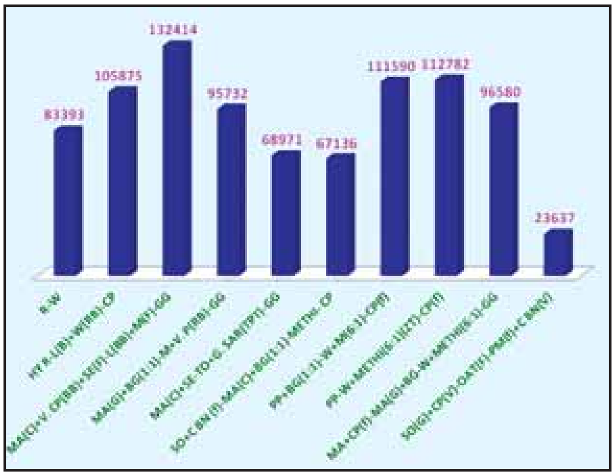


Fig. 9.1.2. Effect of bio-intensive cropping systems on Net returns (Rs ha^{-1})

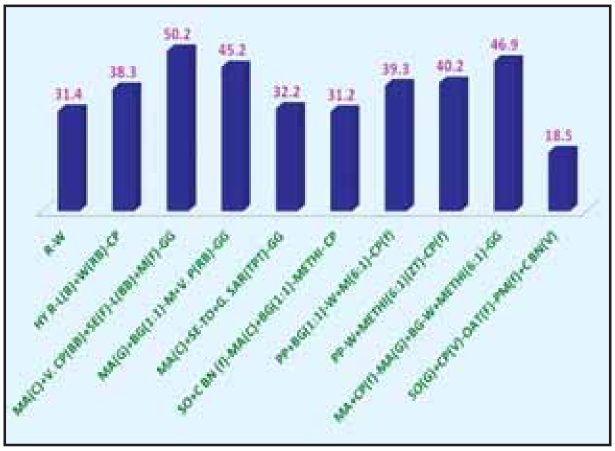


Fig. 9.1.3. Effect of bio-intensive cropping systems on Rice Equivalent Productivity (kg $ha^{-1}day^{-1}$)

Bio-intensive System of raising [Maize + Cowpea] (f) - Maize(G) + Blackgram- Wheat +

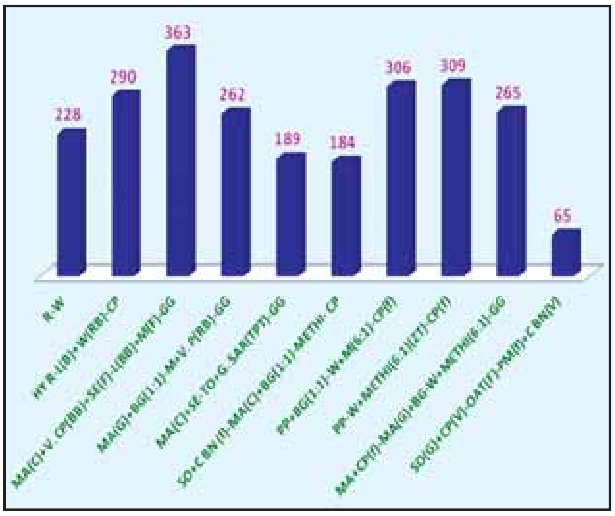


Fig. 9.1.4. Effect of bio-intensive cropping systems on Profitability (₹ ha^{-1} day^{-1})

Methi – Green gram system was also found better which resulted in 17.1 t ha^{-1} as rice equivalent yield with productivity of 49.8 kg grain ha^{-1} day^{-1} and profitability of ₹ 201 ha^{-1} day^{-1}. This system proved to be the second best in the order of merit. The lowest yield (10.0 t ha^{-1}) and profitability (₹ 117 ha^{-1} day^{-1}) was obtained under the conventional rice-wheat systems.

The cropping systems were also evaluated based on physiological parameters for the *rabi* crop season 2011-2012. The bio intensification of different crops affected the growth of crops. Small canopy stature crops in bio-intensification combination like lentil and vegetable pea showed less increase in leaf area index (LAI) i.e. by 9 and 16%, respectively, comparatively with other crops, which also reflected in the decrease of crop growth rate. While comparatively large canopy stature crops like wheat and mustard showed increase in their rate does not vary among crops under zero tillage for different combinations, but in wheat+mustard (6:1) bio-intensification, mustard showed highest photosynthetic rate i.e. 28.84 µmole/m^2/S (table 9.1.1). Further, crop growth rate, photosynthetic water use efficiency (PWUE) and photosynthetic radiation use efficiency (PUE) followed the same trend for mustard. Wheat crop in wheat+methi (6:1) under zero tillage (ZT) showed better photosynthetic water use efficiency among all the intensification combinations. Oat among combinations showed highest transpiration rate. Results in wheat+mustard and wheat+methi bio-intensification showed increase in LAI by 29% and 40%, respectively.

The organic carbon status of the soil increased significantly over the initial values with the inclusion of leguminous crops. Among the ten cropping systems tested, maize (C) + V.Cowpea (BB) + Sesbania (F)- Lentil (BB) + Mustard (F)- Greengram (highest BB-ZT) (G+R) and maize (G) + black gram – V.pea (B) + Mustard (F) (ZT) – Greengram (ZT) (G+R) recorded higher organic carbon content. The increase in carbon content was superior to the other cropping systems (table 9.1.2)

Increase in organic carbon status of the soil may be attributed to the accumulation of root residues and shedding of leaves by leguminous crops. The organic carbon values were less influenced in rice-based cropping system.Cropping systems increased organic carbon content over initial level by 0.01-0.05%, whereas, rice-wheat cropping system resulted in reduction of organic carbon content over initial levels by 0.002%. Similarly progressive increase in available N, available P (4-8 kg ha^{-1}) was observed in cropping sequences involving vegetables, pea, and black gram, green-gram, cowpea etc. There was a buildup of available K in maize based cropping sequences (146-156 kg ha^{-1}). The lowest value of available K was recorded in rice-wheat (125 kg ha^{-1}).

Table: 9.1.1 Morpho-physiological variations under different bio- intensification combinations

Treatments	Crops	Leaf Area Index (LAI) 60 days	Leaf Area Index (LAI) 90 days	Root Length (cm) (45DAS)	Plant Height (cm)	Photosynthetic rate µ mole/m²/s	Transpiration mmole/s	PWUE	PRUE	CGR (4-6 week) g/m²/day
WHEAT	Wheat	3.78	5.87	19.00	91.70	22.20	7.05	3.15	2.22	2.24
LENTIL(B)+	Lentil	4.30	6.80	17.80	34.65	24.70	7.80	3.17	2.47	2.52
WHEAT (FIRB)	Wheat	3.00	5.32	18.20	88.56	22.90	6.17	3.71	2.29	2.10
LENTIL(BB)+	Lentil	5.37	5.89	19.70	38.50	25.20	7.53	3.35	2.52	2.77
MUSTARD(F)	Mustard	4.76	6.50	28.90	148.56	25.20	7.81	3.23	1.68	3.42
MUSTARD+	Veg. Pea	3.48	4.05	21.20	34.90	19.30	8.23	2.35	1.93	1.73
VEG. PEA (FIRB)	Mustard	4.13	6.13	21.60	130.20	26.46	7.69	3.44	2.65	3.61
TORIA+G.	Toria	3.69	5.83	20.70	82.60	23.42	6.29	3.72	2.34	3.00
SARSON(TPT)	G.Sarson	3.90	5.90	19.70	67.40	26.90	8.48	3.17	2.69	3.29
METHI	Methi	3.68	6.40	18.60	36.50	16.90	5.20	3.25	1.69	1.79
WHEAT+	Wheat	4.64	5.98	21.40	85.00	24.70	8.66	2.85	2.47	1.85
MUSTARD (6:1)(ZT)	Mustard	5.00	6.38	29.80	132.00	28.84	8.77	3.29	2.88	4.33
WHEAT+	Wheat	4.20	6.00	22.00	90.00	22.90	6.17	3.71	2.29	1.75
METHI (6:1)(ZT)	Methi	3.89	5.27	18.80	38.20	16.60	5.38	3.09	1.66	2.04
WHEAT+	Wheat	4.25	6.13	21.40	85.80	22.75	7.25	3.15	2.22	1.98
METHI (6:1)	Methi	3.58	4.85	17.90	38.00	17.20	5.63	3.06	1.72	2.07
OAT (F)	oat	4.27	6.90	24.00	118.00	27.90	9.63	2.90	2.79	3.14

Table 9.1.2. Influence of bio-intensive complementary cropping systems on soil properties

Treatments	OC (g kg^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Rice-wheat(Conventional, Flat bed)	3.1	24.3	120
Hy-R-Lentil+Wheat (FIRB)-Cowpea (V+R)	3.1	24.8	118
Maize(C)+Cowpea(BB)+Sesbania(F)-Lentil(BB)+Mustard(F)-gg (BB-ZT)(BBF)	3.7	30.7	153
Maize(G)+Blackgram-Vegpea (B)+Mustard(F)(ZT)-gg (ZT)(G+R)	3.6	28.3	156
Maize(C)+Sesbania-Toria+Gobhisarson-Greengram (ZT) (G+R)(FB)	3.5	31.5	150
Sorghum+Clusterbean(f)-Maize(C)+B.g.-Methi-Onion+Coriander	3.5	32.8	141
Pigeonpea+Blackgram-Wheat+Mustard (ZT)-Cowpea(f)(ZT)(FB)	3.5	31.9	130
Pigeonpea+Soybean-Wheat+Methi (ZT)-Amaranthus(ZT-FB)	3.4	32.5	164
Maize+Cowpea(f)—Maize(C)+BG—Wheat+Methi—GG (G+R)(FB)	3.5	32.2	146
Sorghum+Cowpea—Oat—PM+Clusterbean	3.3	25.1	113

Evaluation of different cropping systems under limited water availability situations

Four cropping systems (pearl millet – wheat, maize – mustard, pigeon pea – barley and sorghum – lentil) were evaluated for productivity and profitability under limited water availability conditions. During *kharif*, no irrigation was given to any of the crops and therefore the yield differences are not there. During *rabi*, these systems were grown under one, two and three irrigations regimes respectively. The effect of limited water availability on wheat equivalent yield and net returns of these cropping systems, are presented in Figs. 9.1.5 and 9.1.6.

Under one irrigation, Sorghum – Lentil cropping system provided maximum wheat equivalent yield (WEY) of 4.09 t ha^{-1} and net returns of about 23700 ₹ ha^{-1}. Under two irrigations, Maize – Mustard cropping system provided maximum WEY of 5.39 t ha^{-1} and net returns of about 37900 ₹ ha^{-1}.Under three irrigations, Pigeon pea – Barley cropping system provided maximum WEY of 9.7 t ha^{-1} and net returns of about 92000 ₹ ha^{-1}, followed by Pearl millet –Wheat (6.42 t ha^{-1}) and about 59000 ₹ ha^{-1}.

Resource conservation and sustaining high productivity through cropping system management and land configuration

To study the effect of different land configurations and cropping systems on resource conservation, system productivity and profitability as well as soil fertility, an experiment with twelve treatment combinations of land configuration [flat bed (FB), furrow irrigated raised bed (RB) and broad bed- furrow (BBF)] and cropping systems with 3 replications were evaluated in the strip plot design. The cropping systems were:

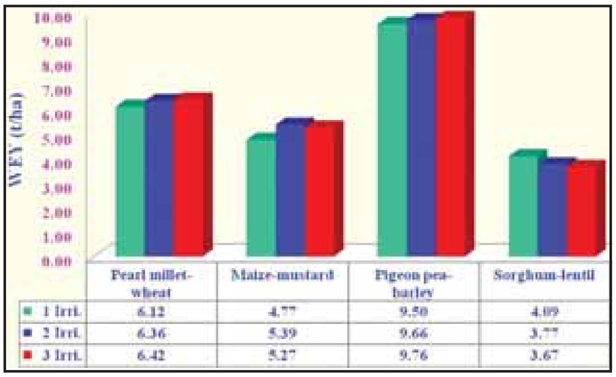


Fig. 9.1.5. Effect of limited irrigation on wheat equivalent yield of cropping systems

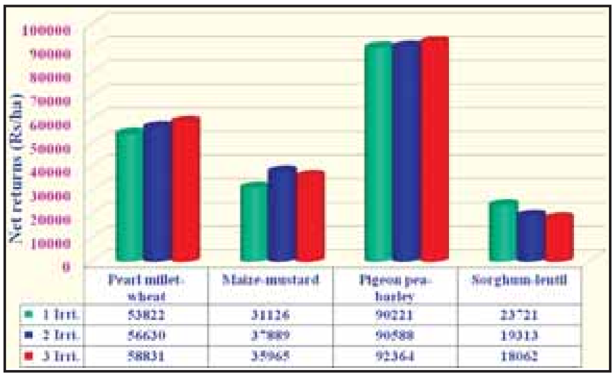


Fig. 9.1.6. Effect of limited irrigation on net returns of cropping systems

1. Flat bed system

kharif	*rabi*	**summer**
Maize (Ma)	Vegetable pea (VP)	Green gram (GG)
Rice (R)	Lentil (L)	Green gram (GG)
Sorghum f (Sf)	Mustard (M)	Green gram (GG)
Pigeon pea (PP)	Wheat (W)	Green gram (GG)

2. FIRB system

kharif	*rabi*	**summer**
Ma (B) + Se (F)	VP (B) + W (F)	GG (G+R)
GG (B) + R (F)	W (F) + L (B)	GG (G+R)
Sf (B) + Se (F)	L (B) + M (F)	GG (G+R)

3. BBF system

kharif	*rabi*	**summer**
[Ma + VC] (BB) (2:1) + Se (F)	VP (BB) + W (F)	GG (G+R)
GG (BB) + R (F)	L (BB) + W (F)	GG (G+R)
[Sf + VC] (BB) (2:1) + Se (F)	L (BB) + M (F)	GG (G+R)
[PP+ BG] (BB) (2:1) + Se (F)	W (BB) + M (F)	Fallow

Note: B – bed, F – furrow, Se – sesbania, VC – vegetable cowpea

The effect of land configuration and cropping systems on rice equivalent yield and water use are presented in Figs. 9.1.7 to 9.1.8.

During *kharif*, Pigeon pea (RB) + sesbania (F) system produced maximum rice equivalent yield, REY (6.38 t ha^{-1}) followed by [Pigeon pea + Black gram] (BB) + sesbania (F) system (5.88 t ha^{-1}) and Pigeon pea (FB) system (5.12 t ha^{-1}) while Green gram (BB) + Rice (F) produced lowest REY (1.05 t ha^{-1}). During *rabi*, vegetable pea (RB) + Wheat (F) system produced maximum wheat equivalent yield, WEY (12.12 t ha^{-1}) followed by Mustard (FB) (6.98 t ha^{-1}) and wheat (FB) (6.18 t ha^{-1}) while Lentil (RB) + Mustard (F) produced lowest WEY (1.75 t ha^{-1}). During summer, green gram after veg. pea(FB) produced 0.85 t ha^{-1}.

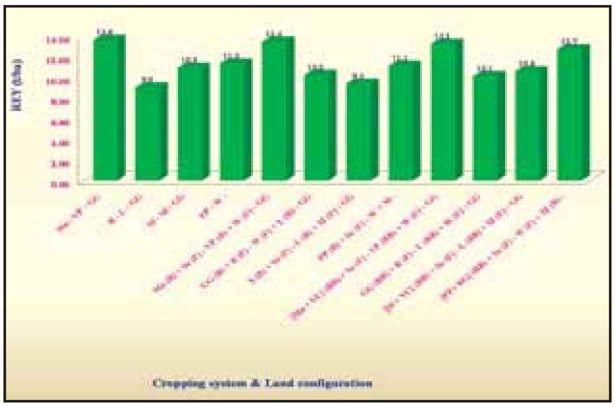


Fig. 9.1.7. Effect of land configuration and cropping systems on rice equivalent yield

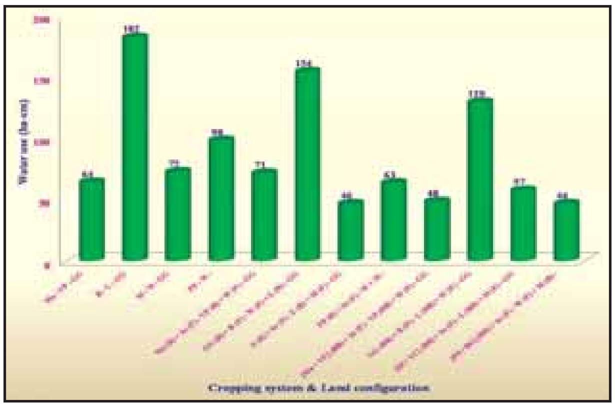


Fig. 9.1.8 . Effect of land configuration and cropping systems on water use

Maize (B) + Sesbania (F) - Veg. pea (B) + Wheat (F) - Green gram, Maize – Veg. Pea – Green gram (FB) and [Maize + Veg. Cowpea] (BB) + sesbania (F) – Veg. Pea (BB) + Wheat (F) – Green gram cropping systems used 71, 64 and 48 ha-cm water, as compared to 182 ha-cm by Rice – Lentil – Green gram (FB) system. Averaged over cropping systems about 29.6 and 43.5 % irrigation water was saved using Raised bed and Broad bed than Flat bed.

Physiological observations for the various crops i.e wheat, lentil, mustard and vegetable pea during rabi season during 2011-2012, showed effect of land configuration. Vegetable pea under Furrow irrigated raised bed (FIRB) showed higher plant height and

Table 9.1.3. Morpho-physiological variations of crops under different land configuration

Treatments	Crops	Plant height (cm)	LAI 30 days	LAI 60 days	Fresh Weight (45 Days)	Dry Weight g/m^2	Physio% water loss % g/m^2	Photo. rate µ mole/ m^2/s	Transpiration mmole/s	PWUE	PRUE
FLAT BED											
	Veg.pea	29.67	1.95	2.97	133.35	18.52	86.11	18.10	8.56	2.11	1.21
	Lentil	44.67	1.04	3.53	47.87	4.52	90.56	23.50	7.31	3.24	1.58
	Mustard	150.33	3.17	5.43	185.25	24.32	86.87	24.60	6.43	3.83	1.64
	Wheat	95.67	1.22	3.20	58.68	10.76	81.66	26.40	9.39	2.81	2.64
BROAD BED FURROW (BBF)											
V.pea+Wheat	Veg.pea	27.33	2.76	3.46	189.20	26.08	86.22	18.30	8.51	2.15	1.22
	Wheat	79.33	1.22	2.39	69.12	8.46	87.77	26.50	9.41	2.82	2.65
Lentil+Wheat	Wheat	90.00	1.18	2.90	68.65	8.36	87.82	26.20	9.38	2.79	2.62
	Lentil	40.33	1.23	2.73	51.33	11.12	78.34	23.90	7.41	3.23	1.59
Mustard+Lentil	Mustard	131.00	1.01	3.00	216.40	20.92	90.33	24.60	6.46	3.81	1.64
	Lentil	30.00	3.47	5.37	40.45	10.60	73.79	23.70	7.31	3.24	1.58
Wheat+	Mustard	67.67	1.17	2.30	172.00	16.48	90.42	24.70	6.48	3.81	1.65
Mustard	Wheat	86.33	2.70	4.63	43.16	8.40	80.54	26.20	9.38	2.79	2.62
FURROW IRRIGATED RAISED BED (FIRB)											
Wheat+V.Pea	Wheat	90.67	2.53	3.75	96.64	10.04	89.61	26.20	9.31	2.81	2.62
	Veg.Pea	38.67	1.72	3.81	216.13	21.56	90.02	18.20	8.48	2.15	1.21
Wheat+Lentil	Wheat	88.33	1.16	3.00	52.43	9.25	82.36	26.30	8.82	2.98	2.63
	Lentil	37.00	1.36	3.00	75.22	8.04	89.31	23.90	7.39	3.23	1.59
Mustard+Lentil	Mustard	141.67	1.38	3.07	307.96	26.00	91.56	24.70	6.47	3.82	1.65
	Lentil	32.00	4.75	5.40	55.84	6.92	87.61	23.70	7.31	3.24	1.58
Wheat+	Wheat	88.00	1.29	2.67	45.92	7.92	82.75	26.50	9.29	2.85	2.65
Mustard	Mustard	95.00	3.25	5.23	186.56	16.92	90.93	24.70	6.45	3.83	1.65

higher leaf area index (LAI) in comparison to the Flat bed (FB) and Broad bed furrow (BBF) system, While mustard showed higher plant height with high photosynthetic water use efficiency with lesser transpiration rate amongst all the treatments. In initial stage of growth, Lentil showed higher LAI under both land configuration i.e. FIRB and BBF, in the mustard+lentil treatment but after 60 days it shows some stagnation which may results due to shading effect of mustard while in other treatment lentil does show low LAI even in the initial stage too. Physiological %water loss indicates the amount of water in the crop plants, showed that lentil under flat bed, mustard in BBF and FIRB while veg. pea in FIRB showed highest % physiological water loss i.e around 90% (Table 9.1.3.), indicate that these crops used maximum water among all the crops. Other parameters like photosynthetic rate, transpiration, photosynthetic water use efficiency (PWUE) and photosynthetic radiation use efficiency (PRUE) does not follow a definite trend. Overall physiological observations indicate that Land configuration affects the various physiological parameters in *rabi* crops.

Farm Mechanization, Tillage and Conservation Agriculture

Evaluation of different resource conservation technologies for planting of rice

The comparative performance of different methods of rice planting, namely; hand transplanting (HT), transplanting by self-propelled transplanter (MT), transplanting by manual transplanter (MaT), bed planting (BP), zero till drilling (ZT), strip till drilling (ST), rotary till drilling (RT), drum seeding (DS) and sprouted broadcasting (BS), with respect to rice yield (Y), benefit: cost ratio (B: C), energy output: input ratio (EE), water use (WU), infiltration rate (IR) and weed infestation (We) was evaluated. The effect of planting methods on rice yield, benefit: cost ratio and energy efficiency and effect of planting methods on rice yield over the years are depicted in Figure 9.1.9 and Figure 9.1.10 respectively.

It was noted that the rice (Saket – 4) yield was higher in MT (9.9%), MaT (8.0%), ZT (6.9%), ST (2.4%), RT (0.8%) and BP (0.4%); but lower in

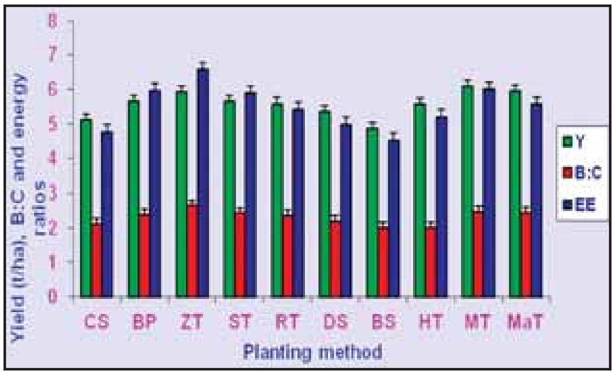


Fig. 9.1.9. Effect of planting methods on rice yield (Y), benefit: cost (B:C) and energy ratios (EE) ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT _ Transplanting by manual transplanter)***

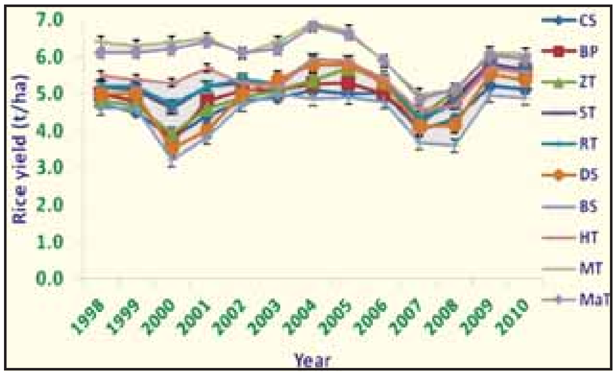


Fig. 9.1.10. Effect of planting methods on rice yield over the years ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT _ Transplanting by manual transplanter)***

DS (3.4%), CS (8.0%) and BS (11.2%), respectively, compared to traditional HT (4.63 t ha^{-1}). The net return was 48 higher in ZT, 43 and 40% higher in MT and MaT; 20 to 31% higher in DS, BP, RT and ST; but 1 and 9% lower in CS and BS, respectively, compared to HT (Rs. 18280 ha^{-1}). The B: C ratio was 31% higher in ZT, 16 to 22 percent higher in ST, MaT, MT, BP and RT; 8 and 4 % higher in DS and CS; but at par in BS, respectively, compared to HT (1.62). Energy output: input ratio was 27% higher in ZT, 16 to 8% higher in all the methods except DS, CS and BS, where it was 4 to 12% lower, compared to HT (4.33). The water use was 36% lower in BP; 2 to 9 per cent lower in all other methods except CS, DS and BS, where it was 4 to 8% higher, compared to HT (200 ha-cm). The infiltration rate was maximum in BP (82 mm day^{-1}) and lowest (34 to 38 mm day^{-1}) in the three transplanting methods because of puddling. The weed dry matter was 69 to 223% higher in all the methods but 38 and 40 percent lower in MaT and MT, compared to HT (64 kg ha^{-1}).

To assess the influence of different tillage treatments on soil organic carbon, various fractions of SOC, macro and micronutrient and their distribution to 60cm depth in soils from long term experiment of resource conservation technologies. The treatments were conventional sowing (CS), zero tillage (ZT), roto tillage (RT), bed planting (BP) and strip tillage (ST). In ZT, the bulk density was greatest near the soil surface, whereas it was higher under conventional sowing in 15-30 cm layers compared with zero tillage and bed planting. SOC content was greatest under ZT (7.5 g kg^{-1}), followed by strip tillage and bed planting and lowest under conventional sowing, i.e., 4.45g kg^{-1}. Beneath 30 cm, the SOC concentrations decreased with increasing depth for all tillage treatments.

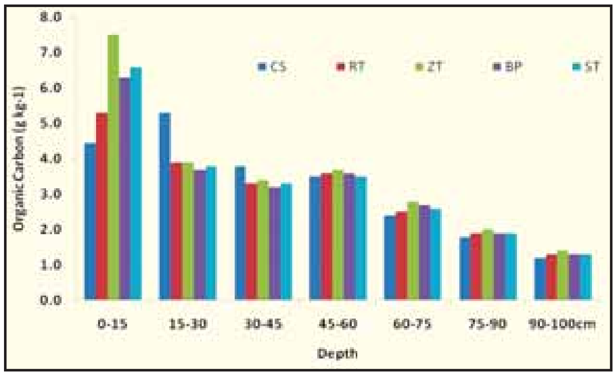


Fig. 9.1.11. Distribution of soil organic carbon under different tillage regimes

Differences in microbial biomass C were limited to the surface of ZT, ST and BP, which was greater than CS and RT. However, this difference was small or no differences in total microbial biomass were measured in deeper depths. The total microbial biomass C, particulate organic C, P and K decreased with increasing depths. Available Zinc (0.59-.65 ppm), available Copper (0.66-2.52 ppm), available Iron (5.22-14.60 ppm) and available Managanese (1.30-7.46 ppm) ranges with different tillage treatments and depths. Distribution of Zn, Fe, Mn and Cu in profile indicated that the micronutrients concentration decreased with increasing soil depth in all the treatments with some exceptions (Conventional sowing). Beneath 30cm, the micronutrient concentration decreased with increasing depth for all tillage regimes and there were no significant differences between treatments. The higher content of micronutrients in surface soil might be due to higher content of organic carbon. The critical limits for soil available Zn, Fe, Mn and Cu are 0.6 mg kg^{-1}, 4.5 mg kg^{-1}, 3.5 mg kg^{-1} and 0.2 mg kg^{-1}, respectively. With these critical limits, the micronutrient content of the plots indicates that resource conservation technologies practices caused improvement in available micronutrient status of soils.

Higher content of micronutrient cations in the plots may be attributed to increase in organic carbon content.

Puddling requirement and mat type nursery raising technique for mechanized transplanting of rice

Mat type nursery raising technique for transplanter

It was observed under on-station as well as on-farm situations that the best combination for nursery raising was a size of 5.0 m x 1.2 m nursery bed, sown at 30 kg ha^{-1} seed (Saket - 4) rate and transplanting 16 to 20 days old seedlings at height of seedling (105–115 mm), root length (40-45 mm), trunk diameter (3.2-4.2 mm), thickness of seedling at the base of root (3.6-4.3 mm), leaf stage (3-4) and about 20 thousand seedlings m^{-2} (Table 9.1.4).

Puddling requirement for transplanter

For determining optimum puddling requirement for rice transplanter, 4 levels of puddling; 0, 1, 2 and 3 passes of peg type puddler, were tried. In zero pass of puddling treatment, only dry tillage was done. The optimum puddling requirement for rice transplanter was one operation of puddler with corresponding puddling index of 42.3 percent, depth of puddle profile of 55.4 mm, bulk density of 1.52 t m^{-3}, water content of 48.7 percent and penetration resistance of 1650 k Pa (Table-9.1.5).

Table 9.1.4: Rice yield (t ha^{-1}) obtained at different seed rates and ages of seedling transplanted by the transplanter

Seed rate(kg ha^{-1})	Age of seedling (days)				Mean
	16	20	25	30	
30	5.2	5.0	4.9	4.5	4.9
35	5.0	4.9	4.5	4.0	4.6
40	4.9	4.5	4.0	3.6	4.2
Mean	5.0	4.8	4.5	4.0	-
CD at 5%	Seed rate= 0.09, Age of seedling= 0.11				

Table 9.1.5: Characteristics of puddle bed as influenced by puddling level

Efficiency Parameter	Puddling level (No. of puddler passes)			
	0	1	2	3
Depth of puddle soil, mm	22.5	55.4	63.4	87.5
Amount of dispersion, %	18.5	42.3	44.5	56.5
Bulk density of puddle profile, t m^{-3}	1.63	1.52	1.59	1.68
Water content of puddle profile, %	35.3	48.7	49.8	49.9
Penetration resistance of puddle profile, k Pa	1950	1650	1750	1850

Performance of rice transplanter

The performance of rice transplanter was good and was dependent on the condition of puddle bed, density of seedlings in the mat and operator's skills. Average number of hills m^{-2} was found to be 44. The growth and subsequent establishment of the transplanted seedlings were faster having 0.44 million hills ha^{-1} with 18-20 active tillers $hill^{-1}$. Under normal conditions the transplanter recorded 0.18 – 0.20 ha h^{-1} field capacity, 2.35 – 2.6 l ha^{-1} diesel consumption and planting of 3-4 seedlings per hill with average inter-hill spacing of 100 mm, standing angle of transplanted seedlings 70-75 degree and transplanting efficiency of 90 - 93 %. The uniform growth of crop was due to uniform depth of placement of seedlings at uniform spacing with equal number of seedlings per hill, resulting in higher yield in mechanically transplanted field.

The grain yield of rice (Saket - 4) as affected by different levels of puddling and methods of transplanting is given in (Table-9.1.6). The results indicated that, the yield increased with puddling operations. The increase in grain yield was highest in one pass of puddler, both under manual (5.7%) and mechanical transplanting (7.3%), over zero pass. This increase in two passes of puddler was 3.7 and 5.2% under manual and mechanical transplanting respectively. The yield increase under three passes was 1.7% in manual and 3.3% in mechanical transplanting over two passes. The average increase in mechanical transplanting was 6.5 percent compared to manual transplanting.

Table 9.1.6: Grain yield of rice as affected by different puddling levels and transplanting methods

Puddler passes	Transplanting method	Grain yield ($t\ ha^{-1}$)
Zero	Manual	4.35
	Mech.	4.52
One	Manual	4.60
	Mech.	4.85
Two	Manual	4.77
	Mech.	5.10
Three	Manual	4.85
	Mech.	5.27

A comparison of cost under manual and mechanical transplanting revealed that the mechanical transplanting by rice transplanter provided considerable saving in labour (80%) and cost of operation (58%); higher yield (9.9%), net returns (43%), benefit: cost ratio (22%), energy output: input ratio (16%); while requiring less specific cost (18%) and specific energy (14%) compared to manual transplanting (Table-9.1.7).

Table 9.1.7: Comparative economics and energy use of manual and mechanical transplanting of rice

Parameter	Manual transplanting	Mechanical transplanting
Net income, Rs ha^{-1}	18,280	26,160
Benefit: cost ratio	1.62	1.98
Specific cost, Rs kg^{-1}	6.41	5.23
Specific energy, k cal kg^{-1}	693	597
Energy output: input ratio	4.33	5.03

Evaluation of different machines for direct dry seeding of rice

Five machines for direct dry seeding of rice, namely; conventional drill (CS), zero-till drill (ZT), strip-till drill (ST), rotary-till drill (RT) and bed planter (BP) were evaluated using uniform seed (Saket - 4) rate of 30 kg ha^{-1}. Under ZT, ST, RT and BP sowing was done directly without any field preparation but sowing under CS was done after preparing the field with two harrowing, 2 cultivator passes and one planking operations. The row spacing was kept at 180 mm in CS, ZT, ST and RT, and 120 mm in BP.

The performance parameters of different rice seeding machines showed that ZT, ST, RT and BP of rice saved time (89 to 86%), labour (87 to 83%), diesel (88 to 60%), cost (82 to 65%), energy (88 to 61%) and also irrigation water (8 to 38%) as compared to conventional sowing (Table-9.1.8). The zero till drilling produced higher rice (16 %), net returns (49%), B: C ratio (25 %) and energy output: input ratio (39 %) while requiring lesser specific cost (20 %) and specific energy (28%), compared to conventional sowing.

The rice yield, economics and energy use affected by different methods is given in Table-9.1.9. The rotary till drilling produced higher rice (9.6%), net returns (27%), B: C ratio (13%) and energy output: input ratio (15%) while requiring lesser specific cost (11%) and specific energy (13%), compared to conventional sowing. The strip till drilling produced higher rice (11%), net returns (33%), B: C ratio (16%) and energy output: input ratio (25 %) while requiring lesser specific cost (13 %) and specific energy (20 %), compared to conventional sowing. The bed planting produced higher rice (9 %), net returns (25 %), B: C ratio (11%) and energy output: input ratio (24%) while requiring lesser specific cost (10%) and specific energy (20%), compared to conventional sowing.

Evaluation of drum seeder for direct seeding of sprouted rice

The performance of drum seeder was evaluated against broadcast method of direct sowing of

Table 9.1.8: Performance parameters of different rice seeding machines

Parameter	ZT drill	Strip-till drill	Bed planter	Roto-till drill	Conventional drill
Effective field capacity, ha h^{-1}	0.45	0.42	0.38	0.35	0.47
Field Efficiency, %	57	51	51	57	60
Fuel consumption, l ha^{-1}	8.0	10.5	10.0	27.0	68.0
Cost of sowing, Rs. ha^{-1}	860	1060	980	1690	4810
Energy requirement, MJ ha^{-1}	465	606	582	1534	3942

Table 9.1.9: Yield, economics and energy use in different methods of direct dry seeding of rice

Parameter	ZT drill	Strip-till drill	Bed planter	Roto-till drill	Conventional drill
Grain yield, t ha^{-1}	4.95	4.74	4.65	4.67	4.26
Straw yield, t ha^{-1}	5.8	5.6	5.5	5.7	5.2
Net income,Rs.(1000)ha^{-1}	27.0	24.0	22.5	23.0	18.0
Benefit: cost ratio	2.12	1.96	1.88	1.91	1.69
Specific energy, k cal kg^{-1}	547	607	610	661	758
Energy output: input ratio	5.49	4.94	4.92	4.54	3.96
Specific cost, Rs kg^{-1}	4.89	5.29	5.50	5.44	6.12

sprouted rice under unpuddle condition. The pre-germinated rice (Saket - 4) seeds were sown at the rate of 30 kg ha^{-1}. The performance of 8- row drum seeder was satisfactory (field capacity = 0.065 ha hr^{-1}, field efficiency = 45%, Cost of operation = Rs 610 ha^{-1} and energy requirement = 78 MJ ha^{-1}). Drum seeding provided higher rice yield (8.8%), net returns (33%), B: C ratio (8%), energy output: input ratio (9%) while requiring lower specific energy (8%) and specific cost (7%) compared to broadcasting method of sprouted seeding of rice (Table-9.1.10).

Table 9.1.10: Economics and energy use of different methods of seeding of sprouted rice

Parameter	Drum seeding	Broadcasting
Grain yield, t ha^{-1}	4.47	4.11
Net income, Rs. (1000)ha^{-1}	22.0	16.5
Benefit: cost ratio	1.76	1.63
Specific energy, k cal kg^{-1}	722	785
Energy output: input ratio	4.16	3.82
Specific cost, Rs. kg^{-1}	5.88	6.35

Evaluation of different drill machines for planting wheat succeeding rice

The comparative performance of different machines namely; bed planter (BP), zero-till drill (ZT), strip-till drill (ST), rotary-till drill (RT), and conventional drill (CS), in terms of wheat yield (Y), benefit: cost ratio (B: C), energy output: input ratio (EE), water use (WU), infiltration rate (IR), *Phalaris minor* (PM) and other weeds (OWE) was assessed. The effective field capacities of RT, ST, ZT, BP and CS were 0.42, 0.39, 0.52, 0.35 and 0.45 ha h^{1}, respectively (Table-9.1.11).

The rotary, strip and zero till drilling and bed planting were time saving (70, 78, 83 and 75%), labour saving (76, 73, 78 and 70%), diesel saving (65, 85, 87 and 87%), cost saving (71, 78, 82 and 77%), energy saving (65, 84, 87 and 86%) and also irrigation water saving (10.6, 10.2, 11.0 and 35%) compared to conventional sowing of wheat. Also, there was saving of about 20-25% in seed and fertilizer inputs in bed planting compared to

Table 9.1.11: Comparison of performance of bed planter (BP), zero (ZT), strip (ST) and rotary-till (RT) drills with conventional drill (CS)

Parameter	CS	BP	ST	ZT	RT
Row spacing, mm	180	120	180	180	180
No. of operations (including seed bed preparation)	6	1	1	1	1
Effective field capacity, ha h^{-1}	0.45	0.35	0.39	0.52	0.42
Field efficiency, %	61	60	58	63	60
Fuel consumption, l ha^{-1}	56.3	7.6	8.7	7.5	19.7
Cost of sowing, Rs. ha^{-1}	4985	1121	1090	893	1443
Energy requirement, MJ ha^{-1}	3190	436	497	428	1112
Grain yield, t ha^{-1}	4.91	5.10	5.37	5.26	5.18
Benefit: cost ratio	2.78	3.13	3.13	3.12	3.10
Specific energy, k cal kg^{-1}	653	539	532	526	542
Energy output: input ratio	4.59	5.56	5.63	5.70	5.53
Specific cost, Rs. kg^{-1}	5.98	5.25	5.17	5.25	5.25

conventional sowing. Zero, strip and rotary till drills and bed planter provided higher wheat yields (4-9%), net returns (9-13%), cost effectiveness (11-12%) and energy efficiency (20-24%); required lower specific energy (17-19%) and specific cost (5-8%); and reduced *Phalaris minor* (44-77%), other weeds (61-72%), compared to conventional sowing of wheat (Fig. 9.1.11).

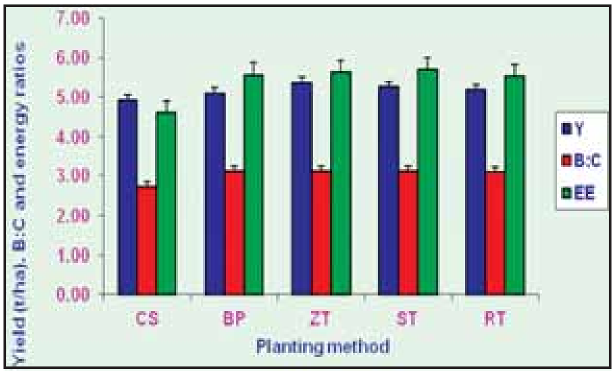


Fig. 9.1.11. Effect of planting methods on wheat yield (Y), benefit: cost (B:C) and energy ratios (EE) ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)***

The effect of different resource conservation technologies on soil organic carbon (OC), mean weight diameter of aggregates (MWD) and percent change in OC and MWD revealed that there was an improvement in soil properties by the use of these drills. Zero till drilling resulted in maximum moisture content at all the growth stages of crop, minimum cone index and bulk density, and maximum OC and MWD than any other method. Bed planting, and zero and strip till drilling improved soil organic carbon (15-38%) whereas rotary till drilling and conventional sowing reduced OC (2-11%) after twelve crop cycles. Bed planting, and zero and strip till drilling also improved mean weight diameter of aggregates, MWD (18-72%), whereas rotary till drilling and conventional sowing reduced MWD (13-19%) after twelve crop cycles.

Evaluation of different crop residues management practices in rice-wheat cropping system

A field experiment is in progress since 1998 to study the energy requirement and cost of recycling of rice-wheat straw after combine harvesting and to evaluate the performance of subsequent crops in straw recycled fields. The recycling was done by rotavator and achieved in shallow layer only (30-70 mm). The action of rotavator was to impart rotation to successive bites of soil so that chopped/ broken straw falls between these bites for uniform mixing with the soil. After harvesting of rice and wheat, three straw management practices (recycling, retrieval and burning) were practiced before the planting of next crop. Self-propelled transplanter was used for transplanting of rice after wheat straw recycling. Zero, strip and conventional drills were used for wheat sowing after rice straw recycling. It was observed that for recycling of rice (6 to 7 t ha^{-1}), as well as wheat straw (8 to 9 t ha^{-1}), the degree of recycling was 80-85% and cost and energy of recycling of Rs 2970 ha^{-1} and 2630 MJ ha^{-1}, respectively. There was appearance of yellowing in seedlings at the initial stage but subsequent establishment and growth of crops was found similar to non-straw recycled fields. The recycled wheat straw got decomposed after about 50 to 55 days in rice fields.

The effect of different crop residue management practices on yield, benefit: cost ratio (B: C) and energy efficiency (EE) of rice and wheat are given in Figure 9.1.12. The *insitu* recycling of wheat straw produced 13 and 10 per cent higher rice yield than straw retrieval and burning treatments, respectively. The net returns under straw recycling were 22 and 15 per cent higher; B: C ratio and energy output: input ratio were 6 and 4% higher, and 2 and 4 per cent lower; and specific cost and specific energy 6 and 4 per cent lower, and 2 and 5 per cent higher,

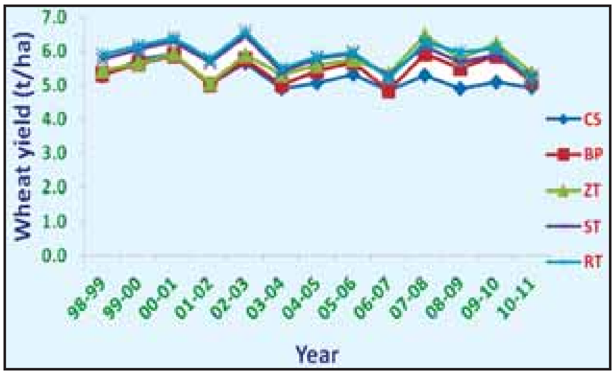


Fig. 9.1.12. Effect of planting methods on wheat yield over the years ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)***

respectively. The recycling of rice straw increased the wheat yield (8%), net returns (11%) and B: C ratio (2%), but decreased energy output: input ratio (5%); and increased specific energy (6%) but decreased specific cost (1%) compared to straw retrieval treatment.

The effect of crop residue management practices on the yield of rice and wheat over the years is depicted in Figures 9.1.13, 9.1.14 and 9.1.15. Crop residue recycling and burning improved soil organic carbon, SOC (39 and 8%) whereas retrieval decreased SOC (9%) compared to initial values after

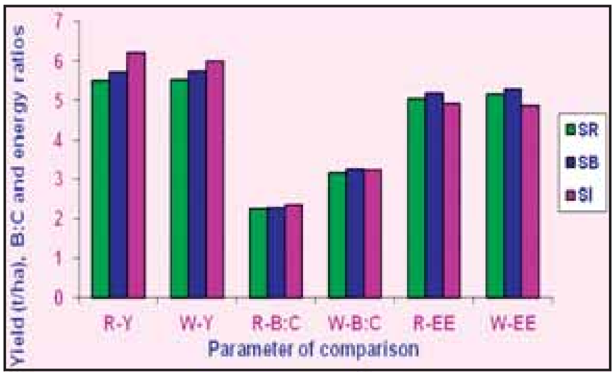


Fig. 9.1.13. Effect of crop residue management practices on yield (Y), economics (B:C) and energy efficiency (EE) of rice (R) and wheat (W) ***(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)***

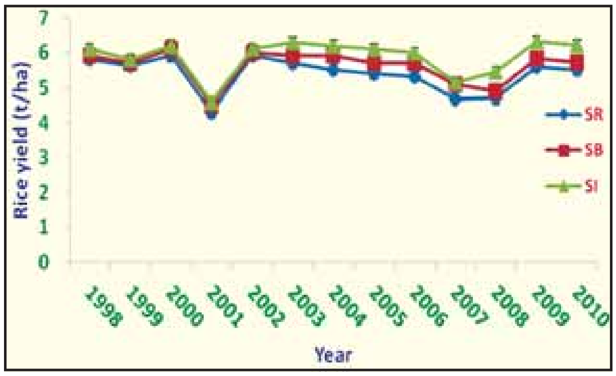


Fig. 9.1.14. Effect of crop residue management practices on rice yield over the years ***(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)***

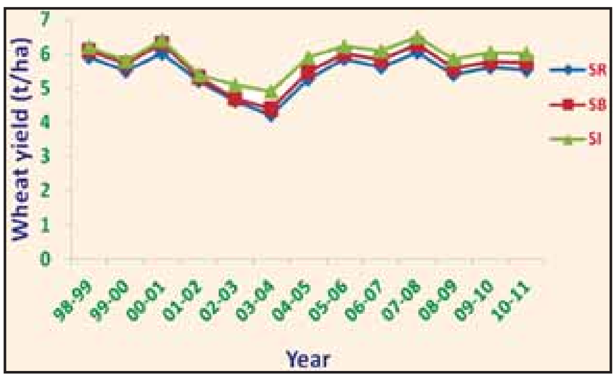


Fig. 9.1.15. Effect of crop residue management practices on wheat yield over the years ***(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)***

twelve crop cycles. The recycling also improved SOC (54 and 30%) compared to retrieval and burning treatments. Crop residue recycling improved mean weight diameter of aggregates, MWD (15%), whereas retrieval decreased MWD (6%) compared to initial values after twelve crop cycles. The recycling also improved MWD (22 and 16%) compared to retrieval and burning treatments. The recycling of crop residues improved soil moisture content (14%), bulk density (3%) and cone index (22%) compared to residue retrieval.

Crop Nutrient Management

Reclamation of saline- sodic soils for better crop production and soil health

There was reduction in the PMN in the saline sodic soils by 34-45 percent over the normal soils (17.4 mg kg^{-1}). Use of amendments such as gypsum, FYM, Press mud and green manure either in isolation or in combination led to increase in potentially mineralizable nitrogen over the saline-sodic control plots. Introduction of *Dhaincha* as green manure further increased the nitrogen mineralization potentials in saline sodic soils over and above the other inorganic amendments. Impact of cropping systems (Rice-wheat, Rice-mustard and Rice-barley) along with *in situ* residue incorporation of the respective crops also had the similar trend of potentially mineralizable nitrogen in the soil.

Thus, 25% higher N application in both rice and wheat gave 17-22 percent higher system productivity (REY) in all amendments (Table 9.1.12).

Response of 25% excess N application was observed in all treatments as well as cropping systems. After the 4 crop cycle, the REY increase due to 25% excess N application in rice- wheat was 1.0 to 2.9 t ha^{-1} (lowest in press mud to highest in control), in rice- mustard was 1.1 to 1.8 t ha^{-1} (lowest

Table 9.1.12: Mean, standard deviation and range of values of potentially mineralizable N (N_0) under different amendments in saline - sodic soils

Treatments	Mean	SD	CV %
Normal soil	17.4	5.4	15.4
Control (Saline sodic soil)	12.4	6.1	25.0
Gypsum (Gyp)	13.2	3.8	23.7
FYM	12.8	3.2	19.0
Gyp + FYM	13.6	6.4	24.3
Press mud	13.1	5.2	35.5
Press mud + Gyp	14.2	5.7	27.1
Gyp + *Dhaincha* (GM)	13.6	3.6	25.4
Press mud + Gyp + GM	14.2	2.4	18.3
Gyp + FYM +GM	14.4	3.9	25.1
Press mud + Gyp + FYM	14.8	2.7	22.4
Press mud + Gyp + FYM + GM	15.7	5.1	21.4

in Gyp + *Dhaincha* to highest in Press mud + Gyp + FYM) and in rice- barley was 1.4 to 2.8 t ha^{-1} (lowest in FYM to highest in Press mud + Gyp + FYM + GM). Higher nitrogen application further enhanced the *in situ* decomposition of residues for all crops as was evident from the CO_2 measurements under field conditions. Higher nitrogen application further enhanced the decomposition of residues for all crops (Table 9.1.13).

Utilization of spent wash effluents for crop production and soil amendment

Plant characteristics of sugarcane and biomass productivity

Sugarcane grown with the dilution of effluents varied in their plant characteristics. Cane length was significantly higher with 50% Effluents and declined thereafter under flat bed planting however, it was further improved with the raised bed planting. Cane

Table 9.1.13: Effect of excess N application on rice equivalent yield in saline- sodic soils under different cropping systems

Treatments	Rice-wheat		Rice-mustard		Rice- barley	
	RN	25% excess N	RN	25% excess N	RN	25% excess N
Control	9.7	12.6	6.1	7.7	7.0	8.9
Gypsum (Gyp)	9.6	12.1	5.4	7.2	7.1	9.1
FYM	8.2	9.9	4.8	6.2	5.2	6.6
Gyp + FYM	8.1	10.6	4.7	6.0	6.3	7.9
Press mud	10.1	11.1	5.8	7.5	7.4	9.4
Press mud + Gyp	7.2	8.9	5.3	7.0	5.8	7.4
Gyp + *Dhaincha* (GM)	7.1	9.4	5.3	6.4	7.2	9.1
Press mud + Gyp + GM	10.7	13.2	6.3	7.8	6.5	8.6
Gyp + FYM +GM	8.4	10.1	5.6	6.86	5.4	6.9
Press mud + Gyp + FYM	11.2	13.4	5.7	7.5	6.4	8.2
Press mud + Gyp + FYM + GM	11.4	14.2	6.8	8.8	8.1	10.9

*RN: recommended N applied in individual crops

girth was however statistically *at par* under all effluent treatments under flat bed planting. Raised bed planting significantly increased the plant girth up to 50% Effluents. Weight per cane also followed the similar pattern as with the cane girth. Mileable cane numbers were significantly increased with the effluents water up to 50% dilution under both methods of planting. Number of clumps was however unaffected irrespective of water quality and type of planting. Interaction of planting and dilution of water was significant for cane length, cane weight and mileable cane numbers.

Cane yield was significantly higher under 50% Effluents irrigation over the normal irrigation water (85.1 and 89.4 t ha^{-1} under flat and raised bed planting, respectively). Dilution of water less than 50% however, declined the yield under both planting methods. Interaction of water and planting method was significant for cane productivity. Green trash yield was also significantly higher under 50% Effluents irrigation over the normal irrigation water (17.3 and 17.4 t ha^{-1} under flat and raised bed planting, respectively). Increasing the concentration of effluents further declined the trash yield. Interaction of effluent water dilution and planting method significantly affected the green trash yield. Cane recovery was also affected with the dilution of effluents and planting method. Recovery efficiency was significantly increased up to 50% Effluents irrigation (8.6%) over the normal water (6.8%) and declined with the further increasing the concentration of effluents water. Dilution of irrigation water and planting method further improved the recovery efficiency.

Soil characteristics

Effect of effluents with different dilution and planting methods on soil chemical properties showed that soil pH was unaffected with the use of effluents irrigation irrespective of the water dilution and planting method. There was slight increase in the soil EC under the flat bed planting. High presence of Na in the effluents water affected the SAR values in the soil. SAR was slightly but significantly increased with concentration of effluents water. SAR was maximum with the 100% effluent irrigation as 19.4 and 16.4, respectively with flat bed and raised bed planting. There was significant increase in the DTPA extractable Fe, Mn, Cu and Zn under both the planting methods. Interaction of water and planting method was however was non significant for all soil chemical parameters (Table 9.1.14).

Microbial biomass carbon (MBC) was monitored in the soil after end of the experiment. Under 50% effluents trash incorporation in the soil had highest MBC (577 mg kg^{-1}). MBC declined significantly with increase in the concentration of effluent water. Soil Organic carbon (SOC) was also highest with the 100% effluents (4.2 g kg^{-1}) and declined with the dilution of the effluent water. However, MBC: SOC ratio was highest with the 50% effluents. In the raised bed planting, both MBC and SOC were higher than the flat bed planting at all treatments. But, the MBC: SOC ratio for 75 and 100% effluents was slightly higher over the flat bed. As compared to the control soil (without trash application), MBC was 7.2-9.2 % higher in flat bed and 8.1-10.8 % higher in raised bed planting. SOC increase with trash application was 10.8-15.6% higher in flat bed and 11.4-15.4% higher in raised bed over control soil. Increase in MBC and SOC were not showing any definite trend in together.

Total N in soil was highest with 50% effluents (0.62 and 0.65 g kg^{-1} in flat bed and raised bed, respectively). The C: N ratio of the soil was lowest 6.6 with 50% effluents and highest with 100% effluents in flat bed. In raised bed, it was lowest as 6.5 in normal water and 50% effluents and highest (7.4) in 100% effluents.. The presence of higher C/N ratio in 100% effluent concentration buttresses the presence of higher N content in the effluent. Also, the use of N by microorganisms for metabolic

Table 9.1.14. Soil characteristics after effluent irrigation

Treatment	pH	EC (dS/m)	SAR	Zn(mg/kg)	Cu(mg/kg)	Fe(mg/kg)	Mn(mg/kg)
Initial soil	7.6	2.1	13.8	2.0	1.8	46.7	23.5
Flat bed planting							
Normal water	7.6	2.2	14.2	2.1	2.0	47.2	24.2
25% Effluents	7.4	2.6	16.5	2.4	2.2	53.8	26.4
50% Effluents	7.6	2.7	18.4	2.4	2.2	54.1	26.8
75% Effluents	7.7	2.8	18.9	2.8	2.8	54.6	27.1
100% Effluents	7.8	2.8	19.4	2.8	3.0	55.1	27.3
LSD (P 0.05)	NS	0.15	1.3	0.3	0.2	2.4	0.2
Raised bed planting							
Normal water	7.6	2.1	13.8	2.1	2.0	48.1	23.7
25% Effluents	7.6	2.5	15.4	2.4	2.4	52.3	24.8
50% Effluents	7.8	2.5	15.9	2.8	2.4	54.1	25.1
75% Effluents	7.8	2.6	15.9	3.5	2.8	54.6	25.4
100% Effluents	7.8	2.7	16.4	3.8	3.1	54.8	26.3
LSD (P 0.05)	NS	NS	0.9	0.3	0.15	2.2	0.2

activities did not in any way reduce the C/N ratio below that of control. The change in the C: N ratio of the soil was marginal irrespective of the concentration of the effluents water and planting method.

Soil respiration as measured in terms of CO_2 evolved from the soil surface during residue decomposition was higher under raised bed (0.13 - 0.17 mg CO_2 kg^{-1} soil d^{-1}) than the flat bed (0.12-0.15 mg CO_2 kg^{-1} soil d^{-1}). Soil respiration was also highest with the 50% effluents. The variation in the C: N ratio of the residue could be one of the reasons for higher respiration in raised bed planting.

Trash residue decomposition vs effluent irrigation

Irrigation with effluent water changed the soil characteristics as well as the sugarcane crop including trash residue. Further decomposition trash residue in the soil was increased upto 50% effluent application,. Microbial biomass carbon, soil organic carbon and the ratio of MBC: SOC were highest upto 50% effluent together with raised bed planting. It appears that after a certain intensity of effluent irrigation with high load of BOD and COD, the biological activities of the soil are adversely affected and thus the sugarcane trash decomposition in the soil. Soil respiration as measured in terms of CO_2 evolution from the soil surface clearly indicated the high respiration rate with trash incorporation in the soil together with 50% effluent and raised bed planting. Process of CO_2 evolution under field condition is mainly biological in nature and then it is liable to be inhibited at some concentration of pollutants in soil, as in this case at 75 and 100% effluents the CO_2 evolution is being retarded progressively with increased effluent concentration. In case of raised bed planting, trash residue decomposition is higher due to the lower C:N ratio of the residue produced in the field and higher activities of rhizospheric soil enzymes.

Study on water and nitrogen use efficiency of different varieties of rice under aerobic condition

The experiment was conducted to find out the water and nitrogen use efficiency of rice-wheat cropping system under aerobic condition. Four cultivars (Subhangi, PRH 10, Saket 4 and Pro-agro 6444) with three types of N application (normal urea, neem coated and sulphur coated) and 3 level of soil moisture tension (0, 20 and 40 kPa) with three replications were evaluated in split plot design during *kharif* 2011.

Rice productivity varied in accordance with irrigation water scheduling and modified slow release urea used in different cultivars. Rice productivity was maximum (6.03 t ha^{-1}) at zero irrigation water tension (Fig 9.1.16), which is at par with 20 kPa and statistically significant with 40 kPa (Table 9.1.15). Maximum harvest index (40.62 %), panicle length (17.8 mm), test weight (16.78 g) and effective tillers/m2 (378) were obtained under 0 kPa moisture tension. However, highest number of grains/panicles (62.8) obtained under 20 kPa moisture tension

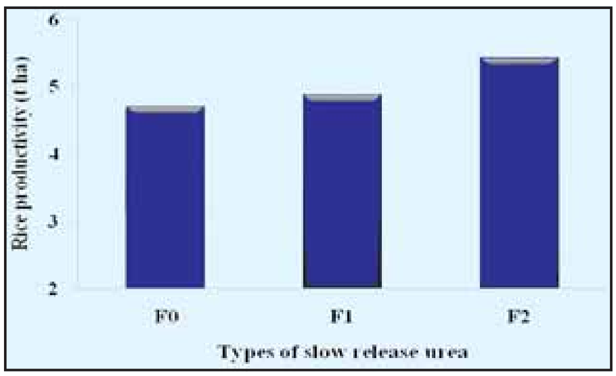


Fig 9.1.16: Effect of Irrigation water tension (kPa) on rice productivity (t ha^{-1})

Table 9.1.15. Yield and Yield attributes of rice under different treatements

Treatments	Grain Yield (q ha^{-1})	Straw yield (q ha^{-1})	HI (%)	Length of panicle (cm)	No. of grains/ panicle	1000 grain weight (g)	No of effective tillers/m^2
M0	6.03	8.70	40.62	17.8	62.7	16.78	378
M1	5.38	8.29	38.96	15.7	62.8	16.45	360
M2	3.61	7.46	32.31	11.9	58.0	16.35	288
SEm(±)		0.61	0.37	0.87	0.63		5.9
CD(5 %)	7.52	2.39	1.45	2.4	2.5		23.1
F0	4.70	8.02	36.31	15.2	59.7	16.32	344
F1	4.88	8.33	36.14	15.0	61.3	16.53	343
F2	5.43	8.11	39.43	15.1	62.5	16.74	339
SEm(±)		0.45	0.22		0.53	0.095	
CD(5 %)	5.55	1.26	0.63		1.49	0.27	
V1	3.94	7.92	32.83	14.1	56.5	19.81	317
V2	5.20	7.99	38.92	15.4	61.7	15.61	347
V3	4.59	8.02	35.82	14.4	62.3	16.06	338
V4	6.29	8.68	41.62	16.5	64.2	14.63	366
SEm(±)		0.52	0.36	0.35	0.61	0.11	5.9
CD(5 %)	9.36	1.45	0.72	1.0	1.72	0.31	16.8

Rice productivity was maximum with sulphur coated urea (5.43 q ha^{-1}) (Fig. 9.1.17), which is statistically significant over neem coated and normal urea. Higher number of grains/panicle and test weight, which are statistically significant may be the reason for higher rice productivity under sulphur coated urea.

Among the varieties, Pro-agro 6444 gave maximum rice grain yield of 6.29 t ha^{-1}, which was statistically significant over others (Fig 9.1.18). The yield attributes such as length of panicle, number of grains/panicle and effective tillers/m^2 was more for Pro Agro 6444. PRH 10, Subhangi and Saket 4 gave lower yield by 17, 27 and 37 %, respectively compared to Pro-agro 6444.

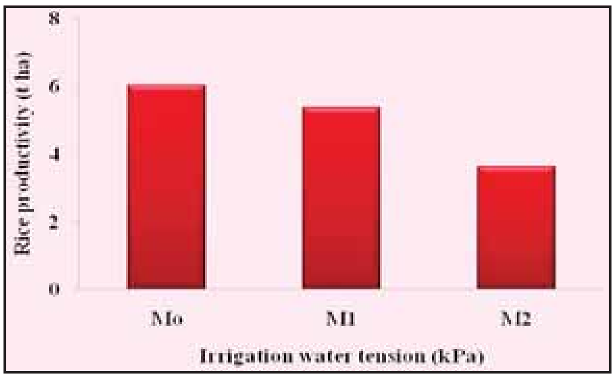


Fig. 9.1.17: Effect of modified slow release urea on rice productivity

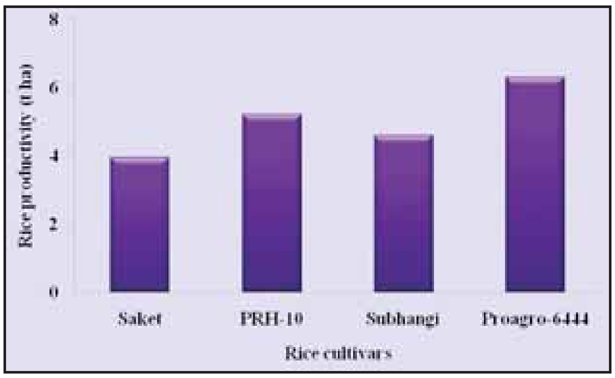


Fig 9.1.18. Effect of cultivars on rice productivity

Crop Climate Relationship and Climate Resilient Agriculture

Physiological evaluation of rice and wheat genotypes under changing climatic scenario

A field experiment was conducted during three consecutive crop (*kharif-rabi)* seasons of 2008-2010 to evaluate 20 genotypes of rice and wheat for their phenology and growth in relation to climatic conditions and to monitor different morpho-physiological parameters in relation to productivity of the crop. Twenty five days old seedlings were transplanted in the field on July 2nd, June 18th and July 7th during 2008, 2009 and 2010 respectively. Twenty wheat genotypes were sown on 25th, 17th and 25th November of 2008, 2009 and 2010 respectively. For better understanding crop wise pooled data of three years are described below.

Physiological evaluation of rice genotypes

Observations were recorded on various phenophases and morpho-physiological parameters of growth and productivity (Fig.9.1.19-21). All 20 genotypes of rice were primarily divided in to basmati and non-basmati types. On the basis of number of days required for maturation both types have been further divided for the ease of understanding the morpho physiological characters. Basmati genotypes have been divided in to four groups i.e. <100 days, 101-110 days, 111-120 days and >120 days and non-basmati types have divided in to three groups i.e. <90 days, 90-100 days and >101 days.

Phenological variations were observed in panicle initiation (PI), 50 % flowering (Fl) and physiological maturity (PM). The range of panicle initiation was 49-73 days after transplanting, (DAT) among the basmati types and 41-63 DAT among the non-basmati types. The values for 50 % flowering (Fl) for basmati was 59-87 and for non-basmati was 49-73 DAT. Basmati genotypes physiologically matured between 95-123 DAT and non-basmati genotypes required 78-107 DAT to attain physiological maturity (Pm). Among the basmati genotypes Pusa Sugandha 4 was reported as too short duration cultivar and Tadawadi basmati was as too long duration cultivar. Poornima and Narendra 359 were reported as short and long duration cultivar respectively in case of non-basmati genotypes. Panicle initiation data showed the same trend as in case of physiological maturity but data pertaining to 50% flowering deviated from the trends described earlier (Fig. 1).

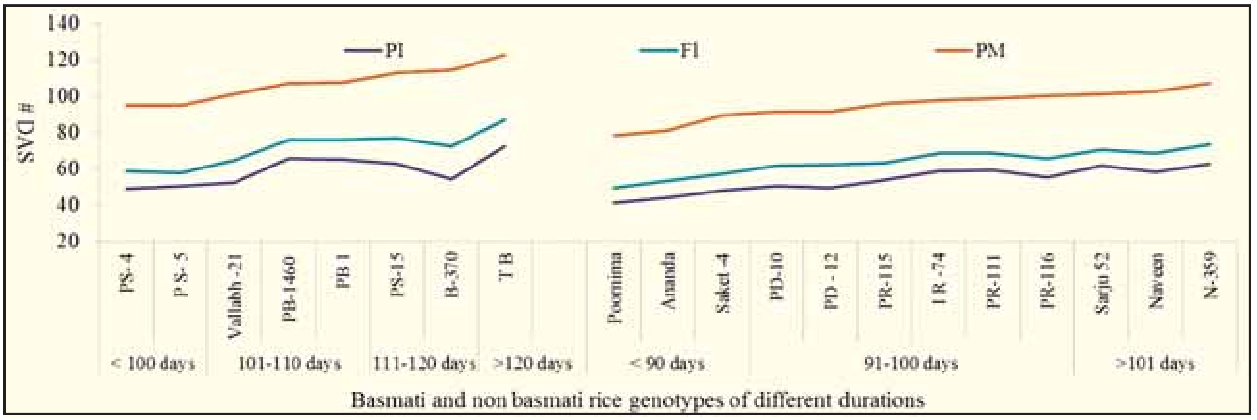


Fig. 9.1.19. Phenological variations in Panicle initiation (PI), 50% Flowering (Fl) and physiological maturity (PM) of the rice genotypes

Shoot length (cm) ranged between 110-145 among the basmati genotypes and 91-122 among the non-basmati genotypes. Pusa Sugandha 5 was reported as short statured cultivar and Tadawadi basmati as long statured cultivar among the basmati whereas, Poornima and Naveen were reported as short and long statured cultivar among the non-basmati genotypes. Maximum leaf area index (LAI) was reported at 50% flowering stage and it was significantly higher in non -basmati genotypes. The range of maximum LAI was 4.2-5.2 in basmati and 4.3-6.6 in non-basmati genotypes. In most of the cultivars under non- basmati types, Max. LAI was remained higher than 5 (Fig. 20).

Significant variations in yield and yield attributing characters in terms of tillers (m^{-2}), panicle length (cm), grains/panicle, test weight (g), grain yield (q ha^{-1}), biomass (q ha^{-1}), HI (%) of both basmati and non-basmati genotypes were reported. The range of tillers numbers (m^{-2}) of basmati genotypes was very close to non-basmati genotypes but mean panicle length (cm) was significantly higher in basmati (27.4) than the non-basmati (23.8) genotypes. The range of numbers of grains/panicle of basmati genotypes was highly scattered (45-136) but in non-basmati genotypes range was shorter (92-125). No significant variation n mean value of grains/panicle was reported between basmati and non-basmati genotypes. Numbers of grains/panicle was reported significantly higher in Pusa Sugandha 15(136) and Basmati 370 (127) whereas it was significantly too lower in Tadawadi Basmati (45) among basmati genotypes. Numbers of grains/panicle in PR 115 (125) was found significantly higher but it was lower in Poornima (92) and Ananda (95) genotypes of the non-basmati group. Significantly higher test weight (g) was found in Pusa Sugandha 4, Pusa Sugandha 5 and Vallabh 21 whereas, it was lower in Basmati 370 and Tadawadi Basmati among the basmati genotypes. Test weight (g) was found significantly higher in Pant Dhan 10, Pant Dhan 12, IR 74, PR 116 and Narendra 359 whereas, it was lower in Poornima, Saket 4, PR 111, Sarju 52 and Naveen. Biomass accumulation was lower in basmati (114-147 q ha^{-1}) than the non-basmati (106-160 q ha^{-1}) but the range was too large in case of non-basmati genotypes. The range of grains yield (q ha^{-1}) of basmati genotypes was highly scattered (21-48) but in non-basmati genotypes range was shorter (42-69). Significantly lower grain yield was reported in basmati group than non-basmati genotypes. Grain yield (q ha^{-1}) was significantly lower in Pusa Basmati 1 (40), Basmati 370 (37) and Tadawadi Basmati (21) among the basmati type whereas Vallabh 21 (48), Pusa Sugandha 4 (47), Pusa Sugandha 5 (47),

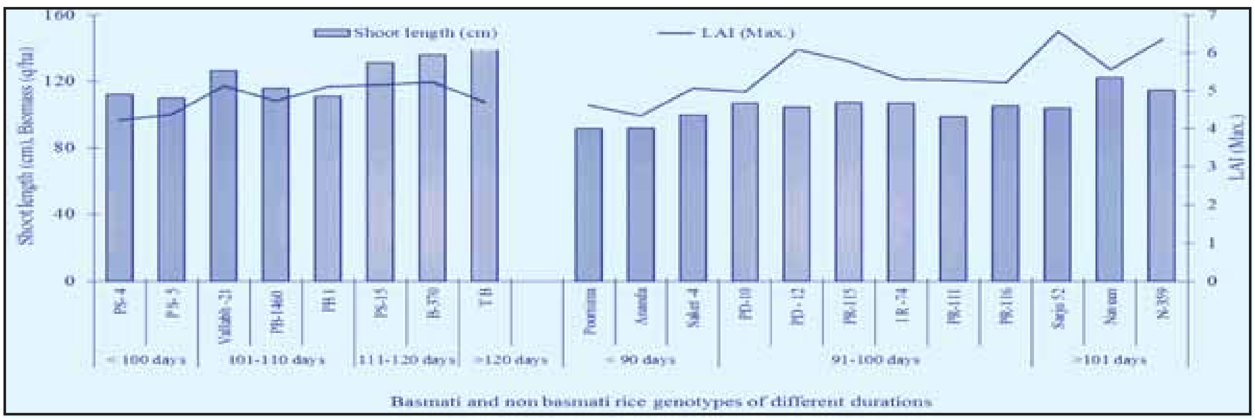


Fig. 9.1.20. Shoot length (cm) and maximum leaf area index (LAI) of the rice genotypes

Busa Basmati 1460 (44) but Pusa Sugandha 15 (46) were yielded significantly higher among the basmati genotypes. Significantly higher grain yield (q/ha^{-1}) was reported in PR 115 (69), Narendra 359 (67), IR 74 (65), PR 111 (61) and Naveen (63) and lower in Poornima (42) and Anand (45) among the non-basmati genotypes. Higher grain yield of basmati group was due to higher maximum LAI, panicle length, grains/panicle, test weight, biomass and harvest index and the correlation coefficient (r) of the grain yield with maximum LAI, panicle length, grains/panicle, test weight, biomass and harvest index were 0.60, 0.83, 0.70, 0.75, 0.52 and 0.90 respectively. But number of tillers (m^{-2}) was negatively associated with grain yield (r=0.70). In the case of non-basmati genotypes, the correlation coefficient (r) of the grain yield with tillers (m^{-2}), maximum LAI, panicle length, grains/panicle, test weight and biomass were 0.67, 0.60, 0.61, 0.79, 0.38, and 0.98 respectively. But harvest index did not show significant correlation with grain yield (Fig. 9.1.21).

Significantly lower rate of photosynthesis (µmole CO_2 m^{-2} s-1) was reported in basmati genotypes i.e. Pusa Sugandha 4, Pusa Sugandha 15, Basmati 370 and Tadawadi basmati. Rate of photosynthesis was significantly higher in Pusa Sugandha 5, Vallabh 21 and Pusa Basmati 1 in basmati group whereas, Saket 4, IR 74, PR 111 and PR116 showed significantly higher rate of photosynthesis among the non-basmati group. Rate of photosynthesis was significantly correlated with grain yield of basmati genotypes (r=0.50) but it was non-significant with non-basmati genotypes. Rate of transpiration (m mole H_2O m^{-2} s^{-1}) was significantly higher in only one cultivar (Vallabh 21) of basmati genotypes and in three cultivars (Pornima, Saket 4 and IR 74) of non-basmati genotypes. Significantly lower rate of transpiration was reported in four cultivars (Pusa Sugandha 4, Pusa Sugandha 5, Basmatin 370 and Tadawadi basmati) of basmati genotypes and Sarju 52 of the non-basmati genotypes. The positive and significant correlation coefficient (r=0.45) between rate of transpiration and grain yield was reported in basmati genotypes but it was non-significant in the case of non-basmati genotypes. Photosynthetic water use efficiency (PWUE, m mole CO_2 mole^{-1} H_2O) was higher in general in the case of basmati genotypes in comparison to non-basmati genotypes. Significantly higher photosynthetic radiation use efficiency (PRUE) was reported in cultivars like Vallabh -21, Pusa Basmati1460, Pusa basmati 1, among the basmati group and Poornima, Ananda, Saket 4, Pant Dhan

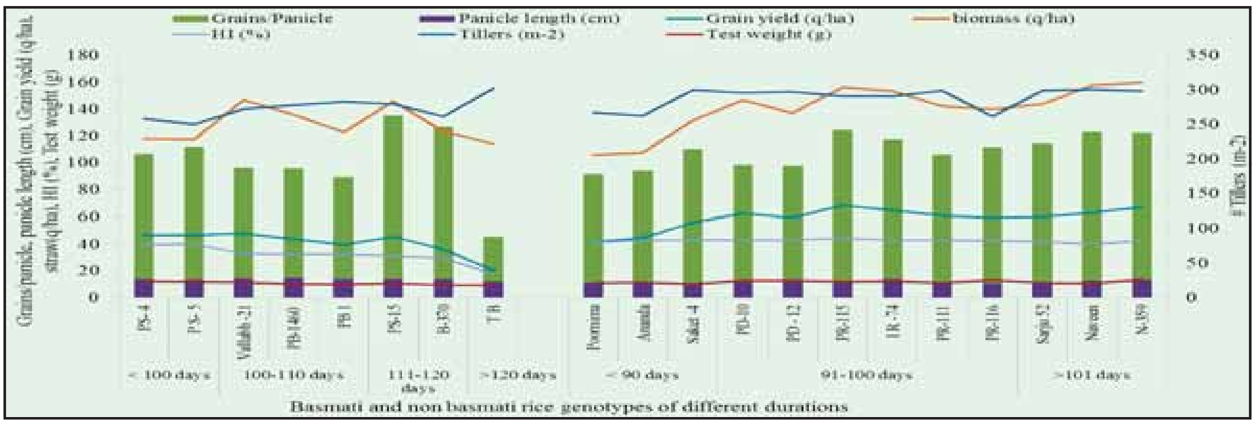


Fig. 9.1.21. Tillers (m^{-2}), spike length (cm), grains/spike, test weight (g), grain yield (q ha^{-1}), biomass (q ha^{-1}) and HI (%)) of the rice genotypes

10, PR-115, PR-111, and Naveen among the non-basmati group (Fig.9.1.22).

Total heat unit requirement i.e. growing degree days (GDD_{PM}) was significantly higher (1849 °Cd) in basmati genotypes than the non-basmati genotypes (1675 °Cd). Growing degree days (GDD) required for panicle ignition (GDD_{PI}) and 50% flowering (GDD_{An}) were also higher in basmati than the non-basmati types. Heat use efficiency (HUE, kg ha^{-1} $^{0}Cd^{-1}$) in basmati genotypes was higher in short duration cultivars but it was lower in short duration cultivars of the non- basmati genotypes. Overall non-basmati genotypes showed significantly higher HUE than the basmati genotypes. Radiation use efficiency (RUE, gMJ^{-1}) was also higher in basmati genotypes and among the basmati genotypes it was higher in short duration cultivars. But reverse trend was observed in case of the non-basmati genotypes (Fig.9.1.23).

Physiological evaluation of wheat genotypes

Observations were recorded on various phenophases and morpho-physiological parameters of growth and productivity (Fig.9.1.24-25). All 20

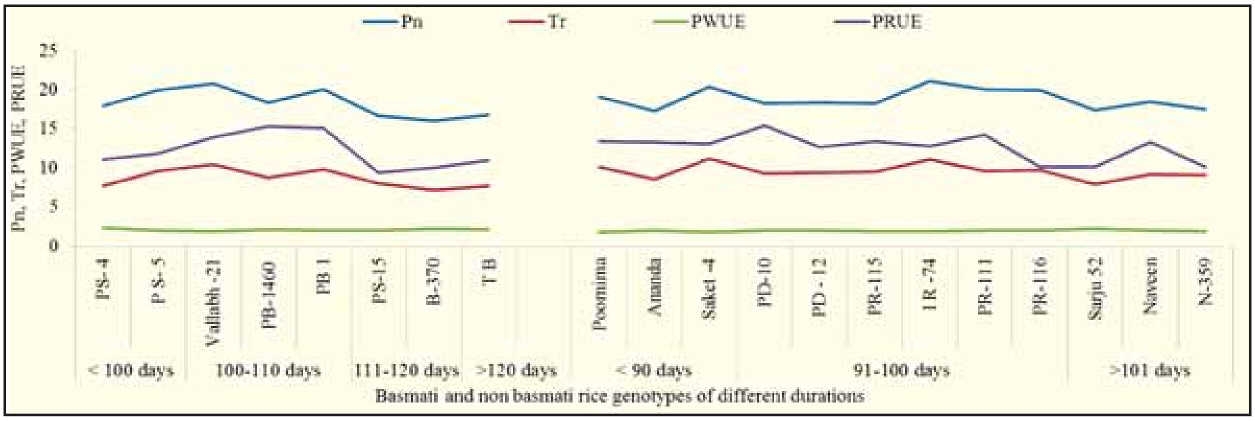


Fig. 9.1.22. photosynthesis (μ mole CO_2 m^{-2} s^{-1}) rate of transpiration (m mole H_2O m^{-2} s^{-1}) photosynthetic water use efficiency (PWUE, m mole CO_2 $mole^{-1}$ H_2O) photosynthetic water use efficiency (PWUE, m mole CO_2 $mole^{-1}$ H_2O) of the wheat genotypes

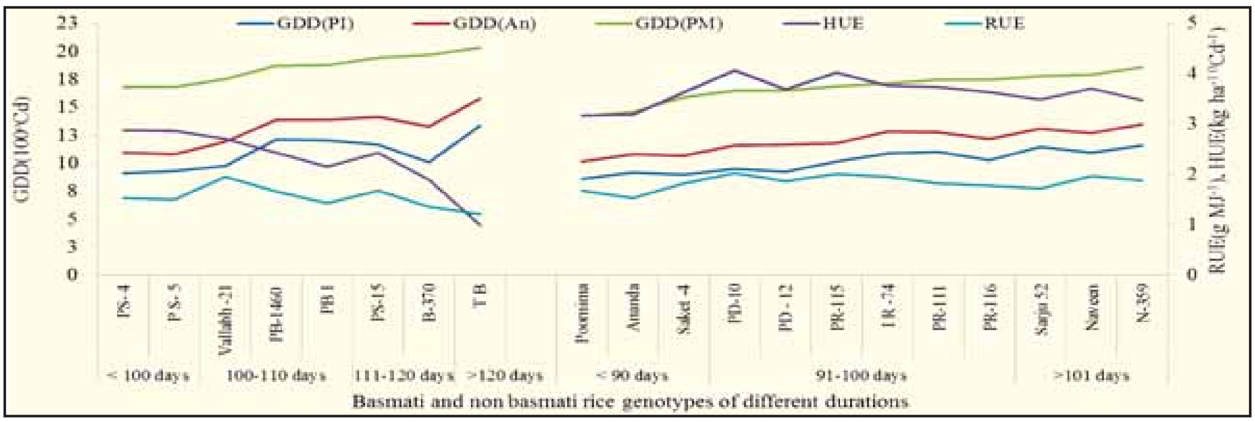


Fig. 9.1.23. Growing degree days for panicle initiation (GDD_{PI}), 50% flowering (GDD_{An}) and physiological maturity (GDD_{PM}), heat use efficiency (HUE, kg ha^{-1} $^{0}Cd^{-1}$) and Radiation use efficiency (RUE, gMJ^{-1}) of the rice genotypes

genotypes of wheat were primarily divided in to three groups on the basis of grain yield i.e. low yielding (50 q ha^{-1}), medium yielding (51-55 q ha^{-1}) and high yielding (> 55 q ha^{-1}). Phenological variations were observed in spike emergene (SE), 50 % flowering (Fl) and physiological maturity (PM). The range of spike emergence was 56-69 days after sowing (DAS) and RAJ 3765, HD 2733, DBW 17 and HD 2687 were reported significantly late in terms of spike emergence whereas, PBW 343, DBW 1and WH 1021 were reported as significantly early in spike emergence. Mean of Days taken to spike emergence in low, medium and high yielding cultivars were 60, 61 and 65 DAS and it was negatively associated with grain yield (r=0.96). The values for 50 % flowering (Fl) were 93-104, 95-105 and 100-104 DAS for low yielding, medium yielding and high yielding cultivars of wheat. Significantly higher days taken to FL stage in PBW343, HD 2733, PBW 509 and PBW 343 whereas significantly lower days were taken in UP 2425, HI 1544, PBW 226, WH 1021, UP 2565 and PBW 550. The mean values of days for FL were 98, 99 and 102 DAS in low yielding, medium yielding and high yielding cultivars of wheat. Higher number of days taken to attain the FL was converted in to higher yield and correlation coefficient (r) with grain yield was 0.97. All the 20 genotypes physiologically matured between 128-136 DAS. Among the low yielding cultivars, HI 1544 (128 DAS) required significantly lower days and HD 2733 (136 DAS) required higher days to attained the physiological maturity. The range of days taken to PM was 128-135 DAS in medium yielding cultivars whereas it was 134-136 DAS for high yielding cultivars. The mean values of days for PM were 132, 132 and 135 DAS in low yielding, medium yielding and high yielding cultivars of wheat. Higher number of days taken to mature the cultivars was converted in to higher yield and correlation coefficient (r) with grain yield was 0.97 (Fig.9.1.24).

Shoot length (cm) of wheat genotypes ranged between 83-93 with mean value of 88 and mean value of high yielding cultivars was significantly higher (90 cm) than the medium and low yielding groups. Shoot length of PBW 509, WH 1021 and RAJ 3765 were significantly higher whereas, WH 542 and DBW 17 were reported as short statured cultivars. Shoot length of the cultivars were highly associated with the grain yield and correlation coefficient (r) was 0.95. Maximum leaf area index (LAI) was reported at 50% flowering stage. Non-significant difference was reported among the genotypes and the range of maximum LAI was 4.2-5.2 (Fig. 9.1.25).

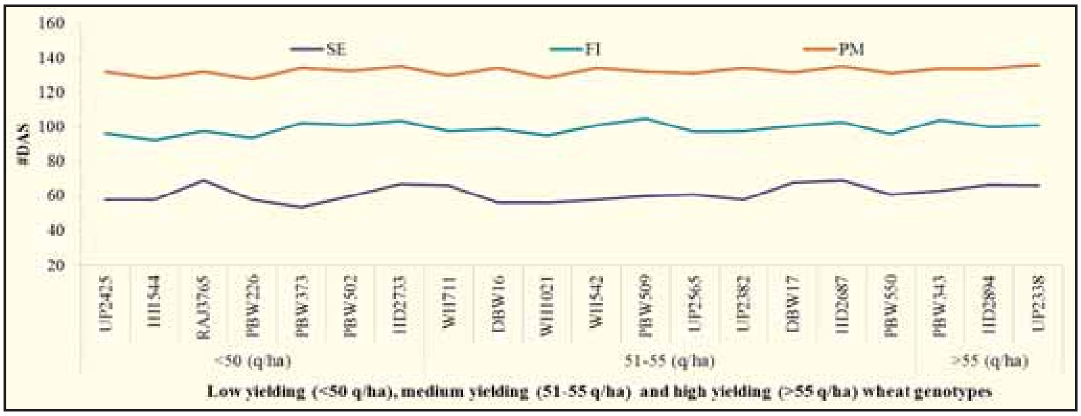


Fig. 9.1.24. Phenological variations in spike emergence (SE), 50% Flowering (Fl) and physiological maturity (PM) of the wheat genotypes

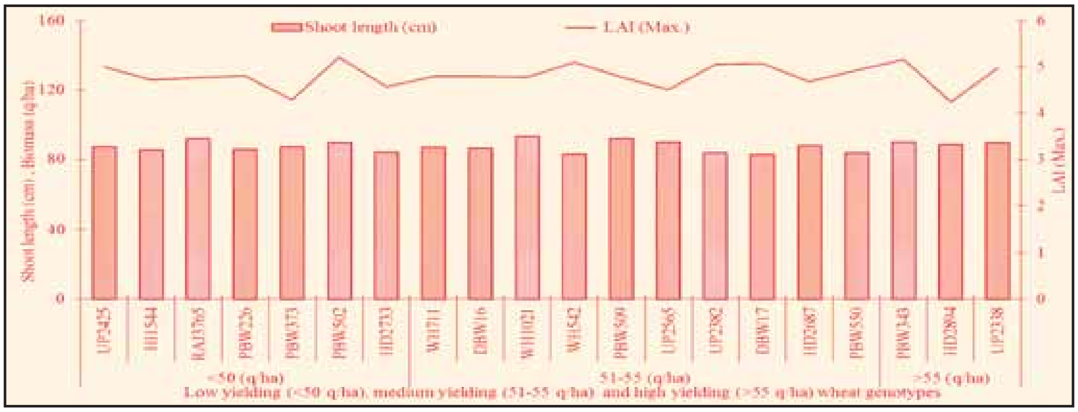


Fig. 9.1.25. Shoot length (cm) and maximum leaf area index (LAI) of the wheat genotypes

Significant variations in yield and yield attributing characters in terms of tillers (m^{-2}), spike length (cm), grains/spike, test weight (g), grain yield (q ha^{-1}), biomass (q ha^{-1}) and HI (%) of genotypes were reported. The range of tillers numbers (m^{-2}) of low yielding genotypes was 433-475, medium yielding genotypes was 413-484 and high yielding genotypes was 468-471. But no significant difference in number of tiller was reported among the genotypes. However, tiller number (m^{-2}) was significantly associated (r=0.31) with grain yield. Spike length (cm) was significantly higher in high yielding groups but non-significantly associated with grain yield. The mean value of number of spikelet/spike of high yielding cultivars was significantly higher (21) and it was significantly lower for low yielding cultivars. Number of spikelet/spike was found highly associated with grain yield and correlation coefficient

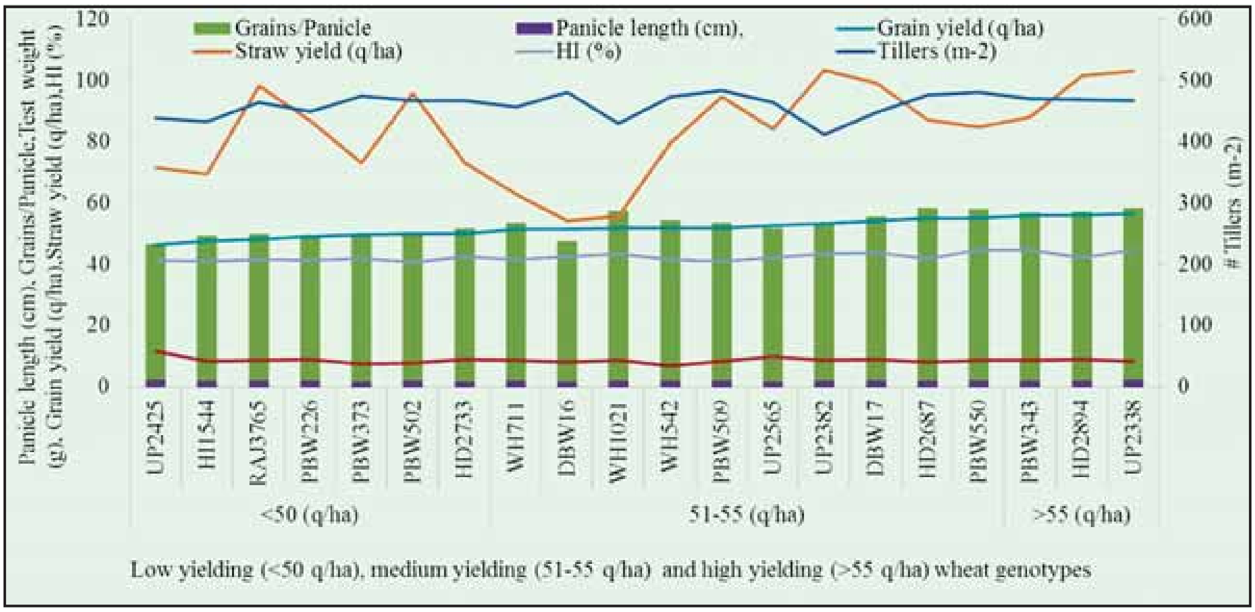


Fig. 9.1.26. Tillers (m^{-2}), spike length (cm), grains/spike, test weight (g), grain yield (q ha^{-1}), biomass (q ha^{-1}) and HI (%)) of the wheat genotypes

(r) was 0.73. Number of grains/spike was significantly higher in high yielding groups and lower in low yielding groups. Mean values for low, medium and high yielding groups were 50, 55 and 58. Number of grains/spike was highly associated with grain yield and correlation coefficient (r) was 0.87. Test weight (g) was found significantly higher in UP 2425 cultivar of low yielding group and lower test weight was reported in PBW 373 and WH 542. No significant association between test weight and grain yield was reported. Range of biomass accumulation (q ha^{-1}) was 113-133 and mean values were lower in low yielding (118) and higher in high yielding (129) cultivars of wheat. Significantly higher biomass accumulation (q $ha^{-1)}$ was reported in HD 2894 (133) and lower in UP 2425(112.7). Biomass accumulation was significantly associated with grain yield with correlation coefficient value of 0.85. Significant variation was reported in grain yield of low yielding, medium yielding and higher yielding of the wheat genotypes. The range of grains yield (q ha^{-1}) of wheat genotypes was highly scattered (47-57). The mean values of grain yield (q ha^{-1}) were 49, 53 and 56 for low yielding, medium yielding and high yielding cultivars of wheat. The range of mean values of harvest index (%) of the low yielding, medium yielding and higher yielding cultivars of wheat genotypes were 41-43, 41-45 and 42-45. No significant variation was reported in HI among the cultivars but a very significant correlation was found between HI and grain yield (r=0.71) of the wheat cultivars (Fig.9.1.26).

The range of rate of photosynthesis (µ mole CO_2 m^{-2} s^{-}1) of the wheat genotypes was reported from 20-24. There was no significant correlation between photosynthesis rate and grain yield of wheat genotypes but significantly higher photosynthesis rate was reported from the cultivar UP 2338 belonging to high yielding group whereas significantly lower photosynthesis rate was reported from the cv. HD 2733 belonging to low yielding group. The range of rate of transpiration (m mole H_2O m^{-2} s^{-1}) was 5.5-7.4. Significantly higher rate of transpiration was reported in RAJ 3767, PBW 343 and HD 2687 whereas lower rate of transpiration was reported from the HI 1544, WH 711, WH 1021 and WH 542. But there was no significant association between grain yield and transpiration rate was established. Significant variation in photosynthetic water use efficiency (PWUE, m mole CO_2 $mole^{-1}$ H_2O) was reported in wheat genotypes but no significant difference was observed among the groups of the cultivars. Higher PWUE was reported in HI 1544, WH 711 and WH 542 and lower PWUE was reported in HD 2687. The range of photosynthetic

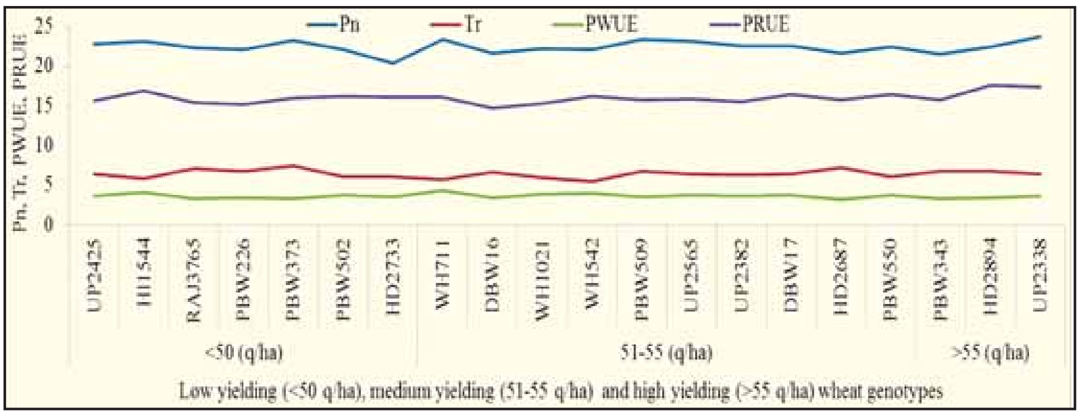


Fig. 9.1.27. photosynthesis (µ mole CO_2 m^{-2} s^{-}1) rate of transpiration (m mole H_2O m^{-2} s^{-1}) photosynthetic water use efficiency (PWUE, m mole CO_2 $mole^{-1}$ H_2O) photosynthetic water use efficiency (PWUE, m mole CO_2 $mole^{-1}$ H_2O) of the wheat genotypes

water use efficiency (PWUE, m mole CO_2 $mole^{-1}$ H_2O) was 14.7-17.6 reported in wheat cultivars. Significantly higher PRUE was reported in HD 2894 and UP 2338 whereas, it was significantly lower in DBW 16. Photosynthetic radiation use efficiency was significantly associated with grain yield of wheat and correlation coefficient (r) was 0.38 (Fig.9.1.27).

Heat unit requirement i.e. growing degree days (GDD_{SE}) for spike emergence was significantly higher in high yielding cultivars (836 °Cd) whereas, it was lower in low yielding cultivars (761 °Cd). GDD_{SE} was also significantly associated grain yield and correlation coefficient (r) was 0.52. The range of growing degree days required for 50% flowering (GDD_{Fl}) was 958-1274 °Cd with mean values for low yielding, medium yielding and high yielding cultivars were 1076, 1072 and 1109 °Cd. The GDD_{Fl} was not associated with grain yield. The range of total growing degree days required for physiological maturity (GDD_{PM}) of wheat genotypes was 1648-1815 °Cd whereas, the mean value for low yielding, medium yielding and high yielding cultivars were 1737, 1724 and 1782 oCd. (GDD_{PM}) was significantly associated (r=0.34) with grain yield of the wheat genotypes. Heat use efficiency (HUE, kg ha^{-1} $^{0}Cd^{-1}$) was significantly higher in high yielding cultivars (3.2) and lower in low yielding cultivars (2.8). HUE was significantly correlated with grain yield of wheat cultivars with very correlation coefficient (r=0.91). Radiation use efficiency (RUE, gMJ^{-1}) was also higher in high yielding cultivars with mean value of 1.7 and lower in low yielding cultivars with mean value of 1.6. RUE was highly correlated with grain yield and correlation coefficient was 0.44 (Fig. 9.1.28).

Climate change: Effects on productivity of Rice-Wheat cropping system in western plain zone of Uttar Pradesh and its mitigation by using DSSAT model

A field experiment was started during *kharif* 2010 to calibrate and validate the DSSAT model to find out the effects of climate change on productivity of wheat-wheat cropping system and its mitigation strategies by using DSSAT model in western plain zone of Uttar Pradesh. Two wheat genotypes *viz,* PBW 343 and BW 226 with two levels of Nitrogen (60 Kg ha^{-1} and 150 Kg ha^{-1}) were sown on three different dates viz, D_1 (4th week of October), D_2 (4th week of November) and D_3 (4th week of December) with four replications during *Rabi* 2010-11. Two rice genotypes *viz,*

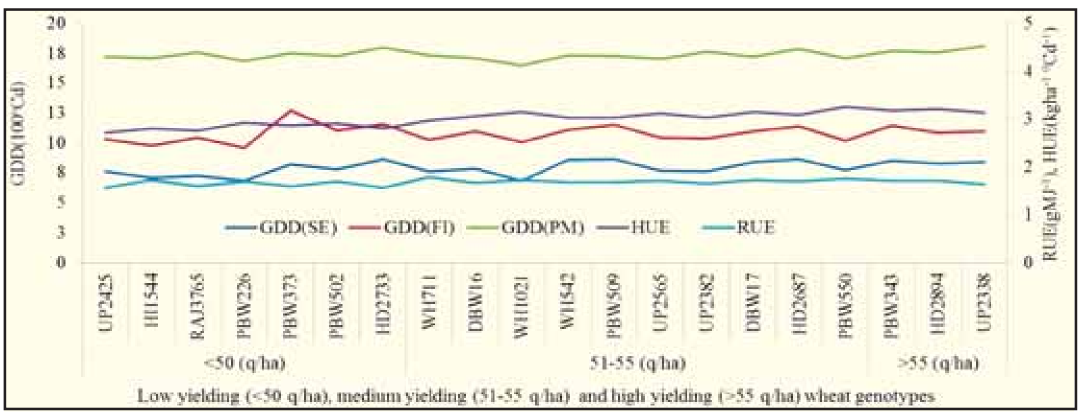


Fig. 9.1.28. Growing degree days for spike emergence (GDD_{SE}), 50% flowering (GDD_{Fl}) and physiological maturity (GDD_{PM}), heat use efficiency (HUE, kg ha^{-1} $^{0}Cd^{-1}$) and Radiation use efficiency (RUE, gMJ^{-1}) of the wheat genotypes

Pusa Sugandha 4 (PS 4) and Saket 4 with two levels of Nitrogen (60 Kg ha^{-1} and 150 Kg ha^{-1}) were transplanted on three different dates viz, D_1 (3^{rd} week of June), D_2 (1^{st} week of July) and D_3 (3^{rd} week of July) in four replications during *Kharif* 2011.

Effects of sowing date and nitrogen levels on phenology of wheat

Significant variations in phenological events *viz*, panicle initiations (PI), anthesis (AN), heading (HE) and physiological maturity (PM) were observed among the treatments both in main plots and sub plots (Fig. 9.1.29). Wheat cv. PBW 226 required significantly lower days to attain the Pi irrespective of date of sowing then cv. PBW 343. Panicle initiation was significantly early in PBW 226 fertilized with 60 Kg N ha^{-1} and sown on D_3 (32.0 DAS). Days taken to heading were 64.3 to 48.3 DAS across the treatments. Significantly lower days was taken by PBW 226 fertilized with 60 Kg N ha^{-1} and transplanted on D_3. Anthesis required significantly higher (106 d) DAS in PBW 343 fertilized with 150 Kg N ha^{-1} and sown on D_1 over other treatments where as PBW 226 fertilized with 60 Kg N ha^{-1} and sown on D_3 needed lower (85 d) days. Similar trend was observed for attaining the physiological maturity and PBW 343 matured earlier than PBW 343 irrespective of date of transplanting. In general, D_3 required lower days to reach a particular growth stage followed by D_2 and D_1. However, higher dose of nitrogen (150 Kg N ha^{-1}) delayed the maturity of both wheat cultivars in all three dates of transplanting.

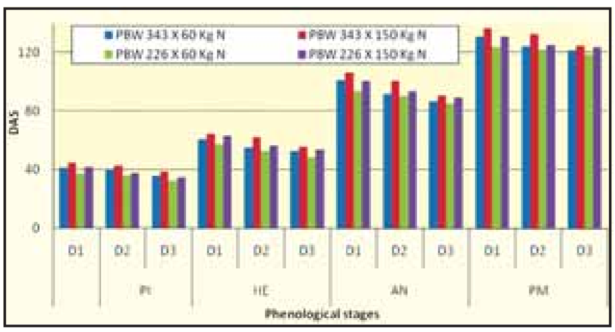


Fig. 9.1.29. Effects of sowing date and nitrogen levels on phenological stages in PBW 343 and PBW 226 wheat genotypes

Effects of sowing date and nitrogen levels on Leaf Area Index of wheat

Linear increase in Leaf Area Index (LAI) was observed in both wheat genotypes up to anthesis (Fig. 9.1.30) and declined thereafter in all the treatments. LAI was higher in PBW 343 than PBW 226 genotypes irrespective of date of transplanting and nitrogen level. Significantly lower LAI was recorded in D_3 than D_2 and D_1 at all growth stages of both genotypes. However, higher dose of nitrogen increased the LAI in both wheat genotypes.

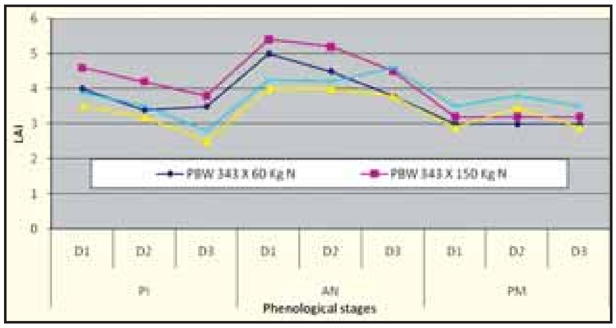


Fig. 9.1.30. Effects of sowing date and nitrogen levels on Leaf area index (LAI) in PBW 343 and PBW 226 wheat genotypes

Effects of sowing date and nitrogen levels on grain yield, heat use efficiency and radiation use efficiency of wheat

Grain yield was higher in D_1 sowing fertilized with 150 Kg N ha^{-1} in both wheat genotypes across the treatments. Higher grain yield (6.0 t ha^{-1}) was recorded in PBW 343 fertilized with 150 Kg N ha^{-1} and sown on D_1 whereas lower grain yield (2.4 t ha^{-1}) was observed in PBW 343 fertilized with 60 Kg N ha^{-1} and sown on D_3 among all the treatments. Heat use efficiency (HUE, Kg/ ^{o}Cd) was reported relatively higher in PBW 343 than PBW 226 irrespective of treatments.

Effects of date of transplanting and nitrogen levels on phenology of rice

Significant variations in phenological events *viz*, panicle initiations (Pi), anthesis (An) and physiological maturity (Pm) were observed among the treatments both in main plots and sub plots. Panicle initiation

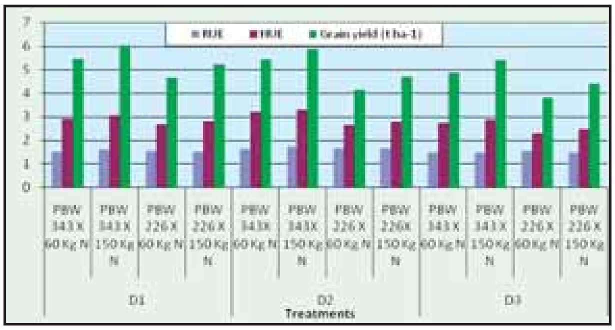


Fig. 9.1.31. Effects of date of transplanting and nitrogen levels on grain yield (t ha^{-1}), heat use efficiency (HUE, Kg/^{o}Cd), and radiation use efficiency (RUE, g/Mjm^{-2}) in PBW 343 and PBW 226 wheat genotypes

was significantly early in Saket 4 fertilized with 60 kg N ha^{-1} and transplanted on D_3 (34.0 d) followed by D_2 (36.0 d) and D_1 (38.0 d). Similar trend was reported in PS 4. Anthesis required significantly higher days after transplanting in PS 4 fertilized with 150 Kg N ha^{-1} and transplanted on D_1 (69 d) over other treatments where as Saket 4 fertilized with 60 Kg N ha^{-1} and transplanted on D_3 needed lower (51.5 d) days. Similar trend was observed for attaining the physiological maturity and Saket 4 matured earlier than PS 4 irrespective of date of transplanting. In general, D_3 required lower days to reach a particular growth stage followed by D_2 and D_1. However, higher dose of nitrogen (150 Kg N ha^{-1}) delayed the maturity of both rice cultivars in all three dates of transplanting (Fig.9.1.32).

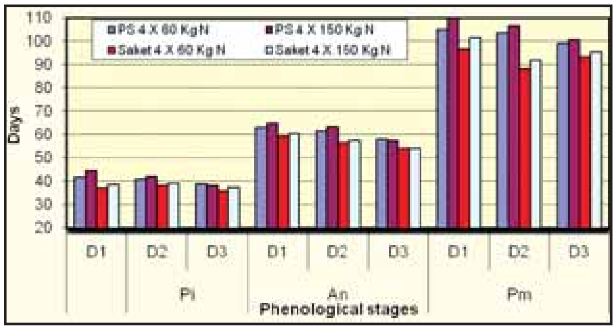


Fig. 9.1.32. Effects of date of transplanting and nitrogen levels on phenological stages in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

Effects of date of transplanting and nitrogen levels on Leaf Area Index of rice

Linear increase in Leaf Area Index (LAI) was observed in both rice genotypes up to anthesis and declined thereafter in all the treatments. LAI was higher in Saket 4 than PS 4 genotypes irrespective of date of transplanting. Significantly lower LAI was recorded in D_3 than D_2 and D_1 at all growth stages of both genotypes. However, higher dose of nitrogen increased the LAI in both rice genotypes (Fig.9.1.33).

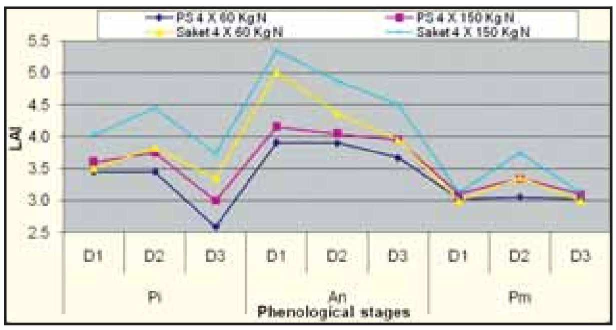


Fig. 9.1.33. Effects of date of transplanting and nitrogen levels on Leaf area index (LAI) in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

Effects of date of transplanting and nitrogen levels on grain yield and heat use efficiency of rice

Grain yield was higher in D_2 transplanting fertilized with 150 Kg N ha^{-1} in both rice genotypes over other treatments (Fig.9.1.34). Higher grain yield (6.3 t ha^{-1}) was recorded in Saket 4 fertilized with 150 Kg N ha^{-1} and transplanted on D_2 whereas lower grain yield (3.7 t ha^{-1}) was observed in PS 4 fertilized with 60 Kg N ha^{-1} and transplanted on D_1 among all the treatments. Heat use efficiency (HUE, Kg/ ºCd) was reported relatively higher in Saket 4 than PS 4 irrespective of treatments. Mean HUE of all four treatments transplanted on D_2 (3.06 Kg/ ºCd) was higher than D_1 (2.47 Kg/ ºCd) and D_2 (2.48 Kg/ ºCd). Higher dose of Nitrogen increased the HUE in general (Fig.9.1.34).

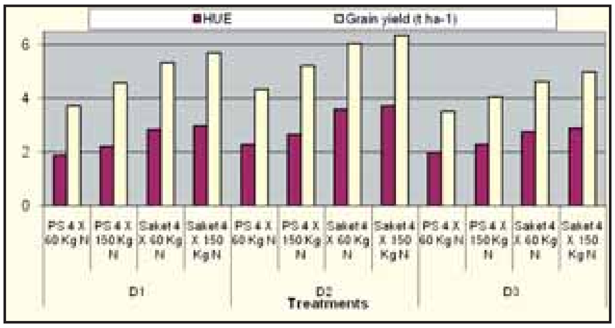


Fig. 9.1.34. Effects of date of transplanting and nitrogen levels on grain yield (t ha^{-1}), heat use efficiency (HUE, Kg/ ºCd), and radiation use efficiency (RUE, g/Mjm^{-2}) in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

Besides study of different agronomic managements on productivity of rice-wheat cropping system for different genotypes of rice and wheat, different soil parameters were also studied after each rice-wheat cycle. The post harvest soil samples (0-45 cm at every 15 cm interval) were taken after the completion of rice-wheat cycle, i.e., after wheat harvest in 2011. Soil pH varied from 7.7 to 7.92 with different treatments and depths. The bulk density (BD) of the surface soil was 1.45 Mg m^{-3} at the commencement of the experiment. It increased with the increased soil profile depth measuring 1.53 Mg m^{-3} to 1.56 Mg m^{-3} for different treatments (Fig.9.1.35). The BD values were greater at 30-45cm than the initial values, indicating tendency towards sub-surface compaction.

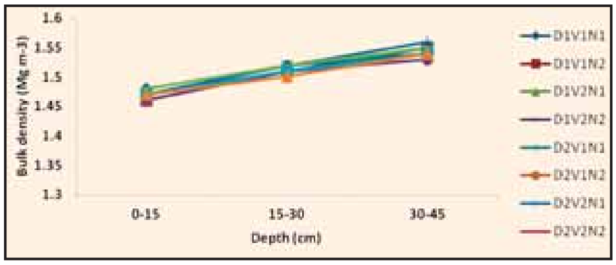


Fig. 9.1.35. Profile-wise soil bulk density variations among the different treatments

Soil organic carbon (OC) measured up to 0-45 cm depth revealed that plots treated with 150 kg N ha^{-1} in rice and wheat have greater OC as compared to lower dose of N treatment. Initial OC content was 4.7 g kg^{-1} and it increased to 4.8 g kg^{-1} due to application of higher doses of nitrogen (Fig.9.1.36). Increasing levels of nitrogen application has helped in increasing the organic carbon content, which is due to increased contribution from the biomass, as it is also observed that with increasing levels of fertilizer application, the crop yields had increased.

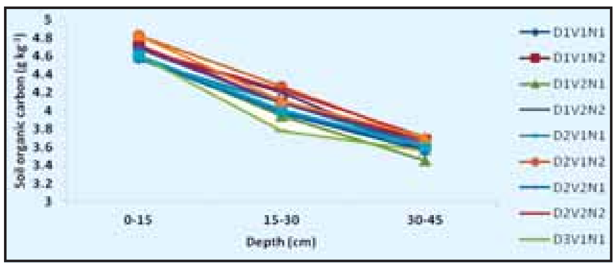


Fig. 9.1.36. Profile-wise soil organic carbon variations among the different treatments

The organic carbon showed a decreasing trend with depth and different treatments, and at 30-45 cm depth, the values were approximately 30% lower to those in 0-15 cm layer.

Data on the distribution of available P in the soil profile revealed a decrease in soil P with increasing soil depth, irrespective of the treatments. The available P across the different treatments at 0-15 cm depth varied from 29.5 to 30.7 kg ha^{-1} and with increasing depth the values varied from 15.9 to 17.7 Kg ha^{-1} (Fig.9.1.37). Similarly, available K varied from 142 to 150 kg ha^{-1} at 0-15 cm depth and showed a decreasing trend with depth (Fig.9.1.38).

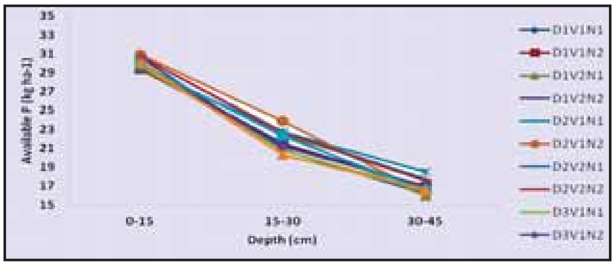


Fig.9.1.37. Profile-wise soil available phosphorus variations among the different treatments

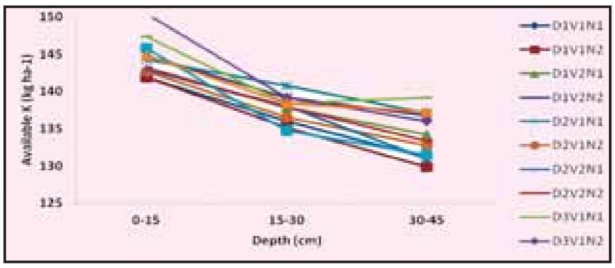


Fig.9.1.38. Profile-wise soil available potassium variations among the different treatments

***D1- 3rd week of June; D2- 1st week of July; D3- 3rd week of July V1-Pusa sugandh-4; V2- Saket4; N1- 60 kg ha^{-1}; N2-150 Kg ha^{-1}

Carbon Sequestration Potential of Rice-Wheat Cropping System under Different Soil Management Options

In high productivity zones of Indo-Gangetic plains, it has been observed that rice-wheat system is showing symptoms of fatigue, witnessed by stagnating or declining yields. One of the major reasons for such stagnation in yield is the decline in soil organic matter quantity and quality. Maintenance of soil organic carbon (SOC) has been recognized as a strategy to reduce soil degradation in agricultural systems. Long term studies have shown that practices like improved fertilizer management, manuring and compost application, residue incorporation, crop rotation, green manuring, reduced tillage, irrigation methods and restoration of waste land enhanced soil carbon build up and storage. The present study is undertaken to assess the long term impacts of nutrient management practices and tillage practice on SOC and SOC fractions, and on soil aggregation, proportion of water stable aggregates. In addition to this, farmer's perception about SOC status and management was also studied.

Distinct difference of microbial biomass carbon (MBC) content was observed among different treatments and at different depths in a long term rice-wheat system. Continuous application of FYM along with NPK (NPK+FYM) resulted in significantly higher soil MBC over NPK at all four locations. Across the locations highest MBC contents in surface soil was recorded in Kalyani and lowest in Ludhiana. The particulate organic carbon (POC) content of the soil in all the treatments at Kalyani was significantly higher (625 to 1243.4 µg g^{-1} in 0-15 cm) over the soils under the same treatment at all other locations. Significantly higher mineralizable carbon (Cmin) content was recorded in a continuous NPK applied plots over control at all soil depths in all four locations. At Ludhiana and Sabour, partial substitution of N through crop residues and green manure resulted at par Cmin content. Kalyani recorded the highest Cmin content in different integrated nutrient management system and (NPK+FYM) recorded the highest (1127.5 µg g^{-1}) in 0-15 cm layer (Table 9 .1.16).

Table 9.1.16. Different soil organic carbon fractions in different integrated integrated nutrient management system under different agroclimatic situation in Indo-Gangetic plains in 0-15 cm depth

	Microbial biomass carbon (μg g^{-1})				Particulate organic carbon (μg g^{-1})				Mineralizable carbon(μg g^{-1})			
	Ludhiana	Kanpur	Sabour	Kalyani	Ludhiana	Kanpur	Sabour	Kalyani	Ludhiana	Kanpur	Sabour	Kalyani
Control	101^{d}	128^{c}	119^{d}	288^{c}	335^{d}	400^{d}	379^{d}	625^{e}	274^{d}	344^{d}	344^{d}	559^{d}
NPK	174^{c}	216^{b}	200^{c}	426^{b}	655^{c}	698^{c}	707^{c}	1046^{d}	538^{c}	578^{c}	585^{c}	896^{c}
NPK+ FYM	265^{a}	308^{a}	298^{a}	515^{a}	1025^{a}	939^{a}	1117^{a}	1434^{a}	767^{a}	718^{a}	853^{a}	1127^{a}
NPK+ PS/ WS	233^{b}	309^{a}	285^{ab}	486 a	889^{b}	916^{a}	1063^{ab}	1334^{b}	650^{b}	721^{a}	809^{ab}	1066^{a}
NPK+ GM	218^{b}	298^{a}	275^{b}	455^{b}	838^{b}	854^{b}	1039^{b}	1243^{c}	608^{b}	665^{b}	775^{b}	982^{b}

Values in the same column followed by different lower case letters (a-d) are significantly different at p=0.05 according to Duncan's Multiple Range Test for separation of means

In general, bulk density increased from the surface to the subsurface layers irrespective of locations and treatments. Among the treatments application of organics has resulted in significantly lower bulk density as compared to control, at 0-15, and 15-30 cm soil depth in Sabour, while all other locations recorded at par soil density at all soil depths. With respect to locations, the control treatment in Sabour recorded significantly higher bulk density (1.56 Mg m^{-3}), than in Ludhiana (1.44 Mg m^{-3}) and Kalyani (1.42 Mg m^{-3}), while in Kanpur it was at par (1.47 Mg m^{-3}). Incorporation of FYM with mineral fertilizers increased the percentages of large sized aggregates and the percentage of macro aggregates increased and micro aggregates reduced with FYM addition along with NPK in a long term rice wheat system.

For the assessment of Farmers' perception about SOC status and its management, data were collected with the help of pre-structured interview schedule from the farmers of 3 districts *viz*. Varanasi, Mirzapur and Chandauli of Uttar Pradesh.

From each district 1 block was selected randomly and from each block 3 villages were selected randomly. A total of 36 farmers from 9 villages were contacted for data collection. It was found that the average land holding per farmer was 3 ha. out of which 2 hectares were irrigated and 1 hectare was rainfed. Rice-Wheat was the major cropping system adopted by 86 percent of the farmers followed by Maize-Wheat (16 percent) and Bajra-Wheat (14 percent) in the study area. The major intercropping system was Wheat+Mustard, whereas, Gram+Mustard/Linseed was the mixed cropping system found in the study area. The results revealed that incorporation was the prevalent practice for SOC management by the farmers. About 78 percent of the sample farmers practiced FYM incorporation, 19 percent practiced green manure incorporation, whereas 11 percent practiced the incorporation of vermicompost (Table 9.1.17).

The farmers used to incorporate FYM @ 10 t ha^{-1}, and paddy and wheat stubbles @ 2 t ha^{-1} annually into the soil. Burning of crop residues was not reported by any of the sample farmers. As regards farmers' perception, majority (63 percent) of the sample farmers reported (Table 9.1.18) that the organic matter incorporation into the soil had increased over the last 10 years with the result of

Table 9.1.17 . Soil organic carbon management pattern of farmers

Sl. No	Type of Organic sources	Method of management(% Respondents)		
		Incorporation	Burning	Removal
1.	Rice straw	37.8	0.0	0.0
2.	Wheat straw	35.1	0.0	0.0
3.	FYM	78.4	0.0	0.0
4.	Green Manure	18.9	0.0	0.0
5.	Vermicompost	10.8	0.0	0.0


Photo. 9.1.1: Scientists- farmers interactions during survey

Table 9.1.18. Farmers' perception on SOC status and its effects over last 10 years

Attributes	Response categories (%)		
	Increased/Improved	Remained same	Decreased/Degraded
Quantity of organic materials added	62.5	21.9	15.6
Water holding capacity	65.6	21.9	12.5
Productivity	75.0	15.6	9.4
Environmental effects	6.3	78.1	15.6

improving the soil fertility, soil water holding capacity, and overall productivity. Therefore, study indicates that the SOC, POC, MBC status and soil aggregation and water stable aggregates in the soils of Indo Gangetic Plains under rice-wheat was improved by application of inorganic fertilizer along with organics.

Data Base unit

Digitization of database of on-station and on-farm experiments of cropping systems under AICRP on IFS

Creation of database of experiments conducted under on- farm and on-station Experiments

Under the On Farm Research experiments entitled, "Sustainable Production System", "Response of Nutrients" and "Diversification and Intensification of cropping systems" conducted at ECF centres of AICRP-IFS during 2009-10, the data was structures and digitized in respect of treatment wise yield for ECF different centers.

Also digitized database ecosystem wise, season wise for on station experiments conducted during 2009-10 at different centers. The data was formatted by plot size, unit grain yield, interaction of replications and treatments pertaining to experiments entitled," Identification of need based cropping systems for different agro-ecosystems", "Permanent plot experiment on integrated nutrient supply system in cereal based crop sequences", "Long range effect of continuous cropping and manuring on soil fertility and yield stability", "Resource conservation technologies" and "Organic farming".

Long term trend analysis by fitting appropriate linear / non-linear asymptotic curves/model

Linear/non-linear and asymptotic trend equations/ models were attempted for rice –rice cropping system data of 2(a) permanent plot experiment on INS system in cereal based crop sequence conducted at different centers of AICRP-IFS since inception. The Polynomials of linear and higher degree, Gaussian model, Simusoidal, Hoerl model, Logistic model, Exponential model, Power fit model, MMF model, Richards's model, Weibull and Harris models were attempted. The best fit model which gave maximum R^2 value were found to be the best fitted model to exhibit trend and estimated yield .

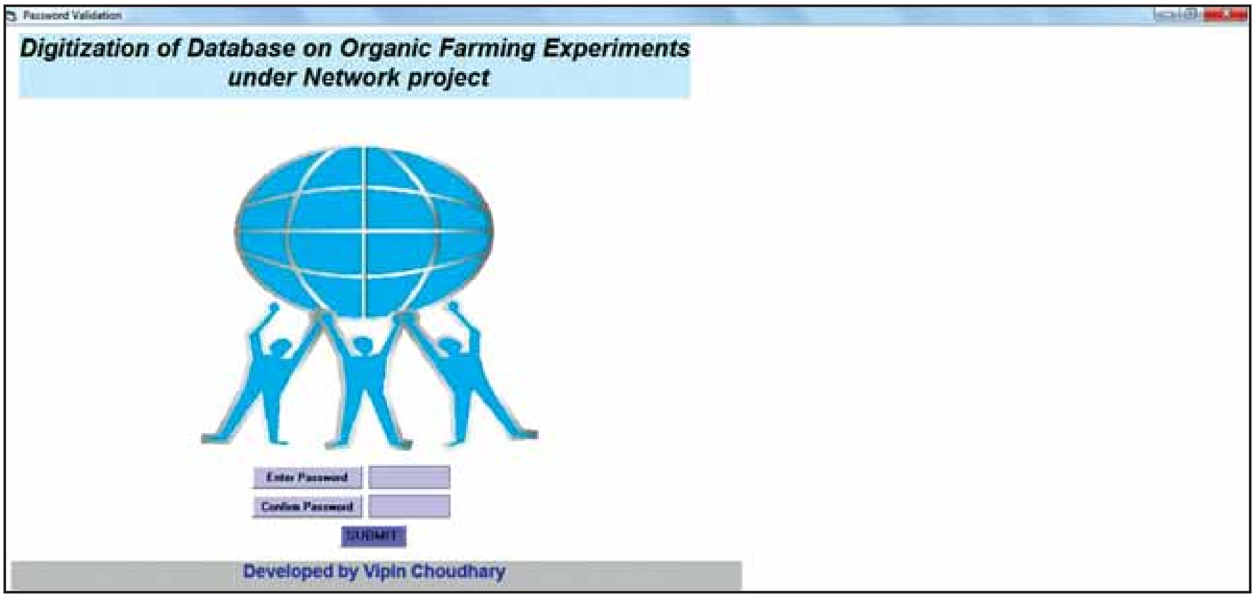
Database on Organic Farming Experiments under Network project is being developed in GUI mode (Graphical user interface) initially Visual basic programming language is using as front end while SQL server /MS Access as back end. The Relational Database approach is used to design the database. The fundamentals of Normalization theory have been used to normalize the different tables of the database.

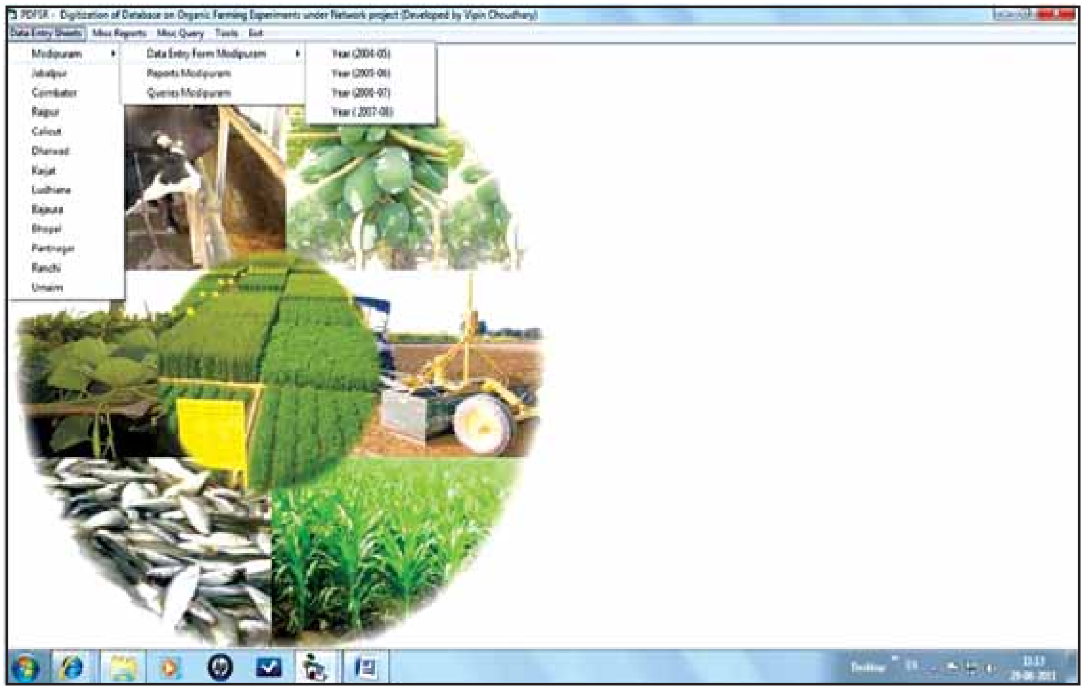
Thirteen master tables on the following network centers are designed to provide the relationship among them.

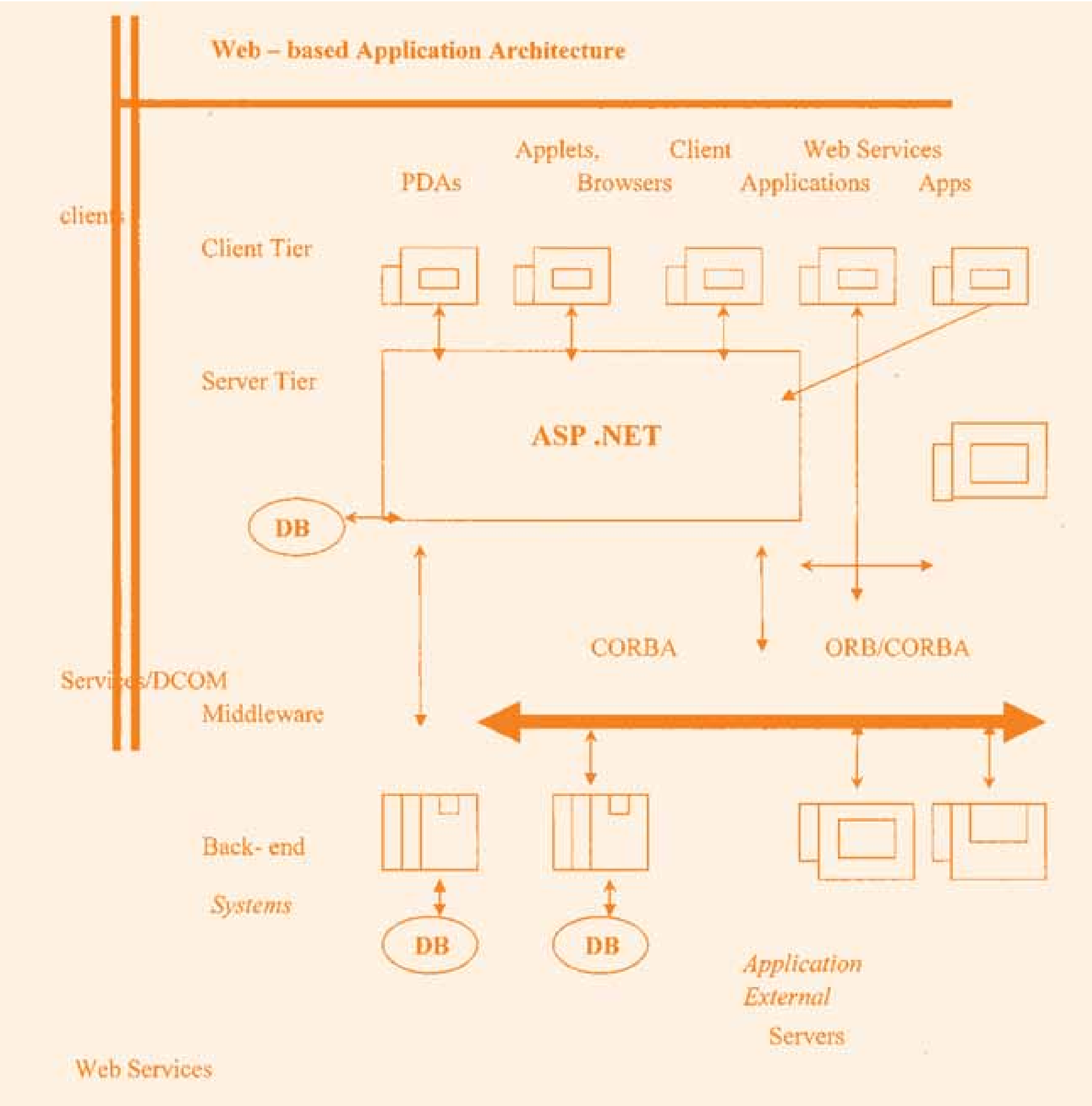
Network Centers :- Bajuara (HP), Pantnagra (Uttarakhand), Ludhiana (Punjab), Modipuram (UP), Bhopal (MP), Jabalpur (MP), Raipur (Chhatisgarh), Ranchi (Jharkhand), Coimbtore(TN), Calicut (Kerala), Karjat (Maharashtra), Dharwad (Karnatka), Umiam (Meghalya).

Architecture

- At present system is standalone but in future the system will be a web-based application
- It is based on client-server three tier distributed structure technology
- Can be accessed from any node on the Internet through a web-browser


Password Validation
Digitization of Database on Organic Farming Experiments under Network project
Enter Password
Confirm Password
SUBMIT
Developed by Vipin Choudhary


PDFSR - Digitization of Database on Organic Farming Experiments under Network project (Developed by Vipin Choudhary)
Data Entry Sheets
Misc Reports
Misc Query
Tools
Exit
Modipuram
Jabalpur
Coimbatore
Raipur
Calicut
Dharwad
Karjat
Ludhiana
Bajaura
Bhopal
Pantnagar
Ranchi
Umaim
Data Entry Form Modipuram
Reports Modipuram
Queries Modipuram
Year (2004-05)
Year (2005-06)
Year (2006-07)
Year (2007-08)


Web – based Application Architecture
Applets,
Client
Web Services
PDAs
Browsers
Applications
Apps
Client Tier
Server Tier
ASP .NET
DB
CORBA
ORB/CORBA
Middleware
Back- end
Systems
DB
DB
Application
External
Servers
Web Services

Effect of crop establishment technique and residue management options on response to K application under rice-maize system

A field experiment under rice-maize system was conducted on a Typic Ustochrept soil at the research farm of Project Directorate for Farming System Research, Modipuram, Meerut (29-^{0}4' N, 77^{0}46' E and 237 m asl), India. Twelve treatments comprising 06 in main plot i.e., transplanted puddle rice followed by conventional till maize ((TPR-CTM), direct seeded rice followed by conventional till maize ((DSR-CTM), no-till and direct seeded rice followed by no-till maize (ZTDSR-ZTM) along with residue retained on surface (+R) or removed from field (-R) and in sub-plot 02 treatments with (75 kg K_2O ha^{-1}) and without K (no-K) were compared in split-plot design with four replications. Meerut district located in western Uttar Pradesh represents irrigated, mechanized and input-intensive area of Upper Gangetic Plain zone (UGP) of the IGP region (IGPR) of India. The soil of the experimental field was sandy loam (15.9% clay, 18.1% silt, 66.0% sand) of Gangetic alluvial origin, very deep (>2 m), well-drained, flat (about 1% slope) and classified as Typic Ustochrept. At onset of experiment surface soil (0-20 cm soil depth) was mildly alkaline (pH 8.1), low in OC (<0.5%) and available N (131 mg kg^{-1}), and medium in Olsen-P (9.5 mg kg^{-1}) and exchangeable K (113 mg kg^{-1}) content.

Study reveals that rice as well as maize productivity varied in accordance with different crop establishment practices, residue management options and K use (Table 9.1.19). Averaged across the years, highest K response in rice was noticed with TPR-CTM (610 kg ha^{-1}) followed by DSR-ZTM (445 kg ha^{-1}) and ZTDSR-ZTM (330 kg ha^{-1}) treatments. Such response under succeeding maize crop was of 735, 410 and 340 kg ha^{-1}, respectively. Further, K responses were comparatively higher under residue removed plots (620 to 632 kg ha^{-1}) than its retention on surface (287 to 307 kg ha^{-1}) in both the crops. Growing DSR (rice) also has pronounced effect on K response of succeeding CTM (maize) crop and compared with TPR-CTM yield gain in maize due to K application was lower by 43.6% and 44.6% in residue removed (-R) and residue retained (+R) plots, respectively as. The least K responses under

Table 9.1.19: Response to K application (kg ha^{-1}) in rice and maize crop with different crop establishment practices and residue management options under rice-maize system at Modipuram

Crop establishment technique	Residue removed (-R)	Residue retained* (+R)	Mean K response
	Rice		
TPR-CTM	830	390	610
DSR-CTM	630	260	445
ZTDSR-ZTM	450	210	330
Mean K response	637	287	462
	Maize		
TPR-CTM	920	550	735
DSR-CTM	510	310	410
ZTDSR-ZTM	430	250	340
Mean K response	620	370	495

*Maize residue was incorporated before rice transplanting

TPR= Transplanted puddle rice, DSR=- Direct seeded rice, ZT DSR= No-till and direct seeded rice, CTM= Conventional till maize, ZTM= no- till maize

ZTDSR-ZTM plots along with +R in both rice (210 kg ha^{-1}) as well in maize crop (259 kg ha^{-1}) indicating the significant K contribution through residue which was further attributed due to undisturbed soil physico-chemical environment under no-till system.

Precision nutrient management using GIS-based spatial variability mapping under Upper and Middle Gangetic Plain Zones of India

Geo-statistical analysis and GIS-based mapping provides opportunity to assess variability in the distribution of native nutrients and other yield limiting/ building soil parameters across a large area and thus aid in developing appropriate nutrient management strategies leading to better yield and environmental protection. Research evidences reveals direct correlation between variability and production conditions and have achieved improvement in production and profit under different scales of operation by managing variability. However, studies on site-specific nutrient management in integration with spatial nutrient variability using GIS are still rare. In this context, a study was initiated to assess the spatial variability of physico-chemical properties and native nutrient pools in agricultural soils across selected soil types and cropping systems of the Upper and Middle Gangetic Plain (UGP and MGP) zones using GIS- based mapping.

Since the study domain was very wide, to minimize the number of samples and economize associated cost, cropping system based geo-referenced sampling was done instead of fixed grid. In this strategy, judicious stratification of sample in UGP and MGP and further in NAARP zone, and District level using "Proportionate Area Method" was done. Further, for distribution of samples among different cropping systems in a District, Area Spread Index (ASI) approach was used. During 2011-12, bio-physical characterization of existing cropping system and geo-referenced soil sampling was made in Western Plain Zone (NAARP zone) of UGP transact of the Indo-Gangetic Plain (IGP).

Farmer's participatory survey conducted in Western Plain zone (WPZ) indicates that sugarcane-ratoon-wheat is the most predominant cropping system which occupies nearly 60% acreage of the total cultivated area of the zone followed by rice-wheat system (23%). Since dairy is one of the pre-dominant enterprise in this region, sorghum/pearl millet (fodder) based system were also found to some extent. Fertilizer use in this zone is quite imbalanced especially with respect to K and S application and skewed towards N application. Of the total N, P and K use, nitrogen alone shares 68-71%, and the share of P was 27-30.4%. Contribution of K in total fertilizer use was restricted in the range of 2.0 to 3.2% leading to wide N: P: K ratio and indicating the fertilizer management practices of the region non sustainable.

In general, large farmers (>4ha) adopt combine harvesting and burn rice residue in situ, whereas, medium and small farmer remove it for animal feed or domestic consumption. In sugarcane, whole dry leaves remain in the field after harvest of plant crop, while burning of residue or its removal after ratoon harvest before field preparation of succeeding of wheat crop is often practiced. Use of FYM was mainly with small farmers (<2ha), which they apply at 20-30 t ha^{-1} at 1-2 year interval, whereas medium and large farmers use it rarely. Different sources of irrigation water indicate that rice crop receives maximum K input through irrigation (on an average 61 kg K ha^{-1}), followed by sugarcane (on an average 48 kg K ha^{-1}).

Different soil fertility parameters analyzed after harvest of crops grown in the zone indicate that it varied with cropping system followed, nutrient used and agronomic management practices adopted. An enumeration of Fig. 1 indicates that soils of Western

Plain Zone fall under low to medium category of organic carbon content. Averaged across the cropping system and locations, 96%, 21%, 13% and 22% soil were low and 4%, 72%, 76%, and 57% soil under medium category for N (<280 ka ha^{-1}) , P (<10 ka ha^{-1}) , K (<130 ka ha^{-1}) (Fig. 9.1.39) and S (<10 mg kg^{-1}) content wherein responses to fertilizer application can be expected (Fig. 9.1.40). Analysis of micro-nutrients viz., zinc, iron, manganese and copper in different cropping systems indicated varying degree of deficiency for these nutrients. Averaged over the location and cropping system, magnitude of deficiency for Zn (d”0.6 ppm), Fe (d”4.5 ppm), Mn (d”2.0 ppm) and Cu (d”0.2 ppm) was 36%, 17%, 10 and 7%, respectively (Fig.9.1.41). Surface maps of all these soil fertility parameters were prepared using

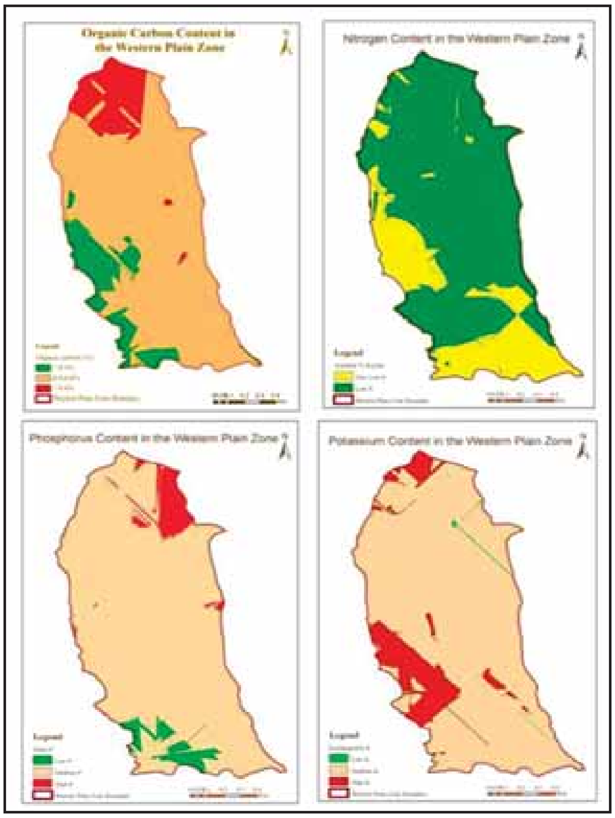


Fig. 9.1.39: Predicted surface map for Organic carbon content, available N, Olsen-P and exchangeable K content using Ordinary Exponential Kriging in Western Plain Zone

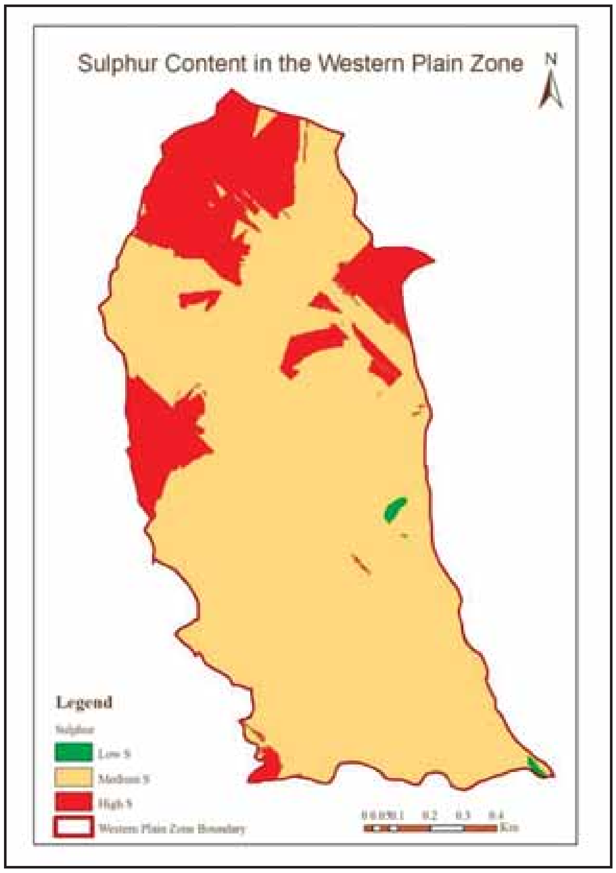


Fig. 9.1.40: Predicted surface map for available S content in Western Plain Zone

semivariogram through Ordinary Kriging. Best-fit model i.e. Exponential Ordinary Kriging with lowest value of residual sum of squares was selected for each soil property and classified map was prepared using geostatistical analysis tool of Arc GIS 10.1. In the view of site- specific nutrient management under pre-dominant cropping systems of Western Plain Zone, fertility zonation map was developed using classified maps of N, P and K.

Over all analysis of the data revealed wide variations in fertilizer use in different cropping system in the surveyed districts. The fertilizer use was in general skewed in favour of N, whereas nutrients like K, S and micronutrients were generally neglected. Soil samples were analysed for macro- and micronutrients, revealed marked variability across the districts and cropping systems. Such variability in soil fertility status was also mapped using Ordinary Exponential Kriging with the help of ArcGIS 10.1.

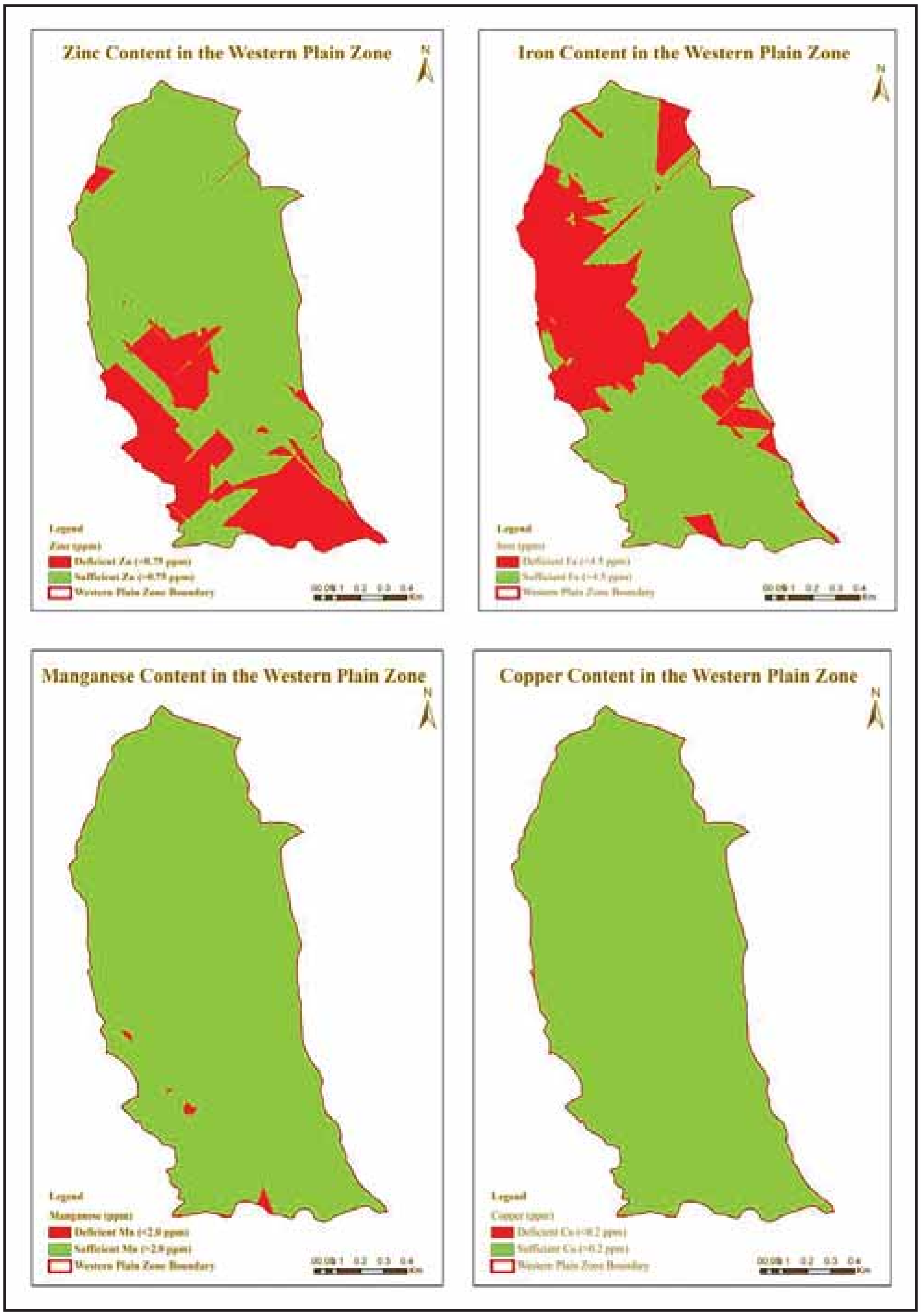


Fig. 9.1.41: Predicted surface map for DTPA-Zn, Fe, Mn and Cu content in soil in the Western Plain Zone

9.2 ORGANIC AGRICULTURE SYSTEMS (OAS)

Studies on improvement of soil organic carbon in rice-wheat system under resource conservation technologies

An experiment on "Studies on improvement of soil organic carbon in rice-wheat system under resource conservation technologies" was initiated during *kharif 2008* season, in which the main plot treatments were direct seeded rice (DSR), SRI method of rice cultivation (SRI) and conventional rice cultivation. In these main plot treatments, four sub-plot treatments like zero tilled wheat (ZT), bed planting of wheat (FIRB), conventional tilled wheat (CWS), and happy seeder planted wheat (HS) were grown during *rabi* season.

In this experiment the agronomic package for SRI method of cultivation involved soil amendment @ 10 t of FYM per ha during final land preparation, transplanting of rice with 10 days old seedling @ 1 seedling per hill and square planting (30 x 30 cms.), applying irrigation at hair crack stage and three inter culture with cano weeder at 15 days, 30 days and 45 days after transplanting of rice to give proper aeration of soil.

Under direct seeded and conventional method of rice cultivation, the recommended packages of fertilizers (N_{120} P_{60} K_{40}) for the both the crops were adopted. No organic manure was applied in direct-seeded rice. Conventional package of rice cultivation involved four passes with tiller followed by planking for impounding water, which is required for transplanted rice. Twenty one day old seedling was transplanted at 20 x 15 cm spacing.

Highest grain and straw yield of 5.8 and 7.2 t ha^{-1} of wheat during *rabi*, 2010-11 was recorded under main plot which was designated for SRI method of rice cultivation compared to 4.6 and 6.2 t ha^{-1} respectively under conventional method of wheat cultivation. But the grain yield increase compared to conventional method of wheat cultivation was to the tune of 26.4%. On the contrary, the highest grain and straw yield among sub-plots were 6.7 and 7.3 t ha^{-1} under FIRB systems which were 35.3 and 16.9% higher than the conventional method of sowing wheat and the effect was significant. The yield attributing characters of wheat followed the same trend as with yield under both main and sub-plot treatments (Table 9.2.1).

Table 9.2.1. Yield and yield attributing characters of wheat under RCT

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	1000 grain wt.(g)	Biomass (t ha^{-1})	Effective tillers/m^2	Panicle length (cm)	Grains/ panicle	Plant height (cm)
DSR	4.50	6.3	21.54	10.8	290	20.82	142.1	105.21
SRI	7.00	10.5	24.62	17.5	385	22.91	170.3	118.23
Conventional	6.25	9.06	23.42	15.31	370.25	22.21	152.2	111.4
Control	3.25	4.23	15.91	7.48	150.61	15.5	108.3	90.2
CD(5%)	0.52	1.23	2.35	1.9	24.8	0.63	15.4	6.4

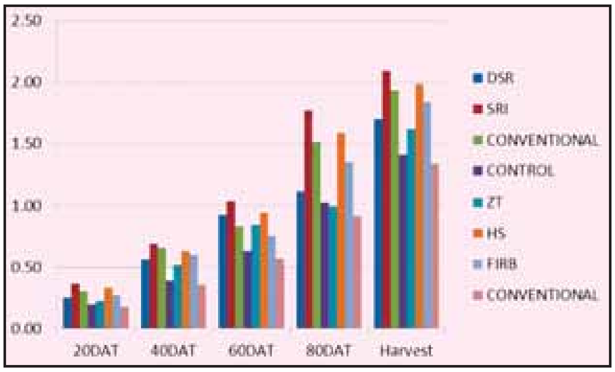


Fig. 9.2.1. Root biomass of wheat under RCT at various growth stages

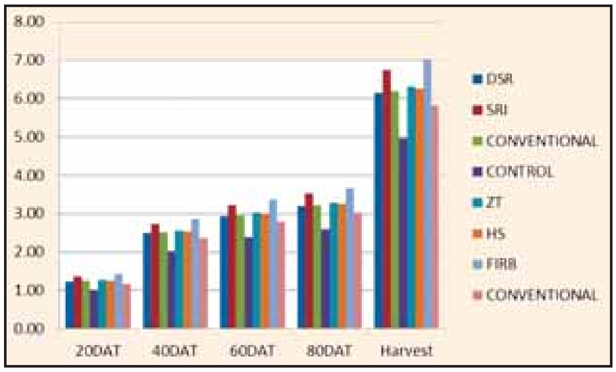


Fig. 9.2.2. Shoot biomass of wheat under RCT at various growth stages

The root and shoot biomass accumulation of wheat at periodic intervals showed increase up to physiological maturity stage. The highest shoot and root biomass were recorded under main plot meant for SRI treatment. Among sub-plot treatments, shoot biomass was maximum under FIRB, but the root biomass was higher under FIRB (Fig.9.2.1&2). Soil properties after harvest of wheat were determined in terms of organic carbon (O.C), carbon (C)., available N, P, K and MBC. Organic carbon and MBC were maximum (6.1 g.kg^{-1} soil and 192.20 μg g^{-1}) under SRI among main plot and 5.9 g kg^{-1} and 172.4 μg g^{-1} soil under happy seeder seeded wheat. Among main plots available N was highest (305 kg ha^{-1}) under SRI also available K (492.0 kg ha^{-1}). But available P was highest (43.1 kg ha^{-1}) under DSR. Among sub-plots, organic carbon was highest (6.2 g kg^{-1} soil) and MBC (180.3 μg g^{-1} soil) under happy seeder. Available N and K were highest (251.0 and 472.0 kg ha^{-1}) under FIRB (Table 9.2.2).

Table 9.2.2: Changes in soil properties under resource conservation techniques after harvest of wheat 2010-11

Treatment	O.C g.kg^{-1} soil	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. (kg ha^{-1})	MBC μg g^{-1} soil
DSR	5.5	197.00	43.10	337.00	157.00
SRI	6.1	305.00	36.21	492.00	200.10
TPR	5.3	242.00	32.5 0	475.00	175.30
CONTROL	4.9	172.00	23.12	257.00	96.30
CD (P = 0.05)	NS	11.20	4.10	25.20	6.90
Sub Plots					
ZT	5.9	245.00	37.41	367.00	172.40
HS	6.2	255.00	39.56	481.00	180.30
FIRB	5.7	251.00	34.87	472.00	175.50
CWS	5.4	230.00	40.23	246.00	167.10
CD (P = 0.05)	NS	19.20	3.82	36.30	7.70

Rice: Highest grain yield of rice (7.0 t ha^{-1}) during *Kharif* 2011 was recorded under SRI method compared to 6.3 t ha^{-1} under conventional method. The percent yield increase under SRI was 12.0%. The straw yield under SRI was 10.5 t ha^{-1}. The yield and yield attributing characters of rice were also highest under SRI method (Table 9.2.3).

Root and shoot biomass accumulation of rice was recorded at periodic interval and the highest biomass accumulation in terms of root and shoot was recorded under SRI irrespective of stages of growth (Fig. 9.2.3&4). Soil properties at physiological maturity stage of rice revealed that organic carbon, available N and K were highest under SRI and available P was highest (44.6) under DSR method of rice cultivation (Table 9.2.4). Microbial population in terms of heterotrophic bacteria, total bacteria, fungi actinomycetes and N fixing bacteria were also highest under SRI at maximum tillering and panicle initiation stages (Tables 9.2.5, 6 & 8). Microbial biomass accumulation showed a periodic increase from transplanting to maximum tillering stage and the maximum quantity of MBC was recorded under SRI compared to other treatments at all growth stages (Table 9.2.7).

Table 9.2.3: Yield and yield attributing characters of rice under RCT

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Plant height (cm)	Ear head length (cm)	1000 grain wt. (g)
DSR	5.1	6.51	105	14.3	35.6
SRI	5.8	7.23	119	15.3	39.9
Conventional	5.35	6.97	99	14.5	36.1
Control	2.63	5.67	82	11.9	28.9
CD (5%)	0.03	0.21	2.1	0.89	1.5
Sub plots					
ZT	5.23	6.45	98	14.4	36.6
HS	5.56	6.69	102	15.3	38.8
FIRB	6.21	7.28	114	15.7	38.2
Conventional	4.59	6.23	100	14.1	35.3
CD (5%)	0.12	0.23	3.5	1.1	0.61

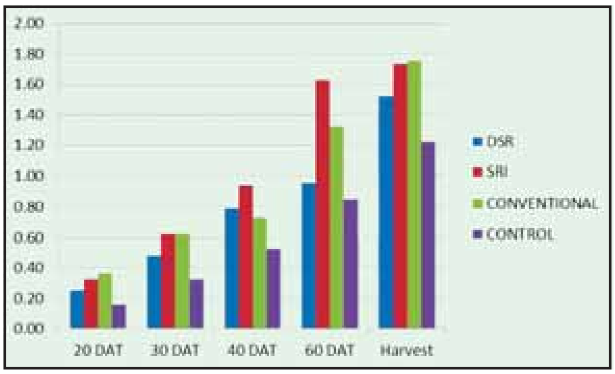


Fig. 9.2.3. Root biomass in rice under resource conservation techniques 2011 at various growth stages

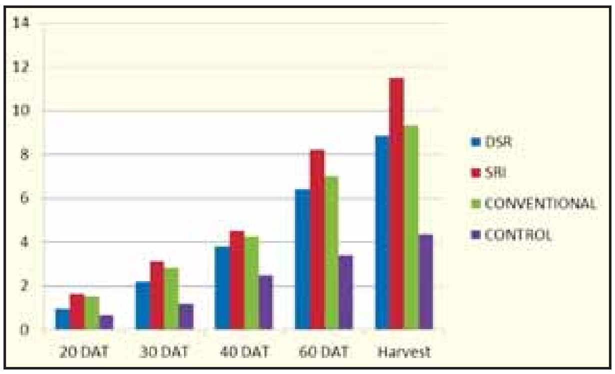


Fig. 9.2.4 Shoot biomass in rice under resource conservation techniques 2011 at various growth stages

Table 9.2.4: Soil properties under various RCT in rice during physiological maturity stage

Treatment	O.C g.kg^{-1} soil	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. (kg ha^{-1})	MBC μg g^{-1} soil
DSR	5.6	189.00	44.62	338.36	157.90
SRI	6.1	303.00	38.37	491.20	192.20
Conventional	5.5	241.10	33.48	478.33	162.20
Control	5.0	175.00	24.32	251.12	91.20
SEM(±)	0.23	8.12	1.23	11.21	6.45

Table 9.2.5: Microbial Population in soil under various RCT in rice during maximum tillering stage

Treatment	Heterotrophic Bacteria	Bacteria	Fungi	Actinomycetes	Nitrogen fixing bacteria		
	$x10^6$	$x10^7$	$x10^4$	$x10^5$	$x10^5$	$x10^4$	$x10^5$
DSR	32.35	106.54	19.50	31.25	132.04	82.30	41.90
SRI	70.01	238.62	26.41	37.60	153.20	100.02	45.21
Conventional	42.50	170.25	19.35	28.30	114.95	85.38	42.06
Control	29.30	89.45	8.2	17.24	58.32	39.40	21.25
SEM (±)	6.4	4.9	2.6	4.7	14.06	6.4	2.50

Table 9.2.6: Microbial Population in soil under various RCT in rice during maximum tillering stage

Treatment	Heterotrophic Bacteria	Bacteria	Fungi	Actinomycetes	Nitrogen fixing bacteria		
	$x10^6$	$x10^7$	$x10^4$	$x10^5$	$x10^5$	$x10^4$	$x10^5$
DSR	35.56	133.52	19.50	30.12	140.21	85.30	42.12
SRI	83.25	308.45	24.50	39.42	168.30	109.5	44.25
Conv	51.20	217.26	18.63	27.56	130.24	90.30	41.95
Control	35.50	114.20	8.12	16.45	63.20	44.15	23.04
SEM (±)	7.92	12.41	2.32	3.57	14.42	8.71	5.62

Table 9.2.7: Changes in MBC under various RCT in rice at various growth stages

Treatment	Transplanting	10 days after transplanting	20days after transplanting	Maximum tillering
DSR	88.12	132.56	160.28	213.60
SRI	95.15	165.50	196.58	258.75
Conventional	63.50	141.29	161.92	186.80
Control	60.24	88.20	132.54	133.50
SEM(±)	6.5	9.8	15.7	22.0

Table 9.2.8: **Estimation of total aerobic Nitrogen fixer from per gram of dry soil at maximum tillering stage**

Treatment	Dilt. 10^{-3}	Dilt. 10^{-4}	Dilt. 10^{-5}
DSR	131.20	82.12	40.25
SRI	152.38	107.75	50.12
CONV	123.41	88.33	41.50
Control	81.26	55.46	29.45
SEM(±)	5.71	8.92	2.4

Photo 9.2.1. Rice under DSR method of rice cultivation

Photo 9.2.2. Rice under TPR method of rice cultivation

Photo 9.2.3. Rice under SRI method of rice cultivation

Development of organic farming package for maize-potato-onion system

The experiment is being conducted since 2003 and has completed 8 crop cycles. Seven treatments *viz.* 50% recommended NPK + Zn + S as per soil test + 50% N as FYM (T_1); 100% organic nutrient sources (FYM), vermicompost and neem oil cake each equivalent to 1/3 of recommended N (T_2); T_2 + intercropping (T_3); T_2 + agronomic practices for weed and pest control without addition of chemical sources of plant protection (T_4); T_2 + bio fertilizers containing N and P carries (T_6) and 100% NPK + Zn + S based on soil test (T_7) were compared at PDFSR research farm.

Highest grain yield of onion during summer 2010 was recorded under T_6 (24.49 t ha^{-1}) which received organic nutrient sources each equivalent to 1/3 N as FYM, vermi compost and neem oil cake plus biofertilizers containing N and P carriers. Percent yield increase under this treatment was 19.72% compared to T_7. The yield increase under other organic nutrient management packages varied from 2.41 to 11.01% (Table 9.2.9).

Table 9.2.9: Crop yield (t ha^{-1}) under various nutrient management packages in maize-potato-onion system

Treatment	Onion	Maize	MEY (t ha^{-1})	% increase/decrease in onion yield over T_7		MEY (t ha^{-1})
	2010-11	2011	2010-11	Onion	Maize	Av. last 3 years
T_1	23.86	5.8	30.20	10.74	20.33	26.47
T_2	23.24	6.02	30.27	11.01	24.89	29.61
T_3	22.5+* 1.25	6.3+2.15	31.83	10.02	30.70	29.97
T_4	22.01	5.85	27.93	2.41	21.35	27.35
T_5	23.11	5.95	29.36	7.67	26.90	28.68
T_6	24.49	6.35	29.49	8.13	31.74	28.73
T_7	20.45	4.82	27.27	-	-	25.44
SEM ±	1.27	0.52	1.53	4.50		1.67

*intercrop for onion and maize were sesbania and cowpea and recorded as green biomass and incorporate *in-situ* after 30 days during interculture operation

Highest maize yield during next *Kharif* was also observed under T_6 at 6.35 t ha^{-1}. It is also interesting to note that organic nutrient management practices helped in improving MEY which varied from 21.35 to 30.74. As per system yield is concerned, the maize equivalent yield during 2010-11 was highest (31.38 t ha^{-1}) under T_3 which received organic sources of nutrients and intercropping of cowpea with maize. The same trend was also recorded in relation to last three years average performance of T_3 with MEY 29.97 t ha^{-1} (Table 9.2.9).

Soil fertility under various organic nutrient management after harvest of onion and maize has been presented in Table 9.2.10. After harvest of onion, highest O.C (6.0 g kg^{-1} soil) was recorded under T_6, available N and MBC under T_3 and that of av. P and K under T_5 which are all organic nutrient

Table 9.2.10: Soil fertility under various nutrient management packages in maize-potato-onion system

Treatment	Onion					Maize				
	O.C.g. kg^{-1} soil	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	MBC µg g^{-1} soil	O.C.g. kg^{-1} soil	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	MBC µg g^{-1} soil
T_1	6.3	268	31.5	260	342.52	6.4	270	31.6	262	346.96
T_2	6.4	248	26.4	217	340.63	6.6	251	26.9	219	348.26
T_3	6.6	282	32.3	205	360.32	6.7	286	32.8	209	368.62
T_4	6.3	265	31.5	215	344.65	6.5	268	31.8	217	349.52
T_5	6.4	227	32.8	241	305.23	6.7	233	33.1	249	312.63
T_6	6.6	255	27.2	232	375.54	6.8	259	28.1	236	382.14
T_7	5.2	217	21.7	178	207.65	5.3	219	21.9	180	211.32
SEM ±	0.25	23.09	4.10	26.45	56.13	0.05	22.97	4.08	27.22	57.13

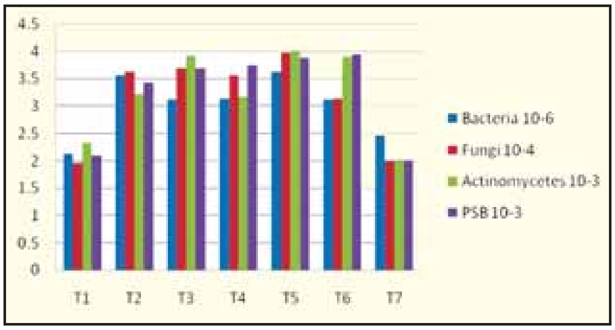


Fig. 9.2.5. Microbial population in MPO system under various Organic nutrient management packages (Onion)

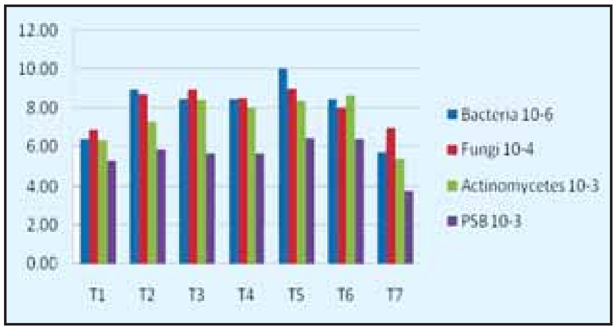


Fig. 9.2.9. Microbial population in MPO system under various organic nutrient management packages (Maize)

Photo 9.2.4. Performance of onion under organic farming

Photo 9.2.5. Performance of onion under chemical fertilizers

Photo 9.2.6. Performance of onion under organic farming

Photo 9.2.7. Potato under organic farming

management packages compared to inorganic or integrated nutrient management packages. The soil fertility status in terms of O.C. av. N, P, K and MBC after harvest of maize was a bit different. Organic carbon was highest 6.88 g kg^{-1} soil under T_6, av. N under T_3 and av. P and K under T_5 and MBC under T_6 compared to inorganic or integrated nutrient management packages.

Microbial population in terms of bacteria, fungi and actinomycetes after harvest of summer season onion and *kharif* maize is presented in Fig.9.2.8. Irrespective of treatments, microbial population was highest under maize crop compared to onion. Further , important fact is that compared to inorganic and integrated nutrient management packages, organic nutrient management packages harbored higher microbial population in terms of bacteria, fungi, actinomycetes and phosphate solubilizing bacteria and treatment T_6 was superior to all.

Performance evaluation of important crops/ cropping systems under organic farming

Yield of basmati rice, rice (Saket-4), maize (grain) and maize (cobs) under organic nutrient management was found to be increased by 20.2, 10.3, 9.7 and 8.2 %, respectively over chemical nutrient management. The corresponding increase in yield over INM was 6.2, 1.9, 2.1 and -5.5 %, respectively.Organic carbon, available P, K, Cu, Zn, Mn and Fe in soil under organic nutrient management increased by 19.6, 5.01, 14.5, 8.82, 1.73, 2.75 and 4.15 %, respectively compared to INM in various cropping systems and was highest.Available N in soil was found higher under INM by 3.90 and 12.0 % over to organic and chemical nutrient management, respectively.

Agronomic evaluation of biodynamic practices and panchgavya for organic cultivation of important crops/cropping systems

Treatment T_5 (BD + FYM + Vermicompost + Panchgavya) recorded 20.9, 15.2 and 17.3% higher grain, straw and biological yield of rice; 32.8, 25.9 and 28.5 % higher grain, straw and biological yield of maize, respectively over control and also recorded highest (19.6 q/ha) pod yield of cowpea.Highest soil organic carbon, Mn, and Fe were recorded under FYM + vermicmpost application while, available N, P, K and Zn was higher under FYM+ vermicompost + *Panchgavya* application.

Insect, pests and disease management in different cropping systems under organic farming

Grain, straw and biological yield of basmati rice under green manure was 8.0, 11.0 and 9.4 %, respectively higher over summer ploughing. Similarly, treated crop yielded 2.8, 2.3 and 2.4 % higher grain, straw and biological yield, respectively over untreated plots.Chickpea and mustard shows higher dry matter accumulation under green manured + treated plots than summer ploughed + untreated plots.Organic carbon, available N, P and K under green manure was 27.8, 26.3, 45.5 and 7.5 % higher over summer ploughing. Micronutrients *viz*, Cu, Zn, Fe, Zn etc. were also recorded higher under green manured plots. The aforesaid nutrients were slightly higher under treated plots over untreated.

9.3 INTEGRATED FARMING SYSTEMS (IFS)

Development of Integrated Farming System Model for Small Farm Holders of Western Plain Zone of Uttar Pradesh

A study on development of Integrated Farming System Model for small farm holders of western plain zone of Uttar Pradesh was started in 2004-05 at PDFSR, Modipuram. After completion of a period of six years, the results of the study were reviewed critically by the Institute Research Committee (IRC) and it was decided to continue the study as such with removal of goat unit and addition of mushroom & biogas units in the existing IFS models. Accordingly, mushroom and biogas units were established in the reported year 2011-12 and goat unit was abolished. The compiled results of the first phase of the study and comparative performance of individual as well as interactive effects of different enterprises of the IFS model during the reported year are summarised here under;

A. Crop Production

During the period under report, the crops/ cropping systems followed and production under respective cropping systems are summarised in table-9.3.1.

Table-9.3.1: Crops and cropping systems followed in 2011-12 and respective productivity.

Cropping systems	Area sq. m. (000,)	Production (Tonnes)				Market value (Rs.)
		Kharif	Rabi	Summer	Total production (SYE)	
Sesbania (GM)-Rice-Wheat-Sugarcane(Summer)-S. ratoon	2800	0.99 (Rice)	1.13 (Wh)	19.0 (S.Cane)	29.54 (14.8t/ year)	70,900 (35450/ year)
Sugarcane(Spring)+cowpea (GF)-S. ratoon	2000	10.0 (GF)	-	14.7 (S.Cane)	17.82	42780 (21390/ year)
Maize+redgram-wheat	1600	0.13 (RG)	0.80 (Wh)	0.45 (Mz)	6.98	16750
Sorghum-rice-potato-Maize+cowpea(GF)	800	0.47 (Rice)	1.5 (Pt)	12.2 (GF)	8.85	21260
Sorghum –mustard-Maize+cowpea(GF)	1600	-	0.42 (Mst)	21.1 (GF)	11.84	28425
Sesbania aculeata -Rice-berseem	800	0.55 (Rice)	8.80 (GF)	GM (Ses.)	6.64	15,950
Sesbania aculeata -rice-oats	800	0.55 (Rice)	8.00 (GF)	GM (Ses.)	6.31	15,150
Total					76.52	1,83,666
Straw/curvi (wheat,rice,maize)					6.41	12,830
Fuel wood (Redgram and mustard etc.)					1.0	1000
Gross						1,97,496

Straw: Wheat -2.41 ton, Rice – 3.33 ton, Maize-0.67: Total=6.41ton @ Rs.3000/ton = Rs.12,830/-
Fuel wood: Redgram and mustard-1.0 ton @ Rs.1000/ton=Rs.1000/-

B. Dairy unit (Milk Production)

Looking in to the mandate of the project and ultimate objectives, the animal unit having total number of 15 animals on dated July 16, 2010 was shortened to half of existing one, by sailing 7 number of animals in 2010 and 1 in 2011. This resulted comparatively less production of milk in reported year than milk production in previous years. Total milk production and other by-products from the unit are listed in table-9.3.2. Besides production of FYM and Vermicompost, the cow dung was also used for fish pond and biogas units, simultaneously. To get round the year green fodder production, sufficient area was put under fodder crops as a part of cropping plan as above (Table-9.3.1). The animals were also fed with balanced dose of concentrates and mineral mixtures.

C. Horticulture

An area of 0.22 ha planted in 2004-05 at the time of establishment of the project is under fruit orchard containing guava and mango as major fruity species and peach, pear, citrus and karonda as boundary and intercrop fruits. Almost all the fruit species have start fruiting. The detail of production of different fruit species is given in table-9.3.3.

Table 9.3.2: Milk and other dairy products and by products produced in 2011-12.

Dairy product	Quantity produced (kg/litre/q/t)	Rate per unit(₹)	Total amount (₹)
Milk	3717 litre	Rs.26/litre	96642
Sold animals	One	23,000/animal	23,000
Vermicompost	18.0 ton	2000/t	36,000
FYM	20.0 ton	175/ton	3,500
Gross income (₹)	-	-	1,59,142

Table 9.3.3: Details of different fruits and vegetables production from orchard unit.

Fruit species	Quantity (kg)	Rate per Kg (₹)	Total Amount (₹)	Particulars
Guava	1540	10	15400	The orchard unit was auctioned during the reported period and only a part of produce was harvested and sold at institute level (Since September,2011, the date of termination of the auctioned period). The yields data are as per recorded figures from the person to whom the orchard was auctioned and the produce sold at institute. Now and onward, orchard unit will not be auctioned and all the production and salematters will be undertaken by the IFS unit staff.
Mango	110	15	1650	
Karonda	560	20	11200	
Citrus	400	20	8000	
Pear	53	10	530	
Brinjal	325	10	3250	
Tomato	210	20	4200	
Green Chillies	50	20	1000	
Berseem (F)	1100	1	1100	
Gross returns			46330	

D. Fish production

Freshwater fish production was started during rainy season of 2005 at 0.1 ha land. A mix of fish species including rohu, katla, mrigal, common carp, silver carps and grass carp were stocked @ 10000 fingerlings per hectare in ratio of 20:20:20:10:20:10. A production of 241.5 kg fish was achieved in the year of 2011 sold @ ₹ 50 per kilogramme generating revenue of ₹ 12075.Keeping in view the economic condition of poor farmers representing small land holders of the region, low input based management system, relying on enhancing the fertility of pond through maintaining sufficient feed in terms of phytoplankton and zooplankton in the pond for entire growth phases, locally available inputs such as raw cowdung and supplementation of rice police mainly during the early growth phase were used. For enriching natural fish feed and keeping pond water clean and safe, inorganic fertilizers NPK and lime were also used periodically. All the pond dykes were covered with different type of plantations like lemon, guava, sesbania, leucenea etc. which not only protected the slopes of the dykes against soil erosion but also provided additional income in term of fruits, fodder, fuel and GM (Photo-). Besides cash income, the vegetation on dykes also served as feed for herbivorous fish species like grass carp. In addition yield parameters, growth rate of the stocked fishes were also recorded quarterly for monitoring the growth of fishes. Higher growth rate was recorded for katla followed by rohu and mrigal among Indian major carps. Among exotic carps, grass carp recorded faster growth rate as compared to other two exotic carps.

E. Apiary (Bee Keeping)

Because of heavy pest (Baravo) infestation during last two years, the unit was suffered a lot and production was badly affected. During reported year, the bee unit was re-established in the month of January, 2011. During this period also the weather was not conducive and prolonged low temperatures again affected the activities of bees and simultaneously the produce of honey. Because of these factors, a low yield of 84 kg was recorded sold @₹ 120/kg generating total revenue of Rs.10080. All care and maintenance is being undertaken to make improvement in this enterprise.

F. Vermicompost

Vermicompost unit produced 18 tons of enriched compost which was recycled / used in production of different field and plantation crops of the unit. To see the effect of different constituents (cow dung and farm by-products/residues) of vermicompost on the quality and nutritional status of the compost so prepared , an experiment was started by mixing various farm by products and residues with cow dung in different ratios. The results of the study will be reported in next report.

G. Boundary Plantations

All the farm field boundaries including fruit orchards and pond dykes have been covered under plantations of perennial fruits and agroforestry plant species (Photo) including jackfruit, “bel”stone fruit, citrus,guava,jamun and Lucenea lucocephala (Subabool) . Most of the planted species have now started given some income and this year more than 100kg of kagji nimboo and large biomass of subabool used as animal fodder was harvested. Stone fruit “bel” (Photo) is also bearing sufficiently good fruit yield. Similarly, considerably high (4.5-6.0 q/ year) fruit yield is being harvested from karonda (Photo) plantations of the orchard boundaries from last three years or so.

H. Newly Introduced Enterprises (Mushroom and Biogas)

As per decision of IRC held in June, 2010, two new enterprises Mushroom and Biogas were added in the existing IFS model. Both the new enterprises were established in 2011 and have start production. Biogas unit (Photo) installed with the help of state dept. NEDA is being used for making food as kitchen gas and is sufficient to need of a small family. The production of gas in winter months was relatively slow but the same was improved by addition of little amount of Urea in gobar slurry. Mushroom unit was started with production of "Dhingary" species initially and later on other species will be grown in coming years. During last three months about 50 kg of mushroom was produced which was sold at a nominal rate of ₹ 40 per kilogram, generating additional revenue of ₹ 2, 000.

Livelihood Analysis: The comparative results (table-9.3.4) of first phase (2004-10) of the study and of successive year 2011-12, inferred that IFS approach is a viable way of ensuring livelihood of

Table-9.3.4: Impact of IFS approach on the productivity of a farm and household security

Household commodities produced at farm of PDFSR under IFS Model	Annual demand of an Indian family (Tones)	Av. Production First Phase (2004-10) (Tones)	Av. Production (2011-12) (Tones)	Market value(Rs.)
A. Crops (0.72ha)				
Cereals	1.55	3.28	4.94 @ Rs.12/kg	59,280
Oilseeds	0.13	0.18	0.42 @ Rs.30/kg	12,000
Pulses	0.20	0.38	0.25 @ Rs.30/kg	7,500
Fodders	36.5	61.03	53.00 @Rs.0.75/kg	40,500
Sugarcane	1.60	24.48	33.7 @ Rs.1800/t	60,660
B. Horticulture (0.22ha)				
Fruits	0.20	1.52	2.66 @ Rs.10-20/kg	36,780
Vegetables	0.90	3.28	2.08 @ Rs.4-20/kg	14,450
C. Livestock (0.32ha)				
Dairy animals (2 buffaloes+ I cow) - Milk	1.12	5.81	3.72*@26/litre(Av. price of buffalo and cow milk)	96,642
***D. Pisciculture (0.10ha) –**				
Fishes	-	0.26	0.24 @ Rs.50/kg	12,050
E. Apiary& others(0.14ha)(Honey)	0.02	0.16	0.12@ Rs.120/kg	10,080
F.Mushroom**	-	-	50kg@Rs.40/kg	2,000
F. Vermicompost	10.00/ha	12.00	18.00 @ Rs.2/kg	36,000
G. Sale of animals	NA	-	One Hebuffalo	23,000
Gross value (Rs.) of all the farm produce	119560	3,62,775	-	4,10,942
Cultivation cost (Rs.)	-	197883	-	2,13,777
Net returns (Rs.)	-	164887	-	1,97,165
Net saving (Rs.) (Net returns – annual demand of a family in term of money)	-	55574	-	77,605

***Size of unit was reduced to half in the year, ** New addition in 2011**

small categories of farmers. Further, the impact of IFS approach in long run is also visible as the production and profitability is on higher side with additional income/ returns achieved from perennial type of enterprises such as horticulture, boundary plantations etc. The percent increase in gross return, net return and annual saving was higher (14.63%, 22.56%, and 48.49%, respectively) as compared to previous years. Interestingly, increase in total cost of production was insignificant (8.03%), which probably was because of addition of new enterprises mushroom and biogas.

Effect of Farm holding size, cultural practices and fertilizer use on soil health status of farmer's field-a case study

The survey work of farm families was conducted in three villages of Sardhana Tehsil of Meerut district during December 2011. It was observed from the survey work that 100 % large and medium categories of farmers were adopting fully mechanized farming and 90 % taking Sugarcane- Sugarcane- wheat cropping sequence and rest of the 10 % was under forage crops like barseem and jwar. Small and marginal farmers were practicing traditional farming and taking vegetables crops such as potato, onion, peas and chilies in the cropping sequences. Almost all the categories of farmers maintain 5-6 milch animals and using their excreta as source of manures in a alternative years but quantum of application was higher in categories of small and marginal farmers because of their small holding size. Application of nitrogenous fertilizer (Urea) @ 150 kg and phosphatic fertilizer (DAP) @ of 150 kg/ha was routine fertilization to Sugarcane-Sugarcane- wheat cropping sequence where as potato crop was cultivated with 250 kg Urea and 125 kg DAP/ha along with 625 quintal FYM while 5-10% farmers applied potassium fertilizer@ 125 kg /ha to Potato crop on an average. In addition to this, vegetables (except potato) and forage crops are grown with application of Organic Manures.

As per soil health of the farmer fields is concerned, the pH value of all the categories of the farmers fields ranged from 6.34 to 7.16 and attains the level of neutral range. The status of organic carbon and NPK of large category of farmers varied from 0.21 to 0.48 %, 137 to 238 kg ha^{-1}, 10.24 to 17.5 kg ha^{-1} and 126 to 149 kg ha^{-1} followed by medium farmers field which ranged from 0.45 to 0.56%, 216 to 274 kg ha^{-1}, 12.5 to 18.2 kg ha^{-1} and 130 to 146 kg ha^{-1} and small farmers field varied from 0.46 to 0.58%, 257 to 285 kg ha^{-1}, 13.5 to 20.50 kg ha^{-1} and 130 to 150 kg ha^{-1} whereas marginal farmers field had organic carbon from 0.56 to 0.68, 256 to 322 kg ha^{-1}, 15.2 to 22.5 kg ha^{-1} and 145 to 192 kg ha^{-1}. It is reveled from the observations of OC, and NPK that soil health of the marginal and small farmer's fields are better than medium and large categories of the farmer's fields.

Development of an IFS model for western plain zone of Uttar Pradesh

The livestock unit in integrated farming system model comprised of one buffalo and one Holstein Friesian cross bred cow with their young ones. 0.32 ha of land allotted for livestock shed and fodder

Photo 9.3.1. Milch buffaloes in IFS Unit

Table: 9.3.5 Individual Milk production of animals in IFS Unit

Animals	Period of milk production	Total milk yield(lit)	Average milk yield (lit)
Buffalo	31Oct, 2011- 31 March, 2012	1260	8.23
HF Cross bred cow	1April, 2011-31 Oct, 2012 and 29 Jan, 2012-31 March, 2012	2457	8.00
Total milk	3717	8.11	

production. The recommended and standard practices were followed for the animals. The animals were feed with 6 kg of dry, 25 kg of green fodder and concentrate feed @ 400 gm /liter of milk in addition to 1.5 kg of concentrate for body maintenance. Total milk produced from these animals was 3717 liters from 1st April 2011 to 31st March 2012. The gross income produced from sale of milk was ₹ 96642.

Development of Integrated Farming System Model for Small Farm Holders of Western Plain Zone of Uttar Pradesh

Fish production

As a part of developing an integrated farming system model for small farm holders of western plain zones of Uttar Pradesh, freshwater fish farming practice was being carried out from 2005 by allocating an area of 0.1 ha land. A mix of fish species including rohu, katla, mrigal, common carp, silver carps and grass carp were stocked @ 10000 fingerlings per hectare in ratio of 20:20:20:10:20:10 during year 2011. A production of 241.5 kg fish was achieved in the year of 2011 and sold @ ₹ 50 per kilogramme generating revenue of ₹ 12075. Keeping in view the economic condition of poor farmers representing small land holders of the region, low input based management system, relying on enhancing the fertility of pond through maintaining sufficient feed in terms of phytoplankton and zooplankton in the pond for entire growth phases, locally available inputs such as raw cowdung and supplementation of rice polish mainly during the early growth phase were used. For enriching natural fish feed and keeping pond water clean and safe, inorganic fertilizers NPK and lime were also used periodically. Periodic water exchange was carried out for maintaining optimum dissolved oxygen level in the pond. All the pond dykes were utilized for different type of plantations like lemon, guava, sesbania, leucenea etc. which not only protected the slopes of the dykes against soil erosion but also provided additional income in term of fruits, fodder, fuel and green manure. Besides cash income, the vegetation on dykes also served as feed for herbivorous fish species like grass carp. In addition yield parameters, growth rate of the stocked fishes were also recorded quarterly for monitoring the growth of fishes. Higher growth rate was recorded for Katla followed by rohu and mrigal among Indian major carps. Among exotic carps, grass carp recorded faster growth rate as compared to other two exotic carps.

9.4 RESOURCE CHARACTERIZATION AND SYSTEM DIAGNOSIS (RCSD)

Characterization and evaluation of farming system in India

The study was undertaken during the year 20011-12 with the objective to identify farming systems across eco-system and size groups in Tamil Nadu state. All Agro-climatic region of the each state will form the base for study. Thirty percent districts from each zone, two representative blocks from each district and three village panchyat from each block will be selected by adopting multistage random sampling. 6 farmers, from each village panchayat consisting 2 each marginal, small and two each medium and large farmers were interviewed on random basis to fill up the pre tested schedule and questionnaire.

North Western Zone of TN

The north western zone comprising the revenue districts of Salem, Dharmapuri, Krishnagiri, Namakkal (Excluding Thiruchenkodu), Perambalur is situated between 11° and 12° 55' N latitude and 77° 28' and 78° 50' E longitude. Area of this region is 16,150 square Km equivalent to 12.4 percent of the state area**.**

Climate

The climate in the zone ranges from semi-arid to sub-humid with frequent occurrence of drought. Four distinct seasons prevailing in the zone. They are south west monsoon (June-September), north-east monsoon (October-December), winter (January-February) and summer (March-May).The hottest months are March. The annual rainfall of this zone (excluding hills) varies from 560 to 1080 mm (CV 19 to 33). The hilly region of Shervaroys, Kollihills receiving the rainfall about 1300 mm. The southwest monsoon, northeast monsoon, winter showers and summer rains contribute 45, 37, 1 and 17 percent respectively to annual rainfall. In Eastern part of the zone the rainfall is higher during northeast monsoon. Whereas the western part of the zone receives maximum rainfall during southwest monsoon. The maximum temperature ranges from 23 to 42 and the minimum temperature ranges from 10 to 31.

Cropping Pattern, Major crops, and Crop sequence

The total area under crops in the zone is 10.15 lakh ha. The area covered under rice, Sorghum, Groundnut, Finger millet, Horsegram, Little millet, Pearl millet, Tapioca, Cotton, Sugarcane , Gingelly, Vegetables , Mango were 14.4%, 17.5%, 13.3%, 12.0%, 8.0%, 7.6%, 4.65%, 3.76%, 3.42%, 2.97%, 2.96%, 1.33%, 1.23%. respectively.

Irrigation

There are three main river systems providing the drainage in the zone.

The Cauvery system

Within the watershed of this system lie the southern portion of Denkanilotta and Dharmapuri drained by the Sanatkumaranadi and the Toppuriver, and the taluks of Salem and Qmalur drained by the rivers Sarabhanganadi and the Tirumanimuthar. It admits irrigation water to Thoppaiyar dam and Nagavathi dam in Dharmapuritaluk, Chinnar dam in Palakodutaluk and Doddahalli dam in Denkanikottataluk.

The Penniyar system

The Penniyar system drains the northern portion of the zone. The bed of Penniyar and its tributaries admit water to KrishnagiriReservioir, Barur large tank, Bada-Talav large tank in Penukondapuramtaluk and many tanks in the vicinity of Kaveripattinam in Krishnagiritaluk, Annasagaram tank and Kolagathur Shelvarayan tank in Dharmapuri, the Pambar dam in Uthangarai, Vaniyar dam, Echambadi dam and Alapuram tank in Harurtaluk and Kelavarapalli dam in Hosurtaluk.

The Vellar system

This is composed of two rivers Vasistanadi and Swetanadi in Atturtaluk uniting east of the zone boundary to form the Vellar of South Arcot. The Vasistanadirising in the Aranuthumalai, along with its tributaries, the Kariyakovil river (which drains the Kalrayans) and the Anaimadavu river admit water to Karaikoil dam and Sundarapatti tank in Atuurtaluk enriching the soil fertility of this area. Wells, tanks and canals are the major sources of irrigation in the zone. Of the total irrigation area of 2.44 lakh ha, about 74 percent is fed by wells, 14 percent by tanks and 10 percent by canals.

Land use pattern

Of the total geographical area of 16.15 lakh ha, only 8.68 lakh ha are cultivated. The gross cropped area is estimated to be around 10.15 lakh ha. Among the taluks, Krishnagiri and Harur in the north and Namakkal, Attur and Perambalur in the south have the maximum cropped area of 8-14 percent of the total cropped area of the zone in each taluk. The cultivated area is below 3 percent in the taluks of Pennagarm and Yercaud. The cropped area ranges from 3 to 6 percent in each of the remaining taluks. Out of 2.0 lakh ha of forest area (12.5 percent of the area of the zone) 25 percent is in Hosur, 14 in Krishnagiri and 12 in Denkanikottataluks in the north. The Shevaroy hills in Yercaudtaluk in the central region of the zone occupy 12 percent of forest area. Uthangarai, Pennagaram, Rasipuram, Sankari and Omalurtaluks have few forests (1 percent and below). In other taluks the forest area ranges from 2 to 9 percent.

Horticulture – status

The North Western Zone of Tamil Nadu, especially Dharmapuri district is highly suitable for increasing horticultural production. Agro-climatic factors such as soils and their fertility status, topography, irrigation, rainfall, temperature and wind and the overall natural environment provide the basic framework for development. As regards the current production, Dharmapuri district alone ranks fifth in the state in area under fruits and vegetables and holds second position for fresh fruits. The district has the maximum area (52 percent) and production under mango in the state and ranks second for tamarind, grapes and guava. Salem district has the maximum area (nearly 60 percent) and production of tapioca in the state. The demand for seedlings, especially of mango and guava, greatly exceeds the existing supply capacity. In Krishnagiri area a number of enterprising nurserymen have undertaken large scale multiplication and supply of mango varieties for local sale as well as for export to neighboring states. Tamarind trees are usually raised along field borders and bunds, but cultivation on a plantation scale is common in many parts of Dharmapuri district. The Department has identified champion trees for large scale multiplication.

Animal Husbandry

Livestock forms an integral part of the day-to-day life and activities of the common farmer in the Zone. Apart from the supply of milk, eggs and meat required for domestic use, many of his farm operations like ploughing, water lifting, transport etc., depend on animal power. The animals also provide him the requirements of farm yard manure, besides some extra income through sale of surplus milk and eggs, wool, hides, skins and other products.The total livestock population including poultry is 37.8 lakhs with poultry population constituting 39 percent, sheep 19 percent, cows 12 percent, draught animals 11 percent, buffaloes 6 percent, heifer calves 5 percent, pigs 4 percent and goats 4 percent.

Table 9.4.1 indicated that Rice +Livestock+ Veg/ Fruits+ Pulses/ Oilseed based farming system were found predominant being adopted by about 44 percent followed by Vegetables+ Fruits+ Livestock +Rice based farming system (15.6 Percent) sample households in high productive zone of Tamil Nadu (TN). Arecanut+ Livestock+ Veg/Fruits + Rice(24 Percent) followed by Vegetables+ Livestock+ Rice+Pulse +cotton based farming system were predominant in North western low productive zone of T.N.

The average size of land holding and income pattern of the sample households of North western zone is given in Table 9.4.2. It can be observed from the table that the average size of land holding was 0.536, 1.296, 2.252 and 2.344 ha for marginal, small, medium and large farmers respectively. The income pattern of marginal farmers comprised of cereals 44.46%, followed by animal husbandry activity with 34.51 %. Whereas, for small farmers were 40% and 23.62 %, medium 31.97 and 16.36 % and for large farmers 14% and 7.1% respectively. It indicates that as farm size increases the share of livestock income decreases. Whereas, horticulture activities was more with medium and large farmers.

As regards to low productive district the average size of land holding was 0.65, 1.15, 2.63 and 5.60 ha for marginal, small, medium and large farmers respectively. The income pattern of marginal farmers comprised of animal husbandry activity with 34.46 % followed by cereals 23.05%, whereas small farmers of this district have 44.07% of income from the vegetables followed by animal husbandry 16.0%. The category of medium and large farmers also has the same trend.

Cauvery Delta Zone

Cauvery Delta Zone (CDZ) lies in the eastern part of Tamil Nadu between 10.00-11.30, N latitude and between 78.15 – 79.45 E longitude. It is bounded by the Bay of Bengal on the East and the Palk straight on the South, Trichy district on the west, Perambalur, Ariyalur districts on the north west, Cuddalore district on the North and Puddukkottai district on the South West. Total area of the zone is 24,943 sq.km. in which 60.2 percent of the area i.e., 15,00,680 hectares are under cultivation. And 50.1 per cent of total area of cultivation i.e., 7,51,302 hectares is the irrigated area. This zone receives an annual normal rainfall of 956.3 mm. The major dams utilized by this zone are Mettur and Bhavanisagar. Canal irrigation, well irrigation and lake irrigation are under practice. The major crops are paddy, sugarcane, cotton, groundnut, sunflower, banana and ginger. Thanjavur district, which is known as “Rice Bowl” of Tamilnadu, comes under this zone. In this zone, rice is the principal crop. In the rice based cropping system, it is either single or double cropped. Third crop rice is grown during summer in some parts. Because of the canal water water supply and with plentiful rainfall during NE monsoon, there cannot be any other crop but rice from September to December. Pulses blackgram and greengram are next importance grown in the rice fallows throughout the delta region from January onwards under no tillage condition. Summer irrigated blackgram is grown with splash irrigation, sowings commencing in April. Gingelly is also sown in April in prepared fields subsequent to summer showers. Vegetables like brinjal, chillies and greens are grown during summer

Table 9.4.1. Predominant Farming Systemin North western zone

(Percentage area covered)

Predominant Farming System	Marginal	Small	Medium	Large	Average
District Krishanagiri (High Productive)					
1.Crop based	**59.4**	**62.5**	**50**	**62.5**	**59.4**
Rice +Livestock+ Veg/ Fruits+ Pulses/ Oilseed	46.9	40.6	43.8	43.8	43.8
Ragi+ Livestock+ Vegetables	6.3	15.6	0	0	7.3
Oilseed+ Pulses+ Livestock+ Vegetables	6.3	3.1	6.3	6.3	5.2
Sugarcane+ Pulses/ Oilseed + Livestock	0	3.1	0	12.5	3.1
2. Livestock based	**31.3**	**21.9**	**43.8**	**0**	**25**
Livestock+ Fodder+ Rice	9.4	0	6.3	0	4.2
Livestock+ Rice+ Vegetables	15.6	12.5	12.5	0	11.5
Livestock+ Veg/Fruits+sugarcane+ Rice	6.3	9.4	25	0	9.4
3. Horticulture Based	**9.4**	**15.6**	**6.3**	**37.5**	**15.6**
Vegetables+ Fruits+ Livestock +Rice	9.4	15.6	6.3	37.5	15.6
Overall	100	100	100	100	100
No. of household	32	32	16	16	96
District Selem (Low Productive)					
1.Crop based	**34.4**	**46.9**	**31.3**	**43.8**	**39.6**
Rice+ Livestock	12.5	21.9	6.3	0.0	12.5
Oilseed+ Pulses+ Livestock+ Vegetables	9.4	0.0	0.0	25.0	7.3
Sugarcane+ Pulses+ Livestock+ veg	3.1	12.5	25.0	12.5	11.5
Cotton+Pulses+L.stock+Oilseed+ Veg/Fruits	9.4	12.5	0.0	6.3	8.3
2. Livestock based	**28.1**	**12.5**	**18.8**	**0.0**	**16.7**
Livestock+ Rice + fodder+ veg	21.9	9.4	0.0	0.0	10.4
Livestock+ Cotton+ Pulse + Veg/Fruits + rice	6.3	3.1	18.8	0.0	6.3
3. Horticulture Based	**37.5**	**40.6**	**50.0**	**56.3**	**43.8**
Vegetables+ Livestock+ Rice+Pulse +cotton	25.0	28.1	6.3	6.3	19.8
Arecanut+ Livestock+ Veg/Fruits + Rice	12.5	12.5	43.8	50.0	24.0
overall	100.0	100.0	100.0	100.0	100.0
No. of household	32	32	16	16	96

Table 9.4.2. Average size of land holding and income pattern of the sample households of North western zone

Crops	Marginal	Small	Medium	Large	Average
			District Krishanagiri (High productive)		
Average size (ha.)	0.536	1.296	2.252	5.296	2.344
Cereals	44.46	40	31.97	14	21.48
Pulses	0.1	0	0.48	0	0.09
Oilseeds	4	3.73	8.51	4.8	4.93
Sugarcane	0	2.11	0	35.9	19.93
Cotton	0	0	0.58	0	0.06
Vegetables	9.01	17.32	13.49	10.8	11.88
Fruits	3.19	12.74	24.92	22.6	24.93
Animal Husbandry	34.51	23.62	16.36	7.1	12.85
Others	4.73	0.44	3.69	4.7	3.85
Overall	100	100	100	100	100.00
Agriculture	53.3	46.3	45.27	59.5	50.35
Horticulture	12.19	30.06	45.27	33.4	36.8
Animal Husbandry	34.51	23.62	16.36	7.1	12.85
Overall	100	100	100	100	100.00
			District Selem (Low productive)		
Average size	0.65	1.15	2.63	5.60	2.51
Cereals	23.05	7.1	9.17	7.19	11.6275
Pulses	4.29	0.56	1.72	0.37	1.735
Oilseeds	8.01	7.94	5.26	20.65	10.465
Sugarcane	2.69	15.19	9.99	3.88	7.9375
Cotton	6.02	3.03	0.75	2.68	3.12
Vegetables	12.31	44.07	41.8	42.84	35.255
Fruits	8.57	6.06	6.93	5.31	6.7175
Animal Husbandry	35.06	16.05	24.38	17.08	23.1425
Others	0	0	0	0	0
Overall	100	100	100	100	100
Agriculture	44.67	33.82	29.41	34.77	35.6675
Horticulture	20.87	50.13	48.73	48.15	41.97
Animal Husbandry	34.46	16.05	21.87	17.08	22.365

Table.9.4.3 Identification of farming systems of sample house hold in low productive district of Cauvery delta zone

Farming systems	Marginal	Small	Medium	Large	Average
Cereal based farming systems					
Rice	28.13	28.13	18.75	12.50	23.96
Rice-rice	0.00	15.63	25.00	12.50	11.46
Rice-blackgram + others	28.13	6.25	6.25	18.75	15.62
Rice-blackgram- livestock + others	12.50	9.38	6.25	18.75	11.46
Rice- seasame	3.13	3.13	18.75	0.00	5.21
Rice- seasame -livestock	12.50	0.00	0.00	0.00	4.17
Rice- seasame - sugarcane - livestock	3.13	9.38	0.00	12.50	6.25
Rice- livestock	12.50	18.75	0.00	0.00	4.17
Sub total	100.00	90.63	75.00	75.00	88.54
Sugarcane based farming systems					
Sugarcane -rice	0.00	6.25	6.25	0.00	3.13
Sugarcane -rice- seasame +others	0.00	0.00	12.50	6.25	3.12
Sugarcane -rice- livestock+ others	0.00	3.13	6.25	6.25	4.17
Sugarcane -rice-rice-blackgram- seasame	0.00	0.00	0.00	6.25	1.04
Sub total	0.00	9.38	25.00	25.00	11.46
Grand total	100.00	100.00	100.00	100.00	100.00

months in limited area in the well drained fertile lands depending upon the underground water source. In light clay loamy soils under gardenland condition is brought out where crops like groundnut, maize, gingelly and irrigated pulses are altered. Banana, sugarcane and ornamentals like jasmine, rose, chrysanthemum, crossandia and arali are the annuals occupying the land for more than one year for the successive returns. Coconut gardens, bamboo and wood lots are scattered in the delta in different densities

Cropping pattern

The cropping pattern of Thanjavur district, as could be evidenced from the various statistical reports is Paddy, coconut, Pulses, Sugarcane and Groundnut in that order. If, Mettur dam is opened on the normal date of 12^{th} June, the farmers could go in for two crops of Paddy namely Kuruvai and Thaladi. If the monsoon is delayed and erratic, they could cultivate only one crop of paddy ie. Samba. They follow the paddy crop with pulses which will be sown just one week before the harvest of Paddy crop.

- Rice (June-Sep.) - rice (Oct.-Jan.) - pulses / gingelly (Feb.-May)
- Rice (Aug.-Jan.) - groundnut (Jan.-April) – gingelly (April-June)
- Rice (Aug.-Jan.) - pulses / gingelly/ cotton (Jan.-April)

- Sugarcane - ratoon sugarcane (Feb.-Dec.) – 2 years rotation

The major crops cultivated in Thanjavur district are Paddy, Pulses, Gingelly, Cotton, Groundnut and Sugarcane. The minor crops like Maize, Soyabean, and Redgram are also grown in uplands. Paddy is the principal crop grown in three seasons viz. Kuruvai, Samba and Thaladi. Pulses like Blackgram, Greengram and cash crops like Cotton and Gingelly are grown in rice fallows. In new delta area, the Groundnut is the principal crop Sugarcane is cultivated both in new delta and old delta. Banana is primarily grown in Padugai lands.

Thanjavur (Low productive district)

Agriculture based farming systems alone play a major role in this district, two types of farming systems were followed in agriculture system. Twenty percent of the farmers are having animal husbandry as subsidiary enterprises. Agriculture play a major source of income, among agriculture rice based farming system and sugar cane based farming system was found most important system for the contribution of total farm income in the area. In rice based farming system, rice alone, rice- pulse, rice-sesame, rice-livestock depends on the Cauvery water release, land utilization and economic status of the farming community. Rice based farming system was found predominant farming system being adopted by about 24 percent sample households followed by rice blackgram and rice- rice system(Table 3).

2.3 Trichy (High productive district)

The farming system is diversified in high productive district of Trichy in Cauvery Delta zone are given in Table 9.4.4.

The farming system consists of agriculture, horticulture and livestock, majority of the farming is agriculture based and consists of rice and rice based crops like pulse and oil seeds, similarly sugarcane also contributed income for agriculture based cropping systems. The horticulture based farming system consists of fruits and vegetables. The banana is the major fruit crop and tapioca is the major vegetable crop. In animal husbandry farming system consists of livestock and goat. Cereal based (77.0%) followed by livestock based farming system (10.4%) were predominating farming systems in the study area.

The average size of land holdings of different categories was 0.83 1.89, 3.14 and 6.75 ha for marginal, small, medium and large farmers respectively in low productive zone. The income pattern indicated that cereals contributed more than 53 percent followed by sugarcane 36 percent income (Table 9.4.5). The size of land holdings of different categories was 0.73 0.88, 1.94 and 2.31 ha in high productive zone for marginal, small, medium and large farmers respectively. The income contribution patterns from cereals are about 40%, vegetable about 18 %, and 14 percent from livestock.

Status of organic agriculture in eastern Himalayan region

As per data gathered from different districts of Meghalaya selected for the study, 62 per cent farmers were found cultivating traditional organic agriculture while 38 pr cent were noticed utilizing meager amount of mineral fertilizer (30 kg ha^{-1}) for crop production**.** However, the organic materials were found to be used mainly for zinger and other vegetables.

Farmer's category

In the analysis of data, it was observed that out of the total sample farmers, 20.9 percent were marginal while 70.9 and 8.1 was of small and large category.

Table 9.4.4 Farming systems of sample house hold in high productive district of Cauvery delta zone

Predominant farming system	Households categories				
	Marginal	Small	Medium	Large	Total
Cereal Based Farming System					
Rice	43.75	34.38	18.75	31.25	34.38
Rice-Livestock+Others	9.38	21.88	43.75	6.25	18.75
Rice-seasame-Livestock+ others	6.25	18.75	12.50	12.50	12.50
Rice-Sugarcane	0.00	6.25	0.00	12.50	4.17
Rice-Blackgram+ others	6.25	3.13	0.00	12.50	5.21
Rice-Vegetables	6.25	0.00	0.00	0.00	2.08
Total A	71.88	84.38	75.00	75.00	77.08
Sugarcane Based Farming System					
Sugarcane-Rice	0.00	0.00	6.25	6.25	2.08
Sugarcane-Rice-Livestock	3.13	0.00	0.00	12.50	3.13
Sugarcane-Rice-Vegetables	3.13	0.00	6.25	0.00	2.08
Total B	6.25	0.00	12.50	18.75	7.29
Vegetable Based Farming System					
Vegetables-Livestock-Rice	3.13	0.00	0.00	0.00	1.04
Vegetables-Rice-Livestock	3.13	0.00	0.00	6.25	2.08
Total C	6.25	0.00	0.00	6.25	3.13
Fruit based farming system					
Banana-Rice-Blackgram	0.00	3.13	0.00	0.00	1.04
Banana-Rice-Sugarcane-Livestock	0.00	3.13	0.00	0.00	1.04
Total D	0.00	6.25	0.00	0.00	2.08
Livestock Based Farming System					
Livestock-Rice	9.38	6.25	6.25	0.00	6.25
Livestock-Rice-Blackgram/seasame	6.25	0.00	6.25	0.00	3.13
Livestock-Sugarcane-Rice	0.00	3.13	0.00	0.00	1.04
Total E	15.63	9.38	12.50	0.00	10.42
Grand Total (A+B+C+D+E)	100.00	100.00	100.00	100.00	100.00

Table.9.4.5. Land holding and income pattern of sample households in Cauvery Delta Zone

(in per cent)

Particulars	Marginal	Small	Medium	Large	All
Low productive Zone					
Size of land holdings (ha)	0.83	1.89	3.14	6.75	2.82
Cereals (Paddy)	41.72	47.6	57.34	59.2	53.51
Pulses	3.58	8.08	3.79	2.6	5.60
Oil seeds	0.81	2.07	8.49	2.43	2.6
Sugarcane	49.48	39.21	30.22	34.71	36.18
Livestock	4.4	3.025	0.15	1.125	2.1
Gross income	100	100	100	100	100
High productive Zone					
Size of land Holdings(ha)	0.73	0.88	1.94	2.31	1.91
Cereals	33.35	47.27	46.30	56.35	39.75
Pulses	1.84	3.83	0.22	0.78	2.78
Oil Seeds	0.95	1.05	4.41	2.22	1.74
Sugarcane	12.95	8.10	15.92	26.05	12.58
Vegetables	31.93	2.25	13.84	9.79	18.18
Fruit crops	1.01	18.94	0.00	0.15	10.86
Livestock	17.98	18.52	19.26	4.56	14.07
Gross income	100.00	100.00	100.00	100.00	100.00

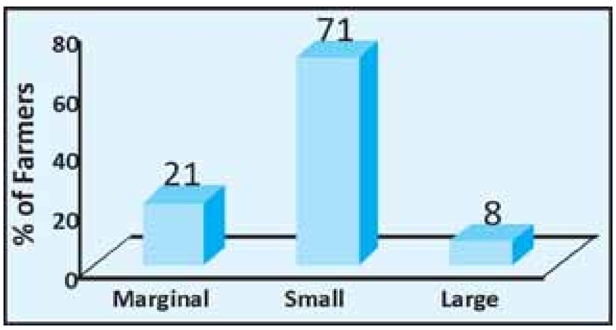


Fig. 9.4.1. Difference in farmers category of Meghalaya state

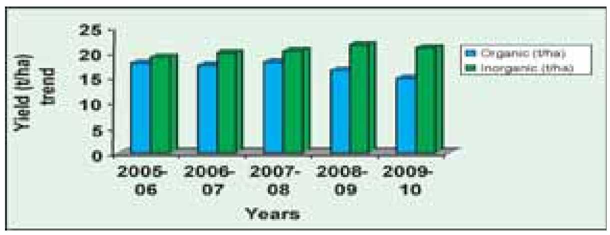


Fig. 9.4.2. Yield trend of rice of organic and inorganic grower

Yield trend of rice

As evident from Fig (9.4.2), the yield trend of rice of organic producers was marked decline while it was observed increasing in case of farmers using inorganic fertilizers. The similar trend was observed in case of maize which is next important crop of the state.

As apparent from Table (9.4.6) the traditional organic growers harvested 15.3 and 15.2 q ha^{-1} paddy and maize compared to 19.8 and 17.8 t ha^{-1} by traditional inorganic producers in Rebhoi district. The similar variation was noticed with different magnitude in other district as evident from data.

The productivity of paddy and maize which is lower than the national average clearly showed that soil fertility status of both group of farmers are very low. However, the higher yield of these crops of inorganic growers indicates that the soil fertility of this farm group is comparatively better than organic producers. As organic farmers neither use organic manure nor fertilizer, it is obvious that their soil fertility status will never improve. The pooled analysis indicated 15.5 and 15.4 t ha^{-1} of paddy and maize productivity of traditional organic farmers while it was 20.9 and 18.0 t ha^{-1} in case of traditional inorganic producers.

Economics of organic and inorganic producers

While computing the economics the influence of yield variation was clearly observed. For instance, because disparity in productivity, the net return in paddy was recorded ₹ 18453/ha for inorganic producers while the corresponding figure for organic producers was ₹ 14749 ha^{-1}. The similar deficit in net gain was also was also noticed in maize in case of organic farmers.

Organic material used by organic producers

- FYM, compost, crop residues and vermi compost are used as organic manures by organic growers.
- FYM and compost are mainly used for ginger and vegetables which are very remunerative crop.
- In rice which is staple food for the farming community, only crop residue and minerals received by the soil through irrigation water meets nutrient requirement of this crop.
- The average consumption of fertilizes used by inorganic rice producers was recorded 30kg/ ha.

Table 9.4.6 Crop Productivity of organic and inorganic producers

District	Paddy (t/ha)		Maize (t/ha)		(%) increase over Conventional organic	
	Conventional organic	Conventional inorganic	Conventional organic	Conventional inorganic	Paddy	Maize
Rebhoi	15.3	19.8	15.2	17.8	29.4	17.1
Jowai	16.8	21.6	14.7	16.9	28.6	14.9
W.K.Hill	15.7	20.6	16.1	18.7	31.2	16.1
E.K. Hill	14.3	21.8	15.8	18.6	52.4	17.7
Average	15.5	20.9	15.4	18.0	34.8	22

Table 9.4.7 Cost and return analysis of organic & inorganic producer

Crop	Organic			Inorganic			increase over organic (%)
	Total Operation cost/ ha.	Gross Income / ha	Net Income / ha.	Total Operation cost/ ha.	Gross Income / ha	Net Income / ha.	
Rice	7133	21882	14749	8035	26488	18453	25.1
Maize	2880	5031	2150	3088	6665	3570	66

9.5 TECHNOLOGY TRANSFER AND REFINEMENT (TTR)

Proven systems based technologies under demonstration

Proven technologies super imposed on twenty five cropping systems viz. improved cultivars ,system for rice intensification (SRI), mechanical transplanting of rice ,nutrient management, *in-situ* green manuring, raise bed planting ,broad bed furrow system ,zero tillage technology ,crop residue management , and farmers practice were demonstrated wheat quivalent yield. WEY and maximum higher net return of different cropping systems were computed.

The wheat equivalent yield (WEY, t ha^{-1}) of rice-cauliflower-bottle gourd, rice- vegetable pea-ladyfinger, rice (SRI)–mustard-summer moong, rice–potato (K. Surya)-summer moong, rice-potato (K. Bad.)- summer moong, rice –potato (K. Bahar)-summer moong and rice–potato (K. Pukhraj)-summer moong were 26, 17, 14 19, 17 , 22& 17 t ha^{-1} receptively followed by farmers practice rice (FP)-wheat (FP)-summar moong (9 t ha^{-1}). Amongst vegetable based cropping systems, the higher net return were recorded in rice-cauliflower-bottle guard, rice–potato (K. Bahar) -summer moong and rice –potato (K.Surya)-summer moong ₹ 430, 288, and 271 per day per ha. respectively (Fig. 9.5.1).

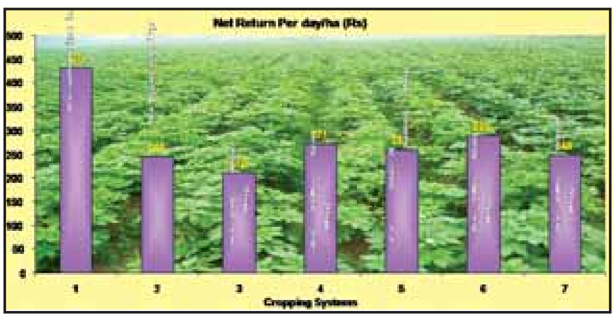


Fig. 9.5.1. Net income (Rs.) per day per ha. from vegetable based cropping systems

Rice – wheat (SSNM), rice-wheat (RDF), rice (RDF) - wheat (ZT) 10 t ha^{-1}, rice –wheat (ST) - dhaincha (GM), rice (rec. NPK) – wheat (BP) - summer moong (GM), rice (MT) - mustard (zero till) - summer moong and rice (RDF) – chickpea(BP) +wheat (F) - summer moong 12, 11 ,11, 10, 11and 11 t ha^{-1} respectively followed by farmers practice rice (FP) - wheat (FP) - summer moong 9 t ha^{-1}. Net return of different cereal based cropping systems were calculated. It had been found that rice (Mech. Trans.)- mustard (Zero Till) - summer moong, rice – wheat (SSNM) and rice (rec. NPK) – wheat (BP) - summer moong (GM) ₹ 215,194 and 185 per day.ha. respectively (Fig. 9.5.2).

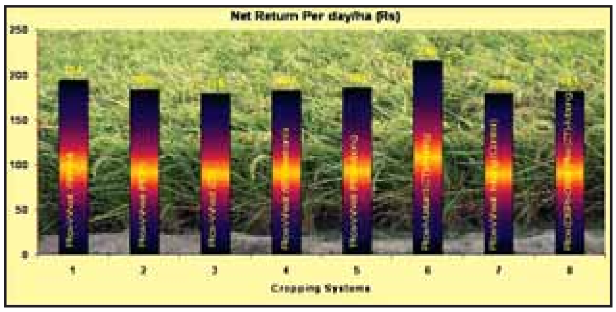


Fig. 9.5.2. Net income (Rs.) per day per ha. from cereals based cropping systems

Rice- chickpea+mustard +summer moong 11 t ha^{-1}, rice-garlic 16 t ha^{-1}, pigeonpea (RB) -wheat (LS) t ha^{-1}, pigeonpea +maize (RB) 1:1- onion 14 t ha^{-1}, pigeonpea +maize (RB) 2:1- wheat (LS) 12 t ha^{-1}, pigeonpea +maize (FB) 1:1 - tomato16 t ha^{-1}, maize(RB)-potato-ladies finger 13t ha^{-1}, maize (RB) -potato- black gram 16 t ha^{-1}, moong (BB) + dhaincha (F) -vegetable pea (BB) +mustard (F) 9 t ha^{-1} and cowpea (BB) + dhaincha (F)- lentil (BB) + mustard (F) 8 t ha^{-1} followed by farmers practice rice (FP) - wheat (FP) - summar moong 9 t ha^{-1}. The highest net retun was recorded amongst pulse based cropping systems viz. pigeonpea +maize (FB) 1:1 - tomato, maize (RB) -potato- black gram and pigeonpea +maize (RB) 1:1- onion Rs.266,258 and 251 per day per ha respectively (Fig-9.5.3).

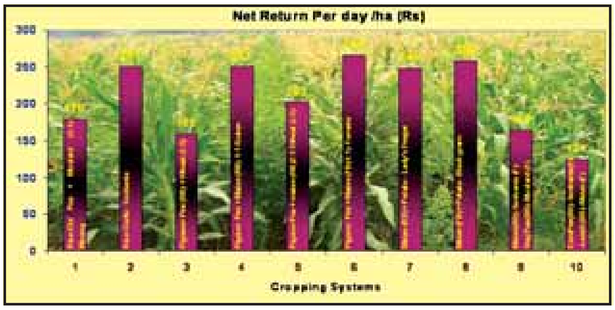


Fig. 9.5.3. Net income (Rs.) per day per ha. from pulse based cropping systems

On 7th September 2011 a kisan gosthi cum launching workshop was organized at Kandisaud where about 72 farmers from near by villages participated. Farmers were distributed with seeds of vegetables mineral mixture, deworming and heat inducers during Kishan gosthi. Similarly, at Koteshwar 52 farmers participated in the workshop cum training programme. Face to face interaction with the farmers regarding crops, livestock, horticultural crops and goat farming etc. was carried out during the kishan gosthi. The scientist of the team expressed their views about farming system improvement as per the need. The team also distributed vegetable seeds for kitchen gardening and medicines for livestock such as deworming in calves,

Photo 9.5.1. Field demonstration (Potato)

Photo 9.5.2. Broad bed demonstration chick pea (BB)+Mustard(F)

Photo 9.5.3. Green manuring (Sesbania)

Photo 9.5.4. Insitu green manuring

mineral mixture for milking animals and heat inducers in anoestrus animals. An interaction meeting with Faculty, scientists and subject matter specialists from G. B. Pant university, Ranichauri campus for gaining information on different varieties suitable for the particular region for *kharif* and *rabi* season crops, fodder and horticulture crops.

Response of wheat varieties to different levels of FYM under organic conditions

Five wheat varieties viz. HI-1544, PBW-550, HD-2781, RAJ-4037 and LOK-1 were evaluated at five different levels of FYM (Control and 10 to 40 t ha^{-1}) in strip plot design. Maximum plant height (105.1 cm) was recorded by wheat varieties HD-2781 followed by HI-1544 (89.0 cm). Among the FYM levels significant differences were observed upto 20 t ha^{-1} (90.6 cm). Likewise significant differences in tillers/m^2 were noted upto 20 t/ha which attained the tillers upto 300 tillers/m^2. Among the varieties RAJ 4037 recorded, the maximum number of tillers (324 tillers/m^2). Non significant differences due to varieties and FYM levels were noted in spike length, grains/ear and test weight. Maximum grain (3998 kg ha^{-1}) and straw (4865 kg ha^{-1}) yields were recorded at 30 FYM/ha, however yield differences were significant only upto 20 t ha^{-1} which recorded 3934 kg ha^{-1} grain and 4613 kg ha^{-1} straw yields of wheat.

Adoption behaviour of different farming system components by farmers of UGP & TGP Zones

A survey was conducted in Hoshiarpur district of Punjab using pre-tested interview schedule in which a total of 50 farmers were contacted for data collection from 10 villages of the district. The survey revealed that Crop+Dairy was the predominant farming system in the district and adopted by 48 per cent of the respondents (Table 9.5.1). Rice-wheat was found as the major cropping system adopted by 46 per cent of the respondents followed by maize-wheat adopted by 42 per cent respondents (Table 9.5.2). Wheat occupied highest acreage per farmer (4.45 ha) followed by Rice (3.52 ha) and

Table 9.5.1. Yield and yield attributes of wheat at different levels of FYM under organic conditions.

	Plant height (cm)	Tillers/m^2	Ear length (cm)	Grains/ ear	Test wt (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
FYM levels							
Control	83.4	255.2	9.2	43.6	42.2	3062	3517
10 t/ha	86.7	280.6	9.9	46.0	43.2	3368	4033
20 t/ha	90.6	299.6	10.3	48.0	43.8	3934	4613
30 t/ha	92.0	308.2	10.5	48.2	45.3	3998	4865
40 t/ha	92.7	308.4	10.3	47.6	50.3	3834	4803
Mean	89.1	290.4	10.0	46.7	45.0	3639	4366
CD (P=0.05)	3.1	25.5	0.7	3.4	1.4	302	450
Wheat varieties							
HI-1544	89.0	276.8	10.7	50.2	47.5	4315	4686
PBW-550	80.0	246.6	10.4	45.6	43.5	3068	3682
HD-2781	105.1	310.4	9.7	44.2	43.9	3826	5226
RAJ-4037	83.0	324.2	9.6	45.8	47.1	3598	4126
LOK-1	88.3	294.0	9.8	47.6	42.8	3389	4111
Mean	89.1	290.4	10.0	46.7	45.0	3639	4366
CD (P=0.05)	16.4	41.5	NS	NS	NS	590	670

Table 9.5.2: Farming systems prevalent in the study area

Sl. No.	Farming system components	% Respondent farmers
1.	Crop + Dairy	48
2.	Crop + Dairy + Agro-forestry	20
3.	Crop + Dairy + Horticulture	8
4.	Crop + Dairy + Horticulture + Agro-forestry	24

Maize (1.94 ha). Wheat was adopted by maximum farmers (90 percent) followed by Maize (78 per cent) and Rice (54 percent). The yield gap analysis revealed that the highest yield gap was in case of groundnut to the extent of 47 per cent.

Study on changes in the trends of crop, animal husbandry and agro-forestry revealed that over the last 10 years, the per farmer average area under wheat increased from 3.24 ha to 4.45 ha, that of rice increased from 1.90 ha to 3.52 ha, that of maize increased from 1.46 ha to 1.94 ha, that of groundnut increased from 0.85 ha to 1.42 ha, that of sunflower decreased from 1.38 ha to 1.21 ha, that of sugarcane decreased from 2.43 ha to 1.90 ha, and that of peas increased from 1.17 ha to 1.62 ha. There was nominal increase in area under fodder crops (Table 9.5.3). The per farmer average area under poplar increased from 0.07 ha to 0.73 ha and that of eucalyptus increased from 0.33 ha to 0.89 ha. The

Table 9.5.3. Major Cropping systems prevalent in the study area

Sl. No.	Cropping system components	% Respondent farmers
1.	Rice - Wheat	46
2.	Maize - Wheat	42
3.	Maize – Peas – Wheat/ Fallow	26
4.	Sunflower – Maize – Peas	16
5.	Groundnut – Wheat/ Maize	12

per farmer average number of cows increased from 4 to 8, that of buffalo increased from 3 to 5, whereas that of bullock remained the same.

The net return per hectare from different crops as reported by the farmers revealed that peas (₹ 79040/-) was the most profitable crop followed by rice (₹ 22675/-), sunflower (₹ 21316/-), wheat (₹ 19908/-), maize (₹ 14425/-) and groundnut (₹ 7514/-). The average net return per tree from poplar was reported to be ₹ 2365/- in 5 years, whereas that of eucalyptus was ₹ 3022/- in 8 years.

As far as recycling of farm products is concerned, each farmer used on an average 1.4 kg of maize grains, 1.3 kg of wheat grains and/or 0.5 kg of rice grains per day for dairy animals. For feeding green fodder to animals, each farmer used on an average 64 kg of Jowar, 13.3 kg of Bajra and/or 13 kg of berseem per day. As regards recycling of farm by-products, each farmer used on an average of 12.8 kg maize straw, 8.2 kg wheat straw and/or 3.9 kg paddy straw per day for dairy animals. They also used about 34 t of FYM per annum as by-product of livestock for the agriculture enterprise. Crop and Dairy enterprises were found to be integrated to the extent of 32.4 per cent.

The majority (60%) of the farmers perceived crop and dairy enterprises as most suitable, having medium cost of production and medium profitability. The agro-forestry enterprise was perceived as having higher profitability and low risk, but somewhat threat to the environment. Crop+Dairy was found the most sustainable farming system in the study area. More than 80 per cent of the farmers reported lack of irrigation water and 45 per cent reported high cost of inputs as major constraints for agricultural enterprise (Table 9.5.5).

Table 9.5.4: Changes and Trends in area under different crops and no. of animals

Sl. No.	Name of enterprise	Area (hectare) or Nos.		% Change
		10 years before	Present	
1.	Rice	1.90	3.52	85.3
2.	Wheat	3.24	4.45	37.3
3.	Maize	1.46	1.94	32.9
4.	Groundnut	0.85	1.42	67.1
5.	Sunflower	1.38	1.21	-18.8
6.	Sugarcane	2.43	1.90	-21.8
7.	Peas	1.17	1.62	38.5
8.	Berseem	0.65	0.73	12.3
9.	Jowar	0.77	0.85	10.4
10.	Bajra	0.89	0.93	4.5
11.	Poplar	0.07	0.73	942.8
12.	Eucalyptus	0.33	0.89	169.7
13.	Cow	4	8	100.0
14.	Buffalo	3	5	66.7
15.	Bullock	2	2	0.0

Photo 9.5.5. Scientists collecting data from farmers

Table 9.5.5: Major Constraints felt by the respondent farmers in the study area

Sl. No.	Constraints	% Respondent farmers
1.	Lack of irrigation due to failure of govt. tube wells	84
2.	High cost of agricultural inputs	45
3.	Lack of veterinary doctors for milch animals	24
4.	Adulteration of milk makes dairy unprofitable	18
5.	Low conception rate of milch animals	15
6.	Lack of electricity for irrigation	14
7.	Lack of quality seed	12
8.	Low price of farm produce	10
9.	Spurious fertilizers and pesticides	8
10.	Problem of marketing of farm produce	6
11.	High risk of crop failure	4
12.	Non-profitability of farming	2

Anusandhan Gaon Ki Aur

The technologies of balanced nutrition in wheat, rice and sugarcane were introduced in the randomly selected Daurala block located 20 km away from PDFSR in Meerut district. Two villages namely, Mahal and Shyampur were randomly selected from Daurala block.

On-Farm Trials on sugarcane

During 2010-11, a total of thirty-two on-farm trials (OFTs) were laid out on balanced fertilizer application in sugarcane in Mahal and Shyampur villages of Daurala block covering four popular varieties viz., COS-8432, COS-8436, COS-767 and COS- 88230. The treatments were T_1-Farmers' practice managed by farmers (NPK&Zn @ 360:70:0:0 kg ha^{-1}), T_2- Farmers' practice managed by scientist, T_3 Recommended dose of NPK(@ 180:80:120 kg ha^{-1}) and T_4 Recommended dose of NPK+ Zinc (25 kg ha^{-1}).

The results (Table-9.5.6) revealed that the improved practice (IP) provided highest yield in case of sugarcane variety COS-8436 (76.73 t ha^{-1}) followed by COS-88230 (75.43 t ha^{-1}), COS-8432 (73.03 t ha^{-1}) COS-767 (68.11 t ha^{-1}). The average yield of farmers' practice (FP) under farmers' management of the varieties COS-8436, COS-88230, COS-8432 and COS-767 were found to be 67.17, 65.17, 62.54 and 58.71 t ha^{-1}, respectively. The increase in yields over the farmers' practice of the sugarcane varieties COS-8436, COS-88230, COS-8432 and COS-767 through recommended doses of NPK and zinc (which consisted about half the dose of nitrogen the farmers used to apply) was 14.24%, 15.75%, 16.77% and 16%, respectively.

The economics of cultivation of sugarcane varieties COS-8432, COS-767, COS-88230 and COS-8436 under the farmers' practice and improved practice was worked out. With an additional expenditure of Rs. 1563 incurred on potash and zinc per hectare, the increase in net return under improved practice was found to be Rs. 20466/-, 18163/-, 19995/- and 18525/- over the farmers' practice in case of varieties COS-8432, COS-8436, COS-767 and COS-88230, respectively. The benefit cost ratio for the varieties COS-8432, COS-767, COS-88230 and COS-8436 under the farmers' practice were 1.54, 1.44, 1.60 and 1.65, respectively, whereas those under improved practice were 1.76, 1.64, 1.82 and 1.85, respectively.

On-Farm Trials on Wheat

For the trials on wheat, 36 farmers were selected randomly from both the villages for conducting on-farm trials (OFTs) during 2010-11. Four treatments were taken under each OFT and each of these treatments was laid on an area of 400 sq. m. The four treatments were- T_1: Farmers' Practice (FP) under scientists' management, T_2: FP +

Table 9.5.6: Impact of OFT on balanced fertilizer application in sugarcane

Variety	No. of OFTs	Yield (t ha^{-1})		% increase in yield over FP
		Improved Practice(IP)	Farmer's Practice(FP)	
COS-8432	12	73.03	62.54	16.77
COS-767	14	68.11	58.71	16.00
COS-88230	3	75.43	65.17	15.75
COS-8436	3	76.73	67.17	14.24

Recommended K, T_3: Recommended NPK, and T_4: Recommended NPK + Micronutrients. The farmers' practice consisted of 200 kg N and 60 kg P_2O_5, whereas the recommended practice consisted of 120 kg N, 80 kg P_2O_5, 60 kg K_2O and 25 kg $ZnSO_4$ per hectare. These treatments were compared with the farmers' practice under farmers' management.

The results (Table-9.5.7) revealed that the improved practice (IP) provided highest yield in case of variety PBW-343 (56.6 q ha^{-1}) followed by HD-2733 (54.27 q ha^{-1}), and PBW-226 (53.02 q ha^{-1}). The average yield of farmers' practice (FP) under farmers' management of the varieties PBW-343, HD-2733 and PBW-226 were found to be 49.98, 47.98 and 46.44 q ha^{-1}, respectively. The increase in yields over the farmers' practice of the wheat varieties PBW-343, HD-2733 and PBW-226 through recommended dose of NPK and zinc were 13.2%, 13.1%, and 14.2%, respectively.

The economics of cultivation of wheat varieties PBW-343, HD-2733 and PBW-226 under the farmers' practice and improved practice was worked out. With an additional expenditure of Rs 647/- incurred on potash and quality seeds per hectare the increase in net return under improved practice was found to be Rs 7889/-, 7199/- and 8299/- over the farmers' practice in case of varieties PBW-343, HD-2733 and PBW-226, respectively. The benefit cost ratio for the varieties PBW-343, HD-2733 and PBW-226 under the farmers' practices were 1.61, 1.54 and 1.56, respectively, whereas those under improved practice were 1.79, 1.70 and 1.75, respectively.

Farmers' perception about the performance of wheat, sugarcane and rice varieties

A study on farmer's perception about the performance parameters of wheat, sugarcane and rice cultivars was carried out with the objective to find out suitability of recent and relatively older varieties of these crops in the adopted villages. A total of four varieties of wheat viz., PBW-343, HD-2733, PBW-226 and PBW-373, five varieties of sugarcane viz., COS-767, COS-768, COS-8432, COS-8436 and COS-88230 and five varieties of rice viz., PB-1, Sugandha-4, Sugandha-5, Sarbati and Saket-4 were selected for their assessment by the farmers, since these varieties were adopted substantially in the adopted villages. The assessment of these varieties being adopted at the time of study revealed that the farmers had preferred different varieties for different attributes. Although yield is the pre-dominant criteria for selection of a particular variety, sometimes crop duration, taste and market demand become the dominating factors in the preference of a variety for adoption.

Capacity building of stakeholders in integrated farming systems through training

A total of 10 training programme/ field/ laboratory/ institute visits and Doordarshan

Table 9.5.7: Impact of OFT on balanced fertilizer application in wheat varieties.

Variety	No. of OFTs	Yield (t ha^{-1})		% increase in yield over FP
		Improved Practice(IP)	Farmer's Practice(FP)	
PBW-343	13	56.63	49.98	13.31
HD-2733	11	54.27	47.98	13.12
PBW-226	12	53.02	46.44	14.18

Table 9.5.8: Detail of training/ other activities

Sl. No.	Title of Programme	Category of participants	Date	No. of participants Male	Female	Total
1.	Institute/Field visit	Farmers from Bagpat district, headed by SMS Agri. Deptt.	04 Jan., 2011	27	-	27
2.	Doordarshan team	Doordarshan team along with Project Director of the Directorate visited the OFT in Mahal village	12 Jan., 2011	9	-	9
3.	Institute/Field visit	Farmers from Bagpat district (UP), headed by SMS Agri. Deptt.	27 Jan., 2011	27	-	27
4.	Institute/Field visit/ laboratory visit	Officers from NABARD (CGM-1, GM-2, DGM-2, DDM-50 and Others-5)	27 Jan., 2011	59	1	60
5.	Institute/Field visit/ laboratory visit	Participants/ delegates of Workshop-cum-consultation meet of NPOF and Organic farming.	23 Feb., 2011	25	-	25
6.	Field visit	Farmers from Shahjahanpur district (UP), headed by SMS Agri. Deptt.	02 Feb., 2011	52	-	52
7.	Off campus training on maize production technologies	Farmers & venue Akaroli village.	24 March, 2011	7	-	7
8.	Field visit	Farmers from Bagpat district (UP), headed by I/C Agri. Ext., Bagpat	6 August, 2011	26	-	26
9.	Field visit	Farmers from Bagpat district (UP), headed by I/C Agri. Ext., Bagpat	11 August, 2011	26	-	26
10.	Field visit	Participants from DASP	11 August, 2011	28	-	28
11.	Farmers training	Collaborative training programme on IFS	5-10 Sept., 2011	29	1	30
	Total			315	2	317

programmes were organized. A total of 317 farmers/ farm women and officers from different states/ district attended the programmes.

Impact assessment of on-campus training

Farmers' Training on *Kharif* crop production technology was organized before the *kharif* season of 2010 in order to upgrade the knowledge of the farmers in cultivation of rice, maize, oilseed (sesame) and pulses (arhar, moong and urd). The farmers were also imparted training on plant protection measures in these crops. The training was of 3 days duration and was organized in the Directorate premises. It was attended by 31 farmers of two villages namely, Mahal and Shyampur of Daurala block of Meerut district. The training was imparted through classroom lecture with power point presentation in Hindi followed by practical session at the Directorate's farm. The participant farmers were also given supportive literature on the crops included in the training.

A questionnaire was developed to assess the impact of training on farmers' knowledge. The same set of questionnaire was given to the farmers before the start of the training and after the end of the training. The detail of training impact is given in tables-9.5.9.

A collaborative training programme on Integrated Farming Systems was organized during 5-10 September, 2011 for the progressive farmers registered with NABARD. The training programme was sponsored by NABARD, Kolkata in which 30 progressive farmers/ representative of farmers club participated. The participants were from seven states of Northern India viz., Himachal Pradesh, Uttarkhand, Punjab, Haryana, Uttar Pradesh, Bihar and Madhya Pradesh. The training was imparted through class room lecture, followed by practical session, and field visits. A compendium of lecture notes and other publications of the Directorate were also given to the trainees. The impact assessment of the training programme was carried out through pre-structured questionnaire and the results are presented in Table-9.5.10.

Table 9.5.9: Impact of training on farmers' knowledge with relation to crop production

Name of crop	% Score obtained by farmers		% Gain in knowledge (B-A)
	Pre-training (A)	Post training (B)	
Rice	8.26	46.32	28.06
Maize	8.26	32.81	29.55
Oil seed	9.29	37.29	27.94
Pulse	12.97	42.42	29.45
Plant protection	12.61	46.74	34.13
Total	12.28	42.10	29.83

Table 9.5.10: Impact of training on farmers' knowledge with relation to Farming system

Name of crop	% Score obtained by farmers		% Gain in knowledge (B-A)
	Pre-training (A)	Post training (B)	
Crop production	28.7	36.6	7.9
Horticulture	58.6	85.6	27
Fishery	45.5	72.4	26.9
Animal Science	35.9	56.5	20.6
Organic Farming	58.6	75.9	17.3
Agril. Engineering	59.3	77.2	17.9
Plant Protection	36.6	45.3	8.7
General	45.7	75.9	30.2
Average gain	46.1	65.7	19.6

On-farm Integrated Farming Systems Management

For selection of new village for the project "On-farm Integrated Farming Systems Management", survey of Madarpur village in Daurala block of Meerut district was conducted by contacting randomly selected 50 farmers to identify the constraints/ problems prevailing in the village in farming systems perspective. Pre-tested interview schedule was used for the survey to ascertain socio-economic profile of farmers, distribution of land holdings for different/ enterprises, major farming systems prevailing in village, adoption of different farm enterprises, farmers' perception about agro-ecosystem, farmers' perception of technological constraints, input use pattern etc. The survey revealed that Agriculture + Dairy (30% adoption) was the predominant farming system in the village followed by Agriculture + Dairy + Horticulture + Agro-forestry (22.5% adoption), Agriculture + Horticulture (12.5% adoption) and Agriculture + Dairy + Horticulture (12.5% adoption).

Front-line demonstration on mustard

Ten Front-line demonstrations on oilseed (Mustard Var. Pusa bold) were laid out in Mahal and Shyampur villages of Daurala block of Meerut district during *rabi*, 2010-11. The comparison of improved practice (use of recommended variety, optimization of the plant population, balanced/


On-farm demonstartion of proven technologies under AICRP-IFS recommended dose of NPK @ 12:60:60 and plant protection) and farmers' practice (use of local variety and NPK @ 80:60:0) was made. The improved practice resulted in increase in yield by 30.62 percent over the farmers' practice (Table-9.5.11).

Economics of cultivation of front-line demonstration on mustard

The economics of both improved practice (IP) and farmers' practice (FP) of mustard variety Pusa bold was worked out. The results revealed that by making an additional expenditure of Rs. 1345/- in the form of fertilizer and quality seed of high yielding variety, the increase in net return under IP was Rs. 11475/- per hectare over FP. As regards benefit cost ratio, it was 1.84 in IP as compared to 1.50 in FP (Table-9.5.12).

Feasibility of turmeric intercropped with sugarcane under organic conditions

An observational study was conducted to find out the feasibility of turmeric intercropping in sugarcane. Plant height in case of both turmeric as well as sugarcane enhanced under intercropping as compared to sole crops. However cane weight was more in sole sugarcane. Comparing sugarcane equivalent yield turmeric sole proved much productive (198.1 t ha^{-1}) as compared to sole sugarcane (38.7 t ha^{-1}) and turmeric intercropped with sugarcane (123.7 t ha^{-1}).

Table 9.5.11: Performance of demonstration on mustard

Practice	Variety	No. of Demonstrations	Yield (q/ha)	% increase in yield over FP
Farmer's Practice	Local	10	17.57	
Improved Practice	Pusa Bold	10	22.95	30.62

Table 9.5.12: Economics of FLD on mustard

Items	IP/ha (A)	FP/ha (B)	Difference (A-B)
Cost of cultivation (Rs.)	27457	26112	1345.00
Yield q/ha	22.95	17.57	5.20
Gross return (Rs.)	50490	39050	11440.00
Net return (Rs.)	23033	12938	10095.00
BC ratio	1.84	1.50	

Table.9.5.13: Component yield, sugarcane equivalent yield of sugarcane and turmeric in sole as well as in intercrop

Treatments	Plant height (cm)	Weight(kg) $cane^{-1}$ & nos. of tuber $plant^{-1}$	Yield (t ha^{-1})	SEY (t ha^{-1})
Sugarcane (S cane+ turmeric)	189.5	0.92	37.9	37.9
Turmeric (S cane+ turmeric)	101.2	0.22	3.0	85.7
Sugarcane (sole)	183.9	0.97	38.7	123.7
Turmeric (sole)	90.7	0.24	6.9	38.7

9.6 EXTERNALLY FUNDED PROJECTS

Ensuring lively hood security through farming systems approach in Tehari District Uttara Khand

Under this project 20 villages were selected at two locations of Tehri district. Total 200 farm families were interviewed for the study. A bench mark survey was carried out at village level. On the basis of preliminary survey, different constraints were identified viz., unavailability of improved variety in local market, imbalanced nutrition in crops, lack of proper irrigation facility, use of traditional cultivation practices in agriculture whereas, insufficient green fodder, parasite and disease problem, poor skill, imbalanced feeding in animals and unavailability of improved agricultural inputs were identified in different farm enterprises adopted by the farmers. On the bases of identified constraints, best possible solutions in terms of interventions viz., improved variety, weed management, improved seeds for kitchen gardening, de worming of calf and mineral mixture for improvement in milk production as well as health improvement, and check the sterility problem of miltch animals, were also given to the 200 adopted farm beneficiaries .

Under the project those farmers adopting crop + live stock farming system, intervention for improving milk production etc. 40 grams mineral mixture with concentrate feed per day was given to each milch animals. It was found that on in average milk production increased 0. 5 to 0.75 lt. per day in comparison to control group and 2 weeks advancement in heating was observed.

Psychological characteristics of Tehri farmer

It was found that the majority of farmers had low attitude and only 10% had high level of attituded towards various improved technologies of different farm enterprises. However, respondents had low, medium and high level of knowledge and these were 45, 32 and 23 respectively. Up to 81 percent of respondents had low to medium level of risk bearing capacity.

Photo 9.6.1. Disease problem in mango plant at field level

Photo 9.6.2. Doordarshan team visited adopted village


Photo 9.6.3. Demonstrations of kitchen garden technology for growing of coriander and vegetable pea

Photo 9.6.4. Feeding of mineral mixture to milch animal

Photo 9.6.5. Administration of broad spectrum Anthelmintic suspension to calf

Cropping System Analysis of India Using Remote Sensing, Geographical Information System and Ground based data

In order to characterize and identify production constraints of various cropping systems in different agro-climatic zones of Indo Gangetic Plain, a diagnostic survey jointly by the Project Directorate for Farming Systems Research (PDFSR) and Space Applications Centre (SAC), Ahmedabad was undertaken. The objectives of this collaborative project were to evaluate and characterize current cropping systems through various parameters/ indicators and suggest required diversification/ intensification and to analyze long term changes in cropping system using historical agricultural information. During the year of reporting 2011-12, we have synthesized the surveyed information and analysed the spatial variations of rice based cropping systems productivity over Pubjab in relation to spatial variability of fertilizer use, fertilizer availability pattern, pH, electirical conductivity (EC) and organic carbon (OC) of soil..

Rice based cropping system is the predominant cropping system, which occupies around 69.2% of the total agricultural area followed by 11.7% under cotton based cropping system. Rice-wheat rotation is the dominant rice based cropping system, which occupies 74.6 % area followed by rice-potato of 24%. The rice-pea, rice-mustard and rice-jai are the minor rice based cropping system followed in Punjab. As the Punjab has well developed irrigation facility (tube well and canals), it has enormous potential of fertilizer use in the region. The most commonly used fertilizers were nitrogeneous, phosphastic and potassic and some micro-nutrients like Zn. The district-wise total fertilizer use (NPK) showed that there exist a large spatial variation of N @ 316 kg ha^{-1} in Gurudaspur district to 158 kg ha^{-1} in Hosiarpur district (Table 9.6.1), of P @ 144 kg ha^{-1} in Muktsar to 58 kg ha^{-1} in Hoshiarpur and of K @ 98 kg ha^{-1} in Firozpur to 0 kg ha^{-1} in Hoshiarpur in rice-wheat cropping system.

A wide inter-district variation exists for fertilizer use per unit cropped area under rice-potato cropping system. On an average 267 kg ha^{-1} N, 265 kg ha^{-1} P and 149 kg ha^{-1} K consumed in rice-potato cropping system. The availability of N also found large scale spatial variation of 238 kg ha^{-1} in Firozpur to 142 kg ha^{-1} in Gurdaspur. The availability of P showed no significant spatial variation. The availability of K also showed large scale spatial variation of 243 kg ha^{-1} in Mansa to 126 kg ha^{-1} in Ludhiana. To know the spatial variation pattern, GIS maps were created for total N,P,K use and available N,P,K (Fig. 9.6.1 & 2).

Spatial variation of EC, pH and OC

The district-wise average EC, pH and OC showed that there exists a wide spatial variability in

Table 9.6.1. Total fertilizer use and available (N,P,K) in rice-based cropping system

Districts	Cropping System	Fertilizer					
		Use kgha^{-1}			Available kgha^{-1}		
		N	P	K	N	P	K
Amritsar	Rice- Wheat	282	101	45	184	12	163
Bhatinda	Rice- Wheat	308	90	16	154	10	163
Firozpur	Rice- Wheat	258	115	98	238	11	231
Gurdaspur	Rice- Wheat	316	77	50	142	11	177
Hoshiarpur	Rice- Wheat	158	58	0	188	9	130
Jallandhar	Rice- Wheat	259	129	38	169	11	146
Kapurthala	Rice- Wheat	239	104	19	182	12	198
Ludhiana	Rice- Wheat	312	134	39	162	15	126
Mansa	Rice- Wheat	314	117	83	196	13	243
Muktsar	Rice- Wheat	208	144	27	152	12	143
Ludhiana	Rice-Potato	175	247	188	163	10	86
Hoshiarpur	Rice-Potato	288	288	150	163	15	168
Amritsar	Rice-Potato	352	252	113	201	17	216
Jallandhar	Rice-Potato	254	271	144	184	13	148

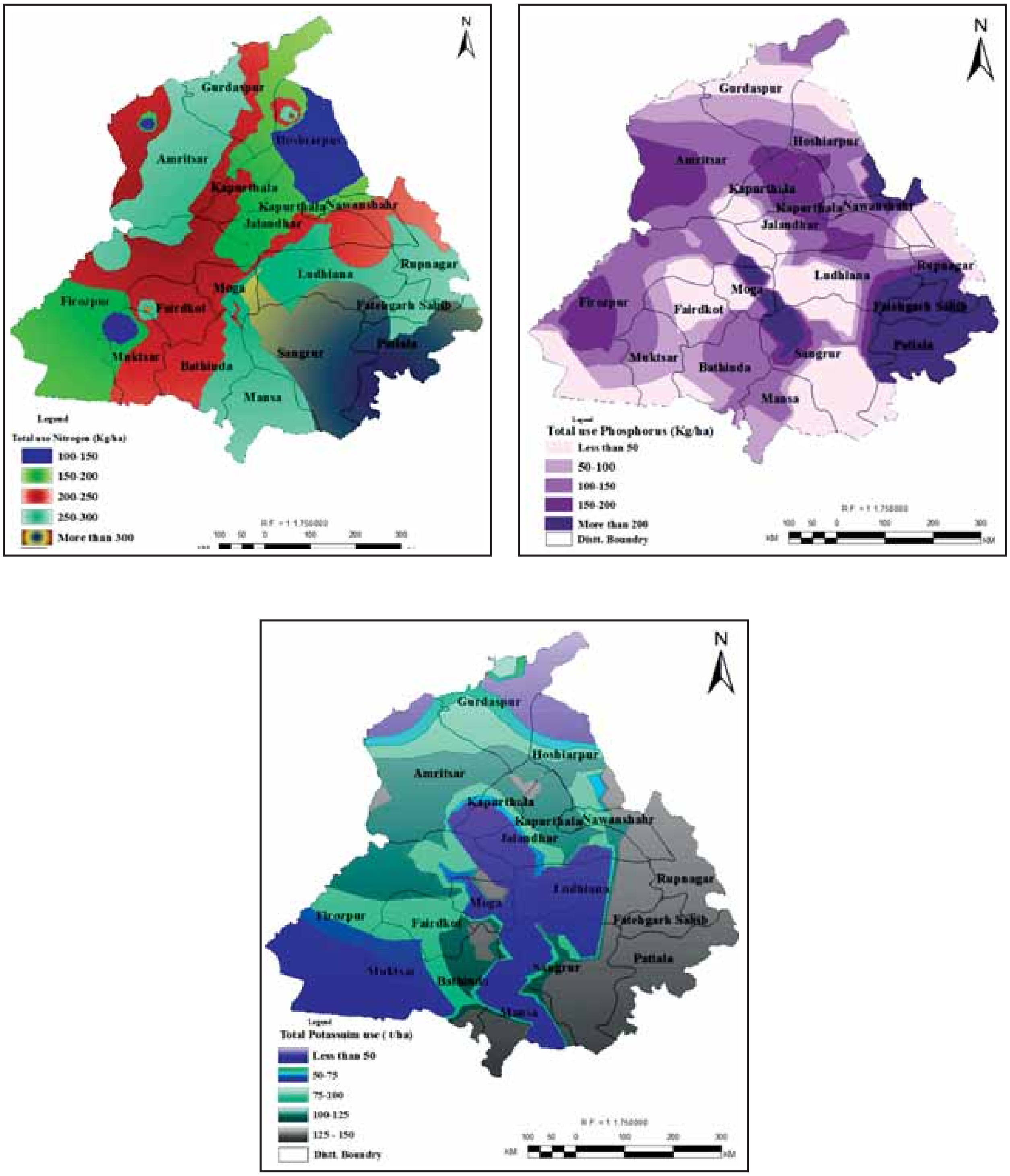


Fig.9.6. 1. Spatial variation of fertizer (N,P,K) use in rice based cropping systems of Punjab

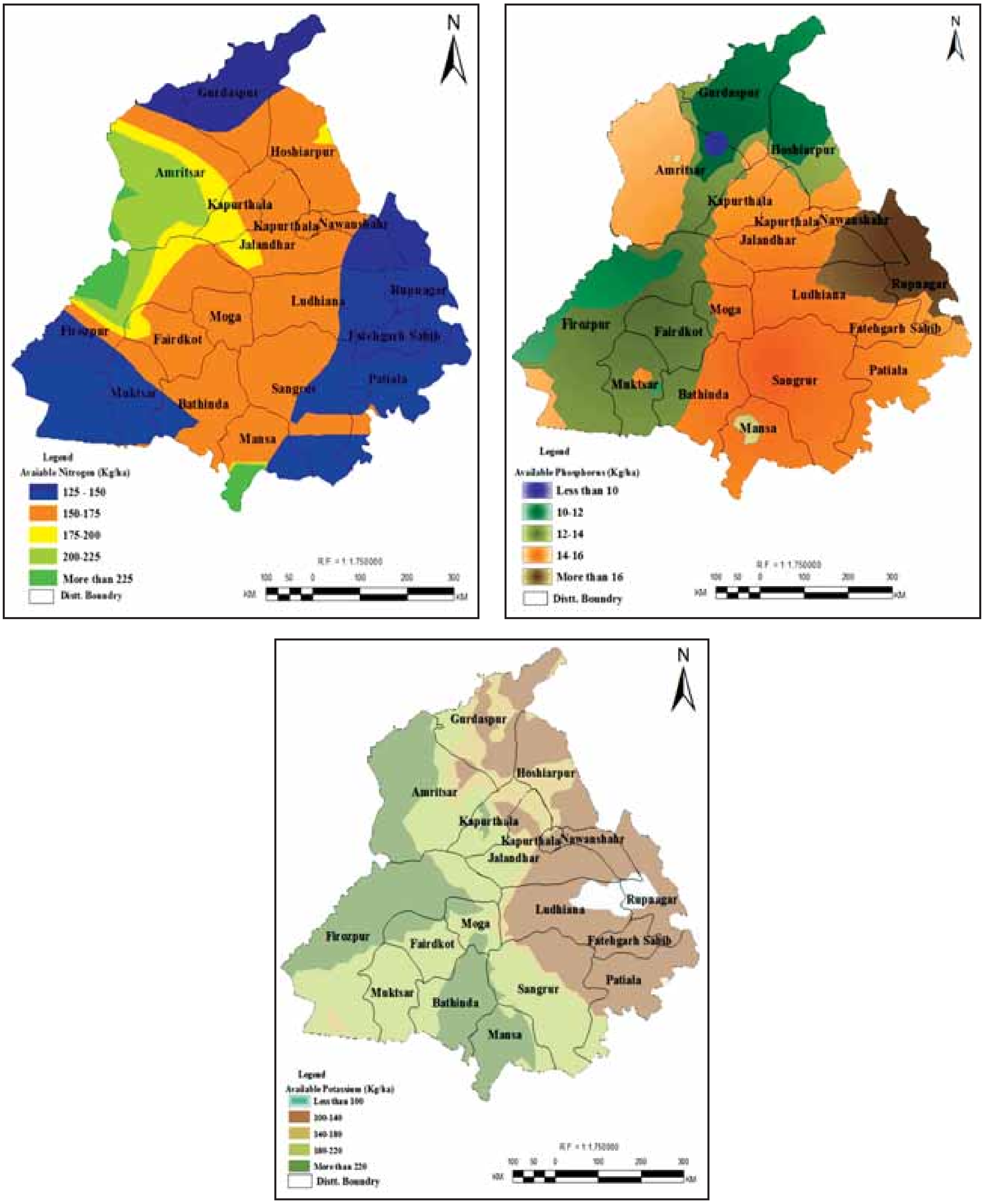


Fig. 9.6.2. Spatial variation of available N,P,K in rice based cropping systems of Punjab

rice based cropping systems of Punjab (Table 2). EC showed a maximum value of 0.41 in Mansa to 0.21 at Firozpur while pH showed highest of 8.5 over Kapurthala under rice-wheat and Hishiarpur under rice-potato.

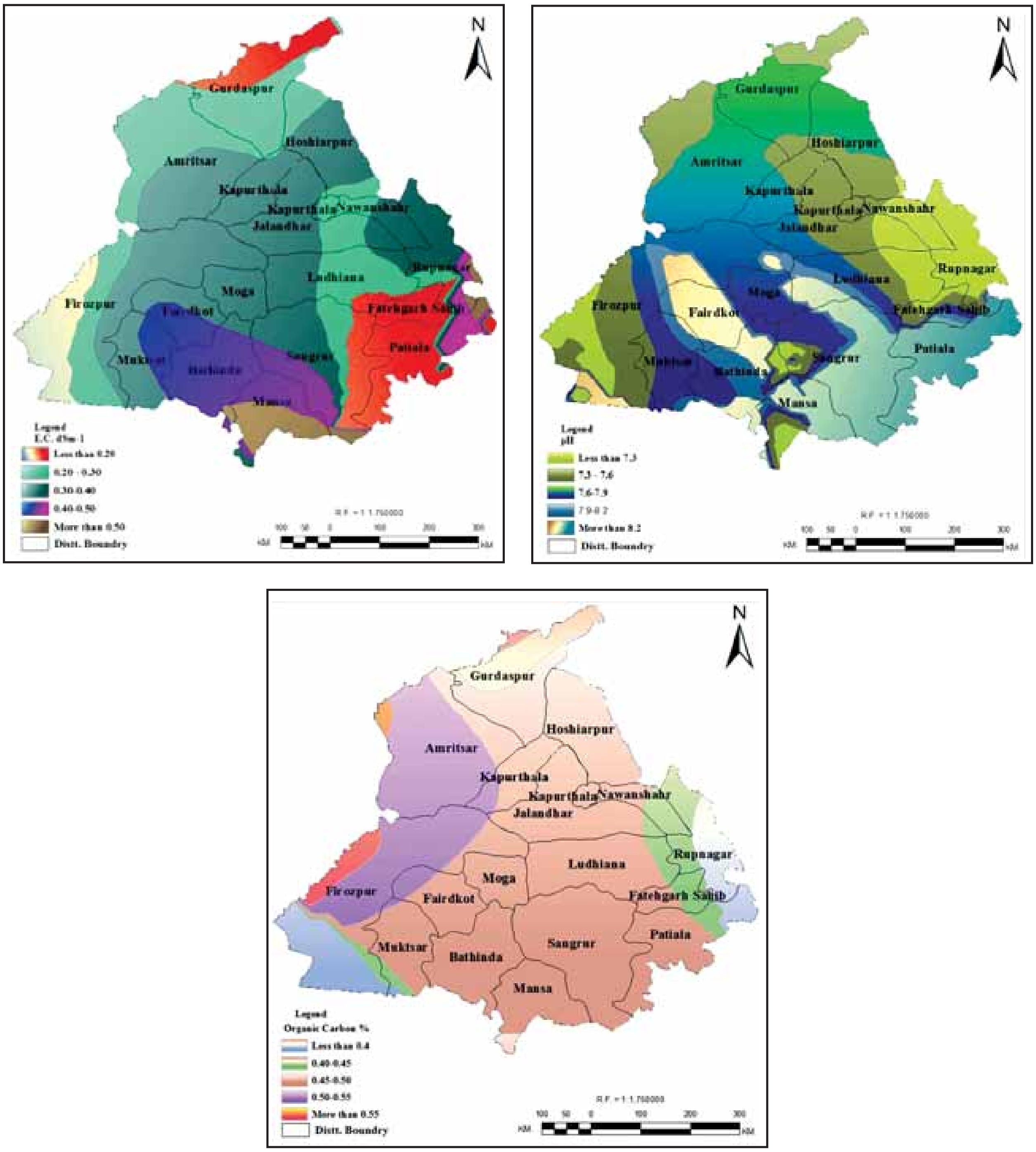


Fig. 9.6.3. Spatial variability of EC, OC and pH under rice-based cropping systems of Punjab

Table 9.6.2. District-wise EC, pH, OC and REY(t ha^{-1}) of rice based cropping systems of Punjab

Districts	Cropping System	EC dSm^{-1}	pH	OC%	REY (t ha^{-1})
Amritsar	Rice- Wheat	0.28	7.8	0.61	12.1
Bhatinda	Rice- Wheat	0.40	8.4	0.49	10.8
Firozpur	Rice- Wheat	0.21	8.3	0.69	13.3
Gurdaspur	Rice- Wheat	0.22	8.1	0.41	11.8
Hoshiarpur	Rice- Wheat	0.28	7.9	0.52	12.5
Jallandhar	Rice- Wheat	0.25	7.8	0.58	13.1
Kapurthala	Rice- Wheat	0.33	8.5	0.58	12.2
Ludhiana	Rice- Wheat	0.22	7.7	0.50	12.1
Mansa	Rice- Wheat	0.41	8.4	0.65	13.4
Muktsar	Rice- Wheat	0.33	8.1	0.50	13.0
Ludhiana	Rice-Potato	0.28	7.3	0.46	15.3
Hoshiarpur	Rice-Potato	0.25	8.5	0.57	13.0
Amritsar	Rice-Potato	0.22	8.3	0.62	17.5
Jalandhar	Rice-Potato	0.26	7.8	0.53	16.5

The organic carbon value showed highest of 0.69 % over Firozpur to 0.41 at Gurdaspur. The spatial variability maps of EC, pH and OC were created under GIS environment (Fig. 9.6.3).

Spatial variability of REY (t ha^{-1}) and relation between EC, OC and pH with system productivity

To know the empirical relationship of yield variability and total N,P,K use and available N,P,K, EC, pH, OC and the yields were grouped into three categories (Fig. 9.6.4) based on the standard deviation (Group I (high) - < 15.9 t ha^{-1}, Group II (normal)- 10.7 – 15.9 t ha^{-1} and Group III(low)- $>$ 10.7 t ha^{-1}). It is found that higher rice equivalent yield of rice based cropping system may be due to higher use of NPK and also with the available N. The variation of available P and K is not significant among the yield groups. REY falls under lower side where areas having lower EC and pH (Table 9.6.3).

Table 9.6.3: Relation between REY under rice based cropping system and fertilizer use, fertilizer availability, EC, pH and OC of the soil

REY Group	Fertilizer						EC	pH	OC
	Use kg ha^{-1}			Available kg ha^{-1}					
	N	P	K	N	P	K			
<15.90	284	249	142	194	13	160	0.24	7.9	0.5
10.65-15.90	277	127	46	174	13	157	0.27	8.0	0.5
>10.65	250	122	28	166	12	168	0.32	8.2	0.6

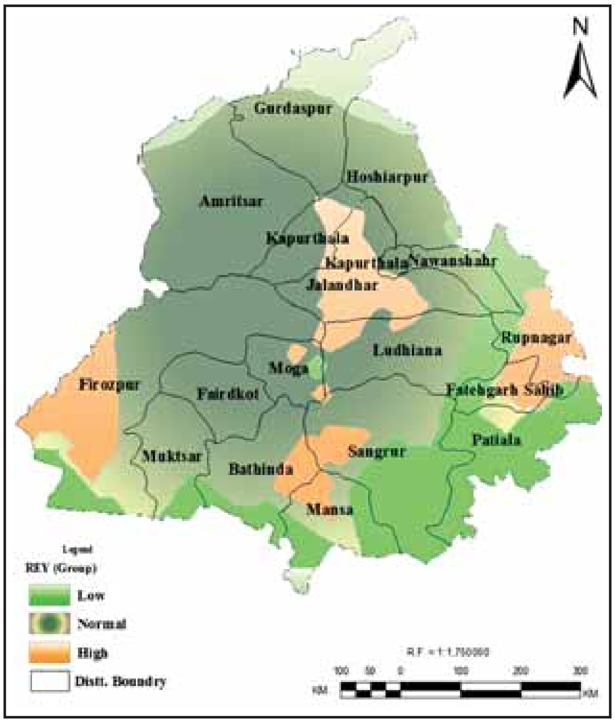


Fig. 9.6.4. Spatial variability of rice equivalent yield (t ha^{-1}) under different groups in rice based cropping system

Study of crop pattern and increase in agricultural produce due to release of water from *Tehri* reservoir for irrigation purpose

During 2011 the impact of release of irrigation water through *Tehri* Dam was studied on increase of farm house-hold income in Agra canal command, East- Ganga canal Command and East Yamuna canal command. Also the overall economic gain at Command level was estimated.

Change in economic status of the farmers

Benchmark studies were conducted under different canal command to assess the change in economic status of different farmers' category (holding size) with introduction of additional irrigation water and interventions made during the study period.

The details about different component enterprises under different canal command are given here as under.

East Ganga Canal Command

Changes in farmers' economic status

At the onset of the study, farmers were mostly having crops and dairy enterprise for their lively hood. On an average, their total income was in the range of 1.47 to 2.13 lakhs (mean 1.18 lakh/family). Of this, crop and dairy shared 77% and 23%, respectively. After 03 years, same farmers from same site were assessed for change due to interventions and it was noticed that farmers have not only raised their crop or dairy productivity, but have also started growing vegetables and fruits. Apart from this, some of the farmers are using waste water for fish production. With such change in farming system, the overall profit was increased from 2.22 to 3.21 lakh (mean 2.63 lakh)/family. Of this, total profit, crop, dairy, vegetable, fruits and fish enterprises share 63%, 22%, 2.3% and 8.6%, respectively. Comparing the contribution of different enterprises under different farmers holding size group, large farmers had maximum contribution through crop, followed by medium (61%) and small farmers (49%) whereas contribution of dairy, vegetable, fruits and fish enterprises was maximum by small farmers (25%, 13% and 12% respectively) followed by medium farmers (23%, 8% and 9%, respectively) and lowest with large farmers (18%, 40% and 8%, respectively) (Fig. 9.6.5).

Further assessment of change in profitability per family / year indicates that maximum profit was acquired by large farmers (0.94 lakh/year) followed by medium farmers (0.72 lakh/year) and small farmers (0.58 lakh/year).

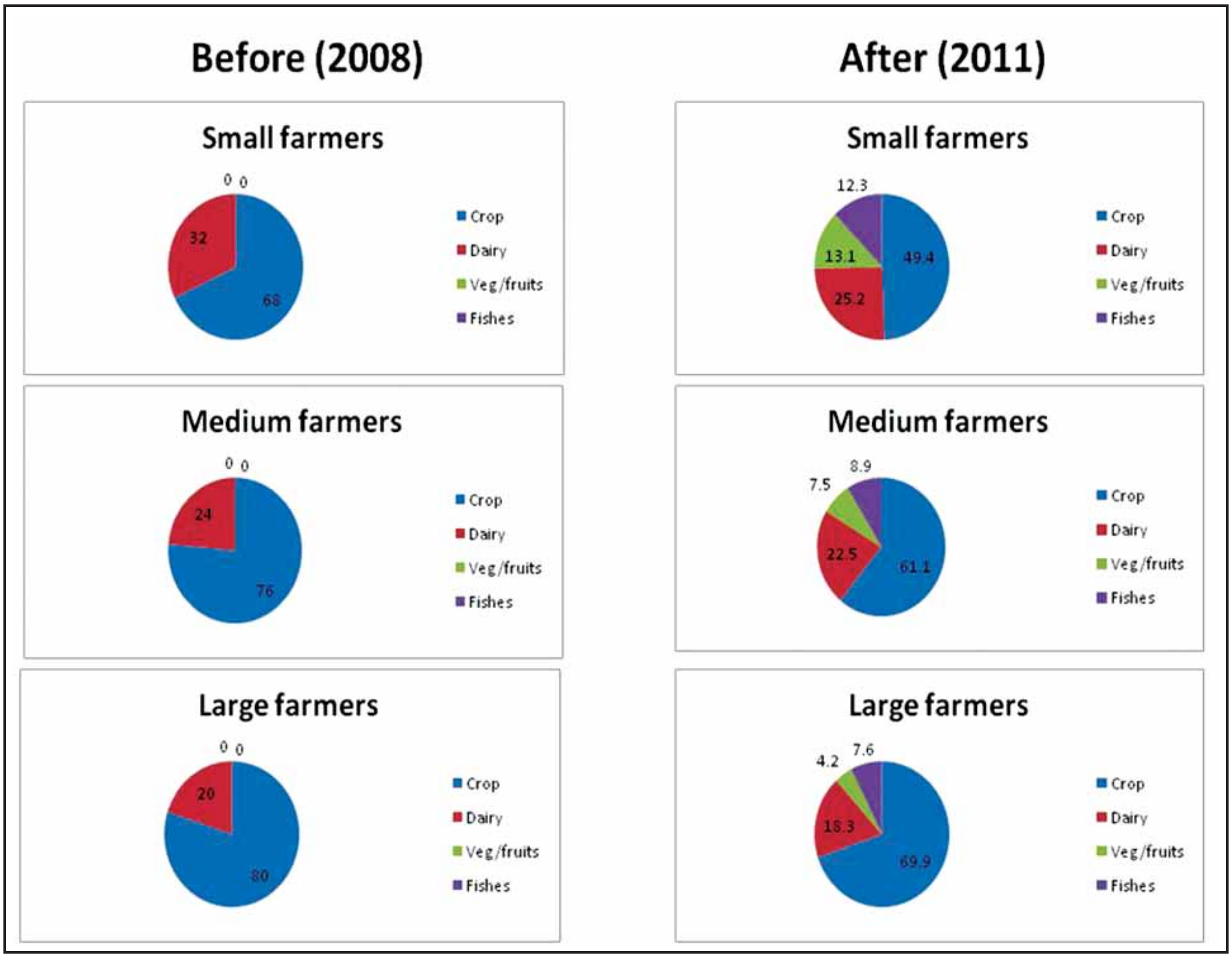


Fig. 9.6.5. Contribution of different enterprises (%) of farmers on total profit under East Ganga Canal command

Changes in farmers' expenditure status

The routine expenditure on food, education, clothing, health, communication, transport and general maintenance were assessed at the beginning as well as completion of the study. In general, farmers spent maximum on food, education, clothing, health, communication, transport, general maintenance etc. After 03 years of study, it was noticed that farmers had started spending more on their daily life and on imparting better educational facilities to their children. Their food quality, health care, clothing, communication and transport expenditure had increased sizeably. After deducting these expenses, their net savings had improved ranging from 0.66 lakhs to 1.26 lakhs/family/year (Fig. 9.6.6). Further summarizing the data within the different farmers holding size, the maximum net balance was accrued with large farmers (1.33 lakhs/family/year)., followed by medium (0.65 lakh/family/year) and small farmers (0.62 lakh per family/year).

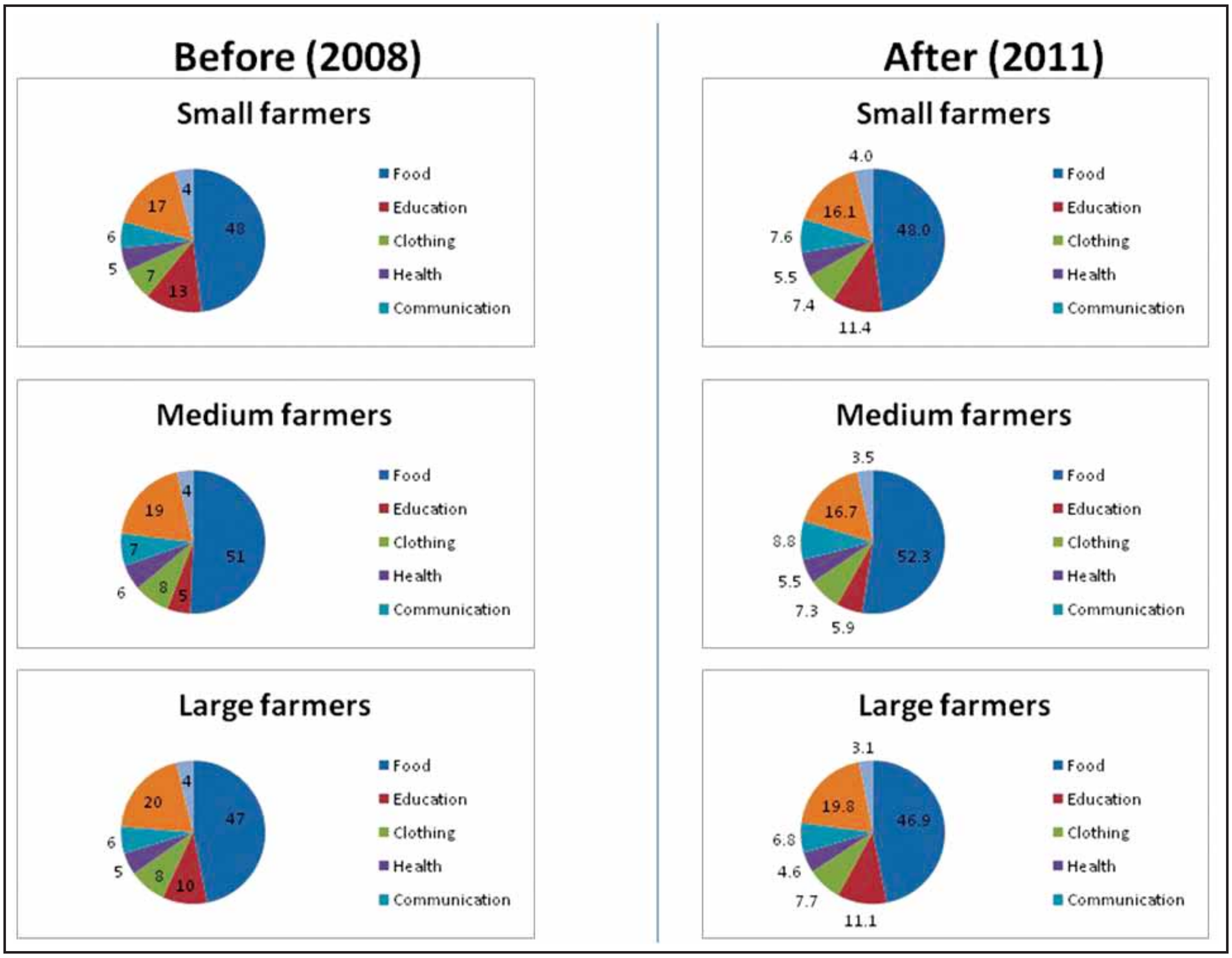


Fig. 9.6.6: Changes in expenditure status of farmers (%) under East Ganga Canal Command

East Yamuna Canal Command

Changes in farmers' economic status

Although the additional irrigation water could not be released in EYC during the study period but the intervention made during the study had significant impact on the profitability of the farmers. In general, crop and dairy enterprise were common in this region but due to technological intervention, some of the farmers have started growing vegetables and fruits also. In villages Mehrampur and Sadpur Kala, farmers in each village had started fisheries with seedlings of Rohu, Katla and Mrigal. A comparison made after 03 years of technological intervention, it was noticed that the farmers started getting 0.35 to 1.78 lakhs additional income due to all these interventions (Fig.9.6.7).

Changes in farmers' expenditure status

With increasing income, farmers have started spending more on education, health, transport, communication facilities and other routine expenses. The net saving was also increased ranging from 0.39 to 1.67 lakh per family per year. Further classifying the data under different holding size group, maximum saving was with large farmers (Rs. 2.33 lakh/family/

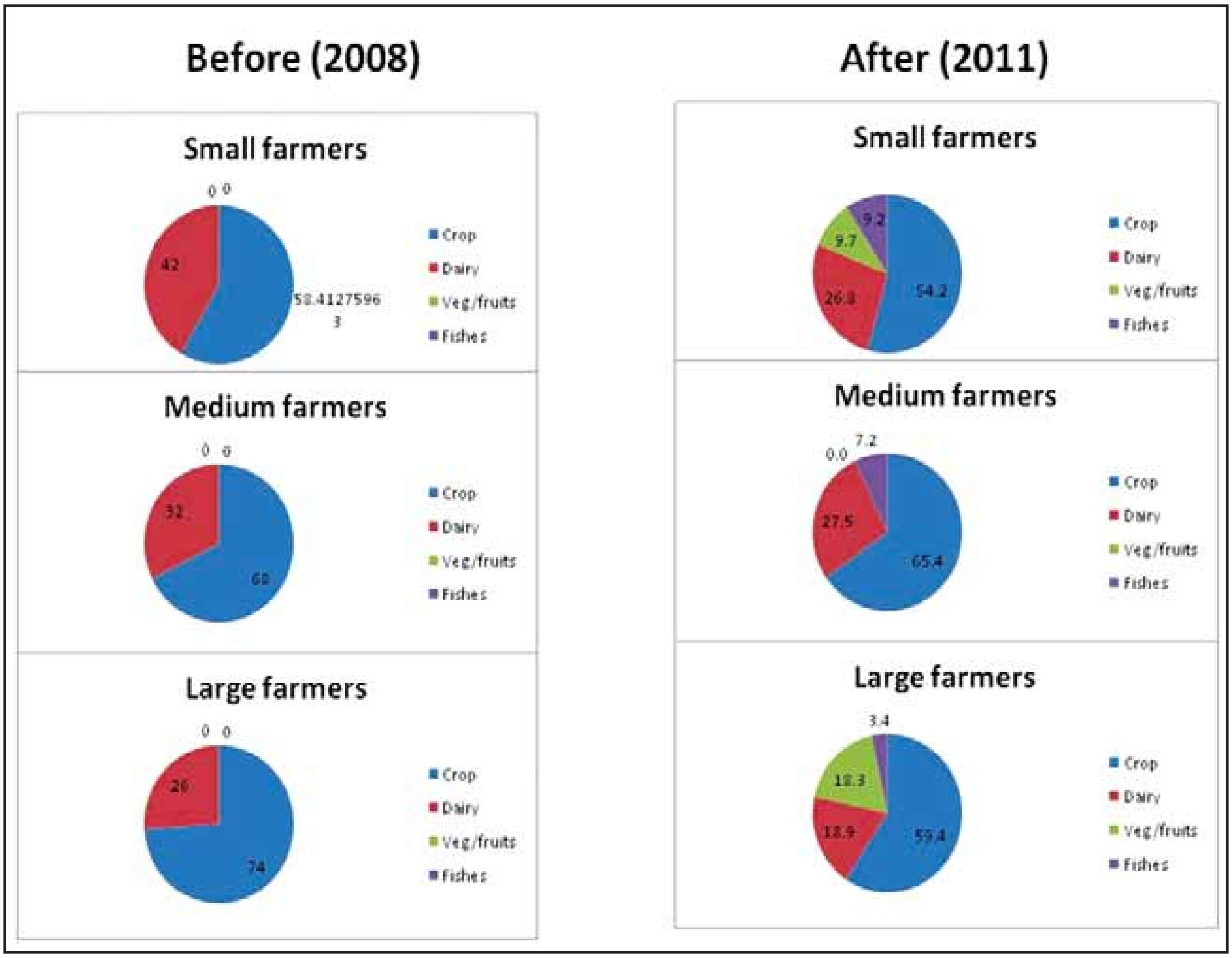


Fig. 9.6.7: Contribution of different enterprises (%) with farmers on total profit under East Yamuna Canal Command

year) followed by small farmers (Rs. 0.99 lakh/family/year) and medium farmers (Rs. 0.90 lakh/family/year). It is pertinent to mention that more expenditure was also in the same fashion, which may be ascribed to small and large farmers who had started growing vegetables and horticultural crops for commercial purpose. The contribution of different enterprises on total profit with farms and change in daily expenditure during study period is given in Fig. 9.6.8.

Agra Canal Command

Changes in farmers' economic status

Alike EGC, crop and dairy enterprises were pre-dominant enterprises with the farmers. Due to continuous availability of irrigation water farmers had started growing vegetable and fruits for their own consumption as well as for marketing. The overall profitability with different farm enterprise were

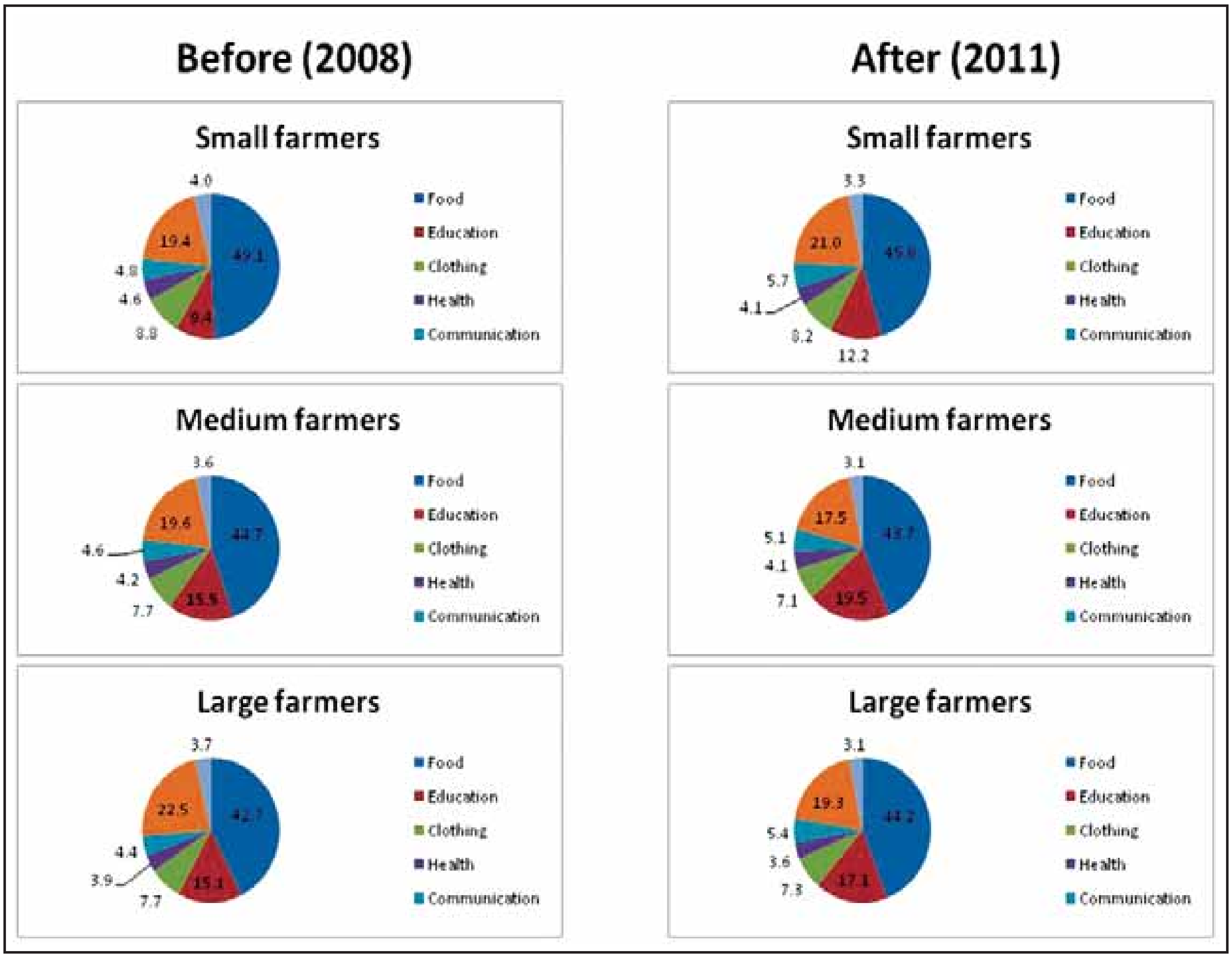


Fig. 9.6.8: Changes in expenditure status (%) of farmers under East Yamuna Canal Command

increased by 0.12 to 1.64 lakhs/family /year (mean Rs. 0.89 lakhs) due to better irrigation water availability and technological intervention. The average improvement with small, medium and large farmers was of 0.44, 0.68 and 0.58 lakhs/ family/ year. Of these, income improvement 10-11% was shared by the horticultural crops i.e., vegetables and fruits (Fig. 9.6.9).

Changes in farmers' expenditure status

With improvement in economic status, farmers have started using more balanced food, imparting better education to their children, spending more on quality bearing, health, transport and communication etc. All these components are indicators of a better living being and over-all development of farming community. Even after increase in their daily expenses, the net saving was also improved which they may use for infra-structural development and other futuristic purposes. The over-all increase in saving in Agra Canal Command was in the range of Rs. 0.06 to 1.41 lakhs (mean Rs. 0.53 lakhs/family/ year). Further categorising the annual saving under different farm holding size group, it was maximum with medium farmers (Rs. 0.47 lakhs /family / annum), followed by large farmers (Rs. 0.20 lakhs / family / annum) and small farmers (Rs. 0.020 lakhs / family

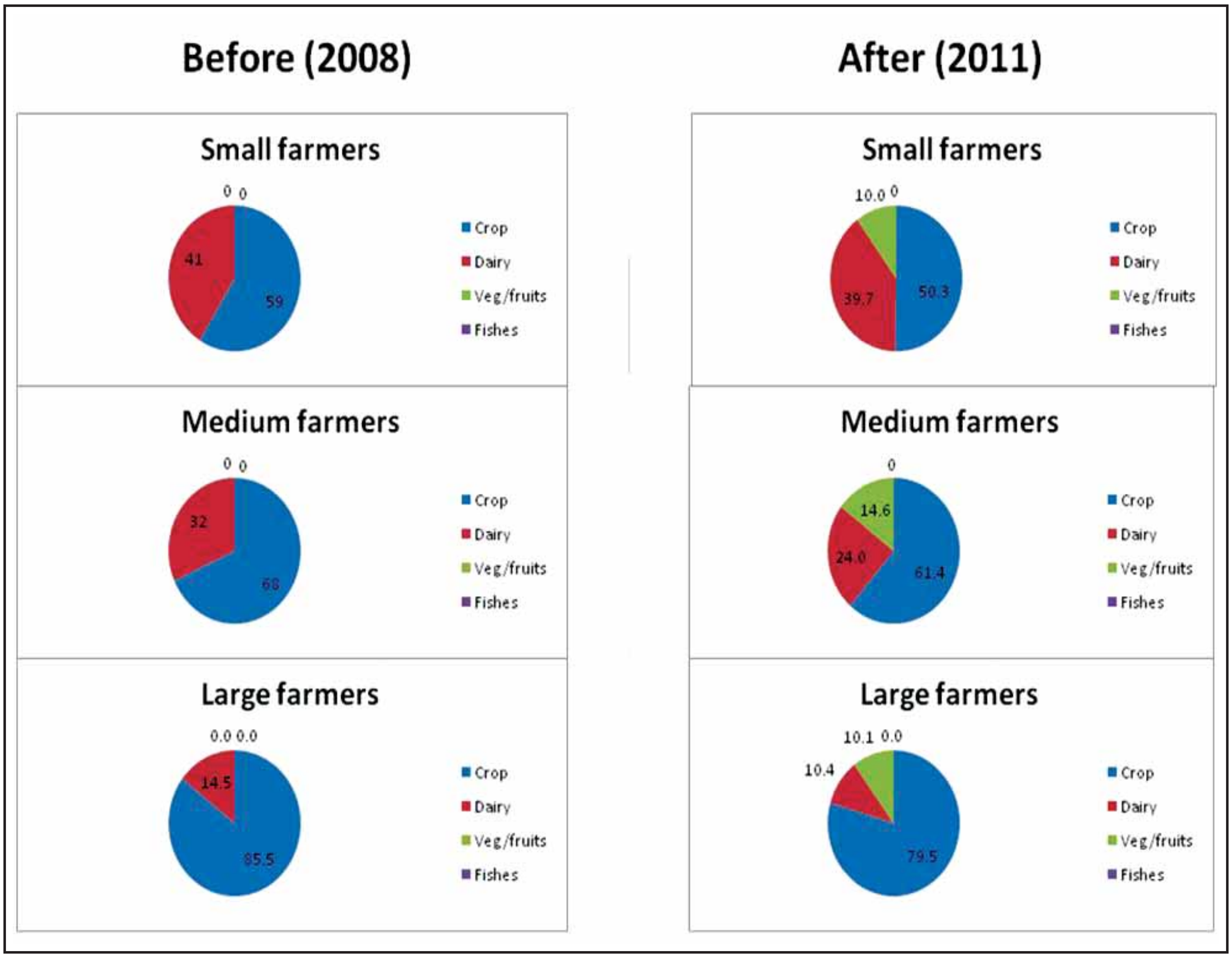


Fig. 9.6.9: Contribution of different enterprises (%) with farmers on total profit under Agra Canal Command

per annum. Percent change in expenditure on daily needs of the farmers in different categories are given in Fig. 9.6.10.

Impact of irrigation water availability on overall productivity and profitability of agricultural produce in Agra Canal Command

Area under different crops

Area under different predominant crops was obtained from Divisional Canal Department, Agra and it was used as basis for estimation of change in agricultural produce in whole Agra Canal Command.

Agra Canal Command is basically divided into two divisions, namely, Upper Division Canal and Lower Division Canal Command. The Upper Division Canal Command is spread over Faridabad, Mathura and Palval district and Mewat region, whereas Lower Division Canal Command covers the significant areas of the district Agra, Mathura and Bharatpur. Area under different crops in each district falling under Agra Canal Command (Upper Division Canal and Lower Division Canal) is given in Table 46. In *kharif*, maximum area was under rice (5840 ha) followed by fodder crop (2801 ha), sorghum and bajra (1274 ha) and lowest under Green Manure crop like dhaincha (0.8 ha) in Lower

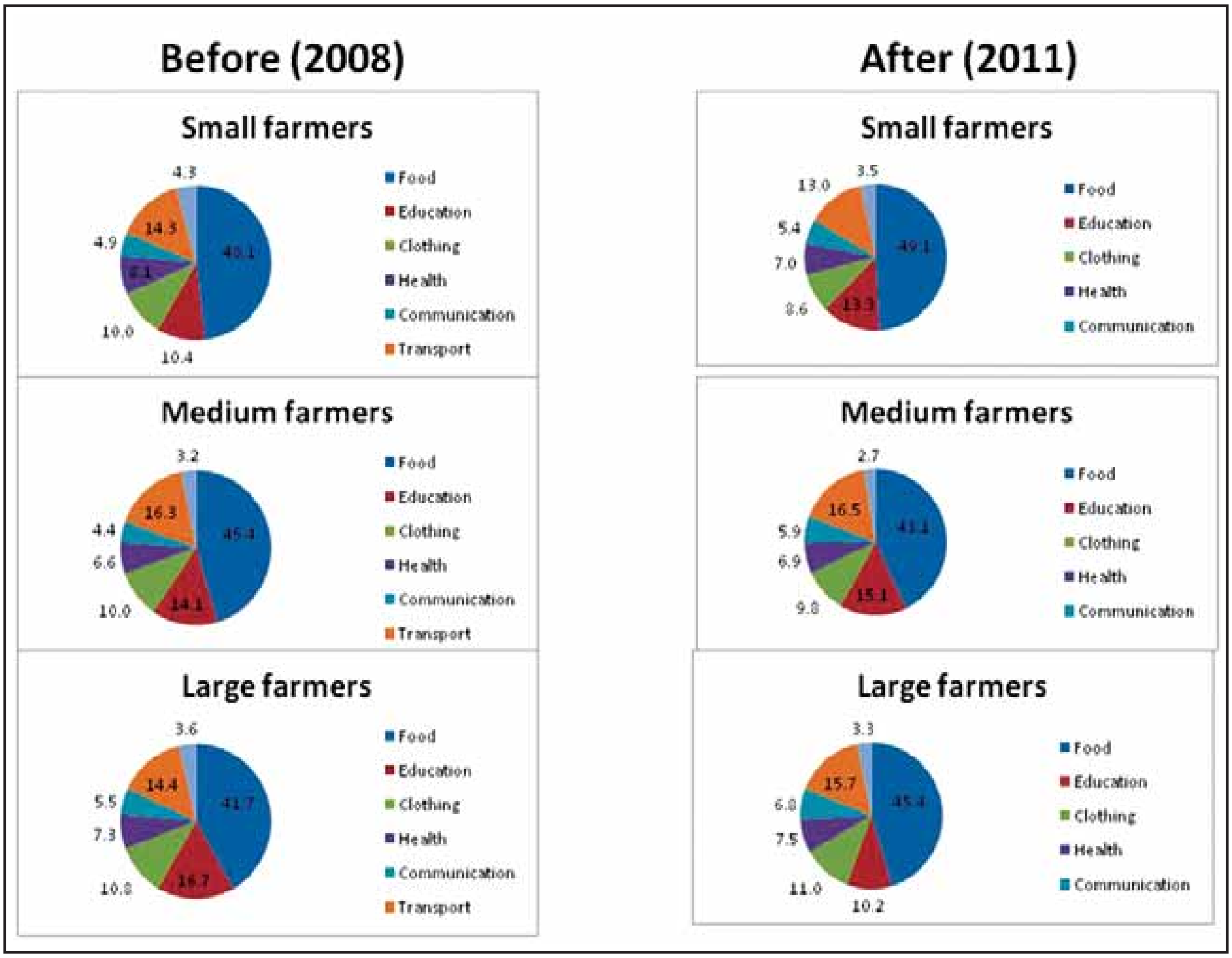


Fig. 9.6.10: Changes in expenditure status (%) of farmers under Agra Canal Command

Canal Command. The crops like wheat, barley and chickpea had highest area during *rabi* season in Lower Division Canal command. Similar area spread under Upper Division Canal command was with rice (8072 ha) followed by fodder (1975 ha), sorghum, bajra (503 ha), sugarcane (191 ha) during *kharif* and in wheat, barley and chickpea (31062 ha), pea, mustard and masoor (834 ha), barseem (834 ha) and potato (603 ha) during *rabi* season (Fig. 9.6.11).

Apart from these, some minor area under aromatic and high value crops like flowers etc was also seen but the reported area was not available for these crops. During discussion with farmers, it was noticed that regular and more availability of water brought some additional area under different crops but due to non availability of such data, only area reported by irrigation division is used herewith for estimation purpose.

Change in productivity

Change in productivity under different pre-dominant crops of *kharif* and *rabi* seasons were assessed based on the yield data recorded from a unit area during the bench mark survey made in year 2008 and 2011. The per cent difference during the period in each crop's productivity was used for extrapolation of data for whole canal command.

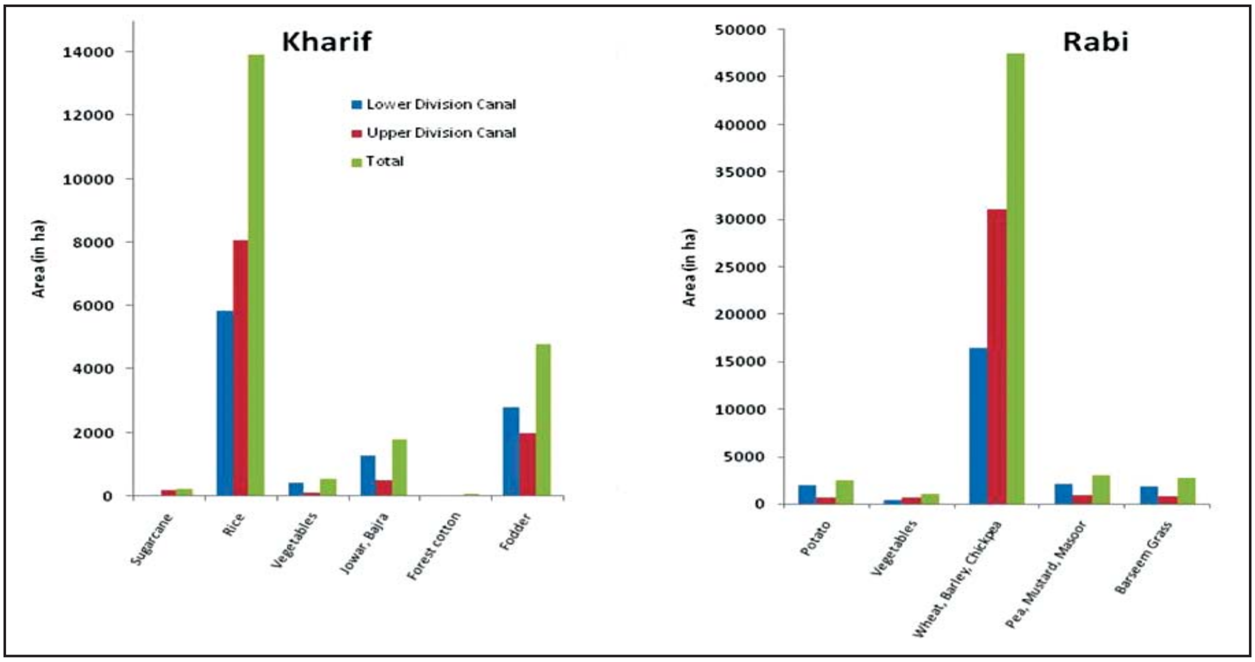


Fig 9.6.11: Area under *kharif* and *rabi* and total different crops of Lower and Upper division Canal commands due to additional irrigation water release

With the availability of irrigation water, the total increase in production of sugarcane crop was 517 t, rice (5677 t), vegetables (2893 t), fodder yield (32047 t), Sorghum and bajra (711 t) and cotton (1.3 t) during *kharif* season and 11 t, 26125 t, 2586 t, 12520 t, 1018 t and 56525 t under sugarcane, potato, vegetables, wheat + barley + chickpea, pea + mustard + Lentil and barseem grass, respectively.

Availability of irrigation water has more pronounced effect on productivity of upper division canal command and on crop like sugarcane (3399 t), rice (13624 t), vegetables (2677 t), Sorghum (630 t), pearl millet (2.5 t), pigeon pea (9 t), moong (39 t), fodder (29852 t), cotton (340 t) and fruits (52 t) during *kharif* season. Such an increase in *rabi* season crops were 28 t in fruits, 294 t in potato, 526 t in vegetables, 171 t in sugarcane, 18267 t in wheat, 626 t in barley, 400 t in mustard crop in upper division canal command (Fig. 9.6.12). It is pertinent to mention here that better irrigation facility not only enhances the economic yield but also increases the bio-mass production which also has economic value as feed for animals, fuel for human beings and carbon management viewpoint for sustained livelihood security.

Change in economics

In Lower division canal (Agra, Mathura, Bharatpur) farmers generally grew sugarcane, rice, vegetables, sorghum, pearlmillet, cotton, fodder, green manures during *kharif* and potato, vegetables (chilies, cauliflower, brinjal, cabbage, spinach etc.), wheat, barley, chickpea, pea, mustard, lentil and barseem as fodder during *rabi* season.

The total annual economic gain in *kharif* season due to agricultural produce was of Rs. 98,56,30,346, which was comparatively higher than that of *rabi* season crops i.e., Rs. 49,71,02,851. Since water availability during *kharif* season (Monsoon season)

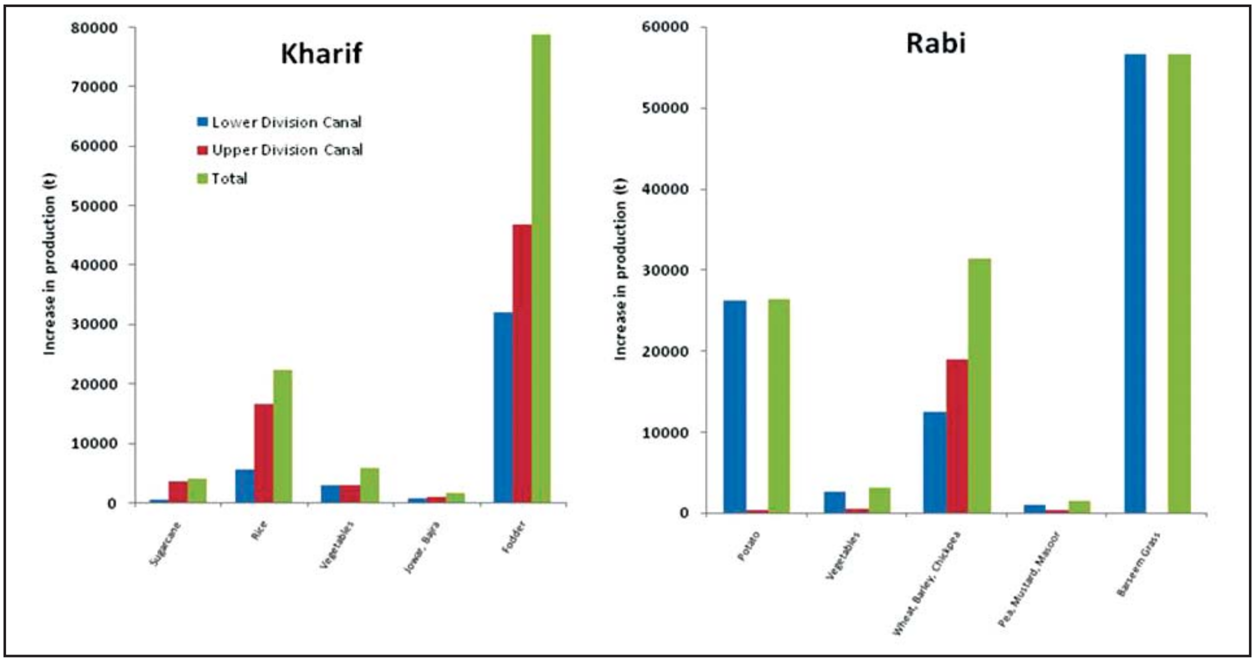


Fig 9.6.12: Increase in production (t) of different crops of Lower and Upper division Canal commands due to additional irrigation water release

was better than that of *rabi* season crops, the production gain and economics was more during *kharif* season combining the *kharif* and *rabi* season profitability, lower division canal had an extra profit of Rs. 1,48,27,33,198 due to 1100 cusec additional water release. Further, comparing the distribution of profit among different districts of Lower Division canal, it was found maximum under district Mathura, followed by Agra and Bharatpur. Comparatively smaller gain under Agra and Bharatpur may be visualized as lower availability of water under tail ends of canal command.

Alike lower division canal command, Upper division canal command (Faridabad, Mathura and Palval) was also benefitted for different crops like sugarcane, rice, vegetables, Sorghum, pearlmillet, cotton, fodders etc in *kharif* and sugarcane, potato, vegetables, wheat, barley, chickpea, pea, mustard, masoor and barseem etc during *rabi* season. The overall economic gain due to yield improvement of these crops was to the tune of Rs. 26, 25, 50,923 during *kharif* season crops. The annual benefit due to water release was estimated up to Rs. 50, 05, 35,998 under Upper division canal command. Of these profit, maximum gain was accrued in district Faridabad followed by Mathura and Palval.

Combining the gains by both canal divisions, the overall annual economic benefit for Agra Canal Command was of Rs. 198, 32, 69,196 of which more than 75% was shared by lower division canal command (Fig. 9.6.13 & 9.6.14). It is pertinent to mention that the economic gain was estimated for agricultural produce only and other farming system enterprises like dairy and live stocks, poultry, fisheries, apiary, piggery etc were not taken into consideration due to non availability of secondary data set on canal command basis, otherwise the total estimation would have been much higher than that estimated here.

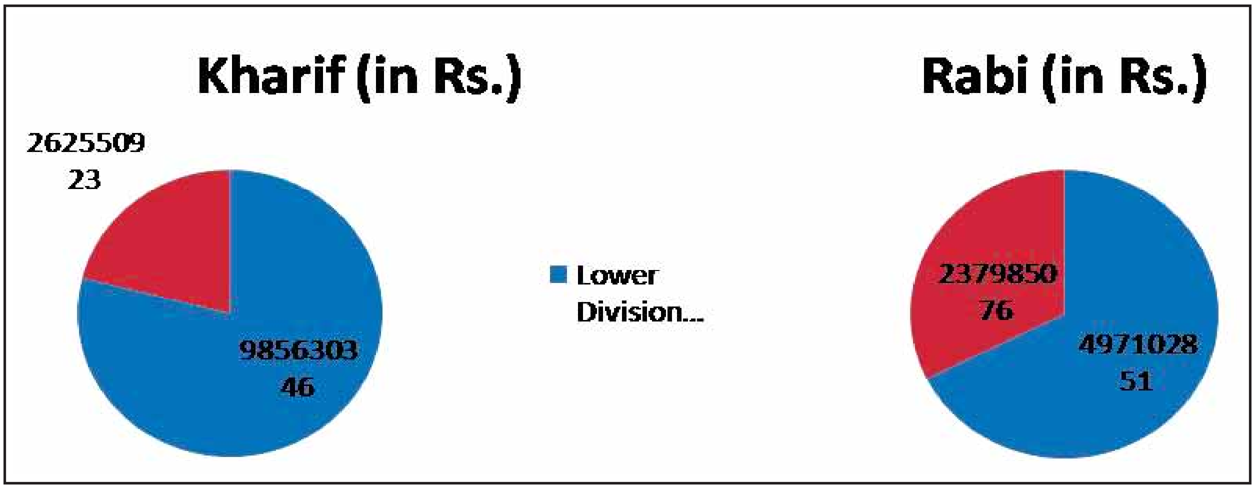


Fig .9.6.13: Contribution of LDC and UDC in total increase in profit during *kharif* and *rabi* season in ACC

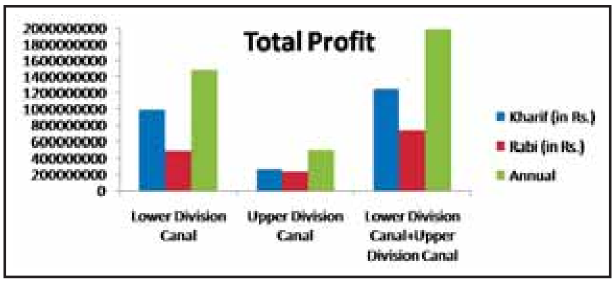


Fig 9.6.14: Net annual gains due to additional irrigation water release in LDC, UDC and in ACC

Over all analysis of results indicate that with availability of additional irrigation water, a positive effect on water productivity, water table depth and improvement of socio-economic status of farming situation in the studied region was observed. The scientific interventions made during study for improvement in cropping/farming system had pronounced effect on overall development of the farming community in study domain. The overall economic gain with crop enterprise in Agra Canal Command was estimated to be Rs. 198.33 crore/ annum due to additional release of irrigation water through *Tehri* dam. Such benefit will be more if it would have been estimated in farming systems approach. Further, these results suggest that the availability of irrigation water had a positive sign in all component enterprises viz. live-stock, horticulture, vegetables and fisheries etc and there is a need to utilize the available water more scientifically and in a judicious manner.

10. LINKAGES AND COLLABORATIONS IN INDIA AND ABROAD, INCLUDING EXTERNALLY FUNDED PROJECTS

a. *Local institutions in the area (educational, research and infrastructural facilities)*

Strong linkage and collaboration with sister concerns: Project Directorate on Cattle, Meerut and Central Potato Research Station Campus Modipuram; as well as S.V.B.P. University of Agriculture & Technology, Modipuram.

b. *National institutes and agricultural universities*

There are centers of All India Coordinated Research Project on Integrated Farming Systems Research in all the State Agricultural Universities across the country. Also, there are centers of National Project of Organic Farming at 13 State Agricultural Universities. There is research collaboration with Space application Center, Ahmedabad; Tehri Hydropower Development Corporation (THDC) Project, Rishikesh; CRIDA, Hyderabad; CARI, Portblair; ICAR RC Umiam; ICAR RC Goa; CRRI, Cuttack; DRMR, Bharatpur; DMR, New Delhi; DWR, Karnal; DOR, Hyderabad; IIPR, Kanpur and ICAR RC Patna.

c. *International institutes*

There is research collaboration with International rice Research Institute, Philippines; CYMMIT, Mexico; USAID, USA; SAARC Agriculture Center Dhaka; IPNI, Canada; and CSIRO, Australia.

d. *Extension and development agencies*

There is linkage and collaboration with NABARD, THDC, State Agricultural Universities, KVKs, and State Line Departments for extension and development.

11. CENTRES OF AICRP ON INTEGRATED FARMING/CROPPING SYSTEMS AND NETWORK PROJECT ON ORGANIC FARMING

Under the aegis of '*AICRP on Integrated Farming Systems'* on-station research is going on at 31 main canters and 11 sub centers. These centers are engaged in basic an applied research and are located at SAUs or their Regional Research Stations or agriculture colleges of those general universities, or ICAR Institutes where strong agricultural research base is available. Whereas, on-farm research is going on at 32 centers. These centers are engaged in farmer's participatory research. On-farm research Centers earlier known as Experiments on Cultivator's Fields (ECF Centers) are located in Different agro-climatic zones. These centers are shifted from one zone/ farming situation to another zone/ farming situation every 3-4 years. The locations of the different FSR centers during the year under report are given below. The Network Project on Organic Farming is being operated at 13 cooperative centers. Locations of these centers are given below and depicted in Map-1 and 2.

Centres of 'AICRP on Integrated Farming Systems'

During the year 2010-11 research under the aegis of AICRP-IFS was going on at following centres:

A. ***Main Centres (25)*** **–** All located in research centres of SAUs and undertaking IFS as well as cropping systems research.

B. ***Sub-centers (12)*** **-** All located in research centres of SAUs or research centres of general universities having strong set up for agronomic research and undertaking only cropping systems research, except at Varanasi where research on IFS component was also taken up.

C. ***On-Farm Research Centres (32)*** **-** These centers were engaged in farmers' participatory research and are located in different agro- climatic zones under the jurisdiction of concerned university. These centers are shifted from one zone/farming situation to another zone/ farming situation every 3-4 years.

D. ***Voluntary Centres (5)*** **-** All located in ICAR Institute and undertaking IFS research component only.

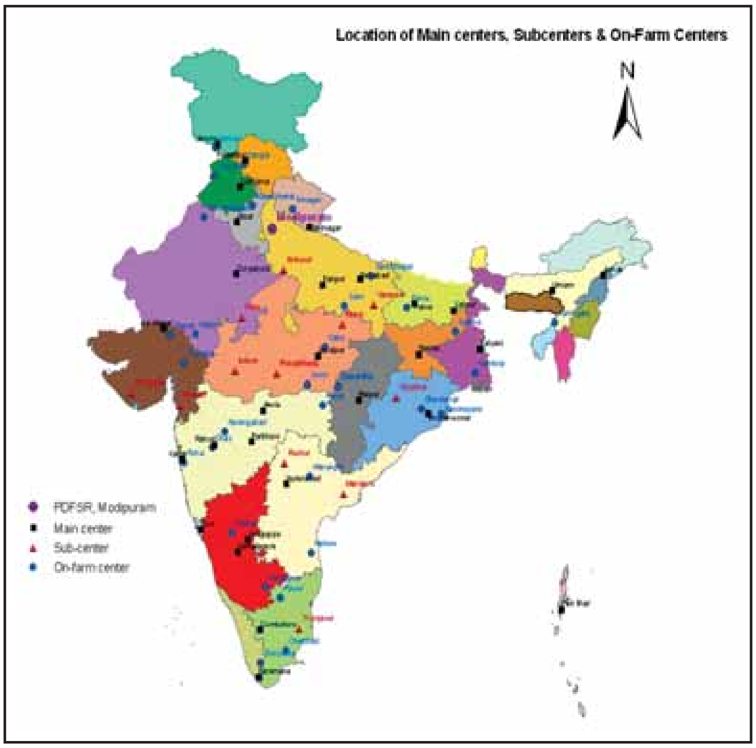
The location of the different AICRP-IFS centers during the year under report is given below and depicted in Map-1.

I. On-Station Research Centres

- ***Arid ecosystem*****:** Hisar (Haryana), S.K. Nagar (Gujarat) and Siruguppa (Karnataka)
- ***Semi-arid ecosystem*****:** Modipuram$ (U.P.), Ludhiana (Punjab), Bichpuri* (U.P.), Kanpur (U.P.), Durgapura (Rajasthan), Kota*(Rajasthan), Indore*(M.P.), Junagarh* (Gujarat), Akola (Maharashtra), Rahuri (Maharastra), Rudrur*(A.P.), Parbhani (Maharastra), Rajendranagar (A.P.), Kathalagere (Karnataka) and Coimbatore (T.N.).
- ***Sub-humid ecosystem*****:** Faizabad (U.P.), Varanasi*(U.P.), Pantnagar (Uttarakhand), Powarkheda*(M.P.), Jabalpur (M.P.), Rewa*(M.P.), Raipur (Chhattisgarh), Ranchi (Jharkhand), Chiplima*(Odisha), Bhubaneswar (Odisha), Patna$(Bihar) and Sabour (Bihar).
- ***Humid ecosystem*****:** Jammu (J. & K.), Palampur (H.P.), Kalyani (W.B.), Shillong$(Meghalaya) and Jorhat (Assam)
- ***Costal & island ecosystems*****:** Thanjavur*(T.N.), Maruteru*(A.P.), Navsari*(Gujarat), Karmana (Kerala), Port Blair$(A. & N. Islands), Ela$ (Goa) and Karjat (Maharashtra)

[Centres marked with (*) are sub centres, and marked with ($) are voluntary centres]

Map. 11.1. Various AICPR-IFS Centers located across the country



Map. 11.2. Location of main centers, sub centers and on farm centers of AICRP-IFS

II. On-Farm Research Centers

- ***Arid ecosystem*****:** Hanumangarh (Rajasthan), Deesa Dist. Banaskantha (Gujarat**),** Gadag (Karnataka)
- ***Semi-arid ecosystem*****:** Warangal (A.P.), Thasara Dist. Kheda (Gujarat), Kurukshetra (Haryana), Bengaluru (Karnataka), Aurangabad (Maharashtra), Chas Dist. Ahmednagar **(**Maharashtra), Amritsar (Punjab), Udaipur (Rajasthan), Paiyur Dist. Krishnagiri (T.N.), Chettinad Dist. Sivaganga (T.N.), Saini Dist. Kaushambi (U.P.)
- ***Sub-humid ecosystem*****:** Nellore Dist. Warangal (A.P.), Patna (Bihar), Kawardha Dist. Kabirdham (Chattishgarh), Dumka (Jharkhand), Katni (M.P.), Seoni (M.P.), Hiwra Dist. Gondia (Maharashtra), Mahisapat Dist. Dhenkanal (Odisha), Srinagar Dist. Pauri Garhwal (Uttarakhand), Sant Kabirnagar (U.P.)
- ***Humid ecosystem*****:** Akbarpur Dist. Karimganj (Assam), Kangra (H.P.)**,** Dhiansar Dist. Jammu (J. & K.), Kakdwip Dist. 24 Pargans (South) (W.B.)

Coastal & island ecosystem**:** Thiruvalla Dist. Pathanamthitta (Kerala), Jajanga Dist. Kendrapara (Odisha). Roha Dist. Raigad (Maharashtra)

Costal ecosystem: Kampasagar Dist. Nalgoda (A.P.), Sadanandpuram Dist. Kollam (Kerala), Mulde Dist. Sindhudurg (Maharastra), and Panipila Dist. Nayagarh (orissa).

B. Network Project on Organic Farming

Bajaura (H.P.), Pantnagar (Uttarakhand), Ludhiana (Punjab), Modipuram (Utter Predesh), Bhopal, Jabalpur (M.P.), Raipur (Chhattisgarh), Ranchi (Jharkhand), Coimbatore (T.N.), Calicut (Kerala), Karjat (Maharashtra), Dharwad (Karnataka), Umaiam (Meghalya).

Map. 11.3. Location of Network Project on Organic Farming

12. GENERAL/MISCELLANEOUS

12.1 LIST OF PUBLICATIONS

A. Research/Review Papers

Dwivedi, B.S., Singh, V.K. and V. Kumar 2011. Balanced fertilization for maximizing the rice-wheat system productivity under Typic Ustochrept soils of western Indo-Gangetic Plain. Journal of Farming Systems Research and Development 17 (1& 2): 1-14 (In press).

Gangwar, K.S., Chaudhary, V.P., Pandey, D.K., Gangwar, B. and Singh, K.K. (2012). Mechanization practices in rice-wheat cropping systems in Upper Gangetic plains of India. Agricultural Mechanization in Asia, Africa and Latin America, 43 (2): 66-74.

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Shukla, N.D., Kumar, Sunil, Singh, Yogendra. 2011, Impact of modern agriculture of ground water utilization – A case study of district Meerut, *An International Journal of Progressive Agriculture*. 12(1):46-55(2012)

Singh D., Shamim M., Pandey R. and Kumar V. 2012. Growth and yield of wheat genotypes in relation to physiological and environmental constraints under timely sown irrigated condition. *Indian journal of plant physiology* (In Press).

Singh, D., Singh, P. Singh, J.P. and Vipin Kumar. 2011. Physiological studies on Cotton and Wheat genotypes for compatability and productivity in Cotton-wheat system. *J. Farming Systems Research and Development* 14 (2):286-90.

Singh, J.P., Gangwar B., and Pandey, D.K. 2011. Nutrient Management in Farming System Perspective. *Indian Journal of Fertilizers*. 7 (11):16-21.

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B. Abstracts/seminar/symposium

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Singh, V.K. and Gangwar, B. 2012. Crop diversification for enhancing income and resource use efficiency. Presented in National Symposium on "Rice-based Farming Systems for Livelihood Security of Rice Farmers under Changing Climate Scenario" held at Chiplima, Odisha, 27-29 February, 2012.

Singh V. K. attended "National Symposium on Noni Sciences" held during 1-2 October, 2012 at Chennai (T.N.)

Singh V. K. attended Biannial workshop on "Secondary, micro- nutrient, and soil water pollutant" held during 9-11 February, 2012 at BCKV Kalyani (W.B).

Singh V. K. participated in round table discussion on refinement of K recommendations in Vertisols" organized by FAI New Delhi held during March 20, 2012 at NASC complex, New Delhi

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I. Television/ Radio talk

Gangwar, B. 2011. *"Krishipranali kyun aur kaise"*, Krishi Darshan Programme, Doordarshan, Kendra Lucknow. Telecast on 27 June, 2011 at 1800-1830 hrs.

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12.2 MEETINGS OF RAC/IRC/IMC

Twenty fifth meeting of Institute Research Committee of PDFSR, Modipuram was held on October 03-04 and 11-12, 2011. The meeting was chaired by Dr. B. Gangwar, Project Director, PDFSR, Modipuram. The meeting started with the expression of heartfelt condolences by the house to one of its prominent members, Dr. A. Sarkar, Principal Scientist (Agronomy) and P. F. (TTR) who left us for heavenly abode on 07-01-2011. The house congratulated and gave a warm welcome to six new members (Dr. Harbir Singh, Dr. N. Ravi Shankar, Dr. Poonam Kashyap, Dr. A. K. Prusty, Dr. R. S. Yadav and Dr. Sudhir Kumar) who joined after the last meeting. The Project Director informed the house that we have to work hard for better output of research in farming system mode. He urged the scientists to fully dedicate and improve the quality of research. The out put should be visible in terms of good publications.

Planning Meeting of QRT held on 9th February 2012

Quinquennial Review Team of PDFSR (Including AICRP-IFS and NPOF) had been constituted under the chairmanship of learned agriculturist Dr Panjab Singh ji, former Secretary DARE & DG ICAR and former Vice Chancellor of BHU Varanasi. The other learned members of the committee are; Dr K. Pradhan, Ex-Vice Chancellor OUAT Bhuvaneshwar; Dr Gyanendra Singh, Ex-Vice Chancellor MGGU Chitrakoot; Dr C.L. Acharya, Ex-Director (Extn.) HPKVV Palampur; Dr D.M. Hegde, Ex-Project Director DOR; Dr W.S. Dhillon, Director, Punjab Horticulture Post-Harvest Technology Centre, PAU Campus, Ludhiana (Punjab); and Dr Anjani Kumar, Pr Scientist (Agri. Economics), NCAP New Delhi.

The planning meeting of the review panel was held on 9th Feb 2012 at Modipuram. During planning meeting the panel was apprised with the infrastructure, research programs, and achievements made during last five years. During meeting, following schedule of region-wise meetings/ visits was finalized by the hon'ble QRT to review progress of individual centres of AICRP-IFS and NPOF.

S.N.	Date(s)	Place of Meeting	Centers to be covered in the State(s) of
1	22-23 March, 2012	SKUAST, Jammu	Haryana, Punjab, H.P., J. & K., & New Delhi (IASRI)
2	28-29 March, 2012	BHU, Varanasi	U.P., Uttarakhand, Bihar & Jharkhand
3	14-15 April, 2012	KAU-CSRC, Karamana (Thiruvananthapuram)	A.P., Kerala & T.N.
4	25-26 April, 2012	ICAR Res. Complex for NEH Region, Umiam	Assam, Meghalaya, & W.B.
5	12-13 May, 2012	SKRAU-ARS, Durgapura (Jaipur)	Gujarat & Rajasthan
6	26-27 May, 2012	OUAT, Bhubaneshwar	Odisha, Chhattisgarh & M.P.
7	09-10 June, 2012	ICAR Res. Complex for Goa, Ela (Old Goa)	Goa, Karnataka & Maharashtra

Dr. Panjab Singh ji, former Secretary DARE & DG ICAR and former Vice Chancellor of BHU Varanasi chairing the QRT meeting held at Directorate

Dr. Punjab Singh ji, Chairman QRT & QRT members are visiting research fields

12.3 PARTICIPATION OF PDFSR SCIENTISTS IN CONFERENCES/ WORKSHOPS/ SEMINAR/ SYMPOSIA etc.

* Dr. B. Gangwar attended "National Symposium on Noni Sciences" held during 1-2 October, 2011 at Chennai (T.N.).

* Dr. Mohammad Shamim attended Agricultural Model Intercomparison and Improvement Project (AgMIP) South Asia Regional workshop organized by AGMIP during 20-24th February, 2012 at ICRISAT, Patancheru, Hyderabad.

* Dr. R. S. Yadav attended the National symposium on 'Agroforestry for Environmental Services, Livelihood Security and Climate Resilient Agriculture: Challenges and Opportunities' Organized at NRCAF, Jhansi during Dec. 03-05, 201

* Dr. Subash N. attended Agricultural Model Intercomparison and Improvement Project (AgMIP) South Asia Regional workshop organized by AGMIP during 20-24th Fand ebruary 2012 at ICRISAT, Patancheru, Hyderabad.

* Dr. Subash N. attended International conference on "Climate Change, Sustainable Agriculture and Public Leadership"(Eds: Dagar and Arunachalam) organized by NCCSD and ICAR during 7-9 February, 2012 at NASC Complex, New Delhi.

12.4 HUMAN RESOURCE DEVELOPMENT

- Dr. A. K. Prusty attended training on "Bioinformatics application in agriculture" at USI, IARI, New Delhi (DBT sponsored training) during 14- 16 December, 2011.

- Dr. A. K. Prusty attended winter school on "Disease diagnostics in fish health management" at CIFE, Mumbai during 10- 30 January, 2012.

- Dr. Mohammad Shamim attended short course on Cropping Systems Models: Applications in Land Resources Management during 5-9th December, 2011 organised by the ICRISAT, Hyderabad and University of Florida, U.S.A.

- Dr. Mohammad Shamim attended an exposure training workshop of SAARC-Australia Project sponsored by CSIRO- Australia, IRRI-Philippines and Australian Centre for International Agricultural Research-Australian Government on "Developing capacity in cropping systems modelling to promote food security and the sustainable use of water resources in South Asia" during 7-11 August, 2012 organised by SAARC Agriculture Centre (SAC), Dhaka, Bangladesh.

- Dr. Mohammad Shamim attended first training workshop of SAARC-Australia Project sponsored by CSIRO- Australia, IRRI-Philippines and Australian Centre for International Agricultural Research-Australian Government on "Developing capacity in cropping systems modelling to promote food security and the sustainable use of water resources in South Asia" 19-25 November, 2012, organised by SAARC Agriculture Centre (SAC), Dhaka, Bangladesh.

- Dr. Mohammad Shamim attended Model Training Course sponsored by Deptt. Of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India on "Conservation Agriculture" organized by PDFSR, Modipuram during 12-19th December, 2011.

- Dr. N. K. Jat attended Winter School on "Recent Advances in Designing and Analysis of Agricultural Experiments" during 29th November to 19th December, 2011 organized at IASRI, New Delhi.

- Dr. N. K. Jat attended the Model training course on "Natural Resource Management" from 12th – 19th March, 2012 organized at PDFSR, Modipurum, Meerut.

- Dr. Poonam Kashyap attended Model Training Course sponsored by Deptt. Of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India on "Conservation Agriculture" organized by PDFSR, Modipuram during 12-19th December, 2011.

- Dr. Subash N. attended an exposure training workshop of SAARC-Australia Project sponsored by CSIRO- Australia, IRRI-Philippines and Australian Centre for International Agricultural Research-Australian Government on "Developing capacity in cropping systems modelling to promote food security and the sustainable use of water resources in South Asia" during 7-11 August, 2012 organised by SAARC Agriculture Centre (SAC), Dhaka, Bangladesh.

- Dr. Subash N. attended first training workshop of SAARC-Australia Project sponsored by CSIRO- Australia, IRRI-Philippines and Australian Centre for International Agricultural Research-Australian Government on "Developing capacity in cropping systems modelling to promote food security and the sustainable use of water resources in South Asia" 19-25 November, 2012, organised by SAARC Agriculture Centre (SAC), Dhaka, Bangladesh.

- Dr. Subash N. attended training program on Decision Support System for Agrotechnology Transfer (DSSAT) organized by AICRP on Agrometeorology under NICARA at CRIDA during 13-17th February 2012.

12.5 SCIENTIFIC MEETINGS, WORKSHOPS, CONFERENCES, WINTER/SUMMER SCHOOL ORGANIZED

Sitting (Left to Right): Dr. Poonam Kashyap, Dr. Lal Bahadur Yadav, Sh. Vyas Muni Mishra, Sh. P.K. Verma, Dr. B. Gangwar (Course Director), Sh. M.P. Singh, Er. Ranbir Singh Randhawa, Sh. S.D. Sharma, Er. Kulbir Khatri,
Standing (Left to Right): Er. Arun Kumar Sharma, Dr. R.P. Mishra, Dr. K.K. Singh (Course Coordinator), Sh. D.K. Pandey, Dr. Mohammad Shamim, Sh. R.R. Nimesh, Sh. D. S. Tomar, Sh. Brijesh Sharma, Dr. Vipin Kumar, Er. Saurabh Arya.

Model Training Course sponsored by Deptt. Of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India on "Conservation Agriculture" was organized during 12-19 December, 2011. Dr. B. Gangwar and Dr. K. K. Singh were the course director and course coordinator respectively of the above training. Officers from state line department of Uttar Pradesh, Punjab and Chattisgarh along with scientist of the Directorate were participated as trainees in the above training programme.

Model Training Course sponsored by Deptt. Of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India on "Natural Resource Management" was organised during 12-19 March, 2012. Dr. B. Gangwar and Dr. K. K. Singh were the course director and course coordinator respectively of the above training. Officers from state line department of Uttar Pradesh, Bihar and Andhra Pradesh, M.P and Chattisgarh along with scientist of the Directorate and IISS, Bhopal participated as trainees in the above training programme.

Sitting (Left to Right): Sh. M. Ravi, Dr. R. P. Mishra, Dr. K. K. Singh (Course Coordinator), Dr. B.Gangwar (Course Director), Sh. C. B. Singh, Sh. Rajeev Seth, Sh. Ramadhar Verma, Sh. Devendra Singh, Sh. V. K. Chaturvedi
Standing (Left to Right): Sh. Shailendra Raj, Dr. N. K. Jat, Sh. Vasu Dev Meena, Dr. O. K. Tomar, Sh. M. Tulasiram, Sh. Rathod Ganesh, Sh. Dileep Kumar, Sh. Abinash Chandra, Sh. Ashok Kumar, Sh. D. K. Sen, Sh. M. R. Netam, Sh. Brijesh Sharma

Training on "Re-Orientation of Technical programme during 12th' Five Year Plan and Execution of On-Farm IFSR" was organised during 4-5 May, 2011

Training sponsored by NABARD-Calcutta-Farmers clubs on "Concepts and methodologies of Farming System Approach and Development of Integrated Farming Systems Models" was organised during 5-10 September, 2011

Training sponsored by NABARD-Calcutta-Farmers clubs on **"**Farming System management for Livlihood Improvement of Small land Holders was orgainsed during 6-10 February,2012.

Dr. Vasu Dev Meena joined the PDFSR, Modipuram, on 25th Jan, 2012 for three months professional institute attachment training programme under the guidance of Dr. Kamta Prasad, Pr. Scientist as mentor.

NICRA Annual Work Plan Meet

The NICRA annual work plan meet was held on dated 21-22 Feb., 2012 under the theme area of climate adaptation and mitigation potential through farming systems and conservation agriculture. The twenty chief agronomists from different AICRP-IFS centres were participated on carbon sequestration in three technical sessions. The first technical session was started on 10.00 am at seminar hall of PDFSR, Modipuram, Meerut. The annual meet programme was started with welcomed by Dr B. Gangwar, Project Director, PDFSR and introduced to all agronomists. After inauguration of programme, Dr. A. K. Singh, DDG (NRM) had given his remarks, words of expectation and guidance of the programme. The overall programme was coordinated by Dr V.P. Chaudhary. The first session was started with the presentation of Dr Ch. Srinivasarao on "Conservation agriculture for soil carbon sequestration and mitigation of GHGs emission" under theme area of carbon sequestration potential in agricultural system and conservation agriculture. The second technical session was started at 2.00 pm on theme area of "Long term crop-weather relationship" and lecture was presented by Dr. B. Gangwar on "Adoption and mitigation potential through conservation agriculture and IFS modules". Third technical session was started on next day at 10.00 am on theme area of methodologies for estimation of GHGS in cropping/farming systems. During this session Dr. S.S. Pal, Principal Scientist had given his presentation on "Guide to field measurement of carbon sequestration". Lastly the programme was closed with discussion among the chief agronomists and scientists on the related topics.

12.6 AWARDS/HONOURS/RECOGNITIONS

An exhibition stall was put up by the Directorate in All India Farmers' Fair (North Zone) and Agro-industrial Exhibition from November 23-25, 2011 organised by Sardar Vallabhai Patel University of Agriculture & Technology, Meerut. The Directorate's stall was adjudged as First in ICAR category.

Dr. A.K. Prusty awarded with first prize in Hindi Debate competition organized during "Hindi Pakhwada" at PDFSR, Modipuram on 26th September, 2011.

Dr. A.K.Prusty awarded with second prize in inter institutional quiz competition held at PDFSR on the eve of annual day celebration on 23rd February, 2012.

Dr. Mohammad Shamim Scientist (Agricultural Meteorology) has been honored with the "Best Paper Award" at the 5th National Seminar on Agrometeorology, held at Bidhan Chander Krishi Vishwavidyalya (BCKV), Kalyani (Paschimbanga), India during 9-10 December, 2011. The best paper award conferred to him by the Indian Association of Agrometeorologists for his outstanding research paper.

Dr.N. K. Jat Scientist (Agronomy) along with Dr. B. Gangwar (Project Director) and Shri. Sunil Kumar, Scientist (Statistics and comp. App.) awarded with "Sriram Pruskar' award for the best article entitled " *Kharif Faslon Mein Akikrat Paushak Tatav Prbandhan*" published in Hindi in June, 2011 issue of '*Khad Patrika'*. The award was conferred to them in the Annual Seminar of 'Fertiliser Association of India' held at Delhi on 7th, December, 2011.

Dr. N. K. Jat, receiving "Sriram' award from Hon. Minister of State for Chemicals and Fertiliser, Sh. S. K. Jena

12.7 EVENT ORGANISED

PDFSR ANNUAL DAY CELEBRATION

The Directorate celebrated its first Annual Day on February 23, 2012 which comprised series of events like Annual Day Lecture by DDG(NRM), Friendly sports, Quiz competition, Fete and Cultural Programme. At the outset, Dr. A.K. Singh, Deputy Director General (Natural Resource Management), Indian Council of Agricultural Research, New Delhi dedicated Pranali Dwar-1 (main gate) to PDFSR. On this occasion he also delivered Annual Day Lecture on the topic "Building climate resilience agriculture through integrated farming systems". In his lecture he called upon the scientists to develop farming system models, which are fit for different farm situations amidst global climate change scenario. He further stressed the need to have alternative remunerative cropping systems to unsustainable cropping systems especially in the north-western part of the country.

Earlier, Dr. B. Gangwar, Project Director, PDFSR welcomed Dr. A.K. Singh on this occasion. On his address, Dr. B. Gangwar called upon the scientists to take the challenges of giving different modules of farming systems, which are remunerative, climate resilient, socially acceptable and environment friendly for small and marginal farmers. To celebrate the day, there were friendly sports and quiz competitions with the staff of Project Directorate on Cattle (PDC), Meerut. In sports, PDFSR team won the volleyball shooting match, whereas PDC team won the tug of war game. In Quiz competition, the PDC team led by Sh. NS Saini and Sh. Chaman Singh won the first prize.

In the afternoon, fete for PDFSR staff and their family members were organized, which consisted of competitions like jalebi race, spoon and marble race, needle and thread race, rangoli, and musical chair competition. In the evening, a thrilling cultural programme was organized which included Ragini performance by All India Radio, Delhi team and variety dance performances by the children of staff members. All winners of games and participants of cultural programme were encouraged by giving attractive prizes. The retired persons of the Directorate were also felicitated on this occasion by the Project Director. The whole day programme was enjoyed by all age group of people.

Honourable DDG (NRM) inaugurating the Annual Day of PDFSR

Cultural evening on the eve of Annual Day of PDFSR

Dr. N.D. Shukla was honoured with "Ramcharitramanas" by the Honourable Project Director

Children are participating in the jalebi race on the eve of Annual Day of PDFSR

12.8 DISTINGUISHED VISITORS

Honorable Deputy Director General (NRM), ICAR, Dr. A. K. Singh, has visited on 23rd February 2011 and inaugurated the main gate of the Directorate.

A team of nineteen scientists/ officers associated with soil testing laboratories of ICAR Institutes / SAUs/ Rubber board, State department of Agriculture and fertilizer industries have visited the Directorate on 16th September 2011.

Dr (Mrs.) Vandana Diwedi, Joint Advisor (Agriculture), Planning Commission has visited the Directorate on 24 – 26th December 2011.

Honourable DDG (NRM) inaugurating the main gate of Directorate

12.9 KISAN GOSTHIS/FARMER'S TRAININGS/FIELD VISITS/ EXIBITIONS ORGANIZED

On 7th September 2011 a kisan gosthi cum Laucnhing workshop was organized at Kandisaud in which about 72 farmers from nearby villages participated. Seeds of vegetables, mineral mixture, deworming and heat inducers were distributed among the farmers during Kishan gosthi. Similarly at Koteshwar on September 06, 2011, 52 farmers were participated in the workshop cum training programme. Face to face interaction with the farmers regarding crops, livestock, horticultural crops and goat farming etc. was carried out during the kishan gosthi. The scientist of the team expressed their views about farming system improvement as per the need. The team also distributed vegetable seeds for kitchen gardening and medicines for livestock such as deworming in calves, mineral mixture for milking animals and heat inducers in anoestrus animals. An interaction meeting with Faculty, scientists and subject matter specialists from G. B. Pant university, Ranichauri campus for gaining information on different varieties suitable for the particular region for *kharif* crops, *rabi* crops, fodder crops, horticulture crops etc.

Photo: 9.6.1. Krishak goshti cum launchiing workshop of externally funded project on Ensuring livelihood security through farming system approach in Tehri district of Uttarakhand" at Kandisod (Tehri)

12.10 हिन्दी पखवाड़े का आयोजन

निदेशालय में दिनॉक 14–28 सितम्बर 2011 तक हिन्दी पखवाड़े का आयोजन किया गया। निदेशालय कर्मियों में राजभाषा के प्रति अभिरूचि पैदा करने तथा दैनिक कार्यो में हिन्दी के अधिकाधिक प्रयोग को बढावा देने के उद्देश्य से हिन्दी पखवाड़े के दौरान कार्यक्रम/प्रतियोगिताएॅ यथा–अन्त्याक्षरी, इमला एवं पत्र लेखन, हिन्दी सामान्य ज्ञान प्रश्नोत्तरी एवं आशुभाषण के अतिरिक्त फाइलों पर हिन्दी में सर्वाधिक कार्य करने वाले अधिकारियों एवं कर्मचारियों तथा वैज्ञानिकों एवं तकनीकी अधिकारियों द्वारा हिन्दी में प्रकाशित किये गये बुलेटिन/शोध–पत्र/लोकप्रिय–लेख को भी प्रतियोगिता में शामिल किया गया। इन प्रतियोगिताओं में भाग लेने वाले तथा प्रथम, द्वितीय एवं तृतीय स्थान प्राप्त करने वाले एकल प्रतिभागी/टोली को पुरूस्कार वितरित किये गये। पखवाड़े के समापन के अवसर पर सभी ने अधिक से अधिक कार्य हिन्दी में करने का संकल्प व्यक्त किया।

हिन्दी पखवाड़े के समापन के अवसर पर पुरस्कार वितरण

Annexure - I

LIST OF CONTRIBUTORS

Name of the Project	PI/Co-PI/Contributor (s)
A. Cropping Systems and Resource Management (CSRM)	
Bio-intensive complementary cropping systems for high productivity and profitability	B. Gangwar & K. K. Singh
Evaluation of different cropping systems under limited water availability situation	B. Gangwar & K. K. Singh
Resource conservation and sustaining high productivity through cropping system management and land configuration	B. Gangwar & K. K. Singh
Evaluation of Different resource conservation technologies for planting of rice	K.K. Singh & R. P. Mishra
Puddling requirement and mat type nursery raising technique for mechanized transplanting of rice	K.K.Singh & R. P. Mishra
Reclamation of saline-sodic soils for crop production and soil health	K. P. Tripathi
Utilization of industrial effluents from spent wash for crop production and soil health	K. P. Tripathi
Study on water and nitrogen use efficiency of different varieties of rice under aerobic condition	R. P. Mishra
Physiological evaluation of rice and wheat genotypes under changing climatic scenario	M. Shamim
Climate change: Effects on productivity of Rice-Wheat cropping system in western plain zone of Uttar Pradesh and its mitigation by using DSSAT model	M. Shamim & S.P. Mazumdar
Carbon Sequestration Potential of Rice-Wheat Cropping System under Different Soil Management Options	S. P. Mazumdar
Digitization of database of on-station and on-farm experiments of cropping systems under AICRP on IFS	G.C. Sharma & Vipin Kumar
Effect of crop establishment technique and residue management option on response to K application under Rice-Maize system	V.K. Singh
Precision nutrient management using GIS based spatial variability mapping under Upper and Middle Gangetic Plain Zone of India	V.K. Singh
B. Organic Agriculture Systems (OAS)	
Studies on improvement of soil organic carbon in rice-wheat system under resource conservation technologies	S. S. Pal
Development of organic farming package for maize-potato-onion system	S. S. Pal
Studies on comparative efficiency of organic, inorganic and integrated nutrient management practices on soil health and crop productivity under various cropping systems	R. S. Yadav & N. K. Jat
C. Integrated Farming Systems (IFS)	
Development of Integrated Farming System Model for Small Farm Holders of Western Plain Zone of Uttar Pradesh	J. P. Singh

Name of the Project	PI/Co-PI/Contributor (s)
Effect of Farm holding size, cultural practices and fertilizer use on soil health status of farmer's field-a case study	M.P.Sharma
Development of an IFS model for western plain zone of Uttar Pradesh	Sanjeev Kumar Kochewad
D. Resource Characterization and System Diagnosis (RCSD)	
Characterization and evaluation of farming system in India	S. P. Singh
E. Technology Transfer and Refinement (TTR)	
Accelerating the proven technologies through Technology Park at PDFSR	M. P. Singh
Anusandhan Gaon ki Aur	B.K. Sharma & Anil Kumar
Adoption behaviour of different farming system components by farmers of UGP & TGP Zones	Anil Kumar, B. K Sharma & R. P. Mishra
Capacity building of stakeholders in integrated farming systems through training.	B.K. Sharma & Anil Kumar
F. Externally Funded Projects	
Ensuring lively hood security through farming systems approach in Tehari District Uttara Khand	B. Gangwar & M.P. Singh
Cropping System Analysis of India Using Remote Sensing, Geographical Information System and Ground based data	N. Subash
Study of crop pattern and maximum agricultural produce due to release of water from Tehri reservoir for irrigation purpose	V.K. Singh

Annexure - II

LIST OF PERSONNEL

(As on 31.03.2012)
Project Director: Dr. B. Gangwar

S.N.	Name and Designation	Discipline
A. SCIENTIFIC		
1.	Dr. K. Prasad, Principal Scientist	Agronomy
2.	Dr. G. C. Sharma, Principal Scientist	Agri. Statistics
3.	Dr. J. P. Singh, Principal Scientist	Agronomy
4.	Dr. S. S. Pal, Principal Scientist	Soil Science & Agri. Chem.
5.	Dr. K. K. Singh, Principal Scientist	Farm Machinery & Power
6.	Dr. M. P. Singh, Principal Scientist	Agri. Extension
7.	Dr. Prem Singh, Principal Scientist	Agronomy
8.	Dr. Anil Kumar, Principal Scientist	Agri. Extension
9.	Dr. M. P. Sharma, Principal Scientist	Soil Science
10.	Dr. V. K. Singh, Principal Scientist	Agronomy
11.	Dr. N. Ravisankar, Principal Scientist	Agronomy
12.	Dr. Harbir Singh, Principal Scientist	Agriculture Economics
13.	Dr. R. S. Yadav, Principal Scientist	Soil Science
14.	Dr. S. P. Singh, Principal Scientist	Agri. Economics
15.	Dr. B. K. Sharma, Senior Scientist	Agri. Extension
16.	Dr. K. P. Tripathi, Senior Scientist	Soil Science & Agri. Chem.
17.	Dr. N. Subash, Senior Scientist	Agro. Met.
18.	Sh. Vipin Kumar, Scientist (SS)	Computer Application
19.	Dr. R. P. Mishra, Scientist (SS)	Agronomy
20.	Dr. V. P. Chaudhary, Scientist (SS)	Farm Machinery & Power
21.	Dr. Chandra Bhanu, Scientist (SS)	Plant Pathology
22.	Dr. Poonam Kashyap, Scientist	Horticulture
23.	Dr. A. K. Prusty	Aquaculture
24.	Dr. Sanjeev Kumar, Scientist	LPM

S.N.	Name and Designation		Discipline
25.	Dr. Mohammad Shamim, Scientist		Agricultural Meteorology
26.	Mr. Sunil Kumar, Scientist		Statistics/Computer Application
27.	Dr. Sonali Paul Mazumdar, Scientist		Soil Science & Agri. Chem.
28.	Dr. Nand Kishore Jat, Scientist		Agronomy
29.	Dr. Sudhir Kumar		Plant Physiology
30.	Ms. Monalisa Pramanik		SWC Engineering
B. TECHNICAL			
1.	Sh. Chet Ram	(T-9)	
2.	Sh. Jagpal Singh	(T-7/8)	
3.	Sh. Krishan Pal	(T-7/8)	
4.	Sh. Yogendra Singh	(T-7/8)	
5.	Sh. D. Tripathi	(T-7/8)	
6.	Sh. S.K. Duhoon	(T-6)	
7.	Sh. R.B. Tewari	(T-6)	
8.	Sh. K.V.Anand	(T-6)	
9.	Sh. Vipin Kumar	(T-6)	
10.	Sh. D.P. Singh	(T-6)	
11.	Sh. Naval Singh	(T-6)	
12.	Sh. Om Kumar Tomar	(T-6)	
13.	Sh. Vinod Kumar	(T-6)	
14.	Sh. Brij Mohan	(T-6)	
15.	Sh. S.P. Singh	(T-6)	
16.	Sh. P.P. Mishra	(T-6)	
17.	Sh. A.P. Dwivedi	(T-5)	
18.	Sh. Brijesh Sharma	(T-5)	
19.	Sh. D.K.Pandey	(T-5)	
20.	Sh. Krishan Kumar	(T-5)	
21.	Smt. Anju Verma	(T-2)	
22.	Sh. Uma Shankar	(T-2)	
23.	Sh. Ashok Kumar	(T-2)	
24.	Sh. Mahendra Prasad	(T-1)	

S.N.	Name and Designation	Discipline
C. ADMINISTRATIVE		
1	Sh. H.S. Chauhan	AAO
2	Shri Anil Agarwal	F.&AO
3	Smt. Alka Jain	Assistant
4	Sh. S.K. Gupta	Assistant
5	Smt. Sheela Devi	Assistant
6	Sh. Jata Kant	Assistant
7	Sh. Ravi Kant Sharma	UDC
8	Sh. Attar Singh*	P.S.
9	Sh. Rai Bahadur	P.A.
10	Smt. Jailata Sharma	P.A.
11	Sh. S.K. Bansal	P.A.
12	Sh. Brij beer Singh	Jr. Steno
13	Sh. Rajesh Kumar	Jr. Steno
14	Sh. Prem Singh	UDC
15	Sh. Rajendra Kumar	LDC
16	Sh. Parmanand	LDC
17	Sh. D.C. Mishra	LDC
D. SUPPORTING STAFF		
1	Sh. Anand Singh	Skilled Supp. Staff
2	Sh. Prem kumar	- do-
3	Sh. Rakesh Kumar	- do-
4	Sh. Rajendra Singh	- do-
5	Sh. Kripa Shankar Pandey	- do-
6	Sh. Ayodhya Prasad Dubey	- do-
7	Sh. Prem Shankar	- do-
8	Sh. Mahabir Singh	- do-
9	Sh. Siddh Kumar	- do-
10	Sh. Harshnath	- do-

NOTES

कृषि प्रणाली अनुसंधान परियोजना निदेशालय

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PDFSR ANNUAL REPORT 2011-12