भाकृअनुप
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PDFSR

वार्षिक प्रतिवेदन
Annual Report
2010-11

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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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 was 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)".** 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 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; 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 to reorientation of on-going programme in to farming system mode. The major research programmes indentified were Cropping Systems and Resource Management, Organic Agriculture 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.

Modipuram **(B. Gangwar)**
26 May, 2011 **Project Director**

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1. सारांश / SUMMARY

भारतीय कृषि अनुसंधान परिषद् द्वारा कृषि प्रणाली अनुसंधान परियोजना निदेशालय (पूर्व नाम फसल प्रणाली अनुसंधान परियोजना निदेशालय) की स्थापना सन् 1989 में मोदीपुरम्, मेरठ में की गयी थी। ग्यारहवीं पंचवर्षीय योजना के दौरान फसल प्रणाली अनुसंधान परियोजना निदेशालय का नाम बदल कर वर्ष 2010–2011 से **कृषि प्रणाली अनुसंधान परियोजना निदेशालय** कर दिया गया।

वर्ष 2011–12 के दौरान विभिन्न कार्यक्रमों के तहत प्रमुख शोध उपलब्धियों का सारांश निम्नवत है।

फसल प्रणाली एवं संसाधन प्रबंधन

नौ फसल प्रणालियों का भूमि विन्यास, यथास्थान हरी खाद, फसल अवशेष सम्मिश्रण, शून्य/न्यूनतम कर्षण एवं अन्तः फसल क्रियाओं के अर्न्तगत मूल्यांकन किया गया। खरीफ में विस्तृत क्यारी पर 1:1 के अनुपात में मक्का (भुट्टा) + लोबिया (सब्जी) एवं कूंड़ में ढ़ेंचा और रबी में कूंड में सरसों एवं विस्तृत क्यारी पर मसूर की तीन पंक्तियां जबकि जायद में क्यारी में मूंग की तीन पंक्तियां उगाया जाना बेहतर पाया गया। इस तकनीक से 21.84 टन/है. धान समतुल्य उपज 59.84 कि.ग्रा./है./दिन उत्पादकता के साथ रू. 140465/है./वर्ष शुद्ध लाभ प्राप्त हुआ।

चार विभिन्न फसल प्रणालियों में तीन सिंचाई व्यवस्थाओं का मूल्यांकन किया गया। खरीफ मौसम में किसी भी फसल में सिंचाई की आवश्यकता नहीं हुई। सिंचाई के आधार पर रबी फसलों में तीन सिंचाइयों पर सर्वाधिक प्रणाली उत्पादकता एवं लाभप्रदता बाजरा–गेहूं में क्रमशः 16.96 कि. ग्रा./है./दिन और रू. 142/है./दिन एवं अरहर–जौ में क्रमशः 25.78 कि.ग्रा./है./दिन और रू. 230/है./दिन दर्ज की गई। दो सिंचाई के तहत 14.95 कि.ग्रा./है./दिन उत्पादकता एवं रू. 190/है./दिन लाभप्रदता के साथ मक्का–सरसों प्रणाली का प्रदर्शन सर्वश्रेष्ठ रहा जबकि एक सिंचाई के तहत 14.71 कि.ग्रा./है. /दिन उत्पादकता एवं रू. 100/है./दिन लाभप्रदता के साथ ज्वार–मसूर फसल प्रणाली सर्वश्रेष्ठ पाई गई।

धान–गेहूं फसल प्रणाली में फसल उत्पादकता, खरपतवार प्रबंधन, जल उपयोग एवं मृदा स्वास्थ्य पर संसाधन संरक्षण प्रौद्योगिकियों के लम्बे समय तक प्रभाव के अध्ययन से ज्ञात हुआ कि गेहूं की परम्परागत बुवाई की तुलना में शून्य, पट्टी और 'रोटरी टिल ड्रिल' से क्रमश 0.55, 0.41 एवं 0.44 है./घण्टे क्षेत्र बुवाई हुई जिससे 57 से 86 प्रतिशत तक समय, श्रम, डीजल, लागत और ऊर्जा की बचत हुई। गेहूं की अधिक उपज (16–22 प्रतिशत), शुद्ध लाभ (27–31 प्रतिशत), लागत प्रभावशीलता

(24–27 प्रतिशत), ऊर्जा दक्षता (34–37 प्रतिशत), गेहूंसा (खरपतवार) में कमी (43–76 प्रतिशत) और सिंचाई जल उपयोग में कमी (9–10 प्रतिशत) पाई गई। गेहूं की परम्परागत बुवाई की तुलना में बेड प्लांटर से 0.35 है./घण्टे के साथ 72 से 86 प्रतिशत समय, श्रम, डीजल, लागत, ऊर्जा और 37 प्रतिशत सिंचाई जल की बचत कर उच्च उपज (15 प्रतिशत), शुद्ध लाभ (30 प्रतिशत), लागत प्रभावशीलता (26 प्रतिशत), ऊर्जा दक्षता (34 प्रतिशत), गेहूंसा में 69 प्रतिशत एंव अन्य खरपतवारों में 67 प्रतिशत की कमी दर्ज की गई। नौ फसल चक्रों के बाद, क्यारी रोपण, शून्य एवं पट्टी कर्षण बुवाई में मृदा जैविक पदार्थ में 15–38 प्रतिशत की वृद्धि जबकि रोटरी कर्षण बुवाई एवं परम्परागत बुवाई में कार्बनिक पदार्थ की 2–11 प्रतिशत कमी हुई। ग्यारह फसल चक्रों के बाद क्यारी रोपण एवं शून्य और पट्टी कर्षण बुवाई से मृदा समुच्चय के औसत वजन व्यास में (18–22 प्रतिशत) सुधार हुआ, जबकि रोटरी कर्षण बुवाई एवं पारम्परिक बुवाई से 13–19 प्रतिशत तक मृदा समुच्चय औसत वजन व्यास में कमी हुई।

धान–गेहूं फसल प्रणाली में फसल उत्पादकता एवं मृदा स्वास्थ्य पर विभिन्न फसल अवशेष प्रबंधन विधियों के प्रभाव का लम्बे समय तक अध्ययन से ज्ञात हुआ है कि अवशेष पुनर्प्राप्ति की तुलना में फसल अवशेष पुनर्चक्रण से धान एवं गेहूं की पैदावार (क्रमशः 13 एवं 18 प्रतिशत) एवं लागत प्रभावशीलता में (क्रमशः 5 एवं –0.3 प्रतिशत) की वृद्धि हुई लेकिन ऊर्जा दक्षता में (क्रमशः 4 एवं 10 प्रतिशत) की कमी हुई। दस फसल चक्रों के बाद प्रारम्भिक मानकों की तुलना में फसल अवशेष पुनर्चक्रण एवं जलाने से मृदा कार्बनिक पदार्थ में (क्रमशः 39 एवं 8 प्रतिशत) वृद्धि हुई जबकि पुनर्प्राप्ति से (9 प्रतिशत) की कमी हुई।

फसल अवशेषों की पुर्नप्राप्ति एवं जलने उपचारों की तुलना में पुर्नचक्रण से मृदा कार्बनिक पदार्थ में (क्रमशः 54 एवं 30 प्रतिशत) सुधार हुआ। ग्यारह फसल चक्रों के बाद प्रारम्भिक मानकों की तुलना में फसल अवशेष पुर्नचक्रण से मृदा समुच्चय औसत वजन व्यास में (15 प्रतिशत) सुधार हुआ जबकि पुर्नप्राप्ति से (6 प्रतिशत) की कमी हुई। पुर्नप्राप्ति एवं जलाने उपचारों की तुलना में फसल अवशेष पुर्नचक्रण से मृदा नमी (14 प्रतिशत), थोक घनत्व (3 प्रतिशत) एवं कोन सूचकांक (22 प्रतिशत) में भी सुधार हुआ।

संसाधन संरक्षण एवं उच्च उत्पादकता बनाएं रखने के लिए फसल प्रणाली प्रबंधन एवं भूमि विन्यास के अध्ययन से पता चला है कि सब्जी मटर (व्यापक क्यारी) + गेहूं (कुंड) प्रणाली से अधिकतम गेहूं समतुल्य उपज (9.0 टन/है.) प्राप्त हुई। इसके बाद सब्जी मटर (क्यारी) + गेहूं (कुंड) प्रणाली (8.9 टन/है.), गेहूं (व्यापक क्यारी) + सरसों (कुंड) प्रणाली (8.8 टन/है.), गेहूं + सरसों (5:1) प्रणाली (8.1 टन/है.) की उपज इससे कम प्राप्त हुई जबकि सरसों (सपाट) में निम्नतम गेहूं समतुल्य उपज (1.0 टन/है.) का उत्पादन हुआ। सब्जी मटर (व्यापक क्यारी) + गेहूं (कुंड) प्रणाली से अधिकतम गेहूं समतुल्य उपज (0.075 टन/है./दिन) प्राप्त हुई। जिसके

बाद सब्जी मटर (क्यारी) + गेहूं (कुंड) प्रणाली (0.074 टन/है./दिन), गेहूं (व्यापक क्यारी) + सरसों (कुंड) प्रणाली (0.074 टन/है./दिन), गेहूं + सरसों (5:1) प्रणाली (0.068 टन/है./दिन) जबकि सरसों (सपाट क्यारी) में निम्नतम गेहूं समतुल्य उपज (0.008 टन/है./दिन) उत्पादित हुई।

पश्चिमी उत्तर प्रदेश में फसल अवशेष प्रबंधन के लिए दूसरी पीढ़ी की मशीनरी (टर्बो सीडर, हैपी सीडर, एवं शून्य कर्षण ड्रिल) के त्वरित प्रयोग से पता चलता है कि टर्बो सीडर एवं हैपी सीडर बुवाई से गेहूं की पैदावार में क्रमशः 5.6 से 5.1 टन/है. की वृद्धि हुई है जो पारम्परिक एवं शून्य कर्षण की तुलना में 12.6 प्रतिशत अधिक थी।

एकीकृत पोषक तत्व आपूर्ति के माध्यम से धान–गेहूं प्रणाली की उत्पादकता बनाए रखने के लिए रिपोर्ट अवधि के दौरान धान की फसल कटाई के बाद मृदा फास्फोरस का विभिनन रूपों में जैसे– जल घुलनशील फास्फोरस एवं ऑलसन फास्फोरस के रूप में मूल्यांकन किया गया है। मृदा में ऑलसन फास्फोरस को जैविक स्रोतों के सम्मिश्रण से रूपांतरित किया गया एवं अधिकतम फास्फोरस सल्फीटेशन प्रेसमड द्वारा उपचारित भूखण्डों में पाया गया है। इसके उपरांत मूंग अवशेष एवं गोबर की खाद द्वारा उपचारित भूखण्डों की तुलना में अन्य स्रोतों से उपचारित भूखण्डों में 10 से 55 प्रतिशत कम ऑलसन फास्फोरस पाया गया। रबी मौसम के दौरान एन.पी.के. का जैविक स्रोतों द्वारा 25 प्रतिशत प्रतिस्थापन ऑलसन फास्फोरस के लिए महत्वपूर्ण नहीं रहा है।

इस दौरान खरीफ में जैविक स्रोतों के एकीकरण वाले भूखण्डों में जल घुलनशील फास्फोरस 1.2 से 3.7 मि.ग्रा./कि.ग्रा. दर्ज किया गया। धान–गेहूं फसल प्रणाली के टिकाऊ उत्पादन मॉडल के विकास से पता चला है कि मृदा परीक्षण पर आधारित पोषक तत्वों की क्षमता पर आधारित धान–गेहूं की उत्पदकता लगातार उच्च बनी रही; जो एकीकृत पोषक तत्व प्रबंधन के विकल्प के समतुल्य पाई गई। रासायनिक उर्वरक द्वारा उपचारित भूखण्डों की तुलना में जैविक एवं एकीकृत पोषक तत्व प्रबंधन के तहत भूखण्डों में 0–20 सेमी. की गहराई पर मृदा पारगम्य प्रतिरोध क्षमता में कमी पाई गई।

सिन्धु–गंगा मैदानी क्षेत्रों में धान–गेहूं फसल प्रणाली में दीर्घ समय तक प्रयोगात्मक भूखण्डों के अन्तर्गत धान में एन.पी.के. सिफारिश मात्रा का 50 प्रतिशत रासायनिक उर्वरकों द्वारा एवं बाकी 50 प्रतिशत गोबर की खाद द्वारा एवं गेहूं में एन. पी.के. में सिफारिश मात्रा का 100 प्रतिशत उर्वरक माध्यम द्वारा उपचारित मृदा में मृदा जैविक कार्बन संचयन एवं जब्तीकरण (0.39–0.56 मेगाग्राम कार्बन/है./वर्ष) में सबसे प्रभावी पाया गया। उपरोक्त फसल क्रम से मृदा जैविक कार्बन का विशाल भण्डारण (0.3–0.5 मेगाग्राम कार्बन/है./वर्ष) संरक्षित किया जा सकता है।

उथली लवणीय–क्षारीय मृदा में उच्च फसलोत्पादन एवं मृदा स्वास्थ्य के लिए मृदा

सुधार परीक्षण कार्यक्रम के तहत यह पाया गया कि धान–सरसों फसल प्रणाली में अधिकतम धान समतुल्य उपज (9.8 टन/है.) प्राप्त हुई। जिप्सम (50 प्रतिशत जी.आर.) + प्रेस मड + गोबर की खाद की प्रयोग से उच्चतम धान समतुल्य उपज प्राप्त हुई। फसल अवशेष सम्मिश्रण की लवणीय–क्षारीय दशाओं में सरसों अवशेषों की अधिकतम अपघटन क्षमता देखी गई। सिंचाई की दृष्टि से जल की 25 प्रतिशत कमी से विभिन्न फसलों की उपज में 18.30 प्रतिशत की वृद्धि हुई। फसल अवधि के दौरान जिप्सम + प्रेसमड + गोबर की खाद अनुप्रयोग से सोडियम का मृदा प्रोफाइल के निम्न स्तर में गमन ज्ञात हुआ परन्तु गैर फसल सूखे की अवधि के दौरान सोडियम का सतह पर पुनः गमन देखा गया। जौ की जड़ों और पत्तियों में सोडियम की मात्रा सरसों और गेहूं की तुलना में अधिक पाई गई।

फसलोत्पादन एवं मृदा संशोधन के लिए शराब भट्टी के तरल उत्प्रवाह की उपयोगिता का मूल्यांकन किया गया एवं औद्योगिक अपशिष्टों से सिंचाई हेतु जल का 50 प्रतिशत प्रतिस्थापन से उच्चतम धान समवन्य उपज, यहां तक कि सामान्य जल से सिंचाई की तुलना में अधिक प्राप्त हुई। सिंचाई जल में कुल घुलनशील ठोस की सान्द्रता अधिक करने पर धान और गेहूं की फसल में फसल सूचकांक में कमी हुई, परन्तु इसका गन्ने की फसल पर कोई प्रतिकूल प्रभाव नहीं देखा गया। सिंचाई के लिए औद्योगिक अपशिष्ट का उपयोग करने से मृदा श्वसन, मृदा एवं पादप दोनों में ही भारी धातुओं के संचय में वृद्धि हुई। दो साल के पश्चात, औद्योगिक अपशिष्ट उपचार में मृदा जैविक कार्बन में मामूली वृद्धि हुई।

धान और गेहूं की 20 प्रजातियों का जलवायुवीय पारिस्थितियों के संबंध में शारीरिकी विकास एवं उत्पादकता के संबंध में विभिन्न आकारिकी व शारीरिकी मानाकें की निगरानी के लिए मूल्यांकन किया गया। गेहूं की प्रजातियों की विविधताएं जैसे लम्बाई (83–96 सेमी.) फसल में बाली का निकलना (बुवाई से 78–95 दिन पश्चात), 50 प्रतिशत पुष्पन (बुवाई से 129–137 दिन पश्चात) एवं विभिन्न आकारिकी–शारीरिकी मानक (बायोमास; लीफ एरिया, प्रकाशसंश्लेषण एवं जल उपयोग दक्षता) जो अनाज पैदावार और उपज घटकों की विभिन्नता के लिए जबावदेह है में देखी गयी है।

अन्य प्रजातियों, जिनमें पुष्पन 100–105 दिनों की तुलना में पी.बी.डब्ल्यू. 226, एच.आई.1544, डब्ल्यू.एच. 1021, पी.बी.डब्ल्यू. 550, राज 3765, यू.पी. 2425, यू.पी. 2565, यू.पी. 2382, डब्ल्यू.एच. 711, एच.डी. 2894, डी.बी.डब्ल्यू. 16 एवं यू.पी. 2338 में पुष्पन (बुवाई से 88–99 दिन पश्चात) जल्दी देखा गया। इन सभी प्रजातियों में शारीरिक परिपक्वता बुवाई से 129–137 दिन पश्चात देखी गई। अन्य प्रजातियों (83–89 सेमी.) की तुलना में यू.पी. 2565, पी.बी.डब्ल्यू. 509, डब्ल्यू.एच. 1021 एवं राज 3765 अपेक्षाकृत (90–96 सेमी.) लम्बे पाए गए। यू.प. 2832, यू.पी. 2425, एच.डी. 2687, पी.बी.डब्ल्यू. 509, पी.बी.डब्ल्यू. 502, यू.पी. 2565 एवं एच.आई. 1544 प्रजातियों में अधिक प्रकाश

संश्लेषण (22–24 μ मोल CO_2/वर्ग मी./से.) देखा गया है जबकि जल उपयोग दक्षता (4. 73–5.60 μ मोल CO_2/मोल जल) डी.बी.डब्ल्यू. 16, डब्ल्यू.एच. 711 प्रजातियों में अधिक थी। अधिक अनाज उत्पादन का अधिक बायोमॉस उत्पदकता (आर–0.80), फसल सूचकांक (आर. –0.66) स्पाइकलेट/बाली (आर–0.69) एवं प्रति बाली दानों की संख्या (आर–0.84) से सीधे तौर पर सहसंबंध दर्शाती है। सामान्यत: शीघ्र पकने वाली प्रजातियों की औसत उत्पादकता (5.2 टन/है.), विलम्ब से पकने वाली प्रजातियों की औसत उत्पादकता (5.4 टन/है.) की तुलना में कम पायी गयी।

'ग्रोईंग डिग्री दिवस' शीघ्र पकने वाली प्रजातियों में (1761–1831^0 दिवस) विलम्ब से पकने वाली प्रजातियों में (1838–1884^0 दिवस) की तुलना में अपेक्षाकृत कम पाये गए एवं ऊष्मा उपयोग दक्षता की विभिन्न प्रजातियों से सकारात्मक सहसंबंध (आर–0.89) देखा गया।

उत्तर प्रदेश के पश्चिमी मैदानी क्षेत्रों में डी. एस.एस.ए.टी. मॉडल का उपयोग कर धान–गेहूं फसल प्रणाली में उत्पादकता पर जलवायु परिवर्तन के प्रभावों एवं इसके दुष्प्रभावों की शमन रणनीतियों को खोजने के प्रयोग से बाली निकलना, पुष्पन एवं शारीरिक परपिक्वता साकेत 4 जिसमें 60 किग्रा. नत्रजन/है. देकर जुलाई के तीसरे सप्ताह बोए गए में जल्दी पाया गया। रोपाई की सभी तीनों तारीखों में नत्रजन की उच्च मात्रा (150 किग्रा./है.) से धान की दोनों किस्मों की परिपक्वता विलंबित हुई। रोपाई की तरीख के प्रभाव से परे 'लीफ एरिया इंडेक्स' साकेत 4 की तुलना में पूसा–सुगंध 4 में अधिक था। नत्रजन की उच्च खुराक से धान की दोनों प्रजातियों में 'लीफ एरिया सूचकांक' में वृद्धि हुई। 150 किग्रा./है. नत्रजन से उर्वरित एवं जुलाई, प्रथम सप्ताह में प्रतिरोपित साकेत 4 में अधिक उपज (6.0 टन/है.) दर्ज की गई जबकि 60 किग्रा. नत्रजन/है. से उर्वरित एवं जून के तीसरे सप्ताह में रोपित पी. एस. 4 में उपज (3.51 टन/है.) कम प्राप्त हुई। पी.एस. 4 की तुलना में साकेत 4 में अधिक ऊष्मा उपयोग दक्षता (4.9 किग्रा./^{0}से0दि0) अधिक थी। सामान्यत: नत्रजन की उच्च मात्रा से ऊष्मा उपयोग दक्षता में वृद्धि हुई। जुलाई के प्रथम सप्ताह में रोपित उपचार की विकिरण उपयोग दक्षता अधिकतम थी। रोपाई की तिथि एवं नत्रजन की मात्रा के प्रभाव से साकेत 4 में पूसा सुगंध 4 से अधिक विकिरण उपयोग दक्षता पाई गई। नत्रजन की उच्च मात्रा से भी दोनों प्रजातियों की विकिरण उपयोग दक्षता में वृद्धि हुई। ऊष्मा उपयोग दक्षता एवं विकिरण उपयोग दक्षता दोनों ही अनाज उपज से अत्यधिक जुड़े पाये गये एवं इनके मध्य सह–संबंध गुणांक क्रमश: 0.95 एवं 0.90 थे।

जैविक कृषि पद्धति

संसाधन संरक्षण प्रौद्योगिकियों के अन्तर्गत धान–गेहूं फसल प्रणाली में मृदा जैविक कार्बन के सुधार पर अध्ययन से पता चला है कि गेहूं की पारम्परिक विधि से खेती से प्राप्त अनाज एवं भूसा उपज (5.33 एवं 6.66 टन/है.) की तुलना में एस.

आर.आई. विधि से अधिक अनाज एवं भूसा उपज (5.58 एवं 6.98 टन/है.) दर्ज की गई। एफ.आई. आर.बी. प्रणाली के अन्तर्गत उपखण्डों में अनाज और भूसा पैदावार क्रमशः 27.8 एवं 28.0 प्रतिशत अधिक पाई गई। गेहूं की फसल के बाद, मुख्य भूखण्डों में अधिकतम जैविक कार्बन एवं सूक्ष्म जैविक कार्बन (क्रमशः 0.58 प्रतिशत एवं 185.2 मिलीग्राम/ग्राम) एस.आर.आई. के अन्तर्गत एवं गेहूं की हैपी–सीडर द्वारा बुवाई विधि में क्रमशः 0. 60 प्रतिशत एवं 172.4 मिलीग्राम/है. पाए गए। मुख्य भूखण्डों में अधिकतम उपलब्ध नत्रजन (30 किग्रा./है.) गेहूं की पारम्परिक विधि से कृषि के अन्तर्गत दर्ज किया गया। उप–भूखण्डों में से, अधिकतम नत्रजन एवं फास्फोरस गेहूं की हैपी–सीडर द्वारा बुवाई के अन्तर्गत थे। धान की उपज पारम्परिक विधि (5.0 टन/है.) की तुलना में एस.आर.आई. विधि के अन्तर्गत (6.05 टन/है.) अधिक पाई गई। एस.आर.आई. के अन्तर्गत भूसा पुआल उपज 11.5 टन/है. थी। धान की अधिकतम कल्ले निकलने की अवस्था पर मिट्टी के गुणों के अध्ययन से पता चला कि अधिकतम जैविक कार्बन, उपलब्ध फास्फोरस एवं पोपड़ा एस.आर.आई. विधि के अर्न्गत अधिकतम उपलब्ध नत्रजन (301.1 किग्रा./है.) धान की पारम्परिक विधि के अन्तर्गत दर्ज किए गए। अधिकतम कल्ले निकलने एवं बाली बनने की अवस्था पर, परपोषी जीवाणु, कुल जीवाणु, कवक, एवं एक्टिनोमाइसीटिस के रूप में अधिकतम सूक्ष्मजीव जनसंख्या एस.आर.आई. विधि के अन्तर्गत पाई गई।

मक्का– आलू–प्याज प्रणाली के लिए एक जैविक कृषि पैकेज विकसित किया गया जिसमें गर्मियों में प्याज की अधिकतम उपज (25.92 टन/है.) टी–6 उपचार जिसमें जैविक पोषक तत्व स्रोत यथा गोबर की खाद, वर्मीकम्पोस्ट एवं नीम की खली प्रत्येक 1/3 नत्रजन एवं फास्फोरस प्रदायक जैव उर्वरक डाले गए, में दर्ज की गई। इस उपचार में टी–7 की तुलना में उपज में 6.57 प्रतिशत की वृद्धि हुई। एक अन्य जैविक पोषक तत्व प्रबंधन पैकेज के अन्तर्गत उपज में 1.64 से 6. 29 प्रतिशत तक वृद्धि हुई। प्याज की फसल के उपरांत, मृदा में अधिकतम जैविक कार्बन टी–6 के अन्तर्गत, उपलब्ध नत्रजन एवं सूक्ष्म जैविक बायोमॉस कार्बन टी–3 के अन्तर्गत एवं उपलब्ध पोटाश टी–5 में दर्ज किया गया जो सभी अकार्बनिक या एकीकृत पोषक तत्व प्रबंधन संकुल थे। मक्का की कटाई के बाद जैविक कार्बन, उपलब्ध नत्रजन, फास्फोरस एवं पोटाश और सूक्ष्म जैविक बायोमॉस कार्बन के मामले में मिट्टी की उर्वरा स्थिति थोडी सी भिन्न थी। अकार्बनिक एवं एकीकृत पोषक तत्व प्रबंधन पैकेजों की तुलना में नत्रजन अधिकतम, जैविक कार्बन (0.66 प्रतिशत) टी–6 में, उपलब्ध नत्रजन एवं सूक्ष्म जैविक बायोमॉस कार्बन टी–3 एवं उपलब्ध फास्फोरस एवं पोटाश टी–5 के अन्तर्गत दर्ज किए गए।

समेकित कृषि प्रणाली

समेकित कृषि प्रणाली (आई.एफ.एस.) दृष्टिकोण एक ओर जहां छोटे किसानों की घरेलू जरूरतों को पूरा करता है, वहीं दूसरी ओर प्रक्षेत्र अपशिष्ट

एवं फसल उत्पाद अवशेषों के पुनः चक्रण द्वारा टिकाऊ फसलोत्पादन में सहायक है।

विभिन्न कृषि दशाओं के लिए विशिष्ट फसलक्रम पहचाने गए। एकल फसल से आई.एफ.एस. में प्रतिदिन मजदूरी (रोजगार) की दृष्टि से कर्मियों की आवश्यकता 181 से 530/है./वर्ष बढ़ी है जो सम्पूर्ण वर्ष नियमित आय के साथ ग्रामीण युवाओं में बेरोजगारी की समस्या हल करने के साथ ही लघु कृषक परिवारों में पशु एवं व्यक्तियों के लिए पोषक चारा एवं भोजन भी प्रदान करता है। खेत का अवशेष, फसल का अवशेष एवं पशुओं के मलमूत्र का पुनःचक्रण मॉडल में प्रक्षेत्र एवं वृक्षारोपण फसलों की कुल एन.पी.के. आवश्यकता का 36 प्रतिशत से भी अधिक पूरा करता है। आजीविका सुरक्षा के अलावा, शिक्षा, स्वास्थ्य और अन्य कई सामाजिक दायित्वों सहित परिवार की अन्य देनदारियों को पूरा करने के लिए पिछले चार वर्षों में रू. 46660 से पांचवे वर्ष में रू. 77930 तक की बचत दर्ज की गई।

सीमान्त किसानों की जीविका एवं समृद्धि सुनिश्चित करने के लिए एक डेयरी आधारित आई.एफ.एस. मॉडल जिसमें फसलें (3800 वर्ग मीटर), डेयरी (2 भेंसे + 1 गाय), बागवानी (अन्तः फसल, संतराः (किस्म किन्नो), ऊतक संवर्धित केला (किस्म–ग्रॉड नेने), अमरूद एवं अन्तःफसल के रूप में सब्जियां एवं पुष्प) वर्मी कम्पोस्ट और सीमा वृक्षारोपण शुरू किया गया।

संसाधन अभिलक्षणन व प्रणाली निदान

कोंकण क्षेत्र में प्रमुख कृषि प्रणालियों में पशुधन के बाद अनाज आधारित प्रणालियां थी। पश्चिमी महाराष्ट्र में प्रमुख कृषि प्रणालियों में गन्ना और इसके पश्चात पशु आधारित कृषि प्रणालियों का प्रभुत्व देखा गया। विदर्भ क्षेत्र में दलहन एवं तिलहन के बाद पशुधन अधारित कृषि प्रणालियों का प्रभुत्व पाया गया। मराठवाड़ा में दलहन और तिलहन के बाद कपास आधारित कृषि प्रणालियां प्रमुख कृषि प्रणालियों के रूप में चिन्हित की गयीं।

कोंकण क्षेत्र में सीमान्त कृषकों के खेत का आकार 0.69 हैक्टेयर एवं बड़े किसानों का 5.09 हैक्टेयर पाया गया। प्रति घर में सदस्यों की औसत संख्या 5 तथा परिवार के मुखिया की शिक्षा 10वीं मानक से नीचे पाई गई। पश्चिमी महाराष्ट्र में विभिन्न स्थानों पर स्थित सीमान्त और बड़े किसानों के खेत का आकार क्रमशः 0.64 व 6.09 हैक्टेयर पाया गया। यहां 6 से अधिक सदस्यों वाले परिवारों में शिक्षा की स्थिति मैट्रिक से नीचे थी। विदर्भ क्षेत्र में मैट्रिक स्तर की शिक्षा वाले 6 सदस्यों के परिवार में खेत का आकार दो खण्डित भूखण्डों में 0.47 हैक्टेयर सीमान्त एवं 7. 99 हैक्टेयर बड़े किसानों के पास पाया गया। मराठवाड़ा क्षेत्र में खेत का आकार दो खण्डित भूखण्डों में 0.66 हैक्टेयर (सीमान्त किसान) से 7. 81 हैक्टेयर (बडे किसान) तक मैट्रिक स्तर की

शिक्षा वाले 6 से अधिक सदस्यों वाले परिवारों में पाया गया। सामान्यतः प्रत्येक घर में दो दुधारू पशु पाए गए।

सभी क्षेत्रों में फसल सघनता 200 प्रतिशत से नीचे थी और फसलोत्पादन में धान्य फसलों का क्षेत्र क्रमशः कोंकण 78 प्रतिशत एवं पश्चिमी महाराष्ट्र 47 प्रतिशत प्रमुख था। विदर्भ क्षेत्र में कुल कृषित क्षेत्र में से तिलहन 32 प्रतिशत, दालें 17 प्रतिशत, अनाज 24 प्रतिशत और कपास 22 प्रतिशत भू–भाग पर उगाये जाते हैं। मराठवाड़ा में सकल कृषित क्षेत्र में अनाज 22 प्रतिशत, तिहलन 23 प्रतिशत, दालें 18 प्रतिशत तथा कपास 17 प्रतिशत में उगाए जाते हैं।

सामान्यतः 2009–10 की कीमतों के आधार पर शादी समारोहों को छोड़कर परिवार की शिक्षा, सामाजिक और धार्मिक गतिविधियों में परिवारों का खर्च रू. 45,832 (सीमान्त किसान) तथा रू. 97351 (बड़े किसान) तक पाया गया। पारिवारिक खर्चों में भोजन 42 प्रतिशत (विदर्भ क्षेत्र) से 57 प्रतिशत (पश्चिमी महाराष्ट्र) प्रमुख मद के रूप में पायी गई। खेत के आकार का शिक्षा, स्वास्थ्य और बीमा के साथ सीधा पर भोजन पर व्युत्क्रम संबंध था। घरों के नमूनों के आधार पर विभिन्न कृषि प्रणालियों में जमीन का विखण्डन एवं उपखण्ड कम विश्वसनीय बाजार, स्वाधिकृत निधि की कमी, घटते प्राकृतिक संसाधनों पर निर्भरता, अच्छी गुणवत्तायुक्त बीज एवं पशुपालन तथा मुर्गीपालन के लिए शेड की अनुपलब्धता आदि अधिक लाभार्जन की प्रमुख बाधाएं देखी गई।

पिछले कई वर्षों से हमीरपुर जिले में भूमिगत जल स्तर में अस्थिरता दर्ज की गई। वर्ष 2004–05 के दौरान अनियमित और कम वर्षा के कारण वर्ष 2009–10 की तुलना में सिंचाई में ऊर्जा खपत अधिक थी। इसी वर्ष 2009–10 की तुलना में गेहूं में सिंचाई की लागत भी 7.8 प्रतिशत अधिक दर्ज की गई। इसके अलावा बहुतायत कृषकों द्वारा दुधारू पशुओं के विकल्प में बकरियां रखना जिले में जल की कमी एवं भूजल स्तर में गिरावट को दर्शाता है।

तकनीकी हस्तान्तरण एवं परिष्करण

मेरठ जिले में पी.डी.एफ.एस.आर. से 20 किमी. दूर स्थिति खण्ड दौराला के महल एवं श्यामपुर गांवों में प्रत्येक 10 किसानों के खेत में गेहूं, धान व गन्ने में सन्तुलित पोषण तकनीकी अपनाई गई। उपचार टी–4 से उच्चतम उपज (4.46 टन/है.) प्राप्त हुई जिसके बाद टी–3 (4.34 टन/है.), टी–2 (4.19 टन/है.) एवं टी–1 (3.84 टन/है.) उपचारों में कम उपज दर्ज की गई। ग्यारह प्रदर्शनों में से गन्ना रोपित फसल में सन्तुलित उर्वरक प्रदान करने के लिए ओ.एस.–767 किस्म में उपज में अधिकतम वृद्धि (13.5 प्रतिशत) दर्ज की गई जबकि गन्ना पैडी फसल में पोटाश प्रदान करने के लिए सी.ओ.एस. 8436 किस्म में उपज में अधिकतम वृद्धि दर्ज की गई। धान की सुगंध 4, सुगंध 5 एवं पी.बी. 1 किस्मों में 20 कृषक प्रक्षेत्र परीक्षणों में कृषक विधि की तुलना में एन.पी.के. की सिफारिश मात्रा से उपज में क्रमशः 10.72 प्रतिशत, 14.66 प्रतिशत एवं 20.49 प्रतिशत वृद्धि

दर्ज की गई। गाजियाबाद जिले के पथारी गांव में तिलहन (सरसों किस्म– पूसा बोल्ड) पर पांच अग्रिम पंक्ति प्रदर्शनों में 26.4 प्रतिशत वृद्धि दर्ज की गई। लक्षित समूहों की विभिन्न श्रेणियों के लिए 3 प्रशिक्षण कार्यक्रम, 1 जागरूकता सप्ताह, 1 समूह चर्चा और 7 यात्राएं आयोजित की गई। वर्ष के दौरान विभिन्न अवसरों पर 1 क्षेत्र दिन एवं 2 प्रदर्शिनयों का आयोजन भी किया गया।

गन्ना–पशुधन–अनाज, अनाज–गन्ना–पशुधन, सूअर पालन–पशुधन–अनाज एवं गन्ना–मछली पालन–अनाज–पशुधन आधारित कृषि प्रणालियों में खरपतवार प्रकोप, नवीनतम उच्च उपज किस्मों के बारे में जागरूकता की कमी, पोषक तत्वों की सिफारिश मात्रा में उपयोग न होने, गन्ने में सफेद लट का प्रकोप, जंगली जानवर, दुधारू पशुओं में संतुलित पोषण की कमी एवं शेड एवं पशुओं की स्वच्छता इत्यादि प्रमुख समस्याएं चिन्हित की गई।

बाह्रय वित्तपोषित परियोजनाएं

धान व गेहूं आधारित फसल पद्धतियों में उन्नत उर्वरक प्रबंधन द्वारा प्रणाली उत्पादकता एवं कृषक के लाभांश को बढ़ाने के लिए पांच पोषक तत्व प्रबंधन विकल्प यथा–

1. कृषक उर्वरक विधि
2. राज्य द्वारा उर्वरक सिफारिश मात्रा
3. उन्नत राज्य सिफारिश जिसमें राज्य उर्वरक सिफारिश की तुलना में नत्रजन की 25 प्रतिशत एवं फास्फोरस एवं पोटाश प्रत्येक की 50 प्रतिशत अधिक मात्रा दी गयी।
4. राज्य मृदा परीक्षण प्रयोगशाला सिफारिश
5. स्थान विशिष्ट पोषक तत्व प्रबंधन (एस.एस. एन.एम.) का मूल्यांकन किया गया।

उपरोक्त सभी पोषक तत्व प्रबंधन विकल्पों में से धान–गेहूं में प्रणाली उत्पादकता के रूप में अधिकतम गेहूं समतुल्य उपज (12.5 टन/है.), स्थान विशिष्ट पोषक तत्व प्रबंधन में एवं इसके बाद मक्का–गेहूं (10.8 टन/है.), मूंगफली–गेहूं (8.86 टन/है.), अरहर–गेहूं (8.83 टन/है.), तिल–गेहूं (7.69 टन/है.) में सबसे कम ज्वार (सूखा चारा)–गेहूं (5.99 टन/है.) दर्ज की गई।

Project Directorate for Farming Systems Research (PDFSR) (Formerly Project Directorate for Cropping Systems Research), was established in March, 1989 with its headquarters at Modipuram, Meerut, U.P. Further, during 11th five year plan PDCSR has been re-nemaed as **Project Directorate for Farming Systems Research (PDFSR).** The summary of major research findings during 2010-11 under various programmes is given below:

CROPPING SYSTEMS AND RESOURCE MANAGEMENT

Nine cropping systems along with land configurations, *in situ* green manuring, residue incorporation, zero/minimum tillage and inter cropping approaches were evaluated. 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 better and resulted in 21.84 t/ha as rice equivalent yield with productivity of 59.84 kg grain/ha/day and net return of Rs.140465/ha/year.

Four cropping systems along with three irrigation regimes approaches were evaluated. No irrigation was needed during *kharif* season in any of the crops. Based on irrigations applied to *rabi* crops, the highest system productivity (16.96 kg/ha/day) and profitability (Rs.142/ha/day) of pearl millet-wheat and pigeon pea-barley (25.78 kg/ha/day & Rs. 230 /ha/day) were recorded when three irrigations were applied. Under two irrigation application the systems involving maize-mustard with production of 14.95 kg/ha/day and productivity Rs. 109 /ha/day performed best while under only one irrigation sorghum-lentil with production of 14.71 kg/ha/day and productivity of Rs. 100 /ha/day was the best.

The long- term effect of different resource conservation technologies in rice-wheat cropping system on crop productivity, weed management, water use and soil health, revealed that zero, strip and rotary till drills covered 0.55, 0.41 and 0.44 ha/h area; saved 57 to 86 % time, labour, diesel, cost and energy; provided higher wheat yield (16 to 22 %), net returns (27 to 31 %), cost effectiveness (24 to 27 %), energy efficiency (34 to 37 %); and reduced phalaris minor (43 to 76 %) and irrigation water use (9 to 10 %); compared to conventional sowing of wheat. Bed planter covered 0.35 ha/h area; saved 72 to 86 % time, labour, diesel, cost, energy, and 37 % irrigation water; provided higher yield (15 %), net returns (30 %), cost effectiveness (26 %), energy efficiency (34 %); reduced phalaris minor (69 %) and other weeds (67 %); compared to conventional sowing of wheat. 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 nine 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 eleven crop cycles.

The long-term effect of different crop residue management practices in rice-wheat cropping system on crop productivity and soil health, revealed that crop residue recycling increased rice and wheat yields (13 & 8 %), and cost effectiveness (5 & -0.3 %) but decreased energy efficiency (4 & 10 %) compared to residue retrieval. Crop residue recycling and burning improved soil organic carbon, SOC (39 and 8%) whereas retrieval decreased SOC (9%) compared to initial values after ten 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 eleven 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.

Resource conservation and sustaining high productivity through cropping system management and land configuration revealed that Vegetable pea (broad bed, BB) + Wheat (furrow, F) system produced maximum wheat equivalent yield, WEY (9.0 t/ha) followed by Vegetable pea (bed, B) + Wheat (F) system (8.9 t/ha), Wheat (BB) + Mustard (F) system (8.8 t/ha), Wheat + Mustard (5:1) system (8.1 t/ha) while Mustard (Flat) produced lowest WEY (1.0 t/ha). Vegetable pea (broad bed, BB) + Wheat (furrow, F) system produced maximum wheat equivalent productivity (0.075 t/ha/day) followed by Vegetable pea (bed, B) + Wheat (F) system (0.074 t/ha/day), Wheat (BB) + Mustard (F) system (0.074 t/ha/day), Wheat + Mustard (5:1) system (0.068 t/ha/day) while Mustard (Flat) produced lowest WEY (0.008 t/ha/day).

Acceleration of second-generation machinery (turbo seeder, happy seeder and zero till drill) for crop residue management in western UP revealed that the yield of wheat by turbo and happy machine drilling were 5.6, and 5.1 t/ ha which were12.6% more compared to conventional and Zero till.

For sustaining rice-wheat productivity through integrated nutrient supply system, soil P fractions were evaluated for water soluble P and Olsen P fractions during report period after rice crop harvest. The Olsen P content in soil was modified with the integration of organic sources and highest being with sulphitation press mud (SPM) applied plots followed by Green Gram residue (GR) applied treatment and FYM application use. The other treatments had 10 to 55% less Olsen P content compared to SPM, GR and FYM used plots. Application of organic sources for 25% NPK substitution during *Rabi* season did not prove its significance for Olsen P content. The water soluble P values ranged between 1.2 to 3.7 mg/kg and was only noticed in treatments where integration of organic source was made during the *Kharif* season.

Development of sustainable production model for rice-wheat cropping system revealed that the rice-wheat productivity remained consistently higher under soil test based nutrient crop recommendation, which was at par to the integrated nutrient management options. Soil penetration resistance was decreased significantly in 0-20 cm depth under organically managed plots and integrated nutrient management options as compared with chemical fertilized plots.

The application of 50% recommended NPK dose through fertilizer +50% N through FYM in rice, 100 % recommended NPK dose through fertilizer in wheat (NPK+FYM) was the most efficient in accumulating as well as sequestering organic C (0.39-0.56 Mg C ha^{-1} yr^{-1}) under long term rice-wheat experiment in Indo-Gangetic Plains. Large amount of organic Carbon (0.3-0.5 Mg C ha^{-1} yr^{-1}) could also be accumulated in the soil depth with the above cropping system.

While reclaiming saline-sodic soil for higher crop production and soil health, Rice- mustard cropping system gave highest rice equivalent yield (9.8 t ha^{-1}) under shallow saline-sodic soil. Use of gypsum (50 % GR) + press mud + FYM gave highest rice equivalent yield. Among the crop residues, mustard residue had highest decomposition potential under saline sodic condition. 25% reduction in irrigation water application increased the crops yield by 18-31 per cent in different crops. Application of gypsum + press mud + FYM led to movement of Na at the bottom of the soil profile during crop period, but Na was observed reappearing on surface during non-crop-dry period. The Sodium content in barley root and leaves was significantly higher over mustard and wheat crops.

Utilization of distillery spent-wash for crop production and soil amendment was evaluated and the substitution of 50% of irrigation water with industrial effluents gave highest rice equivalent yield, even higher than the normal water irrigation. Increasing concentration of total dissolved solids for irrigation water led to decrease in harvest index in rice and wheat, but there was no adverse effect on sugarcane. Use of industrial effluents for irrigation led to increase soil respiration and heavy metals accumulation both in plant and soil. After 2 years, there was slight build up of soil organic carbon in treatments having industrial effluents.

Twenty genotypes of rice and wheat were evaluated for their phenological growth in relation to climatic conditions and to monitor different morpho-physiological parameters in relation to productivity. Genotypic variations in wheat were observed in stature (83-96 cm), crop phenology i.e. spike initiation (78-95 days after sowing, DAS), 50 % flowering (88-105 DAS) and physiological maturity (129-137 DAS), and different morpho-physiological parameters (biomass, leaf area, photosynthesis and water use efficiency) which resulted in accountable variation in grain yield and yield components. PBW-226, HI-1544, WH-1021, PBW-550, RAJ-3765, UP-2425, UP-2565, UP-2382, WH-711, HD-2894, DBW-16 and UP-2338 were early in flowering (88-99 DAS) than other genotypes which flowered in 100-105 days. All these genotypes attained physiological maturity in about 129-137 DAS. UP-2565, PBW-509, WH-1021 and RAJ-3765 were relatively taller (90-96 cm) than rest of the genotypes (83-89 cm). Higher photosynthesis (22-24μ mole CO_2 m^{-2} s^{-1}) was observed in UP-2832, UP-2425, HD-2687, PBW-509, PBW-502, UP-2565 and HI-1544, while water use efficiency was higher (4.73-5.60 μ moles CO_2 $mole^{-1}$ H_2O) in DBW-16, WH-711, HI-1544, PBW-373, PBW-343 and UP-2382. Higher grain yield was associated with high biomass productivity (r=0.80), harvest index (r=0.66), spikelets/ spike (r=0.69) and number of grains per spike (r=0.84). In general, the average productivity of early group of genotype was low (5.2 t ha^{-1}) as compared to long duration genotypes (5.4 t ha^{-1}). Growing Degree Days (^{o}days) was relatively low in the early genotypes (1760-1831^{o}days) than the late maturing genotypes (1838-1884^{o}days) and Heat Use Efficiency was positively associated with the grain yield of the different genotypes (r=0.89).

In the experiment to find out the effects of climate change on productivity of rice-wheat cropping system and its mitigation strategies by using DSSAT model in western plain zone of Uttar Pradesh, panicle initiation, anthesis and physiological maturity were significantly early in Saket 4 fertilized with 60 kg N $ha^{-1}$and transplanted on D_3 (3rd week of July) followed by D_2 (1st week of July) and D_1 (3rd week of June). Higher dose of nitrogen (150 Kg N ha^{-1}) delayed the maturity of both rice cultivars in all three dates of transplanting. Leaf area index (LAI) was higher in Pusa Sugandha 4 than Saket 4 genotypes irrespective of date of transplanting. Higher dose of nitrogen increased the LAI in both rice genotypes. Higher grain yield (6.0 t ha^{-1}) was recorded in Saket 4 fertilized with 150 Kg N ha^{-1} and transplanted on D_2 (1st week of July) whereas lower grain yield (3.51 t ha^{-1}) was observed in PS 4 fertilized with 60 Kg N/ha and transplanted on D_1 (3rd week of June). Heat use efficiency (HUE, Kg/ ^{o}Cd) was higher in Saket 4 than Pusa Sugandha 4. Mean HUE of all four treatments transplanted on 3rd week of July (4.9 Kg/ ^{o}Cd) was higher. Higher dose of Nitrogen increased the HUE in general. Radiation use efficiency (RUE, g/Mjm^{-2}) of D_2 (1st week of July) transplanting was maximum. Higher RUE was reported in Saket 4 over Pusa Sugandha 4 irrespective of date of transplanting and dose of nitrogen. Higher dose of nitrogen also increased the radiation use efficiency in both genotypes. HUE and RUE were highly associated with grain yield and correlation coefficients (r) were 0.95 and 0.90, respectively.

INTEGRATED FARMING SYSTEMS

IFS approach met household needs of small farm holders one way and sustained production through recycling of farm wastes and crop residues on the other side specific cropping sequences for different farm situations were identified. Man days increased from 181 in crop alone to 530 /ha/year in IFS approach which can solve unemployment problem in rural youths with regular income whole the year and catered more nutritious food and fodder for human and animals belonging to small farm holder families. Recycling of farm wastes, crop residues and animal excreta (Cow dung and urine) produced more than 36% of the total NPK requirement of field and plantation crops of the model. Besides livelihood security, Rs. 46660 in first four year to as much as Rs.77930 in fifth year were saved to meet out other liabilities of the family including education, health and many social obligations.

To ensure livelihood and prosperity of marginal farmers a dairy based IFS model including Crops (3800 sq.m.), Dairy (2 buffalo + 1 cow), Horticulture (Fruit plants Mandarin Var. Kinnow, tissue cultured Banana Var. Grain nain, guava and vegetables/ flowers as intercrops) ,Vermicompost and boundary plantations, was initiated.

RESOURCES CHARACTERIZATION AND SYSTEMS DIAGNOSIS

Livestock followed by cereal based farming systems were predominant in Konkan region. Sugarcane followed by livestock based farming systems were major farming systems in western Maharashtra. Pulses & oil seeds followed by livestock based farming systems in Viharwa region. Pulses & oil seeds were followed by cotton based farming systems were predominant in Marathwada. Farm size varied from 0.69 ha for marginal farmers to 5.09 ha for large farmers, about 5 family members per households, education of the family head was below 10th standard in Konkan region. In western Maharashtra, farm size varied from 0.64 ha to 6.09 ha for marginal and large farmers, family size of more than 6 members, education status was below metric. In Vidharba region, farm size varied from 0.47 ha for marginal farmers to 7.99 ha for large farmers, 2 fragmented plots, six family members, about metric standard education. In Marathwada region, the farm size varied from 0.66 ha (marginal) to 7.81 ha per large farmers, 2 fragmented plots, more than 6 family members, about metric education. In general, each household had about two milch animals. The cropping intensity was below 200% in all the regions and cereals constitute major area of crop production (Konkan 78%, Western Maharashtra 47%). The oil seeds 32% pulses 17% cereals 24%, and cotton 22% occupied gross cultivated area in Vidharbha region. In Marathwada, cereals (22%), oil seeds 23%, pulses (18%)and cotton 17% occupied the gross cropped area. In general, households expenditure for maintenance of family including education, social and religious activities excluding marriage ceremonies varied from Rs 45832 (marginal farmers) to Rs. 97351(large farmers) per year. Food constituted the major item of expenditure varying from 42 % (Vidharwa region) to 57 % (western Maharastra). Farm size had inverse relation with the percentage expenditure on food and direct relation with education, health and insurance. As per sample household, fragmentation and subdivision of land holding, less reliable market, scarcity of owned fund, dependence of depleting natural resources, non-availability of good quality seeds (variety and breeds) and sheds for animals, poultry etc. were found major constraints to higher returns of different farming systems

The fluctuation of ground water table over the years was recorded in Hamirpur district. The energy consumed in irrigation during 2004-05 was more compared to 2009-10. It was due to erratic and low rainfall during 2004-05. The cost of irrigation of wheat was recorded 7.8 % higher during 2004-05 compared to 2009-10 and indicated the impact the ground water depletion. Keeping goats on the farm instead of milch cattle by majority of the farmers further showed the scarcity of water and depletion of ground water table in the district.

TECHNOLOGY TRANSFER AND REFINEMENT

Technologies of balanced nutrition in wheat, rice and sugarcane were introduced at 10 farmers field Mahal and Shyampur village of in the Daurala block located 20 km away from PDFSR in Meerut district. Treatment T_4 provided highest yield (4.46 t/ha) followed by T_3 (4.34 t/ha), T_2 (4.19 t/ha) and T_1 (3.84 t/ha). Out of eleven demonstrations, the highest increase (13.5%) in yield was observed in the variety COS-767 for balanced fertilizer application in sugarcane plant crop whereas, the variety COS-8436 recorded highest increase (9.29 %) in yield for potash application in sugarcane ratoon crop. In, 20 farmers field trails, the increase in yields over the farmers' practice of the rice varieties Sugandha 5, Sugandha 4 and PB 1 through recommended doses of NPK (about half the dose of nitrogen the farmers used to apply) were 10.72%, 14.66% and 20.49%. Five Front-line demonstrations on oilseed (Mustard Var. Pusa bold) in Poothari village of Ghaziabad district recorded 26.4% increase in yield. 3 training programmes, 1 awareness week, 1 group discussion and 7 visits were organized for different categories of target groups. One field day and 2 exhibitions were also organized during the year on different occasions.

Major problems identified in sugarcane –live stock- cereal, cereal–sugarcane-live stock, Piggery-Live stock-cereal and Sugarcane-Fishery-cereal-Live stock based farming systems were weed infestation, lack of awareness about latest high yielding cultivars, recommended nutrient management, white grub problem in sugarcane, wild animals, balanced nutrition in milch animals and sanitary and hygienic condition of sheds and animals.

EXTERNALLY FUNDED PROJECTS

In order to increase system's productivity and farmer profits through fertilizer best management practices (BMPs), five nutrient management options (1) Farmers fertilizer practice (FFP), (2) State fertilizer recommendation (SR), (3) Improved state recommendation (ISR) (wherein 25% higher dose of N and 50% higher doses each of P and K as compared to SR were applied), (4) State soil testing laboratory recommendation (STLR) and (5) Site specific nutrient management (SSNM) were evaluated in predominant rice as well as wheat based cropping systems. The system productivity in terms of wheat equivalent yield (WEY) across the nutrient management options was maximum with SSNM in rice-wheat (12.5 t ha^{-1}) followed by maize-wheat (10.8 t ha^{-1}), ground nut –wheat (8.86 t ha^{-1}), pigeon pea-wheat (8.83 t ha^{-1}), sesamum–wheat (7.69 t ha^{-1}) and lowest in sorghum (dry fodder)-wheat (5.99 t ha^{-1}).

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 'All 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 constraints 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 2010-11, 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 Vallabhbhai Patel University of Agriculture & 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 per cent of which is received through southwest monsoon during July to September.

The important weather parameters during 2010-11 are depicted in Figs 5/1-4. Rainfall recorded at Modipuram during the year under report was 726.5 mm. It was 13.4 percent lower than normal rainfall. This was primarily due to lack of rainfall in winter months. The onset of monsoon occurred in the 26th standard meteorological week (SMW) which are the normal week of onset of monsoon at Meerut. The amount was good and brought about sufficient water to the rice and sugarcane crops. Albeit the rainfall was well distributed in the months of July, August and mid September, but no rainfall occurred after 38th SMW (last week of September) to 12th SMW (first week of December). Summer season was very hot and weekly average maximum temperature reached to 45.2 °C in 21st SMW and remained higher than 40.0 °C till end of May. The 3rd week of June of 2010 exposed to highest weekly average minimum temperature of 25.5 °C and lowest (2.7 °C) during 2nd week of January 2011. The lowest average relative humidity (RH) of 28% was recorded in 4th week of April and highest average RH of 79% was recorded in 1st week of February. Number of bright sunshine hours was highest (9.9 hrs) in 3rd week of May and lowest (1.6 hrs) in 2nd week of September. Most of the weeks in the *Kharif* season received less than 6 hours of bright sunshine.

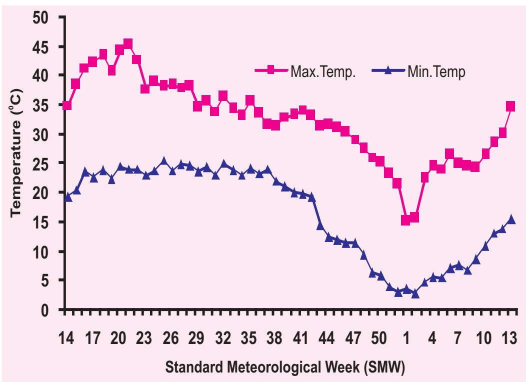


Fig 5/1: Weekly maximum and minimum temperature during crop season (2010-11)

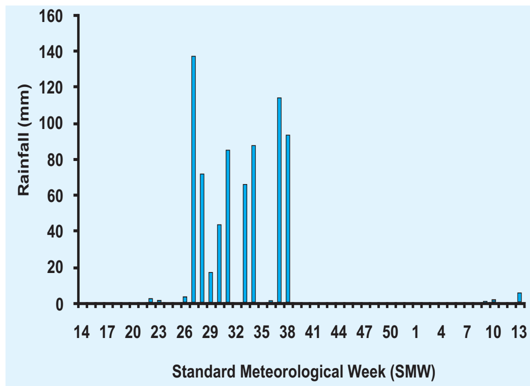


Fig 5/2: Weekly rainfall during crop season (2010-11)

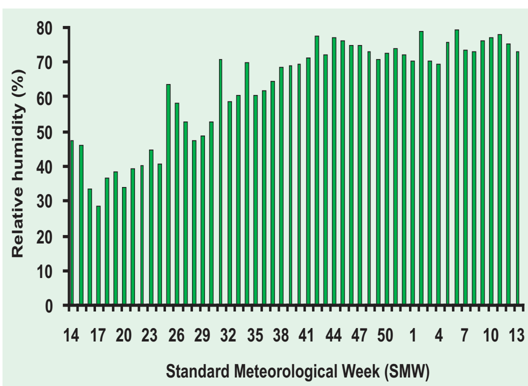


Fig 5/3: Weekly average relative humidity during crop season (2010-11)

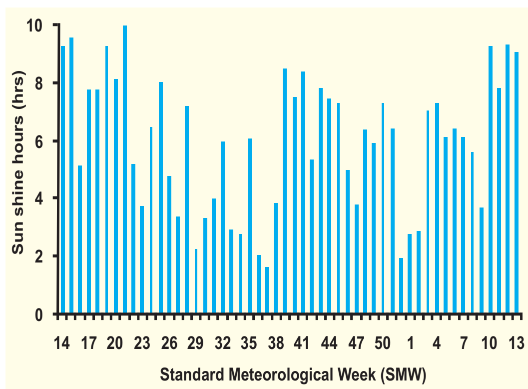


Fig 5/4: Weekly average bright sunshine hours during crop season (2010-11)

6. PERSONNEL

6.1 STRENGTH

Table 6.1 : Staff position as on 31-03-2011

Category	Sanctioned	Filled
RMP	01	01
Scientific	38	24
Technical	25	25
Administrative	16	17**
Supportive	10	10
Total	**90**	**77**

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

6.2 NEW APPOINTMENTS/JOININGS

Dr. Sonali Paul Mazumdar, Scientist (Soil Fertility/Micro Biology/Soil Chemistry) has joined PDFSR, Modipuram on 16-04-2010.

Dr. N. K. Jat, Scientist (Agronomy) has joined PDFSR, Modipuram on 13-04-2010.

Dr. M. P. Sharma, Principal Scientist (Soil Fertility) through transfer from CITH, Jammu and has joined at PDFSR, Modipuram on 23-11-2010.

Dr. N. Subash, has been selected as Senior Scientist (Agri. Meteorology) through ASRB and has joined at PDFSR, Modipuram on 02-02-2011.

Mr. Anil Agarwal, FAO, joined as FAO on 19-03-2011.

6.3 PROMOTIONS

Shri T. C. Sharma, AF & AO promoted to the post of F&AO at DWR, Karnal.

Dr. K. S. Gangwar, promoted to the post of Principal Scientist retrospectively from 27-07-2008.

Dr. Prem Singh, promoted to Principal Scientist from Senior Scientist retrospectively from 01-01-2008.

Shri Jatakant promoted to the post of Assistant on 02-11-2011.

Shri Prem Singh promoted to the post of UDC on 02-11-2011.

Shri Attar Singh promoted to the post of Personal Secretary on 10-03-2011.

6.4 OBITUARIES

Dr. K. S. Gangwar, Principal Scientist (Agronomy) left for heavenly abode on 13-08-2010 after a tragic accident. The Directorate suffered huge and irreparable loss in the form of a renowned agronomist. PDFSR family mourns for Dr. Gangwar and prays almighty to give enough courage to his family to bear with the adversaries.

Dr. A. Sarkar, Principal Scientist (Agronomy) left for heavenly abode on 08-01-2011 due to heart attack. Dr. Sarkar was born on April 01, 1951 at Siliguri district Darjeeling (West Bengal). He joined ICAR service on August 30, 1978. The Directorate suffered huge and irreparable loss in the form of a renowned agronomist. PDFSR family mourns for Dr. Sarkar and prays almighty to give enough courage to his family to bear with the adversaries.

6.5 TRANSFERS

Dr. Akath Singh, Scientist (Sr. Scale) Horticulture, has been relieved from PDFSR, Modipuram on 29-12-2010 on his selection to the post of Senior Scientist, CAZRI, Jodhpur, Rajisthan.

Dr. A. K. Nayak, Principal Scientist, Soil Fertility, has been transferred and relieved from PDFSR, Modipuram on 20-05-2010 to join at CRRI, Cuttak, Orrissa.

Mr. T.C. Sharma, AF&AO has been relieved from at PDFSR, Modipuram on 19-03-2011 on his selection to the post of FAO, DWR, Karnal, Haryana.

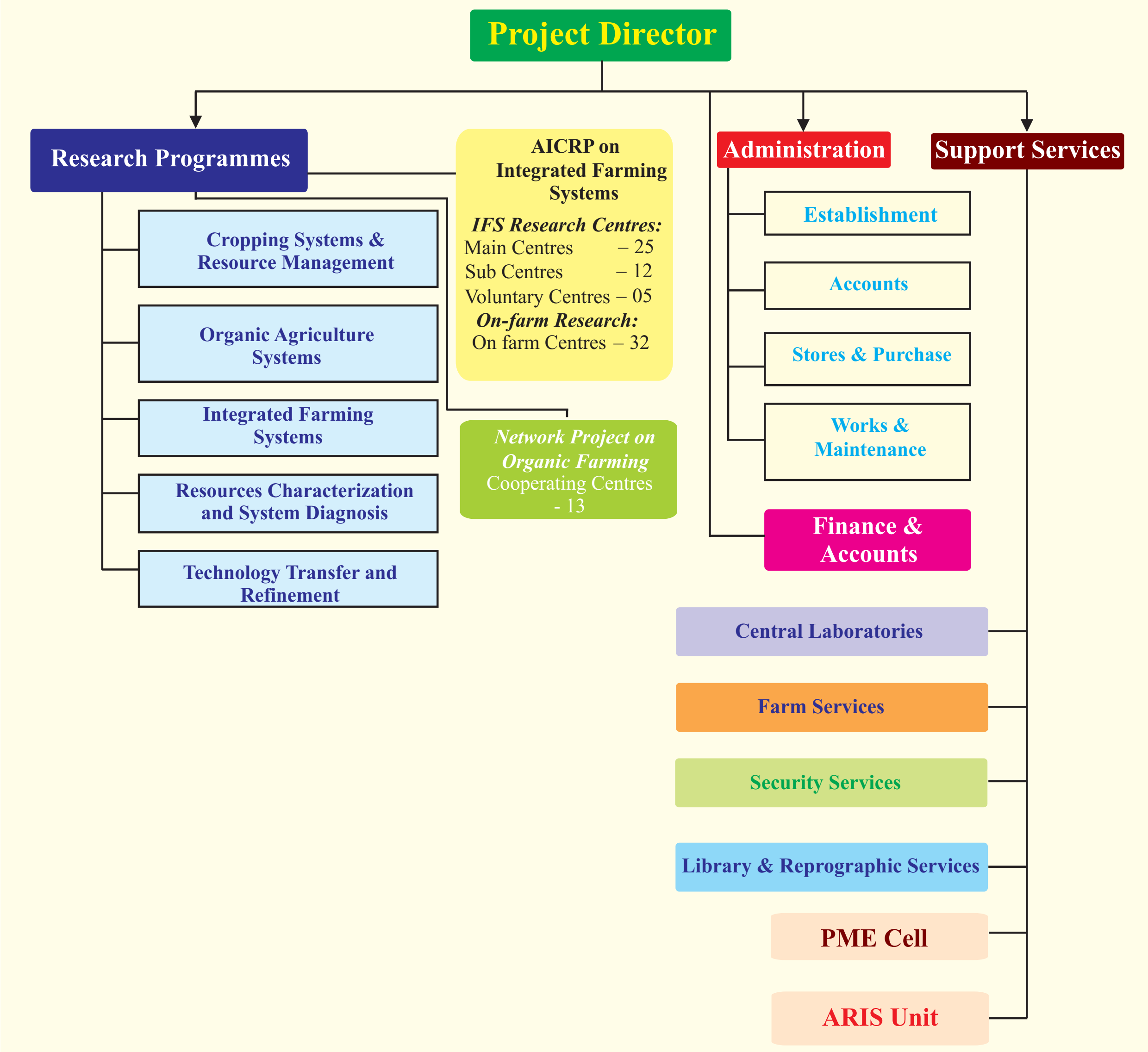
Shri Suryakant, Personal Secretary transferred to NIAM, Baramati on 09-02-2011.

6.6 RETIREMENTS

Dr. R.K. Langar, Senior Scientist has been retired on 30-11-2010.

Dr. Devendra Singh, Principal Scientist has been retired on 28-02-2011.

7. ORGANIZATIONAL STRUCTURE



8. BUDGET

Statement for Review of Expenditure for the period ending 31 Mar 2011

	Non Plan			Plan			NAIP		
	BE/RE	Release	Expenditure	BE/RE	Release	Expenditure	BE/RE	Release	Expenditure
Capital									
Works									
A.1 Land	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
B.1 Office buildings	NIL	NIL	NIL	17.00	17.00	17.00	NIL	NIL	NIL
B.2 Residential buildings	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
B.3 Minor Works	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Other Capital Expenditure									
C. Equipments	1NIL	1NIL	9.98	3.00	3.00	3.08	0.50	0.50	0.26
D, Information Technology	NIL	NIL	NIL	6.00	6.00	5.67	NIL	NIL	NIL
E. Library Books and Journals	NIL	NIL	NIL	19.00	19.00	18.97	NIL	NIL	NIL
F. Vehicles and Vessels	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
G Livestock	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
H. Furniture & fixtures	2.00	2.00	1.99	NIL	NIL	NIL	NIL	NIL	NIL
I. Others	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Total Capital	**12.00**	**12.00**	**11.97**	**45.00**	**45.00**	**44.72**	**0.50**	**0.50**	**0.26**
Revenue									
Establishment Expenses									
A.1 Establishment Charges	636.00	528.69	528.60	NIL	NIL	NIL	NIL	NIL	NIL
A.2 Wages	32.00	28.30	28.31	NIL	NIL	NIL	NIL	NIL	NIL
A.3 Overtime Allowance	0.20	0.20	0.18	NIL	NIL	NIL	NIL	NIL	NIL
B. Pension & Other Retirement Benefits	84.14	79.00	79.03	NIL	NIL	NIL	NIL	NIL	NIL
C. Loans and Advances	13.30	4.14	4.14	NIL	NIL	NIL	NIL	NIL	NIL
Travelling Allowances									
A. Domestic TA / Transfer TA	3.50	3.45	3.45	7.00	7.00	7.00	1.10	1.00	0.67
B. Foreign TA	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Research and Operational Expenses									
A. Research Expenses	9.10	9.05	9.05	50.50	50.50	50.67	11.24	11.14	5.01
B. Operational Expenses	1.00	0.33	0.33	4.00	4.00	4.01	7.92	5.36	7.96

	Non Plan			Plan			NAIP		
	BE/RE	Release	Expenditure	BE/RE	Release	Expenditure	BE/RE	Release	Expenditure
Administrative Expenses									
A. Infrastructure	25.16	13.25	13.24	7.90	7.90	7.91	NIL	NIL	NIL
B. Communication	0.80	0.13	0.13	0.45	0.45	0.48	NIL	NIL	NIL
C.1 Repairs/ Maintenance - Equipments, Vehicles & Others	5.00	0.03	0.03	5.05	5.05	5.06	NIL	NIL	NIL
C.2 Repairs/ Maintenance - Office building	1.80	0.29	0.29	1.00	1.00	1.00	NIL	NIL	NIL
C.3 Repairs/ Maintenance - Residential building	5.00	NIL	NIL	2.95	2.95	2.96	NIL	NIL	NIL
C.4 Repairs/ Maintenance - Minor Works	0.50	0.65	0.65	NIL	NIL	NIL	NIL	NIL	NIL
D. Others (excluding TA)	1.50	2.83	2.83	21.15	21.15	21.19	NIL	NIL	NIL
Miscellaneous Expenses									
A. HRD	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
B. Other Items (Fellowships, Scholarships etc.)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
C. Publicity & Exhibitions	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
D. Guest House – Maintenance	1.00	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
E. Other Miscellaneous	9.00	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Total Revenue	**829.00**	**670.34**	**670.27**	**10NIL**	**10NIL**	**100.27**	**20.26**	**17.50**	**13.64**
Grand Total : Capital + Revenue	**841.00**	**682.34**	**682.24**	**145.00**	**145.00**	**145.00**	**20.76**	**18.00**	**13.90**

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)

A. ALTERNATIVE CROPPING SYSTEMS

Bio-intensive complementary cropping systems for high productivity and profitability

The studies were made to explore the possibilities of evaluating bio-intensive complementary cropping systems so as to ensure efficient resource use with high productivity and profitability. Nine cropping systems along with land configurations, *in situ* green manuring, residue incorporation, zero/minimum tillage and inter cropping approaches were evaluated during 2010-11. The results of experiment have revealed that 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 also found to be remarkably better which resulted in 21.84 t/ha as rice equivalent yield with productivity of 59.84 kg grain/ha/day and net return of Rs.140465/ha/year (Table 9.1/1). The studies on the concept of Bio-intensive complimentary cropping systems" were also initiated at selected centers as and when the existing sequences/treatments/experiments are concluded. The spread of cropping systems and diversification opportunities at district level in the Country planned to be worked out in consultation with NCAP and IASRI. The national level information as generated through cropping systems management programme over the years are published. The publication is

Table 9.1/1. Bio-intensive complimentary cropping systems for higher productivity and profitability as alternative to rice-wheat

Treatments	REY[1] (t/ha/yr)	Gross Return (Rs./ha/yr)	Net Return (Rs./ha/yr)
To Rice- Wheat (Conventional, Flat bed)	9.96	89680	39860
T1 Hy.Rice –Lentil+Wheat (FIRB)—Cowpea (V+R)	13.73	123550	75645
T2 Maize(C) +V.Cowpea (BB) +Sesbania (F)— Lentil (BB)+ Mustard (F)-Greengram (BB-ZT) (BBF)	21.84	196569	140465
T3 Maize(G)+Blackgram- V. Pea(B)+Mustared(F) (ZT)—Greengram (ZT) (G+R)	21.58	194201	132562
T4 Maize(C)+Sesbania- Toria+G.Sarson-Greengram (ZT) (G+R) (FB)	16.62	149618	95465
T5 Sorghum+C.Bean(f)- Maize(C)+B.Gram- Methi –Onion+Coriander	11.50	103500	53950
T6 Pegionpea + blackgram-Wheat+Mustared (ZT)-Cowpea(f)(ZT) (FB)	18.30	164723	128750
T7 Pegionpea + Soybean -Wheat+Mathi (ZT)-Amaranthus(ZT) (FB)	15.76	141805	118615
T8 Maize+Cowpea(f)-Maize(C) +B. Gram-Wheat+Mathi—Greengram (G+R) (FB)	20.87	187789	125785

[1]-Rice equivalent yield

entitled "Resource efficient alternative cropping systems and their production packages for different agro-climatic zones of India".

Evaluation of different cropping systems under limited water availability situation

The experiment was conducted to study the growth, yield attributes and yield of different cropping systems under limited water availability, to monitor the changes in soil fertility in different cropping systems under limited water availability and to workout the economics of different cropping systems under limited water availability. Four cropping systems along with three irrigations regimes approaches were evaluated during 2010-11. Results revealed that no irrigation needed during *kharif* season in any of the crops evaluated under the system. Based on irrigations applied to *rabi* crops, the highest system productivity (16.96 kg/ha/day) and profitability (Rs.142 /ha/day) of pearl millet-wheat and pigeon pea-barley (25.78 kg/ha/day & Rs. 230 /ha/day) was recorded when three irrigations were applied. Under the two irrigation application conditions the systems involving maize-mustard with production of 14.95 kg/ha/day and productivity Rs. 109 /ha/day performed the best while under only one irrigation condition sorghum-lentil with production of 14.71 kg/ha/day and productivity of Rs. 100 /ha/day was the best (Table 9.1/2).

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

A field experiment was started during *Kharif* 2010 to find out the water and nitrogen use efficiency of rice wheat cropping system. Four cultivars (Subhangi, PRH 10, Saket 4 and Arize 6444) with three types of modified slow release urea (normal,

Table 9.1/2. Performance of different cropping systems under limited water availability situation

Cropping system	Yield (t/ha)		WEY (t/ha)	Productivity (kg/ha/day)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Profitability (Rs/ha/day)
	Kharif	*Rabi*					
Number of irrigation (One)							
Pearl millet-wheat	1.13	4.96	5.96	16.24	31500	47540	130
Maize-mustard	2.81	1.30	5.13	14.06	27350	37010	101
Pigeon pea-barley	1.33	5.04	8.85	24.24	31535	78038	214
Sorghum-lentil	1.41	1.15	5.37	14.71	27250	36325	100
Number of irrigation (Two)							
Pearl millet-wheat	1.18	5.00	6.01	16.47	31900	49210	135
Maize-mustard	2.48	1.59	5.46	14.95	27800	39804	109
Pigeon pea-barley	1.41	5.18	9.24	25.31	31945	82551	226
Sorghum-lentil	1.37	1.00	4.79	13.13	27700	29545	81
Number of irrigation (Three)							
Pearl millet-wheat	1.26	5.11	6.19	16.96	32350	51865	142
Maize-mustard	2.11	1.48	4.91	13.45	28250	33241	91
Pigeon pea-barley	1.44	5.26	9.41	25.78	32435	83874	230
Sorghum-lentil	1.52	0.96	4.78	13.09	28150	29375	80

neem coated urea and sulphur coated) and 3 level of soil moisture tension (0, 20, and 40 kPa) with three replications were evaluated in split plot design.

Rice productivity varied in accordance with irrigation water scheduling and modified slow release urea used in different cultivars. Rice productivity was maximum (7.24 t ha^{-1}) at zero irrigation water tension, followed by 20 and 40 kPa (Fig.9.1/1)

Rice productivity was maximum with sulphur coated urea (6.32 t ha^{-1}). Although the neem coated urea had edge over ordinary prilled urea but it was 9% lower to sulphur coated urea (Fig.9.1/2.), which might have played vital role for supplementary requirement of crop, as it is being commonly noticed in this region.

Arize 6444 gave maximum rice grain yield 7.8 (t ha^{-1}) which was statistically higher over others (Fig.9.1/3). PRH 10, Subhangi and Saket 4 gave lower yield by 16, 29 and 45%, respectively, compared to Arize 6444.

Rice cultivars maximum productivity was obtained with irrigation Sulphur coated urea application at 0 kPa. On the other hand lowest productivity was recorded with irrigation schedule 40 kPa with ordinary prilled urea. A increase in rice productivity was noticed with different varieties water scheduling and fertilizer interaction and maximum yield gain was noticed in Arize 6444 cultivar along with irrigation scheduled at 0 kpa and sulphur coated urea.

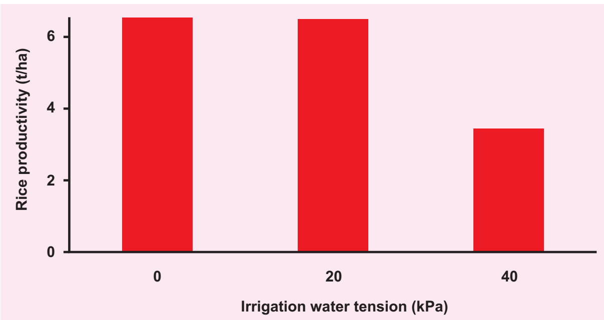


Fig 9.1/1: Effect of Irrigation water tension (kPa) on rice productivity (t ha^{-1})

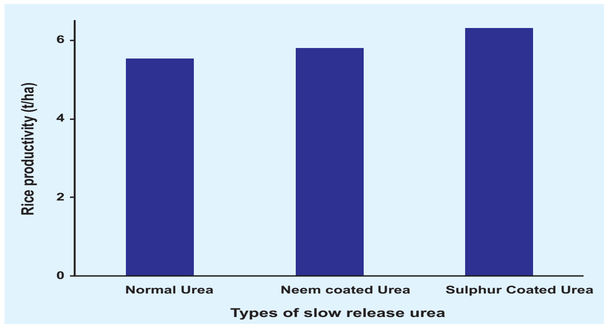


Fig 9.1/2: Effect of modified slow release urea on rice productivity

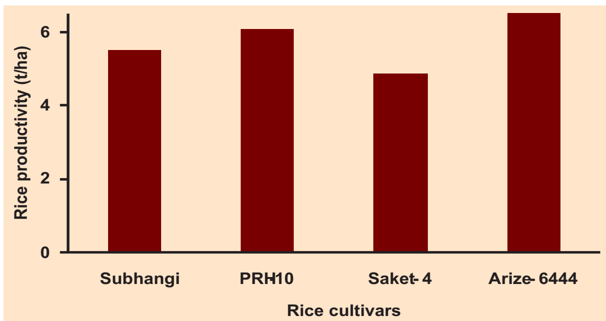


Fig 9.1/3: Effect of cultivars on rice productivity

B. CROP ESTABLISHMENT, TILLAGE AND FARM MECHANIZATION

Tillage and planting management in different cropping systems

The objective was to study the effect of different tillage and planting management techniques in different cropping system to improve crop productivity and soil health. There are no common cropping systems and treatments for all the centers but they vary from center to center.

In rice – wheat cropping system at Kanpur, during *kharif*, hand transplanting provided highest rice yield (4.60 t ha^{-1}) that was 6.2, 22.0 and 33.7% higher than transplanting by transplanter, drum seeding and zero till drilling, respectively. During *rabi*, the conventional sowing provided maximum wheat yield (3.79 t ha^{-1}) which was 3.0, 10.2 and 12.8% higher than strip till drilling, bed planting and zero till drilling, respectively. Both rice and wheat planting methods did not affect yields of wheat and rice. The highest system productivity (8.50 t ha^{-1}) of rice and wheat was recorded with treatment combination of hand transplanting of rice and conventional sowing of wheat.

In rice – wheat cropping system at Pantnagar, during *kharif,* all the treatments were at par, however, drum seeding provided numerically maximum rice (5.89 t ha^{-1}). During *rabi*, zero till drilling (3.93 t ha^{-1}) provided highest wheat that was at par with bed planting (3.73 t ha^{-1}) but 17.3 and 29.7% higher than strip till drilling and conventional sowing, respectively. Both rice and wheat planting methods did not affect yields of wheat and rice. Drum seeding of rice and zero till drilling of wheat was the best treatment combination for maximizing both rice (6.77 t ha^{-1}) and wheat (3.80 t ha^{-1}) yields.

In rice – wheat cropping system at Varanasi, during *kharif*, transplanting by transplanter provided highest rice (6.09 t ha^{-1}) that was at par with hand transplanting (5.93 t ha^{-1}) but 14.7 and 44.6% higher than drum seeding and zero till drilling, respectively. During *rabi*, conventional sowing provided highest wheat (4.34 t ha^{-1}) that was at par with zero till drilling (4.22 t ha^{-1}) but 9.0 and 11.6% higher than strip till drilling and rotavator till drilling. Also, the strip and rotavator till drilling provided wheat yields at par. Both rice and wheat planting methods did not affect the yields of wheat and rice. Transplanting of rice by transplanter and zero till drilling of wheat was the best treatment combination for maximizing both rice (6.28 t ha^{-1}) and wheat (4.17 t ha^{-1}) yields.

In rice – wheat cropping system at Sabour, during *kharif*, transplanting by transplanter provided highest rice (6.36 t ha^{-1}) that was at par with hand transplanting (6.31 t ha^{-1}) but 6.3 and 9.7% higher than drum seeding and zero till drilling, respectively. Among wheat planting methods, strip till drilling provided highest wheat (4.37 t ha^{-1}) that was 3.6, 10.4 and 13.2% higher than conventional sowing, bed planting and zero till drilling, respectively. Both rice and wheat planting methods did not affect the yields of wheat and rice. Transplanting by transplanter in rice and strip till drilling in wheat was the best treatment combination for maximizing both rice (6.42 t ha^{-1}) and wheat (4.46 t ha^{-1}) yields.

In rice – wheat cropping system at Raipur, during *kharif*, zero till drilling provided highest rice (6 t ha^{-1}) that was at par with hand transplanting (5.89 t ha^{-1}) but 8.1 and 8.9% higher than drum seeding and transplanting by transplanter, respectively. During *rabi*, all the treatments were at par but conventional sowing provided numerically maximum wheat yield (2.2 t ha^{-1}). The residual effect of rice and wheat planting methods was significant. Zero till drilling in rice and conventional sowing in wheat was the best treatment combination for maximizing both rice (6.42 t ha^{-1}) and wheat (2.38 t ha^{-1}) yields.

In rice – wheat cropping system at Jabalpur, during *kharif*, all the planting methods provided statistically similar rice yield (3.55 to 4.15 t ha^{-1}). The wheat planting method zero till drilling provided maximum yield (3.96 t ha^{-1}) that was at par with strip till drilling and bed planting but 4.8% higher than conventional sowing, respectively. Hand transplanting in rice and bed planting in wheat was the best treatment combination for maximizing both rice and wheat yields.

In rice – wheat cropping system at R.S. Pura, during *kharif*, transplanting by transplanter provided highest rice (7.33 t ha^{-1}) that was at par with hand transplanting but 49.0 and 68.1% higher than drum seeding and zero till drilling, respectively. During *rabi*, bed planting provided highest wheat (3.80 t ha^{-1}) that was at par with conventional sowing but 11.1 and 12.8% higher compared to zero and strip till drilling, respectively. Both rice and wheat planting methods did not affect the yields of wheat and rice. Mechanical transplanting of rice and conventional sowing of wheat was the best treatment combination for maximizing both rice (7.94 t ha^{-1}) and wheat (3.75 t ha^{-1}) yields.

In rice – wheat cropping system at Palampur, during *kharif*, drum seeding provided highest rice (1.29 t ha^{-1}) that was 69.7 and 222% higher than zero till drilling and manual transplanting, respectively. During *rabi*, all the treatments gave similar yields but conventional sowing gave numerically maximum wheat yield (2.86 t ha^{-1}). Both rice and wheat planting methods did not affect the yields of wheat and rice. Drum seeding of rice and conventional sowing of wheat was the best treatment combination for maximizing both rice (1.27 t ha^{-1}) and wheat (3.35 t ha^{-1}) yields.

In rice – groundnut cropping system at Rajendranagar, during *kharif*, transplanting after normal puddling (after summer green manuring) produced maximum rice yield (3.94 t ha^{-1}) that was at par with transplanting after normal puddling (3.64 t ha^{-1}) but 132% higher than dry seeding. During *rabi*, plowing twice and rotavating twice provided highest ground nut yield (2.72 t ha^{-1}) that was at par with plowing twice and harrowing thrice but 28.9% higher that plowing once and harrowing twice. The summer green manuring in rice benefited only rice crop; and transplanting after normal puddling after summer green manuring in rice and ploughing twice and harrowing thrice was the best treatment combination for maximizing rice (4.35 t ha^{-1}) and ground nut (2.91 t ha^{-1}) yields.

In soybean based cropping systems at Akola, during *kharif*, all the treatments were at par but soybean – *rabi* sorghum system gave numerically maximum soybean yield (3.39 t ha^{-1}). During *rabi* also soybean –*rabi* sorghum system gave maximum soybean equivalent yield (2.00 t ha^{-1}) that was at par with soybean – mustard but 44.9 and 108.0% higher than soybean –chick pea and soybean – safflower systems. The tillage methods did not affect the yield of soybean crop. During *rabi* also, the similar trend was obtained and broad bed furrow (BBF) sowing gave maximum soybean equivalent yield (2.20 t ha^{-1}) that was, respectively, 33.3, 69.2 and 126% higher than zero, minimum and conventional tillage sowings. Soybean – *rabi* sorghum and broad bed furrow sowing system was the best treatment combination for maximizing both the yields of soybean and *rabi* crops.

In soybean based cropping systems at Rahuri, during *kharif*, soybean – chick pea system gave maximum soybean yield (2.81 t ha^{-1}) that was at par with soybean – wheat and soybean – onion but 19.5% higher than pearl millet – wheat, pearl millet – chick pea and pearl millet - onion systems. During *rabi*, soybean – onion equivalent system gave onion yield of 27.89 t ha^{-1} which was at par with pearl millet – onion system; whereas, wheat and chick pea yields, of both the systems with soybean and pearl millet as *kharif* crops, were at par. Soybean – onion system provided highest soybean equivalent system yield followed by pearl millet – onion. Among tillage methods, conventional tillage sowing gave maximum soybean yield (2.85 t ha^{-1}) that was, respectively, 6.7, 14.5 and 25.5% higher than bed planting, minimum and zero tillage sowings. During *rabi* also, the similar trend was obtained. Also, the conventional tillage sowing gave maximum soybean equivalent system yield. Soybean – onion system and conventional tillage sowing was the best treatment combination for maximizing both the yields of soybean and *rabi* crops.

In soybean based cropping systems at Rudrur, during *kharif*, conventional tillage sowing gave maximum soybean yield (2.04 t ha^{-1}) that was 29.1 and 64.5% higher than minimum and zero tillage sowing. During *rabi*, soybean – mustard cropping systems gave maximum soybean equivalent yield (1.95 t ha^{-1}) followed by soybean – safflower (1.92 t ha^{-1}). Soybean – mustard system and conventional tillage sowing was the best treatment combination for maximizing both the yields of soybean and *rabi* crops.

In rice – rice cropping system at Kathalegere, during *kharif*, the system of rice intensification gave maximum rice yield (5.44 t ha^{-1}) that was at par with aerobic method, drum seeding and mechanical transplanting but 13.1 and 27.7% higher than hand transplanting and zero till drilling respectively. During summer also, the system of rice intensification gave maximum rice yield (5.22 t ha^{-1}) that was at par with aerobic method and drum seeding but 31.8, 40.3 and 41.1% higher than mechanical transplanting, zero till drilling and hand transplanting, respectively.

In pearl millet based cropping systems at Hisar, tillage as well as cropping systems did not affect yields of pearl millet. During *kharif*, the yield of pearl millet ranged between 3.46 and 3.87 t ha^{-1}. During *rabi*, conventional tillage provided maximum wheat equivalent yield (3.87 t ha^{-1}) that was at par with minimum tillage but 5.6 and 14.2% higher than zero tillage and bed planting. The pearl millet – wheat cropping system gave wheat equivalent yield of 5.52 compared to 2.41 t ha^{-1} of pearl millet – mustard system.

Performance of different cropping systems under various tillage management

The experiment was initiated in the year 2009 with the objective to find out the effect of different tillage management practices on various cropping systems from the view point of saving water and other resources. The experiment was conducted in split plot design with 3 tillage practices (Conventional, Zero and FIRB) in main plot; and 9 cropping systems (T_1= Transplanted rice-wheat, T_2 = Directed seeded rice-wheat, T_3 = Maize – wheat – green gram F & G, T_4= Pegeon pea – wheat, T_5= Sorghum (F)- toria- wheat, T_6= Pearl-millet (F)- toria-wheat, T_7= Sesame- lentil, T_8 = Maize+ cowpea (F) – mustard , T_9= Cowpea(g)- wheat) in sub- plot with 3 replications. There was little difference among cropping systems under various tillage management like conventional tillage, zero tillage and furrow irrigated raised bed. It was found that 20-25% water was saved in zero and FIRB against conventional tillage.

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 is depicted in Fig. 9.1/4. The effect of planting methods on rice yield over the years is depicted in Fig. 9.1/5. We noted that the rice (Saket – 4) yield was higher in MT (7.3%), MaT (5.4%), ZT (6.3%), BP (1.6%) and ST (1.0%); but lower in RT (0.5%); DS (3.0%), CS (8.6%) and BS (13.5%), respectively, compared to traditional HT (5.72 t ha^{-1}). The net return was 33% higher in ZT, 27 and 24% higher in MT and MaT; 15 to 19% higher in RT, ST and BP; 7% higher in DS; but 3 and 13% lower in CS and BS, respectively, compared to HT (Rs 26440 ha^{-1}). The B: C ratio was 33% higher in ZT, 22 to 18 per cent higher in ST, MT, MaT, BP and RT; 11 and 5% higher in DS and CS; but at par in BS, respectively, compared to HT (1.97). Energy output: input ratio was 26% higher in ZT, 15 to 5% higher in all the methods except DS, CS and BS, where it was 4 to 14% lower, compared to HT (5.57). The water use was 33% lower in BP; 1 to 5 per cent lower in all other methods except CS, DS and BS, where it was 5 to 12% higher, compared to HT (202 ha-cm). The infiltration rate was maximum in BP (76 mm day^{-1}) and lowest (32 to 35 mm day^{-1}) in the three transplanting methods because of puddling. The weed dry matter was 88 to 265% higher in all the methods but 38 and 40 per cent lower in MaT and MT, compared to HT (52 kg ha^{-1}).

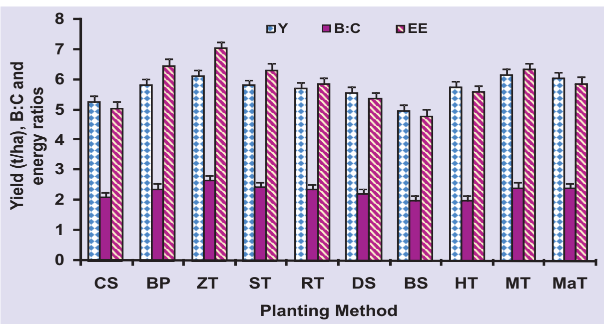


Fig 9.1/4: Effect of planting methods on rice yield (Y), benefit: cost (B:C) and energy ratios (EE) ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT _ Transplanting by manual transplanter)***

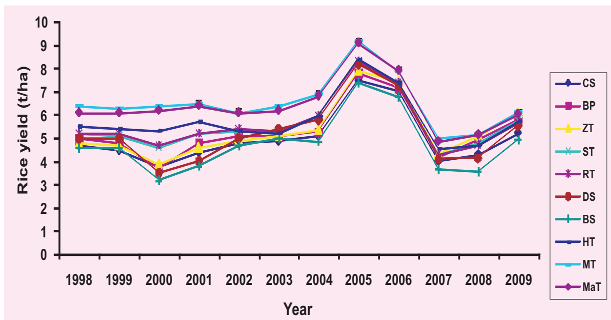


Fig 9.1/5: Effect of planting methods on rice yield over the years ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT _ Transplanting by manual transplanter)***

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 (105–120 mm), root length (40-50 mm), trunk diameter (3.3-4.4 mm), thickness of seedling at the base of root (3.8-4.6 mm), leaf stage (3-5) and about 20 thousand seedlings m^{-2} (Table 9.1/3).

Table 9.1/3. 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) 16	20	25	30	Mean
30	6.2	6.0	5.9	5.5	5.9
35	6.0	5.9	5.5	5.0	5.6
40	5.9	5.5	5.0	4.6	5.2
Mean	6.0	5.8	5.5	5.0	-
CD at 5% Seed rate= 0.14, Age of seedling= 0.16					

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 39.7 per cent, depth of puddle profile of 57.4 mm, bulk density of 1.55 t m^{-3}, water content of 47.4 per cent and penetration resistance of 1475 k Pa (Table 9.1/4).

Table 9.1/4. 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	20.3	57.4	65.3	85.7
Amount of dispersion, %	15.4	39.7	45.3	55.3
Bulk density of puddle profile, t m^{-3}	1.64	1.55	1.58	1.67
Water content of puddle profile, %	33.2	47.4	48.6	49.7
Penetration resistance of puddle profile, k Pa	1900	1475	1600	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 42. The growth and subsequent establishment of the transplanted seedlings were faster having 0.42 million hills ha^{-1} with 15-20 active tillers $hill^{-1}$. Under normal conditions the transplanter recorded 0.18 – 0.20 ha h^{-1} field capacity, 2.35 – 2.51 ha^{-1} diesel consumption and planting of 3-5 seedlings per hill with average inter-hill spacing of 100 mm, standing angle of transplanted seedlings 70-75 degree and transplanting efficiency of 90 - 95%. 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 9.1/5). 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%)

Table 9.1/5. Grain yield of rice as affected by different puddling levels and transplanting methods

Puddler passes	Transplanting method	Grain yield ($t\ ha^{-1}$)
Zero	Manual	5.3
	Mech.	5.5
One	Manual	5.6
	Mech.	6.0
Two	Manual	5.8
	Mech.	6.3
Three	Manual	5.9
	Mech.	6.5

and mechanical transplanting (9.1%), over zero pass. This increase in two passes of puddler was 3.4 and 5.0% under manual and mechanical transplanting respectively. The yield increase under three passes was 1.7% in manual and 3.2% in mechanical transplanting over two passes. The average increase in mechanical transplanting was 7.6 per cent compared to manual transplanting.

A comparison of cost under manual and mechanical transplanting revealed that the mechanical transplanting by rice transplanter provided considerable saving in labour (79%) and cost of operation (57%); higher yield (7.3%), net returns (27%), benefit: cost ratio (21%), energy output: input ratio (13%); while requiring less specific cost (17%) and specific energy (11%) compared to manual transplanting (Table 9.1/6).

Table 9.1/6. Comparative economics and energy use of manual and mechanical transplanting of rice

Parameter	Manual transplanting	Mechanical transplanting
Net income, Rs. ha^{-1}	26,440	33,590
Benefit: cost ratio	1.97	2.39
Specific cost, Rs. kg^{-1}	4.76	3.93
Specific energy, k cal kg^{-1}	538	476
Energy output: input ratio	5.57	6.31

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 (88 to 85%), labour (87 to 83%), diesel (87 to 61%), cost (81 to 65%), energy (87 to 62%) and also irrigation water (6 to 37%) as compared to conventional sowing (Table 9.1/7). The rice yield, economics and energy use affected by different methods is given in Table 9.1/8. The zero till drilling produced higher rice (16%), net returns (38%), B: C ratio (26%) and energy output: input ratio (39%) while requiring lesser specific cost (20%) and specific energy (28%), compared to conventional sowing. The rotary till drilling produced output: input ratio (15%) while requiring lesser specific cost (10%) and specific energy (13%), compared to conventional sowing. The strip till drilling produced higher rice (10%), net returns (24%), B: C ratio (15%) and energy output: input ratio (25%) while requiring lesser specific cost (13%) and specific energy (19%), compared to conventional sowing. The bed planting produced higher rice (11%), net returns (22%), B: C ratio (13%) and energy output: input ratio (28%) while

Table 9.1/7. Performance parameters of different rice seeding machines

Parameter	Zero-till drill	Strip-till drill	Bed-planter	Roto-till drill	Conventional drill
Effective field capacity, ha h^{-1}	0.45	0.43	0.39	0.36	0.48
Field Efficiency, %	61	58	58	62	64
Fuel consumption, l ha^{-1}	8.0	10.5	10.0	25.0	65.0
Cost of sowing, Rs. ha^{-1}	770	980	897	1450	4155
Energy requirement, MJ ha^{-1}	463	604	580	1420	3761

Table 9.1/8. Yield, economics and energy use in different methods of direct dry seeding of rice

Parameter	Zero-till drill	Strip-till drill	Bed-planter	Roto-till drill	Conventional drill
Grain yield, t ha^{-1}	6.08	5.78	5.81	5.69	5.23
Straw yield, t ha^{-1}	7.7	7.2	7.2	7.3	6.8
Net income, Rs ha^{-1}	35,330	31,680	31,350	30,500	25,510
Benefit: cost ratio	2.63	2.41	2.36	2.33	2.08
Specific energy, k cal kg^{-1}	428	478	466	515	597
Energy output: input ratio	7.02	6.29	6.44	5.83	5.03
Specific cost, Rs kg^{-1}	3.57	3.89	3.98	4.02	4.51

requiring lesser specific cost (11%) and specific energy (21%), 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 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 = 0.06 ha/h, field efficiency = 50%, Cost of operation = Rs 500/ ha and energy requirement = 70 MJ/ha). Drum seeding provided higher rice yield (12%), net returns (23%), B: C ratio (11%), energy output: input ratio (12%) while requiring lower specific energy (10%) and specific cost (10%) compared to broadcasting method of sprouted seeding of rice (Table 9.1/9).

Table 9.1/9. Economics and energy use of different methods of seeding of sprouted rice

Parameter	Drum seeding	Broadcasting
Grain yield, t ha^{-1}	5.55	4.95
Net income, Rs. ha^{-1}	28,250	22,900
Benefit: cost ratio	2.19	1.97
Specific energy, k cal kg^{-1}	562	630
Energy output: input ratio	5.34	4.76
Specific cost, Rs. kg^{-1}	4.29	4.77

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 0.44, 0.41, 0.55, 0.35 and 0.48 ha h^{-1}, respectively (Table 9.1/10). The rotary, strip and zero till drilling and bed planting were time saving (80, 79, 85 and 75%), labour saving (70, 75, 76 and 72%), diesel saving (66, 85, 87 and 86%), cost saving (57, 73, 79 and 78%), energy saving (66, 85, 87 and 86%) and also irrigation water saving (9.5, 9.1, 10.6 and 37%) compared to conventional sowing of wheat. Also, there was saving of about 20-25% in seed and fertilizer inputs in bed planting compared to conventional sowing. Zero, strip and rotary till drills and bed planter provided higher wheat yields (15-22%), net returns (27-32%), cost effectiveness (24-28%) and energy efficiency (34-37%); required lower specific energy (26-27%) and specific cost (19-23%); and reduced *Phalaris minor* (43-76%), other weeds (60-73%), compared to conventional sowing of wheat (Fig. 9.1/6). The effect of planting methods on wheat yield over the years is depicted in Fig. 9.1/7.

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

Table 9.1/10. 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}	0.48	0.35	0.41	0.55	0.44
Field efficiency, %	64	62	61	67	63
Fuel consumption, l ha^{-1}	54.6	7.6	8.4	7.2	18.4
Cost of sowing, Rs. ha^{-1}	4050	910	1120	870	1720
Energy requirement, MJ ha^{-1}	3096	436	480	412	1042
Grain yield, t ha^{-1}	5.08	5.85	5.90	6.21	6.09
Benefit: cost ratio	2.96	3.75	3.67	3.74	3.78
Specific energy, k cal kg^{-1}	624	463	464	456	455
Energy output: input ratio	4.81	6.48	6.46	6.59	6.60
Specific cost, Rs. kg^{-1}	5.45	4.29	4.39	4.20	4.19

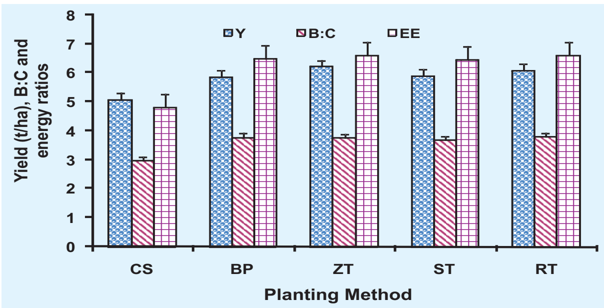


Fig 9.1/6: Effect of planting methods on wheat yield (Y), benefit: cost (B:C) and energy ratios (EE) ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)***

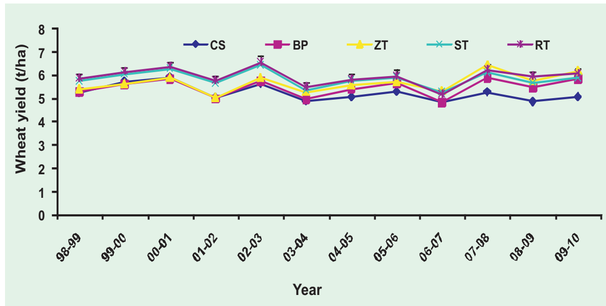


Fig 9.1/7: Effect of planting methods on wheat yield over the years ***(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)***

(15-38%) whereas rotary till drilling and conventional sowing reduced OC (2-11%) after nine 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 eleven crop cycles.

Development of low cost multi tillage - multi crop planter for round grain cereals, legumes and pulses

Seeding machines like zero till drill and bed planter with fluted roller seed metering mechanism are easily available for seeding long grain crops like rice and wheat. These machines cannot be used for seeding round grain cereals, legumes and pulses. Multi crop planters with inclined plate seed metering mechanism are available which can be used for seeding round grain cereals, legumes and pulses. In these planters, different sets of inclined plates are needed for planting different crops. It makes these planters expensive and out of reach of small and marginal farmers. Moreover, every time for planting a different crop, the set of inclined plates needs to be changed. This process is little cumbersome. For different land configurations, different machines are required like zero till drill or bed planters. To overcome these problems, a simple and low cost planting machine was needed to be developed which could plant all round grain cereal / legume / pulse crops on multi tillage / land configuration (conventional drill / zero till drill / bed planter). This machine will have cup-seed type metering mechanism to avoid frequent changing of seed plates. Effort will be made to attach this machine to the available zero till drill / bed planter so that long grain cereals like rice and wheat will also be sown and farmers do not need separate multi crop planter. During January to June 2010, conceptualization, study of available machines and design of parameters of a simple and low cost machine to plant all round grain cereal / legume / pulse crops on multi tillage / land configuration (conventional drill / zero till drill / bed planter) were initiated. The finalized seed metering mechanism of machine is cup-seed type to avoid frequent changing of seed plates. The conceptualization and design parameters of attachment to the available zero till drill / bed planter is also in progress. This will also enable sowing of long grain cereals like rice and wheat and farmers will not need separate multi-crop planter.

Accelerating the adoption of second-generation machinery for managing the crop residue through RCTs in western UP

The field trials were carried out at farmers' field in Hastinapur and Meerut during *rabi* season 2009-10 with the objective to find out the effect of different machineries for crop residue management. The field trials were conducted about 6 t ha^{-1} residue management of rice crop by turbo and happy seeder and zero till drill machine without residue. Farmer participatory field trials were conducted to evaluate and accelerate the adoption of three RCTs machineries (*i.e.* turbo seeder, happy seeder and zero till drill) for rice residue recycling under no-till conditions. The results revealed that the effective tiller, length of panicle and grain number per panicle were found higher under rice residue retention @ 6.0 t ha^{-1} by turbo, happy seeder than zero till drill and conventional method of sowing. Whereas, the number of weeds per m^2 were found more in conventional method (23) followed by zero till drill (17), turbo seeder (5) and happy seeder (8). The yield of wheat by turbo and happy seeder machine were 6.1, 5.9 t ha^{-1} and followed by conventional (5.6 t/ha) and zero till drill (5.5 t ha^{-1}). The wheat yield increased by on average nearly 8.9% in turbo seeder in comparison to conventional method. In addition to this, the saving of fuel in tillage, time and less number of irrigation was gained in the crop residue retention field than conventional method that ultimately led to higher water use efficiency and yield. The results showed that drilling wheat in loose residues using turbo and happy seeder have added advantages of saving water, higher crop yields and improving soil health in long-run over zero-till and conventional till planting(Table 9.1/11).

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 was initiated in *rabi* 2009-10. 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:

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)

Table 9.1/11. Performance of different machineries of RCT on yield and its attributes on wheat

Treatment	Yield (t/ha)	No. of effective tillers (m^2)	Panicle length (cm)	No. of grain / panicle	No. of weeds (m^2)
Zero-till dill	5.5	478	8.6	65	17
Happy seeder	5.9	503	9.1	77	8
Turbo seeder	6.1	510	9.2	83	5
Conventional method	5.6	480	8.7	69	23

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 Wheat Equivalent Yield and productivity during *rabi* 2009-10 are presented in Fig.9.1/8 and 9.1/9.

The highlights of the results are given below:

1) Vegetable pea (broad bed, BB) + Wheat (furrow, F) system produced maximum wheat equivalent yield, WEY (9.0 t/ha) followed by Vegetable pea (bed, B) + Wheat (F) system (8.9 t/ha), Wheat (BB) + Mustard (F) system (8.8 t/ha), Wheat + Mustard (5:1) system (8.1 t/ha) while Mustard (Flat) produced lowest WEY (1.0 t/ha).

2) Vegetable pea (broad bed, BB) + Wheat (furrow, F) system produced maximum wheat equivalent productivity (0.075 t/ha/day) followed by Vegetable pea (bed, B) + Wheat (F) system (0.074 t/ha/day), Wheat (BB) + Mustard (F) system (0.074 t/ha/day), Wheat + Mustard (5:1) system (0.068 t/ha/day) while Mustard (Flat) produced lowest WEY (0.008 t/ha/day).

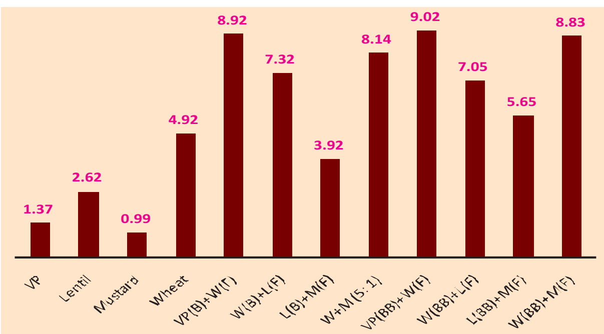


Fig 9.1/8: Effect of land configuration and cropping systems on Wheat Equivalent Yield (t/ha)

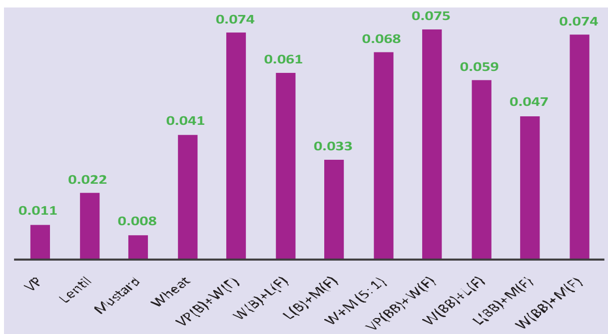


Fig 9.1/9: Effect of land configuration and cropping systems on Wheat Equivalent Productivity (t/ha/day)

C. CONSERVATION AGRICULTURE

Evaluation of different crop residue 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 83-89% and cost and energy of recycling of Rs 2760 ha^{-1} and 2310 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.

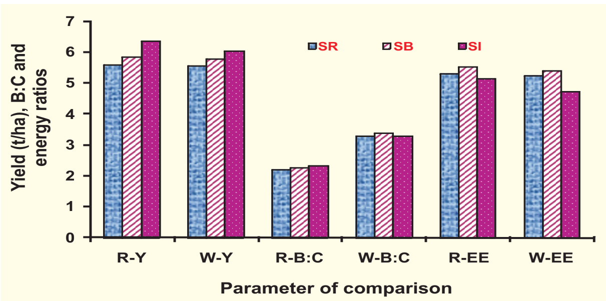


Fig 9.1/10: Effect of crop residue management practices on yield (Y), economics (B:C) and energy efficiency (EE) of rice (R) and wheat (W) ***(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)***

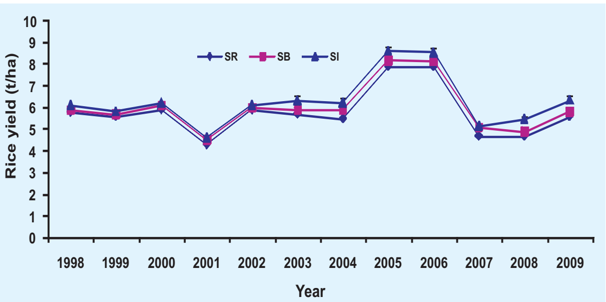


Fig 9.1/11: Effect of crop residue management practices on rice yield over the years ***(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)***

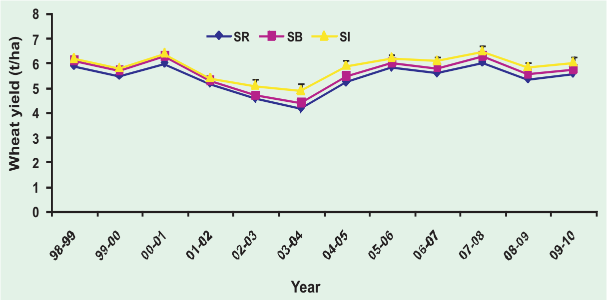


Fig 9.1/12: Effect of crop residue management practices on wheat yield over the years ***(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)***

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 Fig. 9.1/10. The effect of crop residue management practices on the yield of rice and wheat over the years is depicted in Fig. 9.1/11 and 9.1/12.The *insitu* recycling of wheat straw produced 13 and 8 per cent higher rice yield than straw retrieval and burning treatments, respectively. The net returns under straw recycling were 17 and 11 per cent higher; B: C ratio and energy output: input ratio were 5 and 3% higher, and 3 and 6 per cent lower; and specific cost and specific energy 4 and 3 per cent lower, and 3 and 7 per cent higher, respectively. The recycling of rice straw increased the wheat yield (9%) and net returns (9%) but decreased B: C ratio (0.3%), energy output: input ratio (11%); and increased specific energy (12%) and specific cost (0.9%) compared to straw retrieval treatment. Crop residue recycling and burning improved soil organic carbon, SOC (39 and 8%) whereas retrieval decreased SOC (9%) compared to initial values after ten 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 eleven 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.

Resource Conservation Modules for high yield realization of different cropping system

The field trial was undertaken during 2009-10 at Modipuram to study the effect of tillage, mulch and fertilizer management practices on growth, productivity, soil fertility and economics of rice based cropping systems. The experiment was laid out in split-split plot design arranged in a factorial combination of four cropping systems as main plots, two tillage levels (zero tillage (ZT) and conventional tillage (CT) as a sub plots and mulch @ 6 t-ha^{-1}, recommended fertilizers (120:60:40 kg NPK) without mulch and 25% higher than recommended fertilizers (RDF) as sub-sub plots with three replications. In *kharif*, hybrid rice (PRH 10) was planted by mechanical transplanter (self propelled transplant). The grain yield 7.1 tha^{-1} and 6.5 tha^{-1} were obtained in mechanical transplanting and zero tillage respectively. Straw yield was also higher in mechanical transplanting (11.3 t ha^{-1}) over the zero tillage (11.1 t ha^{-1}). Higher grain as well and straw yield of rice under mechanical transplanting was due to higher yield attributes (Table 9.1/12) such as plant height (117.8 cm), number of effective tillers (259.3/ m^2), panicle length (29.7 cm), grains per panicle (249) and 1000 grain weight (25.74 g).

During *rabi* crops, result revealed that cropping systems, tillage levels and RDF x mulch shows significant different in the grain yield and rice equivalent yield (REY). The significantly higher yield was found to be in rice-barely (6.86 tha^{-1}) followed

Table 9.1/12. Effect of tillage levels on Yield & yield attributes of rice

Treatment	Plant height (cm)	Effective tillers (m^2)	Panicle length (cm)	Grains/ panicle	1000-grain weight (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})
Zero-tillage (ZT)	117.0	272.7	29.1	228	24.21	6.5	11.1
Mechanical transplanting (MT)	117.8	259.3	29.7	242	25.74	7.1	11.3

by rice-winter maize (6.58 tha^{-1}) and rice- wheat (6.34 tha^{-1}). The significantly high yield was obtained under treatment mulch (6 tha^{-1}) and 125% RDF and followed by mulch (0) and 125% RDF in rice-wheat system (Table 9.1/13). Similar pattern was also sown in grain yield of barely, mustard and winter maize. The interactions of cropping systems with tillage levels and with RDF x mulch combination were found significant. However, the interaction of tillage levels with mulch x RDF combination was not significant. Results revealed that the conventional tillage (CT) was sown significantly higher grain yield and REY than zero tillage (ZT) in all crops of rice based systems. Whereas, the interaction of cropping systems, tillage levels and RDF x mulch was found non-significant for grain yield and REY.

The conventional tillage (CT) produced significantly higher wheat grain yield (6.41 t ha^{-1}) and rice equivalent yield (REY) (7.35 tha^{-1}) compared to 6.26 & 7.17 tha^{-1} respectively in zero tillage (ZT). Results indicated that significantly more grain yield of barley (6.94 tha^{-1}) and winter maize (6.96 tha^{-1}) was recorded in CT treatment as compared to ZT. However, wheat gave highest rice equivalent yield (7.26 tha^{-1}) and lowest yield was obtained 4.47 t ha^{-1} from mustard in rice based cropping systems. Application of mulch @ 6 tha^{-1} + 25% higher than RDF resulted in significantly higher grain yield (6.27 tha^{-1}) and rice equivalent yield (6.38 tha^{-1}), followed by mulch (0) 25% higher than RDF in wheat crop (Table 9.1/13). Similar results were also obtained other crops. The higher yield under 25% higher than

Table 9.1/13. Grain and rice equivalent yield as influenced by resource conservation modules in different cropping systems

Cropping system	Tillage level	Grain yield (t/ha) Mulch* Fertilizers					REY (t/ha) Mulch* Fertilizers				
		Mulch (0)* RDF	Mulch (0)* 125%RDF	Mulch (6 t/ha)* RDF	Mulch (6 t/ha)*RDF 125%	Mean	Mulch (0)* RDF	Mulch (0)* 125%RDF	Mulch (6 t/ha)* RDF	Mulch (6 t/ha)*RDF 125%	Mean
Rice-wheat	ZT	6.07	6.33	6.16	6.48	6.26	6.94	7.26	7.07	7.43	7.17
	CT	6.16	6.44	6.30	6.75	6.41	7.06	7.38	7.23	7.74	7.35
	Mean	6.12	6.38	6.23	6.62	**6.34**	7.00	7.32	7.15	7.59	**7.26**
Rice-winter maize	ZT	5.77	6.31	5.97	6.71	6.19	4.90	5.36	5.08	5.70	5.26
	CT	6.37	7.12	6.71	7.67	6.96	5.41	6.05	5.71	6.52	5.92
	Mean	6.07	6.72	6.34	7.19	**6.58**	5.16	5.71	5.40	6.11	**5.59**
Rice-barley	ZT	6.60	6.83	6.66	7.00	6.77	5.96	6.17	6.02	6.31	6.11
	CT	6.68	6.99	6.86	7.24	6.94	6.03	6.31	6.20	6.54	6.27
	Mean	6.64	6.91	6.76	7.12	**6.86**	5.99	6.24	6.11	6.43	**6.19**
Rice-mustard	ZT	1.56	1.76	1.66	1.92	1.72	3.79	4.30	4.04	4.67	4.20
	CT	1.75	1.93	1.82	2.28	1.94	4.27	4.70	4.43	5.56	4.74
	Mean	1.66	1.85	1.74	2.10	**1.84**	4.03	4.50	4.23	5.11	**4.47**
CD for cropping system						0.12					0.16
CD for tillage level						0.10					0.11
CD for RDF*mulch						0.10					0.12
CD for cropping system*CD for tillage levels						0.20					0.22
CD for Cropping system*CD for (RDF*Mulch)						0.20					0.25
CD for tillage level*CD for(RDF*Mulch)						N.S.					N.S.
CD for cropping system*CD for tillage levels*CD for (RDF*Mulch)						N.S.					N.S.

recommended fertilizer + mulch @ 6 tha^{-1} may be attributed to increased dose of fertilizer which enhanced the availability of nutrients of growing roots and resulted in vigorous growth of the plants and improved yields. Application of mulch @ 6 t/ha also reduces the weed growth and increase availability water to the plants which resulting in better growth and greater yield of crop.

The harvest index was not affected significantly due to tillage and mulch x fertilizer. However, significantly higher harvest index (42.74%) was recorded in rice-wheat system while lowest was (27.70%) in rice-mustard cropping system.

D. NUTRIENT MANAGEMENT

Integrated nutrient management in transplanted rice-wheat system

A long-term study initiated in *kharif* 1993 on sandy loam (Typic Ustochrept) soil at Project Directorate's research farms, Modipuram, was continued consecutively for the 17th year during 2009-10. The initial values for important soil characteristics at onset of the experiment were pH 7.98, EC 0.42 dS/m, organic carbon 0.41 percent, other P 16.4 kg/ha, available K 96 kg/ha and available S 14.5 kg/ha. Thus, the soil was low in OC, available K and S, and medium in available P content. The experiment was conduct in randomized block design with 11 treatments, including different levels of fertilizer nutrients and partial substitution of fertilizer with farmyard manure (FYM), sulphitation press-mud (SPM), green gram residue (GR) or rice/ wheat residue (CR) (Details of treatments are given in Table 9.1/14. The results pertaining to rice crop during 2009-10 are briefly described here as under.

Grain yield of rice and its productivity dynamics

Fertilizer NPK applied at recommended rate, resulted in significant increase in rice over unfertilized control that recorded lowest yields amongst the treatments (1.72 t/ha) (Table 9.1/14). Application of 45 kg S/ha with recommended NPK+Zn application schedule had further additive effect on improving productivity of the crops. The yield advantage in rice due inclusion of S in fertilizer application schedule over NPK+Zn treatment, was to the true of 29% during 2009-10. Among the organic sources used for integrated nutrient supply, sulphitation press-mud (SPM) along with sub-optimal levels of fertilizer NPK i.e. 75% of recommended NPK was constantly superior to FYM and GR incorporation after 16 crop cycle. Integrated use of SPM + 75% NPK Zn brought an yield advantages of 35% in rice over recommended NPK+Zn application. Such advantage was also noted with integrated FYM and Green gram residue over NPK+Zn treatment but it restricted only upto 21% t/ha in rice. Use of 75% NPK along with SPM or FYM in wheat did not proved beneficial where rice received recommended dose of NPK. Curtailing NPK fertilizer by 25% in both the crops for use of rice/wheat crop residues did not prove advantageous for rice yield as compared to NPK Zn treatments by 10% in rice.

A perusal of yield trends during last 17 years suggested that continuous rice-wheat cropping without fertilizer or manure application resulted in yield reduction by 28% in rice (Table 9.1/14). Fertilizer applied at recommended dose also could not prevent yield decline in rice, although the extent of reduction was smaller (-4.5%) than unfertilized plots. Balancing of fertilizer dose with 45 kg S/ha accounted for higher yield improvement by 8.9% in rice. Among the organic sources used for substitution

Table 9.1/14. Long term effect of integrated nutrient supply on the grain yield (t/ha) of rice and temporal change (%) in its productivity

Treatments		Initial yield	Final rice yield	% Change
Rice	*Wheat*			
Unfertilized	Unfertilized	2.38	1.72	-27.7
NPK Zn	NPK	4.90	4.68	-4.5
NPK Zn+S	NPK +S	5.53	6.02	+8.9
75 NPK+25N (FYM)	NPK	4.81	5.64	+17.3
75 NPK+25N (SPM)	NPK	5.31	6.32	+19.0
75 NPK+GR	NPK	4.63	5.33	+15.1
NPK	75 NPK+25N (FYM)	4.82	4.89	+1.4
NPK	75 NPK+25N (SPM)	5.13	5.22	+1.8
75 NPK +GR	75 NPK+25N (FYM)	4.26	5.02	+17.8
75 NPK+25N (CR)	75 NPK+25N (CR)	4.61	4.77	+1.9
NPK+25N (FYM)	NPK+25N (FYM)	5.24	6.14	+17.1

FYM: Farmyard manure, SPM: Sulphitation press mud, GR: Green gram residues, CR: Rice/wheat residues

of 25% NPK, SPM proved superior over others, and gave 19% extra rice yield over its initial yield. Application of SPM or FYM to rice in monsoon season crop had more pronounced effect than its application in winter crop. Growing of mungbean during fellow period of summer and its residue incorporation after picking of pod before rice transplanting +25% NPK substitution for rice crop gave 15% higher yield advantage over the years.

Effect on P fractions

Soil P fractions were evaluated for water soluble P and Olsen P fractions during report period after rice crop harvest (Table 9.1/15). The Olsen P content in soil was modified with the integration of organic sources and highest being with sulphitation press mud (SPM) applied plots followed by Green Gram residue (GR) applied treatment and FYM application use. The other treatments had 10 to 55% smaller Olsen P content compared to SPM, GR and FYM used plots. Application of organic sources for 25% NPK substitution during *Rabi* season (wheat) did not prove its significance for Olsen P content. The water soluble P values ranged between 1.2 to 3.7 mg/kg and was only noticed in treatments where integration of organic source was made during the *Kharif* (rice) season.

Carbon sequestration potential of rice-wheat cropping system under different soil management options

Due to continuous cropping the gradual depletion of one or more nutrients may have collectively contributed to the yield decline and stagnation in the rice-wheat system in Indo-Gangetic plains. Soil organic matter is of central importance in maintaining soil quality and is now receiving attention due to the potential for carbon sequestrations in soils. The

Table 9.1/15. **Effect of integrated organic use on P fractions**

Rice	*Wheat*	Water soluble-P (mg /kg)	Olsen-P (mg/kg)
Unfertilized	Unfertilized	NIL	22.7
NPK Zn	NPK	NIL	28.1
NPK Zn+S	NPK +S	NIL	31.4
75 NPK+25N (FYM)	NPK	3.7	39.2
75 NPK+25N (SPM)	NPK	2.4	41.7
75 NPK+GR	NPK	2.4	40.3
NPK	75 NPK+ 25N (FYM)	NIL	31.0
NPK	75 NPK+ 25N (SPM)	NIL	30.5
75 NPK +GR	75 NPK+ 25N (FYM)	2.7	37.9
75 NPK+25N (CR)	75 NPK+25N (CR)	1.2	38.2
NPK+25N (FYM)	NPK+25N (FYM)	3.1	40.1

present research was undertaken to study the impact of long term conjunctive use of mineral fertilizers, and organic manures on the soil quality and to evaluate the carbon sequestration potential of the soils in Indo Gangetic plains. Soil samples were collected from long term rice-wheat experiments under AICRP-IFS (2a) at various centers (Ludhiana, Kanpur, Sabour and Kalyani) in Indo-Gangetic plains. This experiment is in progress since 1983-84. All experimental sites are located in Indo-Gangetic plains where rice-wheat is a predominant cropping system. The five treatments have been selected for the study. These included Control (No fertilizer, no organic manure both in *kharif* and *rabi*), NPK (100% recommended NPK dose through fertilizer both in *Kharif* and *rabi*), NPK+FYM (50% recommended NPK dose through fertilizer + 50% N through FYM; 100% recommended NPK dose through fertilizer in wheat), NPK+PS/WS [(50% recommended NPK dose through fertilizer + 50% N through rice cut straw (Kalyani) or 50% N through wheat straw (Ludhiana, Kanpur, Sabour); 100% recommended NPK dose through fertilizer in wheat], NPK + GM (50% recommended NPK dose through fertilizer + 50% N through organic manure; 100% recommended NPK dose through fertilizer in wheat). Soil samples were collected after the harvest of wheat crop (Fig. 9.1/13).

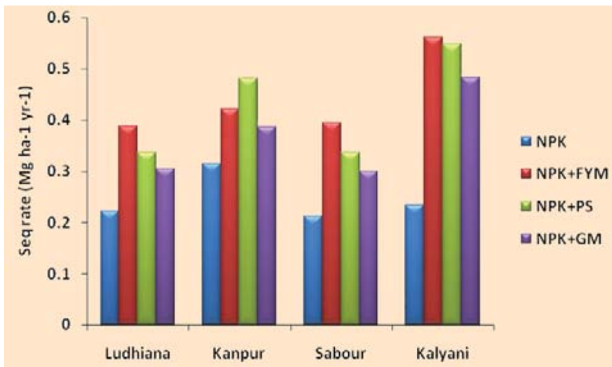


Fig 9.1/13: Effect of different long term nutrient management practices on SOC sequestration under rice-wheat cropping system in different agro-climatic zones

Ludhiana

Maximum accumulation of soil organic C was observed with NPK+ FYM treatment while control plot showed the lowest value (20 Mg ha^{-1}) up to 60 cm depth. Irrespective of depths, the balanced application of NPK+ FYM showed higher accumulation of soil organic Carbon (31 Mg ha^{-1}) over other treatments. All the treatments showed higher accumulation of soil organic carbon in surface soil as compared to sub-surface soil. Soil organic C content in the profile were in the order: NPK +FYM, NPK+PS/WS, NPK +GM. Soil organic C in NPK+FYM, NPK + PS was 30% and 27% higher than that in control, respectively. The amount of sequestered organic carbon was highest in NPK +FYM (0.39 Mg ha^{-1} yr^{-1}) followed by NPK + PS (0.34 Mg ha^{-1} yr^{-1}). The increase in SOC in the above treatments is because of more input of root biomass due to better crop growth.

Kanpur

Cropping with the use of NPK + WS caused a net increase in total soil organic C content as compared to other treatments. In this case the increase was spectacular when WS was conjointly applied with NPK and this treatment was the most significant management system in sequestering C (0.48 Mg ha^{-1} yr^{-1}) followed by NPK +FYM (0.42 Mg ha^{-1} yr^{-1}). The variations in C sequestration rate in different treatments of the present study were due to differential C inputs from left over root biomass. Balanced fertilization with C supplementation provided a congenial environment for microbial growth and thus caused an increase in MBC.

Sabour

Better crop growth and more root biomass production contributed to a larger SOC in organically amended plots. Similarly, application of FYM along with NPK resulted in highest amount of organic Carbon sequestered (0.39 Mg ha^{-1} yr^{-1}) followed by NPK + WS (0.34 Mg ha^{-1} yr^{-1}). Enhanced C sequestration in FYM treated plots might be due to slower breakdown rate. The application of NPK +FYM enhanced the MBC in the soil particularly by 152% to 88% at 0-15 and 15-30 cm depth, respectively.

Kalyani

Cropping with NPK plus organic amendments with FYM, GM and PS, increased the SOC by respectively (70, 71 and 65%) over that control. Although the productivity was low compared to other centres, the rate of C sequestration is high and this may be due to climatic conditions. The climate is moist, subhumid, and subtropical, with an annual average rainfall of 1698 mm (75 to 80% occurs between June and September) which may be congenial for more C sequestration in these soils. Compared to other centres, MBC was maximum (860 µg/g) in Kalyani with NPK + GM treatment

Permanent plot experiment on integrated nutrient management in cereal-based cropping systems

A long-term study is in progress at different centres of AICRP-IFS since 1983-84 in major cropping system of that region. The objectives of the study are to develop suitable integrated nutrient supply and management systems and to study the long-term effect of conjunctive use of fertilizers and organic manures on the productivity of cereal based crop sequences and on soil health. The common treatments at all the centres are given in Table 9.1/16. The cropping system-wise locations for the year under report is given in Table 9.1/16.

The study has revealed that in long-term, substitution of 25-50% N with FYM or green manure in all the major cereal-cereal cropping systems crop yields are recorded to be higher than those under recommended doses of fertilizer-NPK. Among different sources, in general, green manure has been found better than FYM and crop residues in rice-rice growing areas, whereas in other regions FYM performed better. Although at many of the locations yields with both the sources were statistically comparable. Yields under crop residue substitution were, in general, lower than those under recommended fertilizer-NPK. INM has led to

Table 9.1/16. The common treatments at all the centres

Kharif Season	*Rabi* Season
T_1 No fertilizer, no organic manure (control)	No fertilizer, no organic manure (control)
T_2 50% rec. NPK dose through fertilizers	50% rec. NPK dose through fertilizers
T_3 50% rec. NPK dose through fertilizers	100% rec. NPK dose through fertilizers
T_4 75% rec. NPK dose through fertilizers	75% rec. NPK dose through fertilizers
T_5 100% rec. NPK dose through fertilizers	100% rec. NPK dose through fertilizers
T_6 50% rec. NPK dose through fertilizers + 50% N through FYM	100% rec. NPK dose through fertilizers
T_7 75% rec. NPK dose through fertilizers + 25% N through FYM	75% rec. NPK dose through fertilizers
T_8 50% rec. NPK dose through fertilizers + 50% N through straw	100% rec. NPK dose through fertilizers
T_9 75% rec. NPK dose through fertilizers + 25% N through straw	75% rec. NPK dose through fertilizers.
T_{10} 50% rec. NPK dose through fertilizers + 50% N through GM	100% rec. NPK dose through fertilizers.
T_{11} 75% rec. NPK dose through fertilizers + 25% N through GM	75% rec. NPK dose through fertilizers.
T_{12} Farmer's conventional practice	Farmer's conventional practice

(FYM=Farmyard manure, GM=Green manure)

Table 9.1/17. The cropping system wise locations of centres

Cropping systems	Ecosystem/ Centre (State)
Rice-rice	**Semi-arid**: Rajendranagar(A.P.); **Sub-humid:** Chiplima (Orissa); **Humid**: Jorhat (Assam); **Coastal:** Maruteru (A.P.), Bhubaneswar (Orissa), Karjat (Maharashtra), Karamana (Kerala)
Rice-wheat	**Semi-arid**: Ludhiana (Punjab), Kanpur (U.P.); **Sub-humid:** Jabalpur (M.P.), R.S. Pura (J & K), Varanasi (U.P.), Pantnagar (Uttarakhand), Faizabad (U.P.), Sabour (Bihar), Raipur (Chhattisgarh), **Humid**: Kalyani (W.B.), **Coastal:** Navsari (Gujarat).
Rice-maize	**Semi-arid**: Kathalgere (Karnataka)
Rice-mustard	**Semi-arid**: Rudrur (A.P.)
Maize-wheat	**Sub-humid:** Ranchi (Jharkhand)
Pearl millet-wheat	**Arid**: S.K. Nagar (Gujarat), Hisar (Haryana), Junagadh (Gujarat), Bichpuri (U.P.)
Sorghum – wheat	**Semi-arid**: Akola (Maharashtra), Parbhani (Maharashtra), Rahuri (Maharashtra)

substantial improvement in crop yield sustainability and soil fertility parameters (Table 9.1/18).

Long range effect of continuous cropping and manuring on soil fertility and yield stability

This study, which was initiated during 1977-78, was carried out at only few centres in rice-rice (Karamana), rice-wheat (Faizabad and Rewa), maize-wheat (Siruguppa and Kanke) cropping systems with an objective of studying the long-range effects of graded fertilizer levels on yield stability and soil fertility under cereal-cereal cropping with high yielding varieties. Treatments consist of eighteen combinations of 3 levels of N (40, 80 and120 kg ha^{-1}), 3 levels of P_2O_5 (0, 40 and 80 kg ha^{-1}) and 2

Table-9.1/18. Summary of yield trends under different INM treatments

Centre	Yield in Control		Yield in 100% NPK (T_5)		Highest yielding Treatment		Treatments at par with HYT	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Rice-Rice Cropping System								
Rajendranagar	2423	1866	4518	4210	T_{11} (9.4)	T_{10} (11.9)	T_5, T_7, T_{10}	—
Chiplima	2354	3015	5198	5883	T_{10} (18.8)	T_{10} (12.0)	—	T_7, T_9
Jorhat	764	440	1350	770	T_9 (4.5)	T_{10} (7.5)	T_5, T_7, T_{10}, T_{11}	T_2, T_5
Maruteru	2758	1772	6019	5598	T_{11} (5.7)	T_{11} (6.8)	T_6, T_7, T_{10}	T_5, T_9
Bhubaneswar	2004	2709	4874	5407	T_{10} (10.9)	T_{10} (16.4)	T_6, T_7, T_8, T_{11}	T_6, T_7, T_8, T_9
Karjat	3450	3988	5378	7013	T_5 (—)	T_5 (—)	—	—
Karmana	2251	2356	4790	3944	T_6 (15.9)	T_{10} (1.1)	T_7, T_9, T_{10}	T_5, T_6, T_7, T_8
Rice-Wheat Cropping System								
Varanasi	2310	1235	4730	3760	T_6 (8.8)	T_6 (8.1)	—	—
Jammu	2344	1031	4837	3500	T_6 (3.0)	T_6 (2.7)	—	—
Kanpur	1263	839	4358	4570	T5 (—)	T_6 (1.8)	T_6	T_5, T_7, T_{10}, T_{11}
Kalyani	1423	589	3704	2327	T_6 (10.2)	T_6 (7.6)	T_{10}	T_5, T_8, T_9, T_{10}
Ludhiana	1583	1389	5822	4906	T_{10} (15.0)	T_{12} (8.9)	T_6, T_7, T_{11}, T_{12}	T_5, T_7, T_{10}
Kumarganj	1630	705	5207	3383	T_7 (1.6)	T_8 (7.7)	T_5, T_6, T_9, T_{11}	T_5, T_6, T_{10}, T_{11}
Navasari	1805	1334	2771	2495	T_{11} (31.5)	T_{11} (22.4)	T_7	T_6, T_8, T_{10}, T_{11}
Palampur	1891	1137	2142	3494	T_6 (35.1)	T5 (—)	T_8, T_{12}	T_6, T_8, T_9, T_{11}
Jabalpur	1425	710	5707	3430	T_{10} (1.4)	T_6 (5.7)	T_5, T_6, T_{11}	T_7, T_{10}
Pearl millet-Wheat Cropping System								
S.K. Nagar	20	133	755	2261	T_{11} (49.7)	T_6 (32.7)	T_7, T_{10}	T_7, T_9, T_{10}, T_{11}
Hisar	1203	1344	3839	5906	T_6 (4.6)	T_6 (3.2)	T_5, T_7, T_{10}	T_5, T_7,
Junagadh) (with K	818	1530	1481	3900	T_6 (36.1)	T_6 (15.8)	T_8	T_8, T_{10}
Junagadh (without K)	571	1177	954	3508	T_6 (10.2)	T_6 (7.6)	T_{11}	T_5, T_8, T_9, T_{10}
Maize-Wheat Cropping System								
Akola	496	349	4675	2123	T_5 (—)	T_6 (9.2)	T_6, T_7, T_{11}	T_5, T_8, T_{10}
Parbhani	117	412	2642	2685	T_6 (2.9)	T_6 (9.6)	T_6, T_8, T_9, T_{10}	T_5, T_{10}
Rahuri	146	670	3008	3715	T_6 (2.9)	T_6 (9.6)	T_{11}	T_5, T_8, T_9, T_{10}
Sorghum-Wheat Cropping System								
Ranchi	870	1005	3194	2924	T_6 (13.0)	T_6 (16.8)	T_5, T_7, T_8	—

levels of K_2O (0 and 40 kg ha^{-1}) with one absolute control plot in each block. The centre-wise results are presented in table 9.1/19 and their brief description is given below.

Rice-rice cropping system

In a rice-rice system experiment was conducted at Karamana centre and the highest grain yield of rice was recorded at 120 kg N during *kharif* as

Table 9.1/19. Average yield (kg/ha) of crops in different crop rotations as affected by different levels of N,P and K fertilizers during 2008-2009

Crop sequence /Centre	Crop/ Variety	Absolute Control (N0P0K0)	N levels(kg/ha)			S.E. C.D. (5%)	P_2O_5 levels(kg/ha)			S.E. C.D. (5%)	K_2Olevels (kg/ha) (%)		S.Em +C.D. at (5%)	General mean	C.V (%)	Remarks
			40	80	120		0	40	80		0	40				
RICE – RICE																
							***Kharif* Rice**									
Karamana	Aishwarya	4209	3548	3737	3822	207 (415)	3794	3586	3727	207 (415)	3592	3812	169 (339)	3775	18	
							***Rabi* Rice**									
Karamana	Aishwarya	4337	3057	3771	3884	173 (347)	3710	3518	3483	173 (347)	3448	3692	141 (283)	3680	17	(N,PK)**
RICE – WHEAT																
							Kharif - Rice(I)									
Faizabad	Sarjoo-52	859	1748	2426	2868	56 (113)	1621	2481	2941	56 (113)	2182	2513	46 (92)	2135	8	(N,P,K,NP)**
Rewa	IR-36	2296	4155	4536	4903	62 (123)	4221	4561	4811	62 (123)	4379	4684	50 (100)	4212	6	(N,P,K,NP)**
							Rabi - Wheat(I)									
Faizabad	HUW-234	388	1394	1497	1756	69 (138)	237	1992	2419	69 (138)	1411	1687	56 (112)	1383	16	(N,P,K, NP,PK)**
Rewa	WH-147	1211	2552	2764	3455	63 (127)	2434	2953	3384	63 (127)	2810	3037	52 (104)	2679	7	(N,P,K,NP)** ,PK*
MAIZE – WHEAT																
							Kharif - Maize(I)									
I/Siruguppa	M-900	1013	3636	4401	5478	110 (220)	3383	4866	5266	110 (220)	4271	4739	90 (180)	4006	9	(N,P,K, NP,PK)**, NK*
							Kharif - Maize(R)									
III/Kanke	Suwan	542	1623	2063	2281	59 (118)	1272	2126	2568	59 (118)	1877	2100	48 (96)	1782	11	(N,P,K,NP)**
							Rabi-Wheat(I)									
	K-9107	926	2088	2488	2729	65 (131)	1046	2909	3349	65 (131)	2322	2548	53 (107)	2220	10	(N,P,K,NP)**

well as *rabi* seasons with an yield level of 3.82 and 3.88 t/ha. The same was also true with highest dose of P and K in rabi season.

Rice-wheat cropping system

In rice-wheat system the graded dose of N up to 120 kg/ha gave significantly increased yields, the highest being 2.86 and 4.93 t/ha at Faizabad and Rewa, respectively. The same was also true with the highest dose of P and K where yield levels were 2.94 and 4.81 t/ha with 80 kg P_2O_5 at Faizabad and Rewa, respectively. The yield level with the application of K_2O (40 kg/ha) was 2.51 and 4.68 t/ha at Faizabad and Rewa, respectively. At Faizabad, the interaction effects of NPK and NP were highly significant, whereas at Rewa, the effect of nitrogen was significant only during *kharif*. During *rabi* at Faizabad and Rewa the highest dose of N, P, K gave yield level of wheat at 1.75, 2.41 and 1.68 t/ha,and, 3.45,3.38,and3.03 t/ha respectively. During this season the effect of nitrogen was significant and that of PK was highly significant.

Maize-wheat cropping system

In maize-wheat systems the graded dose of NPK at the highest level gave the highest yields during both *kharif* and *rabi* at Kanke and kharif season at Siruguppa. The yield levels were 5.47, 5.26 and 4.73 t/ha, respectively at Siruguppa with NPK at highest level, whereas at Kanke the corresponding yield levels were 2.28, 2.56 and 2.10 t/ha, respectively. At Siruguppa during *kharif* the effects of N, P, K, NP, NK and PK were highly significant whereas at Kanke the effects of NPK and NP were highly significant and that of PK was not significant. The yield levels during *rabi* were also highest with highest dose of N, P and K at Kanke.

E. SOIL AMENDMENT AND WASTE WATER UTILIZATION

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

After 3 years of the experiment, the REY in rice-wheat, rice-mustard and rice-barley cropping systems was highest with gypsum+ press mud+ FYM+ dhaincha treatment as 15.1, 9.2 and 11.4 t ha^{-1}, respectively. REY was followed by gypsum+ press mud+ FYM, gypsum+ press mud and gypsum+ FYM treatments. Application of gypsum, FYM, press mud in isolation as single amendment led to 15.3, 14.5 and 16.4 per cent decline in the REY over their combined use. The system productivity of rice-wheat, rice-mustard and rice barley for three years was as 11.76, 6.73 and 9.72 t ha^{-1}, respectively.

Integrated use of soil amendments had positive impact on nitrogen in soil and also influenced its crop uptake. The NO_3 - N content in soil after three cycles of rice and two cycles of wheat, mustard and barley showed that use of gypsum+ press mud+ FYM+ dhaincha had highest NO_3 - N in soil as 10.8, 11.4 and 11.0 mg kg^{-1} soil respectively in rice-wheat, rice-mustard and rice barley cropping systems. Saline-sodic soil receiving no amendments (control plot) had lowest NO_3 - N (5.2 ±0.4 mg kg^{-1}), although in these plots the same level of nitrogen fertilizer was applied as with the amendment plots. This may indicate the potential of amendments in reducing the loss of the nitrogen from the soil.

Nitrogen use efficiency parameters such as partial factor productivity, agronomic efficiency, recovery efficiency and physiological efficiency of N fertilizer were also highest as 28.5 kg grain (in terms of REY) kg^{-1} N applied, 13.9 kg grain (in terms of REY) kg^{-1} N applied, 32.7% and 40.2 kg grain (in terms of REY) kg^{-1} N taken by the crop, respectively with the gypsum+ press mud+ FYM+ dhaincha treatments.

Utilization of industrial effluents from spent wash for crop production and soil health

In the third year of the experiment, change in the grain: straw ratio (G:S) of rice was found at the similar pattern as with the previous two years with the application of industrial effluents for irrigation. G:S was highest with normal irrigation water both at flat bed (0.79) and raised bed (0.76). However, it declined with the use of industrial effluents as supplements to the normal water. When the quantity of industrial effluents (measured in terms of total solid g m^{-2}) was increased from 200 to 800 g per crop sequence (rice-wheat), the G: S declined subsequently. With the raised bed planting, G: S was higher than the flat bed at all levels of industrial effluent application (200, 400, 600, 800 g total solid m^{-2}). The mean value of G: S with the flat bed and raised bed was 0.37 and 0.44, respectively. This trend was also observed with the wheat crop over three years. This experiment indicated that use of industrial effluents increased the total biomass in rice, wheat and sugarcane crops, but the biomass partitioning was in favor of the by-products.

The mean heavy metal composition of Zn, Cu, Fe, Mn in rice grain after 800 g m^{-2} (equivalent to 100% industrial effluent) in rice grain were 1.65, 1.38, 6.51 and 2.32 mg kg^{-1}, respectively; and in rice straw were 28.2, 25.0, 280.3 and 2.40 mg kg^{-1}, respectively. There was marginal decrease in the Zn, Cu, Fe, Mn content both in grain and straw with lesser intensity of industrial effluent.

The mean heavy metal composition of Zn, Cu, Fe, Mn in wheat grain were 1.43, 1.63, 8.5 and 2.75 mg kg^{-1}, respectively; and in wheat straw were 24.7, 16.2, 175.3 and 2.31 mg kg^{-1}, respectively. There was marginal decrease in the Zn, Cu, Fe, Mn content both in grain and straw with lesser intensity of industrial effluent.

After 3 years of experiment, the soil composition of DTPA extractable Zn, Cu, Fe, Mn and ammonium acetate exchangeable Na were about 12.4, 17.0, 21.3, 13.2 and 34 per cent higher over the initial values at the start of the experiment. The soil organic carbon, microbial biomass carbon, water soluble carbon, soil fulvic acid carbon were marginally increased with the increasing intensity of effluents water.

With the application of 50% industrial effluents (400 g total solid m^{-2}) together with raised bed planting both in main and ratoon crop of sugarcane gave better recovery percentage (10.05 to 10.88) for cane. The study is continuing to find the reason for that.

F. CROP-CLIMATE RELATIONSHIP STUDIES

Physiological evaluation of rice and wheat genotypes under changing climatic scenario

The field experiments were conducted during *rabi* (2009-10) and *kharif* 2010 to evaluate 20 genotypes of rice and wheat for their phenological growth in relation to climatic conditions and to monitor different morpho-physiological parameters in relation to productivity. Wheat was sown on November 17, 2009 during *rabi* 2009-10, while during *kharif* 2010 twenty five days old seedlings of rice were transplanted in the field on July 07, 2010. Observations were recorded on various phenophases and morpho-physiological parameters of growth and productivity.

Genotypic variations in wheat were observed in stature (83-96 cm), crop phenology i.e. spike initiation (78-95 days after sowing, DAS), 50% flowering (88-105 DAS) and physiological maturity (129-137 DAS), and different morpho-physiological parameters (biomass, leaf area, photosynthesis and water use efficiency) which resulted in accountable variation in grain yield and yield components. PBW 226, HI 1544, WH 1021, PBW 550, RAJ 3765, UP 2425, UP 2565, UP 2382, WH 711, HD 2894, DBW 16 and UP 2338 were early in flowering (88-99 DAS) than other genotypes which flowered in 100-105 days. All these genotypes attained physiological maturity in about 129-137 DAS. UP 2565, PBW 509, WH 1021 and RAJ 3765 were relatively taller (90-96 cm) than rest of the genotypes (83-89 cm. Biomass and plant height, on the other hand, were linearly increased up to 84 DAS. Sigmoid growth pattern was observed in tiller numbers m^{-2} and highest tiller numbers were recorded at 60 DAS in all the genotypes. Number of tillers were relatively higher in DBW 26, DBW 19, DBW 24, DBW 17, DBW 18, DBW 22, DBW 23, DBW 28 and DBW 31genotypes (493-551) as compared to other genotypes where it varied from 442 to 487. Higher photosynthesis (22-24μ mole CO_2 m^{-2} s^-1) was observed in UP 2832, UP 2425, HD 2687, PBW 509, PBW 502, UP 2565 and HI 1544, while water use efficiency was higher (4.73-5.60 μ moles CO_2 $mole^{-1}$ H_2O) in DBW 16, WH 711, HI 1544, PBW 373, PBW 343 and UP 2382. Significant genotypic variations in grain yield and different yield contributing parameters (spike length, number of spikelets, number of grains / spike and 1000 grain weight) were observed. Based on the yield performance, varieties were classified as low (< 5.0 t ha^{-1}), medium (5.0-5.5 t ha^{-1}) and high (> 5.5 t ha^{-1}) yielder. Yield performance was higher (5.5-5.7 t ha^{-1}) in DBW 17, HD 2687, HD 2894, PBW 343, PBW 550 and UP 2338, while it was lower (4.6-4.9 tha^{-1}) in UP 2425, PBW 509, HI 1544 and DBW 16. Higher grain yield was associated with high biomass productivity (r=0.80), harvest index (r=0.66), spikelets/ spike (r=0.69) and number of grains per spike (r=0.84). In general, the average productivity of early group of genotype was low (5.2 t ha^-1) as compared to long duration genotypes (5.4 tha^-1). Growing Degree Days (°days) was relatively low in the early genotypes (1760-1831 °days) than the late maturing genotypes (1838-1884 °days) and Heat Use Efficiency was positively associated with the grain yield of the different genotypes (r=0.89).

Phenological variations in rice were observed in panicle initiation (PI), 50% panicle emergence (PE) and physiological maturity in different rice genotypes. Early PI (30-40 days after transplanting, DAT), 50% PE (45-60 DAT) and maturity (65-80 DAT) were observed in Ananda, Poornima, Saket 4, PD 10 and PD 12 among non-basmati types than the fine basmati types (PS 4, PS 5 and Vallabh 21) which were 5-15 days late in maturity. Among basmati types, PS 4, PS 5 and Vallabh 21 were relatively early in maturity (84-90 DAT) than PB 1, PB 1460 and Pant Sugandha 15 (100 DAT), while Basmati 370 and

Tarawadi basmati were late in maturity (105-110 DAT). On the other hand, among non-basmati genotypes, poornima, Ananda, Saket 4, PD 10, PD 12 and PR 115 were relatively early (66-80 DAT) than IR 74, PR 111, PR 16, Sarju 52, Naveen and Narendra 359 (81-95 DAT). Higher leaf area (LAI) was observed in all the non-basmati and early basmati genotypes at 50% PI stage, except in PB-1 where LAI, like and other late basmati genotypes (PB 1460, Pant sugandha 15, basmati 370 and tarawadi basmati) was higher at PI stage. Biomass accumulation and plant height were linearly increased up to maturity in all the genotypes. Tiller number m^{-2} was linearly increased up to 40 days after transplanting (DAT), thereafter it started declining in all the genotypes. Tillers number were more in long duration genotypes in both basmati and non-basmati types. Highest tillers were observed in Tarawadi basmati, Pant Sugandha 15 and Narendra 359 (270-277 m^{-2}) followed by PB 1 (256 m^{-2}), basmati 370 (251 m^{-2}), PB 1460 (251 m^{-2}), Naveen (242m^{-2}) and PR 115 (240 m^{-2}). Photosynthesis (µ mole CO_2 $m^{-2} s^{-1}$), in general, was higher in early basmati (22.9-23.6) and non basmati type (19.1-22.7) than the longer duration in both the groups, except in PR-111. LAI, on the other hand, was relatively lower in early types (4-5) in both basmati & non-basmati types than the longer duration in both the groups (5-7) except in PD 10. Grain yield was higher in early basmati types (4.0-4.8 t ha^{-1}) than the late maturing types (2.2-3.7 t ha^{-1}). On the other hand, among non-basmati types, higher grain yield was observed in late maturing genotypes (5.4-6.4 t ha^{-1}) than the early maturing genotypes (3.6-5.5 t ha^{-1}), except PR 115, which was relatively early but gave high yield (6.4 t ha^{-1}). High grain yield in early basmati genotypes was largely due to high HI (34-41%) as compared to late maturing (20-30%) group of genotypes. Among non-basmati types, HI was also higher in early maturing genotypes (43-46%) but the number of grains/panicles were relatively less (95-109) in these genotypes as compared to late maturing genotypes (110-138) resulting in low grain yield. Total heat unit requirement i.e. Growing Degree Days (GDD) was relatively higher in basmati types (1727.4-2051.7 °C) than the non basmati genotypes (1486.3-1859.0 °C). Heat Use Efficiency (Kg/GDD) and Radiation Use Efficiency (g MJ^{-1}) in basmati genotypes was more in early (2.09-2.79 and 1.45-1.90) than the late maturing (0.97-2.35 and 1.21-1.73, respectively).

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 rice-wheat cropping system and its mitigation strategies by using DSSAT model in western plain zone of Uttar Pradesh. Two rice genotypes *viz,* 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 (3rd week of June), D_2 (1st week of July) and D_3 (3rd week of July) in four replications.

Effects of date of transplanting and nitrogen levels on phenology

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 (Fig. 9.1/14). Panicle initiation was significantly early in Saket 4 fertilized with 60 kg N ha^{-1} and transplanted on D_3 (35.0 d) followed by D_2 (37.0 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 (67.7 d) over other treatments where as Saket 4 fertilized with 60 Kg N ha^{-1} and transplanted on D_3 needed lower (52.7 d) days. Similar trend was observed for attaining the

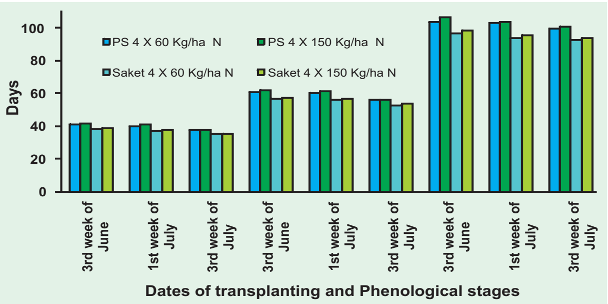


Fig 9.1/14: Effects of date of transplanting and nitrogen levels on phenological stages in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

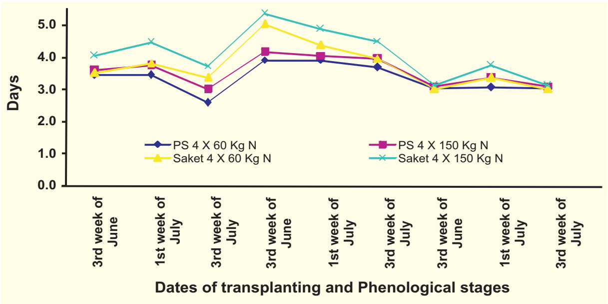


Fig 9.1/15: Effects of date of transplanting and nitrogen levels on Leaf area index (LAI) in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

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.

Effects of date of transplanting and nitrogen levels on leaf area index

Linear increase in Leaf Area Index (LAI) was observed in both rice genotypes up to anthesis (Fig.9.1/15) and declined thereafter in all the treatments. LAI was higher in PS 4 than Saket 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.

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

Grain yield was higher in D_2 transplanting fertilized with 150 Kg N ha^{-1} in both rice genotypes over other treatments (Fig.3). Higher grain yield (6.0 t ha^{-1}) was recorded in Saket 4 fertilized with 150 Kg N ha^{-1} and transplanted on D_2 whereas lower grain yield (3.51 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/ ^{o}Cd) was reported relatively higher in Saket 4 than PS 4 irrespective of treatments (Fig. 9.1/16). Mean HUE of all four treatments transplanted on D_3 (4.9 Kg/ ^{o}Cd) was higher than D_2 (3.0 Kg/ ^{o}Cd) and D_1 (2.3 Kg/ ^{o}Cd). Higher dose of Nitrogen increased the HUE in general. Radiation use efficiency (RUE, g/Mjm^{-2}) of D_2 transplanting was more than D_1 and D_3 transplanting in all the treatments (Fig.9.1/16). However, higher RUE was reported in Saket 4 over PS 4 genotype irrespective of date of transplanting and dose of nitrogen. Higher dose of nitrogen also increased the radiation use efficiency in both genotypes. HUE and RUE were highly associated with grain yield and correlation coefficients (r) were 0.95 and 0.90, respectively.

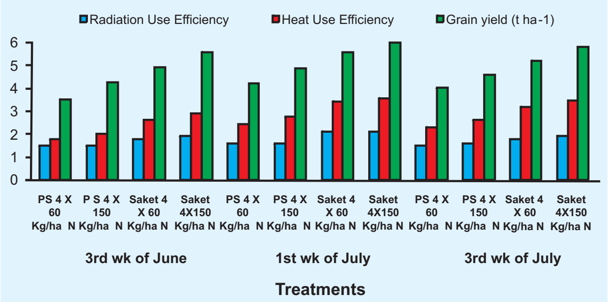


Fig 9.1/16: Effects of date of transplanting and nitrogen levels on grain yield (t ha^{-1}), heat use efficiency (HUE, Kg/ ^{o}Cd), and radiation use efficiency (RUE, g/Mjm^{-2}) in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

9.2 ORGANIC AGRICULTURE SYSTEMS (OAS)

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

The experiment on 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 till wheat (ZT), bed planting of wheat (FIRB), conventional tilled wheat and happy seeder (HS) planted wheat 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 cono 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.

Maximum grain and straw yield of 5.58 and 6.98 t ha^{-1} of wheat during *rabi*, 2009-10 was recorded under main plot which was designated for SRI method of rice cultivation compared to 5.33 and 6.66 t ha^{-1} respectively under conventional method of wheat cultivation. But the grain yield increase compared to conventional method of wheat cultivation was nominal to the tune of 4.30%. On the contrary, the maximum grain and straw yields among sub-plot were 6.07 & 7.59 t ha^{-1} under FIRB system which were 27.8 & 28.0% higher than the conventional method of sowing wheat and the effect

Table. 9.2/1: Yield and yield attributing characters of wheat under RCT (2009-10)

Treatment	Grain yield (tha^{-1})	Straw yield (tha^{-1})	Plant height (cm)	Ear head length (cm)	1000 grain wt.(g)
DSR	4.98	6.23	103	14.5	35.17
SRI	5.58	6.98	107	15.5	39.68
Conventional	5.33	6.66	96	14.8	36
Control	2.82	5.24	80	12.1	28.5
CD (5%)	0.04	0.25	2.8	1.2	1.2
Sub plots					
ZT	5.33	6.67	97	14.7	36.35
HS	5.03	6.28	100	15.5	38.34
FIRB	6.07	7.59	112	15.4	38.01
Conventional	4.75	5.93	97	14.2	35.1
CD (5%)	0.11	0.36	4.3	1.3	0.56

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).

The root and shoot biomass accumulation of wheat at periodic intervals showed a periodic increase up to physiological maturity stage. The maximum 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 (Tables 9.2/2&9.2/3). Soil properties after harvest of wheat were also determined in terms of O.C., available N, P, K and MBC. Organic carbon and MBC were maximum (0.58% and 185.2 mg/g) under SRI among main plot and 0.60% and 172.4 mg/g under happy seeder seeded wheat. Among main plots, available N was maximum (301 kg^{-1}/ha) under conventional method of wheat cultivation, av. N under DSR cultivated plot and av. K under SRI treatment. Among sub-plots, av. N and P were maximum under happy seeder seeded wheat and that of avail K (465 t ha^{-1}) under FIRB treatment (Fig. 9.2/1).

Table.9.2/2. Root biomass (kg ha^{-1}) in wheat under resource conservation technologies (2009-10)

Treatment	20DAT	30 DAT	40 DAT	60 DAT	Harvest
DSR	0.23	0.53	0.88	1.05	1.69
SRI	0.32	0.64	0.96	1.46	1.93
CONVENTIONAL	0.27	0.62	0.78	1.21	1.83
CONTROL	0.18	0.39	0.58	0.81	1.29
SEm±	0.09	0.14	0.19	0.30	0.27
CD (5%)	0.29	0.40	0.60	0.88	0.83
Sub Plots					
ZT	0.21	0.49	0.80	0.94	1.61
HS	0.29	0.59	0.87	1.30	1.84
FIRB	0.24	0.57	0.71	1.08	1.74
CONVENTIONAL	0.16	0.36	0.52	0.72	1.23
SEm±	0.08	0.13	0.17	0.27	0.26
CD (5%)	0.26	0.37	0.55	0.79	0.79

Table.9.2/ 3. Shoot biomass (kg ha^{-1}) in wheat under resource conservation technologies (2009-10)

Treatment	20DAT	30 DAT	40 DAT	60 DAT	Harvest
DSR	1.16	2.61	3.25	4.61	6.23
SRI	2.03	3.48	3.56	6.37	6.98
CONVENTIONAL	1.50	2.93	3.17	6.09	6.66
CONTROL	0.73	0.92	2.01	2.39	5.24
SEm±	0.09	0.47	0.27	0.51	0.48
Sub Plots					
ZT	1.06	2.56	2.97	4.31	6.67
HS	1.85	3.41	3.47	6.25	6.28
FIRB	1.47	2.87	3.10	5.97	7.59
CONVENTIONAL	0.68	0.89	1.86	2.35	5.93
SEm±	0.15	0.58	0.42	0.57	0.61

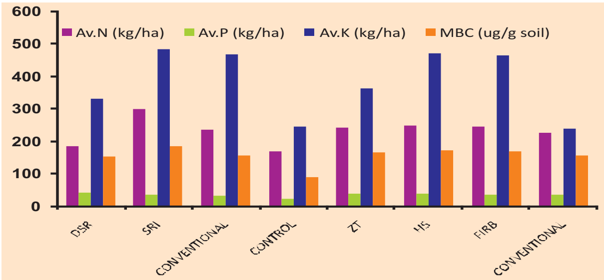


Fig 9.2/1: Change in soil properties under resource conservation techniques after harvest of wheat in rice-wheat system

Rice: Maximum grain yield of rice (6.05 t ha^{-1}) during *Kharif* 2010 was recorded under SRI method compared to 5.00 t ha^{-1} under conventional method. The percent yield increase under SRI was 17.35%. The straw yield under SRI was 11.50 t ha^{-1}. The yield and yield attributing characters of rice were also maximum under SRI method (Table 9.2/4).

Root and shoot biomass accumulation of rice was recorded at periodic interval and the maximum biomass accumulation in terms of root and shoot was recorded under SRI irrespective of stages of growth. Soil properties at maximum tillering stage of rice revealed that organic carbon, available P and K were maximum under SRI and available N was maximum (301.1 kg ha^{-1}) under conventional method of rice cultivation (Table 9.2/5). Microbial population in terms of heterotrophic bacteria, total bacteria, fungi, actinomycetes and N fixing bacteria were also maximum under SRI at maximum tillering and panicle initiation stages (Tables 9.2/6 to 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 9.2/9).

Table 9.2/4: Yield and yield attributing characters of rice under RCT (2010)

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	4.35	8.85	21.52	13.12	261.0	18.89	140.0	99.43
SRI	6.05	11.50	23.80	17.55	380.30	22.11	165.0	129.14
Conventional	5.00	9.30	22.04	14.30	345.02	20.80	149.0	122.43
Control	2.50	4.36	16.51	6.86	153.0	17.21	105.0	90.50
SEM(±)	0.52	1.23	1.52	2.22	25.5	2.8	18.2	5.2

Table 9.2/5: Soil properties under various cultural practices in rice during maximum tillering stage

Treatment	O.C (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K(kg/ha)
DSR	0.3	326.1	37.5	203.3
SRI	0.47	288.5	42.3	240.8
Conventional	0.32	301.1	32.8	201.6
Control	0.32	242.5	25.7	195.3
SEM(±)	0.03	23.3	5.7	11.4

Table 9.2/6: Microbial Population (CFU g^{-1} soil) under various cultural practices in rice during tiller initiation stage (2010)

Treatment	Heterotrophic Bacteria X10^6	Bacteria X10^7	Fungi X10^4	Actinomycetes X10^5	Nitrogen fixing bacteria X10^5	X10^4	X10^5
DSR	27.951	100.36	16.262	25.3	125.33	76.66	36.66
SRI	66.746	231.19	21.666	32.6	148	95.33	40.66
Conventional	40.963	163.75	14.25	23.3	111	80.16	37.33
Control	28	85	6.2	12.3	53	37	18
SEM (+)	9.2	4.5	5.2	4.2	11.6	5.7	1.3

Table 9.2/7: Microbial Population (CFU g^{-1} soil) under various cultural practices in rice during maximum tillering stage (2010)

Treatment	Heterotrophic Bacteria X10^6	Bacteria X10^7	Fungi X10^4	Actinomycetes X10^5	Nitrogen fixing bacteria X10^5	X10^4	X10^5
DSR	33.5	130.5	16.5	27.1	137.9	80.5	37.5
SRI	80.1	300.6	21.9	34.9	162.8	100.1	41.6
Conv	49.2	212.9	14.4	24.9	122.1	84.2	38.2
Control	33.6	110.5	6.3	13.2	58.3	38.9	18.0
SEM (+)							

Table 9.2/8: Changes in MBC (mg g^{-1} soil) under various cultural practices in rice at various growth stages

Treatment	During transplanting	10 days after transplanting	20days after transplanting	Maximum tillering stage
DSR	82	125.7	155.3	207.4
SRI	89	148.3	190.2	250.4
Conventional	60.5	137.1	157.3	180.7
Control	55.4	80.3	120.1	125.8
SEM(±)	7.5	11.2	15.4	21.3

Table 9.2/9: Estimation of total aerobic Nitrogen fixer from per gram of dry soil

Treatment	Dilt. 10^{-3}	10^{-4}	10^{-5}
DSR	125.3	76.6	36.6
SRI	148	95.33	40.6
CONV	111	80.16	37.3
Control			
SEM(±)	5.7	8.5	1.7

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

The experiment is being conducted since 2003 and has completed 6 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), vermi compost 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. The results for the year under report are summarized:

Maximum grain yield of onion during summer 2010 was recorded under T_6 (25.92 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 6.57% compared to T_7. The yield increase under other organic nutrient management packages varied from 1.64 to 6.29% (Table 9.2/10).

The maize crop during next *Kharif* failed due to unforeseen situation. As per system yield is concerned, the maize equivalent yield during 2009-10 was maximum (35.37 t ha^{-1}) under T_3 which received organic sources of nutrients and intercropping of cowpea with maize and radish with potato. The same trend was also recorded in relation of last three years average performance of T_3 with MEY 29.81 t ha^{-1} (Table 9.2/10).

Soil fertility under various organic nutrient management after harvest of onion and maize has been presented in Table 9.2/11. After harvest of onion, maximum OC was recorded under T_6, available N and MBC under T_3 and that of av. K under T_5 which are all organic nutrient 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 maximum 0.66% under T_6, av. N and MBC under T_3 and av. P and K under T_5 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. Irrespective of treatments, microbial population was maximum under maize crop compared to onion. Further, important fact is that compared to inorganic and integrated nutrient

Table 9.2/10: Crop yield under various nutrient management packages in maize-potato-onion system

Treatment	Onion 2009-10	MEY (t ha^{-1}) 2009-10	% increase/decrease in onion yield over T_7	MEY (t ha^{-1}) Av. last 3 years
T_1	20.48	29.05	-15.78	27.23
T_2	24.72	33.64	1.64	29.81
T_3	25.85	35.37	6.29	29.81
T_4	24.76	31.03	1.80	28.28
T_5	24.78	32.62	1.89	29.20
T_6	25.92	32.76	6.57	29.18
T_7	24.32	30.30	-	27.57
SEm±	2.07	2.14		1.05

Table 9.2/11: Soil fertility under various organic nutrient management packages in maize-potato-onion system (2009-10)

Treatment	Onion					Maize				
	O.C. %	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	MBC µg g^{-1} soil	O.C. %	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	MBC µg g^{-1} soil
T_1	0.62	263	29.1	250	316	0.63	270	31.3	258	338
T_2	0.62	238	23.9	195	286	0.64	250	26.7	205	313
T_3	0.64	276	31.4	187	331	0.66	285	35.2	210	356
T_4	0.63	265	28.5	204	318	0.65	270	32.4	218	338
T_5	0.61	213	30.9	231	256	0.63	222	36.4	239	278
T_6	0.65	247	24.9	225	296	0.66	255	32.8	232	319
T_7	0.52	213	20.4	170	185	0.53	218	22.6	178	195
SEm±	0.04	25.12	4.06	27.83	30	0.05	25.17	4.85	25.96	31

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.

Studies on comparative efficiency of organic, inorganic and integrated nutrient management practices on soil health and crop productivity under various cropping systems

Four cropping systems, basmati rice – wheat, rice-barley + mustard - green gram, maize(cobs) – potato – okra, maize – mustard + radish – green gram, were grown under organic , inorganic and integrated conditions. Nutritional requirement of different crops in sequence was supplied based on their N requirement. In organic system, total N requirement of the crop was supplied in equal proportions from two different organic sources. In integrated system, 50 per cent of total N requirement was made equally through organic sources Viz. Farm Yard Manure (FYM) and vermi compost (VC) and remaining N through chemical fertilizers using Urea, DAP and MOP for nitrogen, phosphorous and potash respectively.

Yield attributes of crops

Maximum plant height (131cm), panicles length (24.4 cm), grains/panicle (74) and test weight (20.4 g) of basmati rice were obtained under organic conditions. However, numbers of panicles were more under integrated and inorganic conditions. Likewise, the entire yield attributes *viz* plant height; effective tillers per m^2 and grains/ear were more under integrated conditions, but more test weight under organic conditions in wheat. In coarse rice (Saket 4), panicle height and test weight were more under organic conditions. However, plant height and grains/panicle were more under inorganic conditions. In barley, number of tillers and grains/ear were more under organic conditions, where as plant height was more under inorganic conditions. Likewise, plant height, number of pods, grains/pod and test weight in green gram, plant height, number of okra fruits/plant and okra length in okra; almost all the attributes in maize, mustard and radish were better under organic conditions.

Component crop yields

Maximum yield (3.13 t/ha) of basmati rice was recorded under organic conditions, where as wheat yield (3.75t/ha) was more under inorganic conditions (Table 9.2/12). Likewise, barley, mustard, green gram, potato, okra and radish recorded higher yields under organic conditions as compared to inorganic and integrated conditions. Coarse rice (Saket-4) and maize attained higher yields under inorganic and integrated conditions, respectively.

Rice equivalent yield and net returns

Maximum rice equivalent yield (9.94 t/ha) and net returns (Rs 83762/ha) were recorded by maize (cobs) – potato – okra system followed by basmati rice - wheat in respect of net return and maize-mustard + radish - green gram in respect of rice equivalent yield. Highest B: C ratio was also attained by basmati rice - wheat system under organic conditions.

Soil studies

Under Organic conditions, the initial value of organic carbon (0.56%) increased rapidly to 1.08% after six years. This was mainly due to addition of organic matter (30-50 t/ha/year) in the form of FYM and vermi compost. Likewise, available nitrogen and potash also increased.

Table 9.2/12: Component yield and REY and Net Returns of various cropping systems

Treatments	Component crop yield(t/ha)					
	Basmati rice-wheat					
	Basmati rice	Wheat	REY of the system (t/ha)	Net Returns of the system (Rs/ha)		
Organic	3.13	3.21	5.10	60625		
Chemical	2.79	3.75	5.27	49891		
Integrated	3.12	3.33	5.32	46710		
	Rice- barley+ mustard- g. gram					
	Rice	Barley	+ mustard	Green gram	REY of the system	Net Returns of the system
Organic	4.12	2.92	0.145	0.79	5.32	58986
Chemical	4.67	2.42	0.113	0.68	5.34	39510
Integrated	4.42	2.59	0.123	0.72	5.29	36522
	Maize(cobs)-potato-okra					
	Maize(Cobs)	Potato	Okra	REY of the system	Net Returns of the system	
Organic	9.16	11.25	6.46	9.94	83762	
Chemical	8.48	10.66	4.33	8.03	54237	
Integrated	10.10	11.01	4.83	8.19	62908	
	Maize- mustard+ radish- g. gram					
	Maize	Mustard	+ radish	Green gram	REY of the system	Net Returns of the system
Organic	4.38	0.85	9.58	0.78	6.63	46634
Chemical	4.27	0.64	8.04	0.69	5.87	30479
Integrated	4.86	0.77	8.75	0.74	6.57	37706

Disease and pest management in rice-mustard and rice- chick pea cropping systems

Two cropping systems, basmati rice- chick pea and basmati rice-mustard were taken after green manuring and summer ploughing under two different management practices viz treated (Treating the crops with bio pesticides like Pseudomonas fluorescence, Trichoderma harzianum, garlic, green chillies, Tricogramma japonicum and T. chilonis etc)) and untreated (control).

Yield and yield attributes of different crops

Plant height, panicles/m^2, panicle length, grain and straw yields of basmati rice, mustard and chickpea were more under treated plots as compared to untreated plots both in basmati rice-chick pea & basmati rice-mustard cropping systems. Crops grown after summer ploughing specially, chick pea and mustard provided more yields than those grown after green manuring.

Rice equivalent yields

As indicated in table 9.2/13 and Fig.9.2/2 basmati rice –chickpea system recorded higher REY

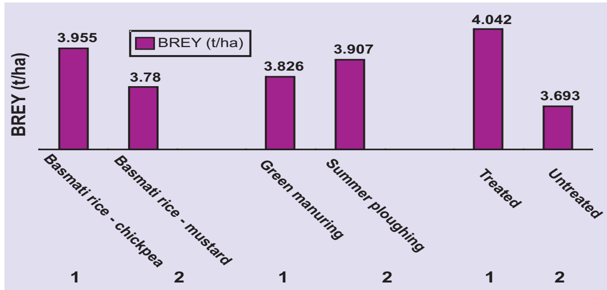


Fig 9.2/2: Effect of different management practices on BREY

as compared to basmati rice-mustard system. Summer ploughing indicated edge over green manuring and all the crops protected with bio pesticides gave better yields than untreated plots.

Table 9.2/13: Rice equivalent yield (t/ha) of different crops under various treatments.

Treatments	Basmati rice-mustard (t/ha)			
	Basmati rice (t/ha)		Mustard (t/ha)	
	GM	SP	GM	SP
Treated	2.70	2.50	1.35	1.45
Untreated	2.33	2.13	1.25	1.40
	Basmati rice -chick pea			
	Basmati rice (t/ha)		Chick pea (t/ha)	
Treated	2.47	2.57	1.54	1.58
Untreated	2.20	2.47	1.46	1.52

GM: Green manuring SP: Summer ploughing

Table 9.2/14: Net returns (Rs/ha) of Basmati rice-chick pea and Basmati rice-mustard systems as influenced by plant protection treatments

Treatments	Basmati rice-mustard (Rs/ha)			
	Basmati rice		Mustard	
	GM	SP	GM	SP
Treated	30350	24700	16070	14800
Untreated	24250	18600	15090	14700
	Basmati rice -chick pea			
	Basmati rice		Chick pea	
Treated	25700	26000	17260	18010
Untreated	21400	25300	16820	17810

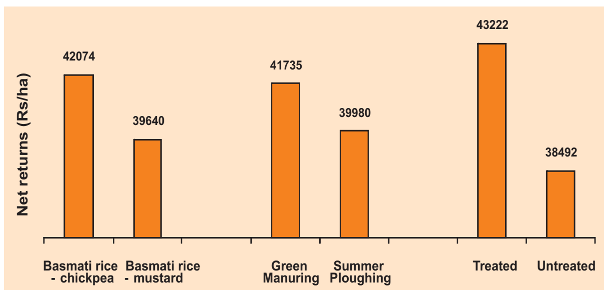


Fig 9.2/3: Effect of different management practices on net returns

Net returns (Rs/ha)

Similar trend akin to BREY was noted for net returns also. Basmati rice –chickpea system recorded higher net returns than basmati rice-mustard system. Green manuring indicated better returns as compared to summer ploughing. Treating the crops with bio-pesticides gave better returns than untreated plots.

Agronomic evaluation of biodynamic practices and Panchgavya for organic cultivation of important cropping systems

Basmati rice-wheat and maize – wheat systems were grown with five bio dynamic treatments viz FYM + vermi compost, BD preparation, FYM + vermi compost + Panchgavya, FYM + vermi compost+ BD preparation and combination of all BD preparation+ FYM + vermi compost + Panchgavya.

Yield and returns: Rice – wheat system recorded more component crop yields as well as REY compared to maize – wheat system. Among various bio-dynamic treatments, application of FYM + VC along with BD preparation and Panchgavya recorded maximum REY in both the systems. Higher gross returns were also recorded with application of all FYM+VC along with BD preparation and Panchgavya, excepting net returns in rice-wheat, which were more in application of FYM+VC.

Evaluation of some new cropping systems involving spices and other high value crops under organic farming

Maize (cob) – Potato – Onion recorded the highest REY followed by Turmeric – green manure. However maximum returns were obtained from Turmeric – green manure followed by Maize (cob) – Potato – Onion.

Table 9.2/14: Component crop yields (t/ha) of the crops in different cropping systems.

Treatments	Maize-wheat (t/ha)		
	Maize yield	Wheat yield	REY of the system
FYM + Vermi Compost	3.24	3.23	2.91
BD Preparation	2.70	2.72	2.44
FYM + Vermi Compost + Panchgavya	3.26	3.12	2.85
FYM + Vermi Compost + BD Preparation	3.24	3.35	2.98
BD Preparation + FYM+ Vermi Compost + Panchgavya	3.48	3.63	3.22
	Rice-wheat		
	Rice yield	Wheat yield	REY of the system
FYM + Vermi Compost	2.98	3.11	4.84
BD Preparation	2.90	2.29	4.27
FYM + Vermi Compost + Panchgavya	2.93	3.07	4.77
FYM + Vermi Compost + BD Preparation	2.94	3.22	4.87
BD Preparation+ FYM+ Vermi Compost+ Panchgavya	3.00	3.34	5.01

Table 9.2/15: Gross and Net returns of the systems as influenced by various treatments

Treatments	Gross returns (Rs/ha)	
	Maize-wheat system	Rice-wheat system
FYM + Vermi Compost	87357	110474
BD Preparation)	74349	96886
FYM + Vermi Compost + Panchgavya	84978	109348
FYM + Vermi Compost+ BD Preparation	89295	104868
BD Preparation+ FYM+ Vermi Compost +Panchgavya	95307	114144
	Net returns(Rs/ha)	
	Maize-wheat	Rice-wheat
FYM + Vermi Compost	42022	59249
BD Preparation	40354	58711
FYM + Vermi Compost + Panchgavya	36883	55873
FYM + Vermi Compost+ BD Preparation	42900	57943
BD Preparation+ FYM+ Vermi Compost+ Panchgavya	46712	58669

Evaluation of rice and wheat varieties for organic production system

15 varieties of rice and 30 varieties of wheat were evaluated under organic conditions. Vallabh 21 followed by pusa basmati 1 in rice and raj 4037 followed by PBW 590 in wheat were superior over others when tested under organic conditions.

Photo 9.2/1. Performance of wheat crop in Basmati rice – wheat system under organic condition

Photo 9.2/2. Potato crop in Maize- potato – okra system under organic conditions

Photo 9.2/3. Turmeric crop under organic condition

9.3 INTEGRATED FARMING SYSTEMS (IFS)

Field crop based IFS Model : Development of integrated farming system model for small farmers of western Uttar Pradesh

To meet basic needs of food and fodder along with nutritional security of small farm holders and also ensuring environmental safety, an institute project on Integrated Farming System was started in 2004 and after completion of six years duration it was concluded in IRC meeting held in June, 2010. The model developed on 1.5 hectare area comprises of crops (0.72 ha), dairy (0.32 ha), horticulture (0.22 ha), fishery (0.10 ha) and miscellaneous (0.14 ha) which was used for goat, apiary, vermicompost, threshing floor and farm building. This model initially was consisting crops including fodders, dairy with improved milch animals (Two buffaloes of murrah breed + one cow of sahiwal breed), horticulture (A multistoried fruits and vegetables unit), apiary (10 bee boxes) and pisciculture. This was further strengthened by establishment of a small vermicompost unit (0.01 ha) in 2006 and goat unit (15 goats) in 2007. In addition, fruit plants (Bel, jackfruit, aonla and jamun) were also planted all around the farm boundaries as wind breaks to protect the field crops and increase the income of the farm. Horticultural field unit boundaries were planted with a bushy tree plants, C*arisa caronda* locally known as "karonda" which served as live fencing and provide considerably high fruit yield (0.4-0.6 t/year) as a bonus. All the farm wastes, by products and crop residues . were properly recycled in to the system itself so that nothing go waste and output of one enterprise worked as input for other enterprises.

From the study it was concluded that IFS approach is a sound management of the resources of a small farm holder which helped to maximize the production and profits without harming the resource base and environment, simultaneously. Crop production besides food for family consumption, provided green fodders and feed concentrates to the dairy animals and also green biomass as feed of fish and goat. In turn animals provided FYM, vermicompost and draught power for crop production and also cow dung used in fish pond as fish feed. Similarly, bees collected nectar from the flowers of a number of field crops and in turn helped in cross pollination which resulted in more grain yield. The system enabled to fulfil most of the household needs of small farm holders one way and other side sustained production through recycling of farm wastes and crop residues. Under IFS approach man days increased more than double which can solve unemployment problem in rural youths. Not only this but this approach enabled to get regular income whole the year and catered more nutritious food and fodder for human and animals belonging to small farm holders families. In addition, a sizable amount of rupees ranging from Rs. 46.6 thousands in first four year to as much as Rs.77.9 thousands and Rs.68.8 thousands /year in subsequent years could be spared to meet other liabilities of the family including education, health and many social obligations.

Crop production

Ensuring household food and fodder requirements and decreased dependency on market, is a pre requisite of any of the research and/or developmental programmes carried out for small farm holders. To achieve this an area of 1.04 ha (69%), out of total 1.5 ha allotted land under IFS model was put under different crops/cropping systems consisting cereals, pulses, oilseeds, vegetables, flowers and green fodder crops. Green fodder crops were raised as an integral part of crops and no any separate area was allocated. Further to meet out the minimum requirement of different commodities (food, fodder, oilseeds, pulses, milk , meat etc.) for an average size of Indian family (7 members) and also to compare the relative production efficiency of different crops (Plates 1-7) under different crop sequences, a total number of 14 crop sequences were tested. The yield, gross and net returns and Benefit: Cost under different cropping systems are summarized in(Table 9.3/1).

The data summarised in Table 9.3/1 revealed that crop sequences i. e Rice- potato-marigold (164.5 t/ha/annum), Sorghum-rice-berseem (146.42 t/ha/annum) and Rice-potato –wheat – *Sesbania aculeate* (131.01 t/ha/annum) were found more productive compared to prevailing sugarcane based cropping systems (87.96 t/ha/annum). The B:C ratio of sorghum (GF) –rice (hybrid) –berseem (3.14) was higher than other cropping systems. Further, the systems enabled to get sufficient amount of green fodders (more than 45 ton/year green and about 8.0 ton dry fodder) round the year in the form of maize + cowpea, sorghum & bajra in summer & rainy seasons and sugarcane tops, berseem & oats etc. in winter months. The economic evaluation of different crop sequences revealed that cropping sequences Sorghum (F) – rice (hybrid) – berseem (Rs.166.63 thousands /ha/annum) followed by Rice (basmati) – potato – marigold (Rs.150.8 thousands /ha/annum)

Table 9.3/1. Productivity and profitability of different crop sequences (2004-2010) under IFS at PDFSR, Modipuram.

S.No	Crop sequences	Yield (SEY) (t/ha/year)	Net returns (Rs./ha/yr)	B:C
1	Sugarcane (Feb) + onion/ tomato-cowpea (GM) - Sugarcane (R) *(Two year rotation)*	95.94	63887	1.53
2	Sugarcane (May) +Cowpea (GM)-ratoon-wheat *(Two year rotation)*	86.98	53818	1.28
3	Maize – chickpea+ mustard – maize+ cowpea (GF) *(One year rotation)*	64.03	35649	1.02
4	Maize-Chickpea*(One year rotation)*	44.58	18431	0.70
5	Sorghum-blackgram-wheat *(One year rotation)*	71.67	42443	1.66
6	Rice – potato- wheat – *Sesbania aculeata* (GM) *(One year rotation)*	131.01	47312	0.56
7	Sorghum+Guar–Oats–Maize+Cowpea*(One year rotation)*	50.39	32762	1.44
8	Sorghum-late sorghum-mustard *(One year rotation)*	38.20	16150	0.62
9	Sorghum-mustard*(One year rotation)*	51.34	39850	2.40
10	Rice-berseem + mustad- pearlmillet*(One year rotation)*	100.62	70162	1.73
11	Rice – berseem + mustard *(One year rotation)*	62.05	36512	1.15
12	Rice- oats*(One year rotation)*	60.17	39351	1.46
13	Rice (basmati) – potato – marigold (One year rotation)	164.54	150812	1.57
14	Sorghum (F) – rice (hybrid) – berseem(One year rotation)	146.42	166637	3.14
15	Maize + red gram – wheat(One year rotation)	82.23	123343	1.94

1. Maize (green cobs) + red gram after harvest of wheat

2. Potato in rice-potato-wheat system

3. A general view of crop production unit of IFS Model

4. To fetch higher income marigold crop can profitable be taken in Basmati rice–potato–marigold system

Photo 9.3/1-4. Promising crops for enhanced income of the small farm holders

and Maize + red gram – wheat (Rs.81.3 thousands /ha/annum), realised higher net returns as compared to prevailing sugarcane based cropping systems (Rs. 53.8-63.9 thousands/ha/annum). This result showed that farmers can include cereals, pulses, oilseeds, potato, marigold and even green fodders to get higher income and ensured household food and fodder securities for fulfilling the daily requirements of human and animals, simultaneously.

Dairy (milk production)

Irrespective of type and breeds, animals are integral part of any of the Farming Systems of the country. Characterization survey conducted in western plain zone of Uttar Pradesh revealed that 96% of farmer families reared milch animals cows and buffaloes, the later however contribute significantly, both in number as well as production of milk. Two buffalos and one cow along with their

Table 9.3/2. Round the Year green fodder production under IFS model at PDFSR, Modipuram.

Name of crops	Green fodder availability (duration)	Av. Annual production of green fodder (t)	Av. Annual production of dry fodder (t)
Sugarcane (cane tops)	Oct. to April	-	8.9
Wheat straw	Round the year	-	2.2
Maize curvi	August to Sept.	-	0.5
Maize+cowpea	May to June	4.4	-
Pearlmillet	June to July	5.0	-
Sorghum	July to Nov.	24.1	-
Berseem	Dec. to April	7.2	-
Oats	Dec. to March	5.3	
Total		46.0	11.6

Note: *Fodder crops were a part of cropping systems under crop production programme and no separate area allocated for the purpose. Further, the cost of production on fodder crops is also included in crops enterprise and not in animals.*

5.

6.

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Photo 9.3/5-7: Milch animals (cows and buffaloes) and major green fodder crops of *rabi* and *kharif*

young ones in first four years and three buffaloes and two cows along with their young ones in subsequent years were kept in dairy unit of the IFS model. High yielding breeds of the buffalo Murrah and cow Holstein Friesian, respectively, were kept in the dairy unit which are most common and best suited for the area. Round the year availability of green fodders were ensured by inclusion of season specific fodder crops in different cropping systems under crop- production programme (Table 9.3/2). Further, to get green fodder during October to December, the months generally lacking in green fodders, sorghum variety Hari Ganga was sown in late September which produced lush green fodder in these months.

Besides green fodders, the animals were fed with balanced concentrates and feed mixtures along with mineral mixture and salt. The details of milk production, gross and net returns from the animal unit during last five years (April, 2005 to March 2010) are given in Table 9.3/3.

The data given in table 3 indicated that a unit of 3-5 milch animals can easily be handled by small farm holders and sufficiently higher profits can be achieved. Beside milk production, the animal unit also produced about 68.5 tonnes of cow dung on fresh weight basis which in tern can add about 60 kg N, 140 kg P_2O_5, 230 kg K_2O and plenty of macro & micro nutrients when added in to the soil. This all can save money equivalent to Rs.69.35 thousands/year. On the other side, when 2/3rd' of cow dung mixed with farm wastes crop residues etc. was utilized in preparation of vermicompost and rest 1/3 was used as fish feed and FYM, in this way the vermicompost unit produced as much as 15 tonnes of enriched vermicompost annually with 2.3% of N, 4 times more than cow dung. The goat animals included in the animal unit was not found good because of high mortality and poor growth of the animals under stall feeding. Later on, it was decided to drop the goat animals from the unit.

Horticulture *(A multi-storied fruit, vegetables and flower production unit):*

Besides cereals, pulses and oilseeds, horticultural crops are nutritionally rich mainly of essential proteins and vitamins which make human

Table 9.3/3. Annual production, gross & net returns from the animal unit under IFS at PDFSR

Year of production	Annual Milk Production (Litre)	Gross returns* Rs 000/year	Net returns Rs 000/year
2005-06	5748	51.85	22.45
2006-07	5667	116.33	40.70
2007-08	2083	111.28	32.29
2008-09	11315***	291.00***	192.67
2009-10	5792***	248.97***	147.02
Mean	6121	163.88	87.02

** This include income from the milk and other** products and by- products of animal unit*
*** Young ones of animals, cow dung, vermicompost and un productive animals*
**** The number of milch animals was doubled during the year and also income from goat unit included and hence more production and profits*

diet complete and help human being physically fit and mentally more sound. To make the family members' diet nutritionally rich and bring prosperity, horticulture enterprise was considered more appropriate to integrate in to the pre-dominant on-farm farming system (crops+ dairy) of the region. An orchard unit of 0.22 hectare was established in the very first year of the IFS model development. Mango & guava as main fruit, papaya as an intercrop fruit and citrus and *Carisa carendis (*Karonda*)* as border fruit plants were planted at recommended spacing and with scientific management practices. Vegetables and flower crops were also raised in between the spaces of fruit trees.

During first two years the fruit plantations were maintained and mortality if any was replaced. Intercropping of fruit papaya and vegetables tomato & brinjal could realized an amount of rupees thirty thousand and sixty eight (Rs.30,068/-) by sale of vegetable tomato in first year and by auctioning the whole produces of the unit including intercrop papaya in second year. The intercrops enabled to meet the initial establishment cost of the orchard. During third year (2006-07), floriculture was also introduced by growing marigold and gladiolus flowers along with vegetables tomato, brinjal and capsicum. Gross and net income generated from the horticultural block during the year were Rs.15.50 thousands/- and Rs.3.37 thousands/-, respectively. This yield and profit was mainly from boarder plantations and intercrops. Similarly in fourth year (2007-08) a number of seasonal crops including flowers, vegetables and green fodder crop (oats) were grown under canopy cover of these fruit trees. These seasonal crops along with fruits had earned money worth Rs. 22.67 thousands/year (excluding 20.5 ton fodder oats) with a net returns of Rs. 13.45 thousands/year. In fifth year (2008-09) also 0.56 ton fruits and 3.20 ton vegetables were produced and sold in open market worth Rs.20.80 thousands/year with a net profit of Rs.14.04 thousands /year. However in concluding year of 2009-10, the unit was auctioned in Rs.9.05 thousands/year on one year

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Photo 9.3/8-9: A view of multi-storeyed fruit orchard (M) unit of the IFS model and seasonal crops brinjal (Vegetable) and papaya (fruit) as intercrops grown in association of perennial fruit tree species mango and guava

contract and a sum of rupees seven hundred (Rs.0.7 thousand/-) only was spent in the form of irrigation water as term condition of the contract and rest expenditure was made from the side of the contractor. In this way on an average the gross and net returns from the horticultural unit were Rs.17.40 thousands and Rs.10.26 thousands per annum which when calculated on per hectare basis comes to Rs.80.56 thousands and Rs.47.51 thousands/ha/year with B:C of 2.44. In this way horticultural crops produce round the year high value crops and provide more employment to the family members as compared to crops alone.

Photo 9.3/10: Fish pond

Fresh water fish production

Increasing human population and decreasing animal population on other side, demands new sources of food supply mainly of meat. Fish production is an emerging field of supply high quality protein and other nutrient rich meat particularly in northern India, southern part of the country being the leading fish production states by habitat. The government of Uttar Pradesh has taken it as a campaign and a number of measures have been taken to popularize the fish production programme in the state including rejuvenating old village ponds and digging new ones and also establishing seed nurseries and hatcheries. Looking in to the importance of fish production, a fish pond with a total living area of 1200 sq.m. and ponded area of 0.088 ha was constructed in the month of August,2004 and the fish species rohu, katla, mrigal and grass carp (zeera seed) was introduced @ 10000 fingerlings/ha as mixed seed. The pond was nourished by cowdung, mustard cake, rice bran and NPK as per recommendations. A level of 1.5 meter of water was maintained by regular watering in the pond. Exercise of fishes for good health was also done on regular intervals of one month. In very first year comparatively less yield (148 kg fresh wt.) than expected was mainly because of less space available for daily exercise of the fishes and high density of fingerlings. To correct this the pond was rejuvenated by removing middle barrier hindering movement of the fishes in to the pond water and putting optimum number of fingerlings for less competition for food and space.

This all improved the situation and the yield of fishes increased from 0.14ton kg in 2005-06 to 0.28 ton in 2007-08, 0.47 ton in 2008-09 and 0.51 ton in 2009-10 .The enterprise realized gross and net returns of Rs.25.91 thousands and Rs.16.06 thousands, respectively in fifth year 2009-2010 of the start of the fish production unit.

Bee keeping (Apiary)

Bee keeping is an enterprise which is being practiced mainly by the orchard owners and or landless families. A small unit of apiary with 10 boxes was started in March, 2004 and was extended to 20 boxes in subsequent year 2005. An average honey yield of 195 kg/year was recorded during first two harvest seasons (2004-05 to 2005-06) with a net profit of Rs. 8103/year from the unit. During third year (2006-07) considerably low yield (90.5 kg)

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Photo 9.3/11-12: A small farm holder can easily handle 5-10 bee boxes without much land space

was produced. The production was badly affected by large scale mortality of bee flies by attack of a parasite insect *Varao mite* on the larvae and pupae of the bee flies damaging more than 70% of the bee colonies. The insect attack was so incidental and wide spread , started in June, 2006 that more than 50% business was completely lost in most of the northern states including Haryana, Punjab,Rajasthan, Himachal, Uttaranchal and western Uttar Pradesh. In our case also 50% boxes were completely damaged by this insect. Despite all, the bee keeping was still beneficial and enable to earn Rs. 3.81 thousands/-as a net profit. The unit was again strengthened in 2007-08 by increasing the boxes from 6 to 19 and despite adverse climatic conditions prevailed during the production period (Oct.-April), not suited to the growth of honey bees and honey production both, about 0.077 ton honey was produced earning a gross and net returns of Rs. 7.75 thousands and Rs. 3.71 thousands respectively. The production further increased in 2008-09 and reached to 0.16 kg/year.

Nutrient budgeting

The farm resources available and recycled either in situ (green manure crops, cowpea intercropped in sugarcane , cane trash, potato leaves, redgram leaves, berseem and other leguminous crops roots and green biomass added after picking of pods etc.) or through composting (vermicompost, FYM) of cow dung & urine mixed with farm wastes was added in to soil in the form of plant nutrients equivalent to 121.7 kg N, 226.8 kg P and 411.9 kg K and considering a realizable amount 30% of the total nutrient incorporated comes to 228 kg of NPK against total NPK requirement 511 kg ha^{-1}/annum for raising all the field and plantation crops (285.3,116.3 and 109.9 of N,P and K ,respectively). This way about 15% of N and a major part of P and K can be added through these organic means and a sizable amount of cash can be saved. In addition to this, nutrient rich fish pond water (twice a year) and silt (once in every four year) was used which further add in to the soil fertility and crop productivity (11-16%) as and where (Mustard/wheat) applied.

13. Vermicompost unit

14. Intercropping of cowpea in sugarcane and *in situ* incorporation in to soil

15. *Sesbania aculeate* green manuring in rice-wheat- Sesbania system

Photo 9.3/13-15: Organic source of nutrients rather cheap than chemical fertilizers and good for maintaining health of the soil and keep environment safe

Employment generation

The diversified and intensive nature of multifarious activities related to different enterprises included in the IFS model provide a lot of opportunities of employment and keeps farmers and their family members engaged whole the year and as such can help in solving unemployment problem of the country mainly in rural youths. The man days required for the production of crops alone was 182/ ha /annum wherein under IFS this number was 2.91 times more (795 man days) than crops alone (Table-9.3/4).

Table 9.3/4. Employment generation through IFS approach

Enterprises	Man days
Crop alone (1.04ha)	189
Dairy (5 Milch animals and their young ones)	365
Fishery (fish pond of 0.10ha)	52
Apiary (10 bee boxes)	38
Goat (15 animals)	91
Vermicomposting (0.01ha)	60
Total IFS (1.5ha)	795 man days (530/ha)

Boundary plantations

To counteract the ill effect of winds during summer and making productive use of field boundaries and vacant land, plantation of fruit tree species (Photo 21-24) having no or little adverse affect on the crops was done . This will also fetch additional income to the family and provide nutritionally rich diet in long run.

Economic evaluation and livelihood analysis of IFS model

Gross and net returns

Gross and net returns under IFS averaged over the year (Table 9.3/5) were Rs. 219.6 thousands ha^{-1}/year and 90.5 thousands ha^{-1}/year, respectively, which were 83.8% and 26.5% more than crops alone (Rs.119.4 thousands and Rs.71.57 thousands ha^{-1}/year.

Photo 9.3/16: Boundary plantation of Aonla

Photo 9.3/17: Boundary plantation of Jamun

Photo 9.3/18: Boundary plantation of Jackfruit, bel and citrus

Photo 9.3/19: Boundary plantation of C*arisa caronda*

Table 9.3/5. Gross and net returns under IFS since start of the project (2004-05 to 2009-10) from an IFS model of 1.5 hectare cultivated land

S.No.	Enterprises	Gross Returns (000, Rs/year)					
		(Av. 2004-06) Initial years	2006-07	2007-08	2008-09	2009-10	(2004-10) Average
1	Crops	88.84	149.33	134.92	149.70	98.37	124.23
2	Animals (Dairy*+Goat**)	51.85*	116.33*	111.28*	291.03**	275.46**	163.88
3	Horticulture	18.98	15.50	22.67	20.80	9.05**	17.40
4	Fishery	2.22	11.20	14.16	15.75	25.91	13.84
5	Apiary	15.61	7.360	7.75	15.40	4.00****	10.02
	Total IFS	177.50	299.73	290.79	492.65	412.79	329.40
		Net Returns (Rs 000/year)					
1	Crops	45.02	104.05	80.35	89.66	53.07	74.43
2	Animals (Dairy*+Goat**)	22.45*	40.70*	32.29*	192.67**	146.13	87.02
3	Horticulture	12.14	3.37	13.45	14.04	8.30	10.26
4	Fishery	-4.21	0.79	4.29	7.80	16.06	4.94
5	Apiary	8.10	-1.54	3.71	9.95	0.80	4.20
	Total IFS	83.51	147.37	134.11	314.12	224.37	135.82

Income from dairy animal alone ** Income from Dairy+ goat animals *** The orchard unit was auctioned for one year and the income from intercrops raised by him are not included in gross and net returns. **** Apiary unit was badly affected by insect *Baravo which* damaged almost all the bee hives, resulting in poor honey production in the year.

This probably was because of inclusion of more enterprising vegetables and flower crops, strengthening of livestock & fishery units, optimum recycling of farm wastes and crop residues and better management of all the enterprises of the model maintaining higher level of production. Overall monitoring and livelihood analysis of the IFS model (Table 9.3/6) revealed that by removing the constraints responsible for yield gaps and optimum integration of farm & eco friendly enterprises in existing on – farm farming system, the farmers can earn 82.47% more profits (Rs.135.82 thousands ha^{-1}/year) than crops alone (Rs.74,435 ha^{-1}/year). As regard to livelihood security, the IFS approach adopted in the model met almost all the domestic family needs of food, fodder, fuel etc. and saved a sizable amount of money ranging from an average value of Rs.46.6 thousands/- in first four years followed by Rs. 77.93 thousands and Rs. 68.86 thousands in fifth and sixth year, respectively, to meet the other liabilities of the family including education, health etc. This saving was exclusive of all the fixed and running cost of IFS model and money required (Rs.119.56 thousands) for household food and fodder requirements of a family.

The data reported above suggests that IFS approach not only fulfil the household needs but enrich diet of human being and animals both and simultaneously keep the people away from the hazards of residual toxicity of the chemicals being used in agriculture on a large scale. Further, diversified nature of the project provides huge employment opportunity for unemployed rural

Table 9.3/6. Impact of IFS approach on the productivity of a farm and household security

Household commodities produced at farm of PDFSR under IFS Model	Production year (Av. of first 4 years) (Tones)	Fifth year (2008-09) (Tones)	Final concluding year (2009-10) (Tones)	Annual demand of an Indian family (Tones)
A. Crops (0.72ha)				
Cereals	3.10	4.01	3.27	1.55
Oilseeds	0.16	0.29	0.15	0.13
Pulses	0.46	0.25	0.21	0.20
Fodders	53.00	90.20	64.0	86.60
Sugarcane	27.70	9.68*	26.4	1.60
B. Horticulture (0.22ha)				
Fruits	1.80	0.56	1.35	0.20
Vegetables	3.10	3.27	4.02	0.90
C. Live stock (0.32ha)				
Dairy animals(Milk)	4.50	11.57*	5.79	1.12
Meat animals(Goat meat)	NA	0.18	0.19 (Rs. 19100)	Goat & fish not consumed by a vegetararian family
D. Pisciculture (0.10ha)				
Fishes	0.15	0.45	0.52	
E. Apiary & others(0.14ha)				
Honey	0.19	0.16	0.04**	0.02
Gross value (Rs.) of all the farm produce	315300	502655	4,12,799	(104196)*** 119560****
Cultivation cost (Rs.)	164441	305163	2,24,375	
Net returns (Rs.)	150859	197492	1,88,424	
Net saving (Rs.) (Net returns – annual demand of a family in term of money)	46663	77932	68,865	

*In reported year, the area under sugarcane was reduced to half of the previous four years and was shifted to green fodder crops because of increase (200%) in animal number of the animal unit and hence less cane production as compared to average production of previous years. Further, the cane yield reported in the year is of plant crop of summer planted sugarcane which is always less than the average yield of plant + ratoon crops of sugarcane. Similar is in the case of milk production. Higher the number of milch animals , higher is the milk production.**The *Varao* an eight legs insect badly damaged the bee hives and a very low yield particularly in sixth year of the model.

***Household consumption in term of money value (Av. of first four years)

**** Household consumption in term of money value (5th and 6th year of production) youths. In addition, a sizable amount of rupees ranging from Rs.46,663 in first four year to as much as Rs.77,932 and Rs.68,865/year in subsequent years to meet other liabilities of the family including education, health and many social obligations.

Development of dairy based integrated farming system model for marginal land holders of western plain zone of Uttar Pradesh

Under AICRP on IFS, the project was started in *kharif* 2010 with an objective to ensure livelihood (food, feed and fodder, fuel etc.) and simultaneously improve the nutritional and financial status of marginal land holders of the region/zone. The technical programme of the project was discussed in detail and was finalized in IRC meeting held during June, 2010. The IFS model (0.70 ha) constituted dairy animals (3 buffaloes + 1 cow), crop unit (3800 m^2), horticultural block with fruit species Mandarin var. kinnow (1800 m^2) & tissue cultured Banana Var. Grain nain (1200 m^2) and Vermicompost unit for composting cow dung of the dairy animals (100 m^2) . The progress made during last six months (July to December, 2010) is given below.

Initial soil fertility

Soil of the project area was analysed for major and micro nutrient status before the start of the project. The test value for organic carbon and available N, P and K are given in Table 9.3/7. The analysis for micronutrient is in process.

Table 9.3/7. Nutrient status of the project area soils

Nitrogen (Av. N) kg ha^{-1}	Phosphorus (Av. P) kg ha^{-1}	Potash (Av. K) kg ha^{-1}	Organic Carbon (%)
144.3	39.5	190.1	0.41

Crop production

To meet the basic food and fodder requirements of the family having an average of seven members and four dairy animals, an area of 3800 sq.m. has been allotted under crops. The area under crops is further divided in to four plots for four crop sequences consisting different crop groups including cereals, pulses, oilseeds, vegetables and green fodder. As the dairy animals were purchased late in December, the fodder crops (oats and berseem) were taken in current *rabi* season only and will follow succeeding summer (maize+cowpea) and *kharif* (sorghum) seasons. The detail of crop sequences taken and growth yield performance of different crops during *kharif* 2010 are summarised in Table 9.3/8 and shown in photos 1-3.

Horticulture (Fruits intercropped with vegetables, pulses and fodder:

Under horticulture, fruit trees Mandarin Var. Kinnow (Photo 9.3/23-24) and Tissue cultured banana var. Grain nain (Photo 9.3/25-26) were planted in an area of 3000 sq.m. To utilize the inter space area in between the rows of the fruit plants, vegetable pea with kinnow fruit and green fodder crops berseem with banana were also taken as intercrops to get economic returns from the very first year of fruit plantations. Intercrops selected were of less competitive and similar requirements of irrigation and nutrients. The next intercrop in kinnow will be greengram/blackgram and suitable vegetables in banana.

Dairy (Milk Production)

Rearing of dairy animals for milk production is an important enterprise among marginal farmers in western plain zones of Uttar Pradesh and sound base of the economic condition of this category of farmers.

Table 9.3/8 : Crop sequences followed and yield of different crops during *kharif* 2010.

S.No.	Crop sequences	Crop/ crops grown during *kharif*;2010	Yield (q/ha)	Production from the farm area of 3800 sq.m. under crop production in IFS model (*Kharif* - 2010)	Family requirement of cereals/ pulses/vegetables/oilseeds per annum
1	Rice-Oats –sorghum (GF)(600 m2)	Rice Var. Sugandha-5	48.80	292 kg	Annual demand cereals –1100 kg, pulses –145 kg, Oilseeds –2 vegetables –365 kg
	Rice –mustard – maize + cowpea(1600 m2)	RiceVar. PHB-17	59.20	947 kg	*Production figures given in the table show that the production from even a small area of 3800 sq.m. and that too from single season kharif crops is equivalent or more than annual food demand of a 7 member family.*
3	Maize + Redgram–wheat(800 m2)	Redgram	18.60	148 kg	
4	Vegetables(K)– wheat-maize(S)(800 m2)	Lady finger	78.20	625 kg	
	Total area under crops including fodders Net area=3800 m2				**Note:** Oilseed crop mustard is taken in current rabi who will satisfy the need of oilseeds required.

20.

21.

22.

Photo 9.3/20-22: Field performance of different crops during *kharif* 2010 – AICRP on IFS Model at PDFSR, Modipuram

Photo 9.3/23: Virus free Mandarin Var. kinnow

Photo 9.3/24: Intercropping of veg. pea with kinnow

Photo 9.3/25: Plantation of tissue cultured banana Var. Grain nain

Photo 9.3/26: Berseem intercropped with banana

Dairy component of IFS model constitute two buffaloes and one cow. For continues milk supply and regular income from the unit it was considered to purchase the animals in part and not at a time. For this, during December, 2010, two buffaloes (Crossbreed Jafarwadi x Murrah) were purchased from open market with an average milk yield of 11 litre/day. One cow (H.F.) will also be added in the unit from our old IFS unit during the month of January/ February, 2011 and simultaneously, the 4th' milch animal one buffalo will be added some where in May/ June 2011. The production and other details of the unit will be reported later.

Photo 9.3/27: Animals in newly established dairy unit in IFS model under AICRP on IFS

Vermicompost

All the cow dung of the animal unit has been collected and are being used for preparation of Vermicompost in the existing structure of the old IFS Model.

Photo 9.3/28: Growth of earthworms in Vermicompost unit of the Project

Boundary plantation

Fruit plants guava and banana were also planted all around the field boundary to act as wind breaks and counteract the adverse effect of winds . In addition to this, the farmer will get regular additional income in long run.

Photo 9.3/29: Guava and banana plantations on the field boundaries

Development of year round production module of mushrooms for small and marginal farmers

Organic Production Technology for Milky Mushroom (Calocybe indica)

An Organic Production Technology for Milky Mushroom (*Calocybe indica*) was evaluated at IFS farm of PDFSR in the month of May 2010. The mushroom was grown organically on pasteurized wheat straw. Spawning was done with wheat grain spawn of milky mushroom @ 6% of the ready wet straw containing 65-70% moisture. Inoculated bags were then incubated at room temperature for 20 days. Casing (3-4 cm thick) was done with steam pasteurized mixture of sandy soil and vermicompost (1:1 vol./vol.). Cased bags and walls of crop room were then regularly sprayed with fresh water 2-3 times daily. The mushroom fruitbodies of 50-150 g were harvested regularly up to 2 months after the emergence of every flush.

The number of fruit bodies (g/5 kg straw) on fresh weight basis and biological efficiency (%) were 17.5, 514.6g and 30.94 respectively (Table 9.3/9). The cost of cultivation, gross income and net income were Rs.20, Rs.40 and Rs.20 per kg of mushroom.

9.4 RESOURCE CHARACTERIZATION AND SYSTEM DIAGNOSIS (RCSD)

A. FARMING SYSTEM CHARACTERIZATION AND CONSTRAINTS ANALYSIS

Characterization and evaluation of farming system in India

The study was undertaken during the year 2009-10 with the objective i) to identify and characterize the farming systems across eco-system and size groups ii) to analyze the productivity and viability of farming systems and to determine the factors contributing for farming systems. All four zones i.e. Kokan region, Western Maharastra, Vidharwa and Marathwada region of Maharastra were selected for the study. All four districts of Kokan, six districts of Western Maharastra, and four districts each of Vidharwa and Marathwada region were selected for farmer's survey. Two representative blocks from each district and three village panchyat from each block were selected by adopting multistage random sampling technique. Ten to twelve farmers from each village panchayat were interviewed giving emphasis to marginal and small farmers. However, medium and large farmers were also interviewed on random basis to fill up the pre tested questionnaire. On the basis of farm size, sample households were selected for the study and presented in the Table 9.4/1. At overall level, sample constitutes 27% marginal, 32% small, 18% medium and 22% large farmers. Care was taken to maintain the representation from each category of farmers. The findings of the first and second objective of the study are as under.

Identification of farming systems

Data pertaining to predominant farming systems is presented in Table 9.4/2. The results indicated that livestock based farming systems were opted by (51% farmers) followed by cereal based (29% farmers) in Konkan region. Sugarcane growers (48%) followed by livestock (30%) were recorded to be involved in sugarcane and livestock based farming systems in Western Maharashtra. In Vidhrwa region, 50% farmers were engaged in pulses,

Table 9.4/1. Farm size on the basis of total and percentage selected sample households in the four zones of the Maharastra

Sr. No.	Name of zone	Marginal	Small	Medium	Large	Total
1	Kokan	60	40	19	14	133
	%	45.11	30.08	14.29	10.53	100.00
2	Western Maharastra	108	80	26	24	238
	%	45.38	33.61	10.92	10.08	100.00
3	Vidharwa	38	85	49	83	256
	%	14.84	33.20	19.14	32.42	100.00
4	Marathwada	29	76	66	68	240
	%	12.08	31.67	27.50	28.33	100.00
	Total	235	281	160	189	867
	%	27.10	32.41	18.45	21.80	100.00

Table 9.4/2. Predominant farming systems in Kokan, Western Maharastra, Vidharwa and Marathwada regions of Maharastra

Zones	Farming systems	No. of farmers	Per cent
Kokan	Livestock	68	51.13
	Cereal	38	28.57
	Fruits & Vegetable	15	11.28
	Spice	12	9.02
	Total	133	100
Western	Sugarcane	113	47.68
	Livestock	72	30.38
	Fruits & Vegetable	34	14.35
	Cereal	19	8.02
	Total	238	100.42
Vidharwa	Pulses and oilseeds	129	50.39
	Livestock	47	18.36
	Cotton	38	14.84
	Cereal	26	10.16
	Fruits & Vegetable	9	3.52
	Spice	7	2.73
	Total	256	100
Marathwada	Pulses and oilseeds	74	30.83
	Cotton	49	20.42
	Sugarcane	47	19.58
	Livestock	45	18.75
	Fruits & Vegetable	15	6.25
	Cereal	10	4.17
	Total	240	100

oilseeds cultivation while 18% farmers were involced in live stock production. In Marathwada, 31 and 20% were observed following pulses and oilseed and cotton based farming systems, These were identified predominant farming systems in this region.

Socio-economic characteristics of sample households

Socio economic characters of households of different zones are given in Table 9.4/3. As regards Kokan region, it was observed that education of the family head was below 10th standard. Farm size varied from 0.69 ha (marginal farmers) to 5.09 ha (large farmers). Family size varied from 6.2 (marginal farmers) to 6.9 (medium farmers) per household. In general, average household had about two deshi cows.

In western Maharashtra, education status was below 10th standard and farm size varied from 0.64 ha (marginal) to 6.09 ha (large). Farmers are having their land on the different places. Family size was more than 6 members and they have about two milch animals. In Vidharba region, the general, the family heads were more educated and had about 10th standard education. Farm size varied from 0.47 ha for marginal farmers to 7.99 ha for large farmers, 2 fragmented plots, six family members and an average household had about two milch animals. Similarly in Marathwada region, average education status of family head was below 10th standard and farm size varied from 0.66 ha (marginal) to 7.81 ha (large farmer), Generally each household has two plots and the no. of family members was more than 6. An average household were keeping two milch animals.

Cropping pattern of sample households

Region wise data related to cropping pattern of Maharasta is presented in Table 9.4/4. The analysis indicated that cereal covered about 78% of cropped area followed by 12.6% under spice, fruits and vegetables (SVF) and 9.2% under pulses and oilseeds in Kokan region of Maharashtra to the gross cropped area (GCA). It also revealed that medium farmers put more area under pulses and oilseeds and SVF group. As farm size increased, the area under cereals decreased and area under pulses and oilseeds increased. The cropping intensity varied from 129% for small farmers to 178% for large farmers. Results indicated that marginal and small farmers were more dependent on cereal crop due to their food security. In case of western Maharastra,

Table 9.4/3. Socio-economic characteristics of sample households in Kokan , Western Maharastra, Vidharwa and Marathwada regions of Maharastra

Particulars	Marginal	Small	Medium	Large	Total
Kokan					
Farm Size (ha)	0.7	1.5	2.9	6.9	3.0
No. of plots	2.2	2.4	2.6	1.8	2.2
Family Size (Nos)	6.2	6.6	6.9	6.5	6.5
Education status of head*	2.0	2.0	2.0	1.7	1.9
Deshi cow (Nos)	1.7	2.2	1.4	0.8	1.5
Cross Breed Cow (Nos)	0.7	0.7	0.7	0.3	0.6
Buffaloes (Nos)	0.6	2.0	1.1	0.6	1.1
Western Maharashtra					
Farm Size (ha)	0.7	1.6	3.0	7.5	3.2
No. of plots	1.5	2.2	2.4	3.9	2.5
Family Size (Nos)	5.1	6.3	6.0	9.9	6.8
Education status of head*	1.7	1.8	1.9	2.0	1.8
Deshi cow (Nos)	1.6	1.2	1.3	1.7	1.5
Cross Breed Cow (Nos)	1.5	2.2	1.8	1.8	1.8
Buffaloes (Nos)	1.3	1.4	2.0	2.3	1.7
Vidherawa					
Farm Size (ha)	0.6	1.7	3.3	8.7	3.6
No. of plots	1.0	1.3	1.9	2.6	1.7
Family Size (Nos)	4.6	5.8	6.2	7.5	6.0
Education status of head*	1.7	2.4	2.5	2.8	2.4
Deshi cow (Nos)	0.8	3.0	1.7	4.8	2.6
Cross Breed Cow (Nos)	0.8	1.3	1.2	2.0	1.3
Buffaloes (Nos)	1.2	2.0	2.2	4.6	2.5
Marathwada					
Farm Size (ha)	0.7	1.3	3.1	7.8	3.7
No. of plots	1.3	1.4	2.3	2.9	2.1
Family Size (Nos)	5.1	4.9	6.2	7.8	6.4
Education status of head*	1.2	1.9	2.1	2.7	2.1
Deshi cow (Nos)	1.9	0.9	2.0	1.7	1.7
Cross Breed Cow (Nos)	0.5	0.4	1.4	2.1	1.7
Buffaloes (Nos)	1.2	1.2	1.7	1.3	1.5
Maharashtra					
Farm Size (ha)	0.7	1.5	3.1	7.7	3.4
No. of plots	1.5	1.8	2.3	2.8	2.1
Family Size (Nos)	5.3	5.9	6.3	7.9	6.4
Education status of head*	1.7	2.0	2.1	2.3	2.1
Deshi cow (Nos)	1.5	1.8	1.6	2.3	1.8
Cross Breed Cow (Nos)	0.9	1.2	1.3	1.6	1.4
Buffaloes (Nos)	1.1	1.7	1.8	2.2	1.7

*Indicates 0=Nil, 1=primary and 2=junior, 3=10th standard

Table 9.4/4. Predominant cropping pattern in Kokan , Western Maharastra, Vidharwa and Marathwada regions of Maharastra

(Area in %)

Farm Size	Cereals	Pulses & Oilseeds	Sugarcane	Cotton	Spice,Veg. & Fruits	Total	GCA(ha)	CI %
Kokan region								
Marginal	83.4	5.0	0.0	0.0	11.5	100	1.0	139.1
Small	76.4	5.8	0.0	0.0	17.7	100	1.9	129.2
Medium	64.5	21.7	0.0	0.0	13.8	100	3.4	120.3
Large	79.0	19.4	0.0	0.0	1.6	100	13.3	176.0
Pooled	78.0	9.2	0.0	0.0	12.6	100	2.9	137.3
Western Maharastra								
Marginal	47.0	7.5	39.3	0.8	5.4	100	0.8	129.2
Small	46.8	9.1	32.7	0.0	11.4	100	2.1	128.8
Medium	45.3	5.4	34.5	0.0	14.9	100	3.7	120.9
Large	50.0	8.9	25.9	0.0	15.2	100	10.5	139.6
Pooled	47.3	7.7	33.1	0.2	11.7	100	4.3	129.6
Vidherwa region								
Marginal	48.1	29.3	0.0	19.9	2.7	100	1.1	151.1
Small	26.1	47.9	0.0	21.7	4.1	100	2.8	165.6
Medium	23.3	49.1	0.7	22.5	4.5	100	5.3	167.0
Large	13.9	57.6	0.0	23.8	4.8	100	15.3	165.5
Pooled	27.9	46.0	0.2	22.0	4.0	100	6.1	162.3
Marathwada region								
Marginal	44.2	22.8	19.4	10.6	3.0	100	1.4	183.2
Small	26.4	37.9	9.4	24.3	1.9	100	2.0	126.1
Medium	23.1	42.7	9.4	21.8	2.9	100	4.4	137.8
Large	23.1	49.2	7.7	13.7	6.2	100	9.4	117.6
Pooled	29.2	38.2	11.5	17.6	3.5	100	4.3	141.2
Maharashtra								
Marginal	55.7	16.2	14.7	7.8	5.7	100	1.1	150.7
Small	43.9	25.2	10.5	11.5	8.8	100	2.2	137.4
Medium	39.1	29.7	11.2	11.1	9.0	100	4.2	136.5
Large	41.5	33.8	8.4	9.4	7.0	100	12.1	149.7
Pooled	45.6	25.3	11.2	10.0	8.0	100	4.4	142.6

results revealed that the region were more diversified in growing crops as compared to cropping pattern of Kokan region because they allocated 47% area under cereals, 33% area under sugarcane, 12% area under SVF and 8% area under pulses and oilseeds. The cropping intensity varied from 120% (medium farmers) to 139% (large farmers). It is clear from the analysis that most of the farmers are single crop growers being prevalence of sugarcane based farming system.

The results obtained from the data of the Vidharwa region, 46% of GCA covered under pulses and oilseeds followed by cereals (28%) and cotton (22%). The area under cereals varied from 14% for large farmers to 48% for marginal farmers while the cropping intensity varied from 151% (marginal farmers) to 167% (medium farmers). The analysis made it clear that marginal farmers were more concerned about cereal crop for meeting their food requirement. As regards to Marathwada region, 38% of GCA covered under pulses and oilseeds followed by cereals (29%) , cotton (18%) and sugarcane (11%). The results indicated that Vidharwa and Marathwada had some similarity in cropping pattern. The cropping intensity varied from 117% for large farmers to 183% for marginal farmers. Analysis also revealed that in general, marginal farmers were more concerned about cereal crop for meeting their food requirement. There is a scope to develop cereal based farming system for marginal farm groups by introducing high value based allied activities on these farms.

Pattern of household's expenditure of sample households

Pattern of household's expenditure is a measure of living standard. If the percantage of expenditure on food items is higher, it indicates that household is just meeting their family food requirement because of low income. Therefore, the analysis of household's expenditure was carried out and presented in Table 9.4/5. The analysis revealed that the household expenditure varied from Rs. 45550 (marginal farmers) to Rs 49819 (large farmers) per annum in Konkan region. Expenditure on food constituted highest share about 51% for large farmers to 61% for marginal farmers followed by expenditure on health and insurance which varied from 10.2% (marginal farmers) to 13.4% (large farmers) respectively. Education is also an important item of expenditure which ranged from 6.4% to 8.7% for marginal and large farmers respectively. The percentage expenditure on food decreased as farm size increased showing inverse relationship between percentage expenditure on food and farm size. As regards to Western Maharastra, the trend was similar in case of education, health and insurance. The total expenditure was higher (Rs. 63252) in Western Maharastra as compared to Konkan (Rs. 47730). It shows that living standard of farmers of Western Maharastra was higher as compared to Konkan region. In case of Vidharwa region, expenditure on food varied from 30% to 53% for large and marginal farmers respectively followed by expenditure on health and insurance which varied from 13.5% (marginal farmers) to 21.8% (large farmers). Share of expenditure was also higher on education ranging from 11.1% to 21.4% for marginal and large farmers respectively. There was a wide gap in average household expenditure of marginal farmers (Rs. 41000) to large farmers (Rs. 131000) per annum.

As regards to Marathwada region, the expenditure on food varied from Rs. 39.1% (large farmers) to 57.4% (marginal farmers) followed by expenditure on health and insurance which varied from 7.3% (marginal farmers) to 15.1% (large farmers). Share of expenditure on education was lowest in comparison to three other regions i.e. Kokan, Western Maharastra and Vidharwa. The expenditure on education ranged from 11.1% (marginal farmers) to 21.4 (large farmers).

In general, households expenditure for maintenance of family including education, social and religious activities excluding marriage ceremonies, varied from Rs. 45832 (marginal farmers) to Rs. 97351 per year based on 2009-10 prices. The analysis also indicated that the percentage expenditure on food had inverse relation with farm size and direct relation with education, health and insurance.

Table 9.4/5. Pattern of sample households expenditure in Kokan , Western Maharastra, Vidharwa and Marathwada regions of Maharastra

(%)

Items of Exp	Marginal	Small	Medium	Large	Total
Konkan					
Food	61.4	56.5	52.8	50.6	55.3
Health & insurance	10.2	11.6	13.0	13.4	12.1
Education	6.4	6.8	8.6	8.7	7.6
Religious	5.1	5.6	4.6	4.3	4.9
Others	16.9	19.5	21.0	23.0	20.1
Total (Rs)	45560	47546	47995	49819	47730
Western Maharastra					
Food	62.3	57.9	53.1	52.6	56.5
Health & insurance	9.7	10.5	11.3	12.8	11.1
Education	9.1	10.5	11.5	11.9	10.8
Religious	3.6	5.4	7.7	5.5	5.6
Others	15.3	15.7	16.4	17.2	16.2
Total (Rs)	43347	58609	69339	81714	63252
Vidharwa					
Food	52.5	41.7	41.9	30.3	41.6
Health & insurance	13.5	16.9	17.7	21.8	17.5
Education	11.1	13.0	12.9	21.4	14.6
Religious	2.9	4.5	4.7	4.2	4.1
Others	20.0	24.0	22.8	22.3	22.3
Total (Rs)	41478	64646	70331	131092	76887
Marathwada					
Food	57.4	50.8	50.2	39.1	49.4
Health & insurance	7.3	10.8	11.5	15.1	11.2
Education	4.1	6.9	6.8	10.5	7.1
Religious	4.9	3.4	4.2	3.4	4.0
Others	26.3	28.1	27.3	31.9	28.4
Total (Rs)	50510	66634	85881	131036	83515
Maharashtra					
Food	57.4	53.5	51.6	45.8	52.1
Health & insurance	11.4	12.0	10.9	14.6	12.2
Education	8.8	8.8	9.7	11.3	9.7
Religious	3.6	3.5	4.8	4.4	4.1
Others	18.8	22.2	23.0	23.9	22.0
Total (Rs)	45832	59927	68274	97351	67846

A number of factor influences the returns from farming system. As per sample household, fragmentation and subdivision of land holding, scarcity of labour, low yield of crops, less reliable market, scarcity of owned fund, depleting natural resources, global warming, non-availability of good quality seeds (variety and breeds) and sheds for animals, poultry etc. were found major constraints restricting higher returns from different farming systems.

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

i) Creation of database of experiments conducted during 2008-09 under on- farm experiments

For digitization of database of experiments entitled, "Sustainable Production System", "Response of Nutrients" and " Diversification and Intensification of cropping systems", the data was structured and digitized pertaining to ECF centres at Udaipur (MPUA&T, Udaipur), Nipani (UAS Dharwad), Arkot (CSKHPKVV, Palampur), Kakdweep (BCKVV, Kalyani), Srinagar (GBPUA&T, Pantnagar), Dhenkanal and Kendrapara (OUA&T, Bhubaneswar), Varanasi and Fatehgarh (NDUA&T Faizabad), Banda (CSAUA&T, Kanpur), Garhwal (GBPUA&T, Pantnagar), Warangal (ANGRAU, Hyderabad), Dhenkanal and Nayagarh (OUA&T, Bhubaneswar), Dhiansar (SKUAST, Jammu), Chas (MPKV, Rahuri) and Ambajogoi (MAU, Parbhani).

ii) Creation of database of experiments conducted during 2009-10 under on-station experiments

Digitized database on various treatments, soil characteristics, yield characteristics and nutrients applied pertaining to experiments of Permanent Plot, Sustainable production Model, Organic farming, Site specific Nutrient Management, Resource conservation Technologies and Identification of need based cropping systems for different agro-ecosystems for the year 2009-10. The centres covered were JNKVV, Jabalpur, Sub Centres-Indore, Rewa and Powerkheda, NDUA&T, Faizabad, CCSHAU, Hissar, TNAU, Coimbatore, RAU, Bikaner, UAS Siriguppa, RAU, Sabour and PAU Ludhiana.

B. DIAGNOSTIC SURVEYS AND SYSTEM ANALYSIS

Impact of ground water table on cropping systems economics and energetic in Bundelkhand region

The survey of Jhansi, Jalaun, Hamirpur and Mahoba districts of Uttar Pradesh falling in Bundelkhand region was conducted during (2009-10) with the objectives: (i) to study the dynamics of ground water profile in Bundelkhand region over time and space and (ii) to study the comparative economics of crop production as influenced by ground water depth and motive for lift. The salient findings of survey of Hamirpur district are presented:

Dynamics of Ground Water Profile

The average depth of ground water table of the district was recorded 30.8 m. during course of survey. The depth of water was 31.2 to 34.4 and 25.3 to 27.6 m. during 2004-05 and 1999-200 respectively (Fig. 9.4/1).

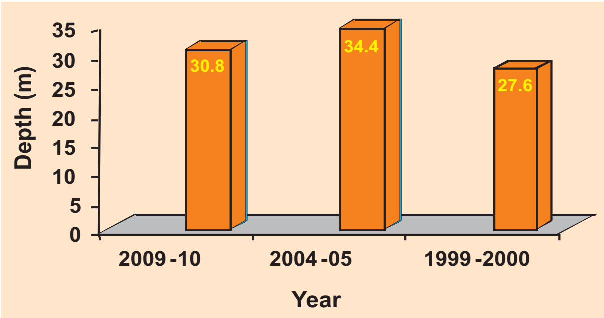


Fig 9.4/1: Average depth of ground water table in District Hamirpur over the year

Energy and cost of water lifting

The consumption of diesel was 2.01 h^{-1} during the year 2009-10 whereas it was 2.65 and 1.15 l h^{-1} during 2004-05 and 1999-2000. The electricity consumption was 3.2 kwh during 2009-10 as against 4.2 and 2.2 kwh during 2004-05 and 1999-2000. The seasonal variation in water depth was recorded 31.4, 31.9 and 35.2 m during rainy, winter and summer seasons of 2009-10 respectively.

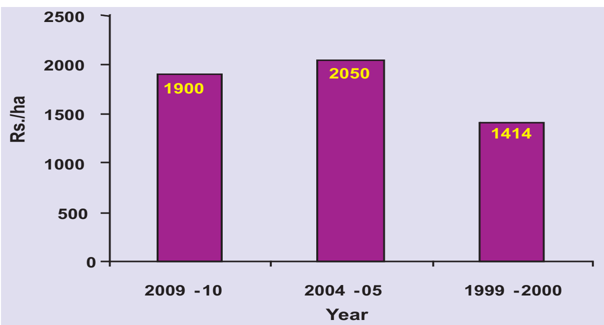


Fig 9.4/2: Change in cost of irrigation (Rs/ha) over the years in Hamirpur

Per hectare irrigation cost was Rs 1900 during 2009-10 while it was Rs 2050, and 1414 for past 2004-05 and 1999-2000 respectively. The change in irrigation cost was recorded due to fluctuation in depth of water table.

The low cost of irrigation during course of survey (2009-10) was primarily due to occurrence of rainfall during the year which increased the water table in the wells. Therefore only 25 hours was required to irrigate one hectare of land during 2009-10. However, during past 5 year, because of erratic and below normal rainfall, water table went down and consumed 27 hrs/ ha for wheat irrigation. As appraised by the farmers, there was normal rainfall during past 10 years which increased the water table and consequently less expenditure was incurred on irrigation. These figures further indicate the impact of ground water table on crop economics.

Impact of ground water table on wheat economics

Wheat is the major cereal crop in Hamirpur district. The average operational cost and net income of wheat computed for 2009-10 were Rs. 16,250 ha^{-1} and Rs. 7,750 ha^{-1} respectively. Irrigation played crucial role in wheat cultivation and contributed 11.7 percent shares in total operational cost. This share was 12.6 and 8.9 per cent during 2004-05 and 1999-2000 respectively.

Economics of crop+ goat farming system

Lack of irrigation facility and fluctuation of ground water table together did not allow the farming community in general and resource poor farmers in particular to harvest good crop yields in the district. Because of this, majority of marginal and small farmers were noted following crop+ goat farming system for enhancing their household income to meet the domestic needs. The net income realized by marginal farmers producing gram on 0.85 hectares of land and rearing 7 goats on the farm, was computed Rs 19,200 as against Rs 20,550 for small farm groups who produced sorghum and wheat on 0.75 and 1.05 hectares of land with 5 goats (Table 9.4/6). The contribution of goats in total farm income for these farm groups was noticed 44.3 and 32.6 per cent respectively. Rearing goats instead of cow and buffaloes clearly indicated the scarcity of water due to low rain fall and depletion of ground water

Table 9.4/6. Economics of crop+ goat farming of farmers of Hamirpur district

Farm groups	Area (ha)	Crops: Cost of Cultivation (Rs)	Crops: Produce (t)	Crops: Gross return (Rs)	Crops: Net return	Goats: No	Goats: Rearing cost	Goats: Production (N0)	Crop + goats: Gross income	Crop + goats: Net gain	Crop + goats: Total cost	Crop + goats: Total income	Crop + goats: Net return (%)	Crop + goats: Share of goats
Marginal	0.85(Gram)	6300	0.85	17000	10700	7	2500	12	11000	8500	8800	28000	19200	43.3
Small	0.75 Sorghum	3800	0.80	8000	4200	5	2300	9	9000	6700	4300	17000	12700	32.6
	1.05 (Wheat)	16350	2.60	26000	9650	0	0	0	0	0	16350	26000	9650	

table in the district. As the annual income realized by marginal and small farm groups from crops indicated in the table was very low and may not cater the family needs, they kept goats on the farm which require less water for their survival compared to other milch animals. These facts again show the impact of ground water table in the study area.

Status of organic farming in eastern Himalayan region

The survey of Meghalaya state of Eastern Himalayan region was conducted during 2010-11 to study the status of organic farming in this region. Re-Bhoi, East-Khasi Hills, West-Khasi Hill and Jaintia Hill district were selected for the survey. Following the multistage stratified random sampling method, 80 farmers from each district were interviewed and data were recorded on the prescribed performa.

In Re-Bhoi and East Khasi Hill districts,70-80% and 60-70% farmers were observed, followed conventional organic agriculture. A majority of them were neither using organic manure nor inorganic fertilizer in crop production. However, 20-30% farmers were recorded to be used pesticides in vegetable crops. In West Khasi and Jaintia Hills, 55-65% and 65-75% farmers, were found applying fertilizers and insecticides in crop production and rest were followed conventional agriculture. Rice was the main cereal crop in Meghlaya state. However, the average productivity of rice is Re-Boi and East Khasi Hills was recorded 1.6 and 1.7 t/ha while in West Khan and Jaintia, the average yield was 1.8 t/ha. Ginger was the most remunerative crop in all the districts. Majority of households were observed various enterprises like poultry, piggery and vegetables on the farm besides crop cultivation. Dominancy of rainfed agriculture was observed in the state. Farmers kept bullocks, cows and goats on the farms mainly for meat purpose and not for milk production and FYM. The farmers were very simple believing in the protection/conservation of natural resources.

9.5 TECHNOLOGY TRANSFER AND REFINEMENT (TTR)

A. TECHNOLOGY PARK

Accelerating the proven technologies through Technology Park at PDFSR

Twenty seven proven cropping systems with supper imposed recommended technologies namely recommended dose of NPK, site specific nutrient management (SSNM), zero tillage (ZT), strip tillage (ST), green manuring (GM) through sesbania and summer moong, mechanical transplanting (MT) of rice, raised bed (RB) planting, direct seeding of rice (DSR) were demonstrated at the technology park. The yield of various cropping systems was calculated in terms of wheat equivalent yield (WEY, t ha^{-1}). The WEY of different cropping systems in decreasing order was Rice–Cauliflower-Bottle guard (22.5 t ha^{-1}), Rice–Potato-Summer moong (18.5 t ha^{-1}), Maize (RB)–Potato–Black gram (16.10 t ha^{-1}), Pigeon Pea + Maize (RB)–Tomato (15.9 t ha^{-1}),

Photo 9.5/1: Balance nutrient management in rice

Photo 9.5/2: Intercropping of Maize+Cow pea

Photo 9.5/3: Balance nutrient management in maize

Photo 9.5/4: Bio-intensification of cropping system

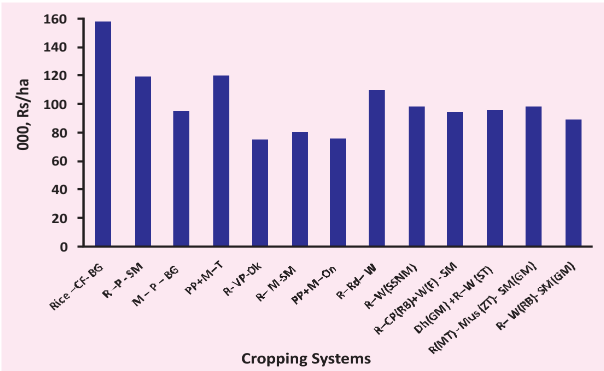


Fig 9.5/1: Net return of different cropping systems (000,Rs./ ha)

Rice- Vegetable pea - Ladyfinger (13.9 t ha^{-1}), Rice–Mustard-Summer moong (13.7 t ha^{-1}), Pigeon Pea+ Maize (RB)–Onion (13.0 t ha^{-1}), Rice–Radish–Wheat (12.6 t ha^{-1}) Rice –wheat (SSNM, 11.9 t ha^{-1}), Rice (Rec.NPK)–Chickpea (RB)+ wheat (F) - Summer moong (11.3 t ha^{-1}), Rice–wheat (ST) - Dhaincha (10.7 t ha^{-1}), Rice (MT)-Mustard (ZT)- Summer moong (10.5 t ha^{-1}) and Rice (Rec. NPK)–Wheat (RB)- Summer moong (10.4 t ha^{-1}). The net return were obtained respectively (Fig.9.5/3), Rice–Cauliflower-Bottle guard (158000 Rs. ha^{-1}), Rice–Potato-Summer moong (119000 Rs. ha^{-1}), Pigeon Pea + Maize (RB)–Tomato (120000 Rs. ha^{-1}), Rice-Vegetable pea - Ladyfinger (130000 Rs. ha^{-1}), Rice–Rice–Radish–Wheat (110000 Rs. ha^{-1}).

Among various rice based cropping systems, WEY was of different systems was : Rice –wheat (SSNM) (11.9 t ha^{-1}), Rice –Chickpea (RB)-Summer moong (11.3 t ha^{-1}), Rice–wheat (ST) -Sesbania (10.7 t ha^{-1}), Rice (MT)-Mustard (ZT)-Summer moong (10.5 t ha^{-1}), Rice– Wheat (RB) (10.4, t ha^{-1}) ,Rice -Wheat (ZT)(9.0 t ha^{-1}) , Rice - Wheat (FP) (9.2 t ha^{-1}), Rice (DSR)-Chickpea (ZT)-Summer moong (8.0 t ha^{-1}) and Rice (DSR)+Sesbania (BM)-wheat (8.3 t ha^{-1}).

Weed management in wheat crop

Phalaris minor and Chinopodium album are predominant weeds, which potentially reduce the productivity of wheat in this area. Farmers participatory on farm trials on weed management in wheat crop were conducted on 36 farmer's fields. The grain yields obtained from improved practices and farmers practices were 4.37 and 3.51 t ha^{-1} respectively, where as the straw yields were 5.83 and 4.52 t ha^{-1} respectively. Grain and straw yields were 24.5 and 29.0% higher in improved practice over the farmer's practices.

Photo 9.5/5: Weed infestation in wheat crop

Photo 9.5/6: Management of weeds through weedicide

B. ON-FARM RESEARCH AND DEMONSTRATIONS

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 wheat

For the trials on wheat, 10 farmers were selected randomly from each village for conducting on-farm trials (OFTs) during 2009-10. Four treatments were taken under each OFT and each of these treatments was laid on an area of 400 sq. m. The treatments were- T_1: Farmers' Practice (FP) under scientists' management, T_2: FP + Recommended K, T_3: Recommended NPK, and T_4: Recommended NPK + Micronutrients (Zinc). 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 revealed that the treatment T_4 provided highest yield (4.46 t/ha) followed by T_3 (4.34 t/ha), T_2 (4.19 t/ha) and T_1 (3.84 t/ha). The average yield of farmers' practice under farmers' management was found to be 3.76 t/ha. Thus, there was an increase in yield of 11.4 per cent through potash application only and 15.4 per cent through recommended doses of NPK which consisted of about half of the nitrogen the farmers of the area used to apply. The application of Zinc contributed 2.7 per cent increase in yield over the recommended NPK treatment, whereas the recommended NPK in combination with Zinc contributed 18.6 per cent increase in yield over the farmers' practice.

During *rabi* 2010-11, thirty-seven (37) farmers were selected randomly from the two villages for conducting on-farm trials (OFTs) which are in progress.

On-farm trials on sugarcane

During 2009-10, 11 demonstrations were laid on balanced fertilizer application in different varieties of sugarcane plant crop and 13 demonstrations were laid on potash application in different varieties of sugarcane ratoon crop in Mahal and Shyampur villages of Daurala block of Meerut district. In case of demonstrations on balanced fertilizer application in different varieties of sugarcane plant crop, the highest increase (13.5%) in yield was observed in the variety COS-767 whereas, that of demonstrations on potash application in different varieties of sugarcane ratoon crop, the highest increase (9.29%) in yield was observed in the variety COS-8436 over the farmers'practice. The details of the results obtained are presented in Table 9.5/1 and Table 9.5/2.

During *kharif* 2010, 32 farmers were selected randomly from these two villages for conducting on-farm trials (OFTs) on sugarcane. 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 farmer management, T_2: FP under scientists' management, T_3: Recommended NPK, and T_4: Recommended NPK + Micronutrients (Zinc). The farmers' practice consisted of 350 kg N and 60 kg P_2O_5, whereas the recommended practice consisted of 180 kg N, 80 kg P_2O_5, 120 kg K_2O and 25 kg zinc sulphate/ha.

Table 9.5/1. Performance of balanced fertilizer application in different varieties of sugarcane plant crop

Sl. No.	No. of demonstrations/ trials	Variety	Average yield (t/ha)		Yield increase (%)
			Farmers' practice	*Improved practice*	
1.	3	COS-767	60.50	68.67	13.50
2.	4	COS-8436	63.37	70.62	11.44
3.	4	COS-8432	59.25	65.12	9.91

Table 9.5/2. Performance of Potash in different varieties of sugarcane ratoon crop

Sl. No.	No. of demonstrations/ trials	Variety	Average yield (t/ha)		Yield increase (%)
			Farmers' practice	*Improved practice*	
1.	3	COS-767	61.67	67.17	8.91
2.	5	COS-8436	73.20	80.00	9.29
3.	5	COS-8432	65.4	70.60	7.95

On-Farm Trials on Rice

The technologies of balanced nutrition in rice were also introduced in these two villages. Twenty (20) farmers were selected randomly from the two villages for conducting on-farm trials (OFTs) during *kharif* 2010. 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 farmer management, T_2: FP under scientists' management, T_3: Recommended NPK, and T_4: Recommended NPK + Micronutrients (Zinc). The farmers' practice consisted of 50 kg N and 60 kg P_2O_5, whereas the recommended practice consisted of 120 kg N, 60 kg P_2O_5, 60 kg K_2O and 25 kg $ZnSO_4$ per hectare.

The results revealed that the increase in yields over the farmers' practice of the varieties Sugandha-5, Sugandha-4 and PB-1 through recommended doses of NPK (about half the dose of nitrogen the farmers used to apply) were 10.72%, 14.66% and 20.49%. The application of Zinc in the varieties Sugandha-5, Sugandha-4 and PB-1 contributed 4%, 3.5% and 5.08% increase in yield, respectively over the recommended NPK treatment, whereas the recommended NPK in combination with Zinc contributed 15.19%, 18.73% and 30.61% increase in yield over the farmers' practice (Fig.9.5/2).

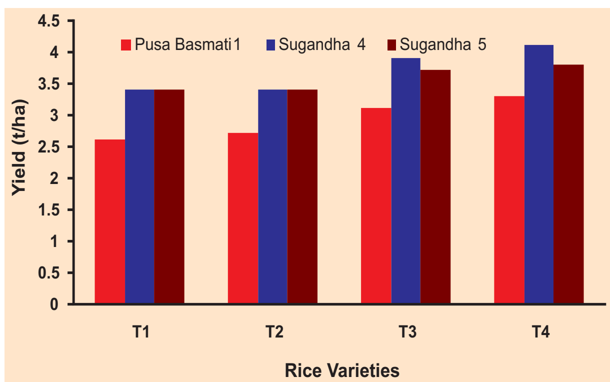


Fig 9.5/2: Performance of balanced fertilizer application in different varieties of rice

Photo 9.5/7: Planting of sugarcane under scientists' management

Photo 9.5/8: Scientist-Farmer interaction in sugarcane field

Photo 9.5/9: Farmer-Scientist interaction during Kisan Gosthi

Photo 9.5/10: PDFSR exhibition in IVRI Kisan Mela

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

A list of relevant independent variables was prepared for the study and indices were developed for their measurement. The interview schedule for data collection was prepared and pre-testing was done in the nearby villages of Daurala block of Meerut district. Based on pre-testing, the interview schedule was finalized and survey was planned in Punjab through discussion with team members. A survey was conducted in Hoshiarpur district of Punjab during the month of October, 2010 using pre-tested interview schedule. A total of 50 farmers were contacted for data collection in 6 blocks of the district. The data is being tabulated for further analysis and interpretation.

C. TRAINING

Capacity building of stakeholders in integrated farming systems through training

A total of 3 training programmes, 1 awareness week, 1 group discussion and 7 visits were organized for different categories of target groups, the details of which are presented in Table 9.5/3.

Table 9.5/3. Details of training/ other activities

Sl. No.	Title of Programme	Category of participants	Date	No. of participants		
				Male	Female	Total
1.	Kisan Gosthi and Training	Farmers	15 April, 2010	35	0	35
2.	Training on *Kharif ki fasalon ki utpadan taknik*	Farmers	5-7 July, 2010	32	0	32
3.	Training on Integrated Farming Systems	SMS of KVKs Zone-I	22-24 July, 2010	20	1	21
4.	Institute/Field visit	B.Sc. (Ag) final year students from Ajmer (Raj.)	25 April, 2010	43	13	56
5.	Institute/laboratory visit	Class 12th students, Gyan Bharati Inter College, Meerut	13 Aug., 2010	8	6	14
6.	Parthenium awareness week	Farmers	7-13 Aug., 2010	45	10	55
7.	Group discussion	Farmers from Bagpat distt.	15 Sept., 2010	60	0	60
8.	Field/laboratory visit	B.Sc. (Ag.) students from . SVPU &T, Modipuram, Meerut	22 Sept., 2010	35	0	35
9.	Field/laboratory visit	B.Sc. (Ag.) students from . SVPU &T, Modipuram, Meerut	28 Sept., 2010	39	1	40
10.	Field/laboratory visit	Ph.D. Agronomy students . from IARI, New Delhi	29 Sept., 2010	12	0	12
11.	Institute/laboratory visit	Trainees from IARI New Delhi.	30 Sept., 2010	19	0	19
12.	Institute/Field visit	104th batch trainees from CSWCR&TI, Dehradun	9 Dec., 2010	18	1	19
		Total	366	32	398	

D. FRONTLINE DEMONSTRATIONS

A. Front line Demonstration

Five Front-line demonstrations on oilseed (Mustard Var. Pusa bold) were laid out in Poothari village of Ghaziabad district, Uttar Pradesh. The details of the results are presented in the Table 9.5/4.

B. Participation in Kisan Mela and Exhibition

- A Field Day was organized at village Mahal of Daurala block in Meerut district on 2nd July, 2010 in which 65 farmers participated and the event was recorded by the team of Doordarshan, Delhi.

- An Exhibition stall was put up by the Directorate in All India Farmers' Fair (North Zone) and Agro-industrial Exhibition from March 10-12, 2010 organized by Sardar Vallabhai Patel University of Agriculture & Technology, Meerut. The Directorate's stall was adjudged as First in ICAR/GOI category.

- An Exhibition stall of PDFSR was put up in IVRI Kisan Mela 2010 organized by Indian Veterinary Research Institute at IVRI campus, Izatnagar, Bareilly, Uttar Pradesh during 01-03 November, 2010. About 500 farmers and other participants visited the Directorate's stall and got acquainted with Directorate's technologies through discussion and supply of literature.

Table 9.5/4. Details of Front-Line Demonstration on Mustard

Practice	No. of demons.	Average yield (t/ha)	% Yield increase	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
Farmers' Local Variety	5	1.9	-	26112	37840	11728	1.45
Improved Variety	5	2.4	26.36	27457	46140	18683	1.68

9.6 EXTERNALLY FUNDED PROJECTS

Evaluating production systems for attaining maximum productivity and profits

In order to increase system's productivity and farmer profits through fertilizer best management practices (BMPs), field experiments were conducted at PDFSR farm to evaluate the performance of five nutrient management options (1) Farmers fertilizer practice (FFP), (2) State fertilizer recommendation (SR), (3) Improved state recommendation (ISR) (wherein 25% higher dose of N and 50% higher doses each of P and K as compared to SR were applied), (4) State soil testing laboratory recommendation (STLR) and (5) Site specific nutrient management (SSNM) were evaluated in predominant rice as well as wheat based cropping systems. The experimental site was characterized by sandy loam soil (160 g clay kg^{-1}, 190 g silt kg^{-1} and 630 g sand kg^{-1}) alkaline in reaction and low in organic carbon (0.48%), available K (166 kg ha^{-1}) and sulphur (3.6 ppm), and high in P (29.1ppm).

In wheat based cropping system, the maximum productivity gain under SSNM treatment over FFP was of 35.4%, 37.9%, 54.4%, 31.0%, 28.6% and 51.0%, respectively for rice, maize, pigeon pea, sesamum groundnut and sorghum (dry fodder). The ISR was at second position in terms of yield performance and had edge over SR and STLR. The increase in yield under ISR over SR and STLR was to the tune of 782 to 1173 kg ha^{-1} in rice, 768 to 1068 kg ha^{-1} in maize, 246 to 310 kg ha^{-1} in pigeonpea, 39 to 80 kg ha^{-1} in sesamum, 200 to 262 kg ha^{-1} in groundnut, and 937 to 1350 kg ha^{-1} in sorghum dry fodder. The yields obtained under SR and STLR were almost similar for different monsoon crops but had significant edge over FFP. Averaged over the cropping systems, the grain yield of succeeding wheat grown on same layout without application of secondary and micronutrient, were highest in SSNM treatment followed by ISR, and the lowest in farmer's practice of fertilizer application. The enhancement in wheat yield in SSNM and ISR treatment options was attributed to larger ear size, more number of grains ear^{-1} and higher number of effective tillers m^{-2}.

The system productivity in terms of wheat equivalent yield (WEY) across the nutrient management options was maximum with SSNM in

Table 9.6/1. System productivity and net return as influenced by nutrient management options in different cropping systems

Nutrient management option	System productivity WEY (kg ha^{-1})					
	Rice-wheat	Sesamum-wheat	Pigeon pea-wheat	Groundnut-wheat	Maize-wheat	Sorghum (F)-wheat
Farmer's Fertilizer Practice (FFP)	10.598	6.434	7.686	7.954	9.697	4.813
State recommendation (SR)	11.999	7.600	8.559	8.512	10.296	5.781
Improved state recommendation (ISR)	13.463	8.128	9.282	9.477	11.051	6.622
State soil test recommendation (STLR)	12.061	7.652	8.236	8.483	10.359	5.859
Site specific nutrient management (SSNM)	14.273	8.639	10.369	9.877	12.540	6.862
Mean	**10.319**	**7.691**	**8.826**	**8.861**	**10.789**	**5.987**

rice-wheat (12.5 t ha^{-1}) followed by maize-wheat (10.8 t ha^{-1}), ground nut –wheat (8.86 t ha^{-1}), pigeon pea-wheat (8.83 t ha^{-1}), sesamum–wheat (7.69 t ha^{-1}) and lowest in sorghum (dry fodder)-wheat (5.99 t ha^{-1}). Averaged over the cropping systems, system wheat equivalent productivity (SWEY) was higher with SR, ISR, STLR and SSNM options by 12%, 23%, 12% and 33% over FFP. On average, SSNM had 19% edge over improved state recommendation treatment. This improvement in SSNM over ISR is mainly attributed due to secondary and micronutrient application in SSNM treatment. Among the cropping systems, the highest increase in SSNM treatment over FFP was recorded in sorghum (F) -wheat (43%) followed by pigeon pea-wheat (35%), sesamum-wheat (34%), rice-wheat (35%), maize-wheat (29%) and lowest in groundnut-wheat (29%), respectively. In SSNM treatment 8.1 to 17.0%, 6.3 to 11.3%, 2.6 to 7.7% and 5.9 to 11.5% additional investment was needed than that of FFP, SR, ISR and STLR treatments. As for as net return was concerned, the SSNM was the premier option among the treatments, which gave Rs. 1,12,716, 1,09,789, 83,363, 73,328, 72,485 and 54,948 ha^{-1} in rice-wheat, maize-wheat, pigeon pea-wheat, sesamum-wheat, groundnut–wheat and sorghum (F)-wheat systems, respectively.

In rice based cropping systems, SSNM did produce an additional yield of 207- 624 kg ha^{-1} in mustard, 442-682 kg ha^{-1} in chickpea, 894-3022 kg ha^{-1}in garlick, 7118-17166 kg ha^{-1} in berseem fodder, 4900-9600 kg ha^{-1} in potato and 592-1226 kg ha^{-1} in wheat over FFP, SR and STLR options. Succeeding rice crop also followed the same trend. Averaged across the cropping system, yield gain over the FFP due to SR, ISR, STLR and SSNM treatment was of 0.68 t ha^{-1}, 1.19 t ha^{-1}, 1.03 t ha^{-1} and 2.20 t ha^{-1}, respectively. The higher productivity of rice was under SSNM mainly attributed due to number of grains ear^{-1}, number of ears m^{-2} and grain weight ear^{-1}. Among various cropping systems, the higher wheat yield was recorded under rice-potato (8.33 t ha^{-1}) followed by rice-berseem (8.3 t ha^{-1}), rice-chickpea (8.0 t ha^{-1}), rice-garlic (8.0 t ha^{-1}), rice-mustard (7.8 t ha^{-1}) and lowest under rice-wheat system. Lower productivity of rice after wheat may be visualized as both cereal-cereal based systems caused several biotic and biotic stresses and had adverse effect on both the crops of the system. On

Table 9.6/2. System productivity and net return as influenced by nutrient management options in different cropping systems

Nutrient management option	System productivity REY (kg ha^{-1})					
	Rice-mustard	Rice-chickpea	Rice-garlic	Rice-berseem	Rice-potato	Rice-wheat
Farmer's Fertilizer Practice (FFP)	9.834	10.247	29.630	10.914	14.408	12.221
State recommendation (SR)	11.101	11.688	40.204	12.326	17.155	13.296
Improved state recommendation (ISR)	12.244	12.336	43.633	12.913	18.136	14.302
State soil test recommendation (STLR)	11.623	11.865	41.669	12.387	17.030	13.138
Site specific nutrient management (SSNM)	13.272	13.838	46.695	13.949	20.542	15.591
Mean	**11.615**	**11.995**	**40.366**	**12.498**	**17.554**	**13.710**

Photo 9.6/1: A view of bumper sesame crop under SSNM plot at Modipuram

the other hand, crops like potato-chickpea having different feeding zone in soil profile as well as ability to leave sufficient residual nutrients on succeeding crops had pronounced residual effect for the next crop of the system. These results clearly indicate the necessity of crop diversification along with appropriate nutrient management options.

On an average, rice equivalent productivity (REY) of winter season crops was 15 to 52% higher in SSNM and 8 to 42% in ISR treatments. The succeeding rice also had similar trend and maximum being with SSNM option (without secondary and micro- nutrients). The cumulative annual productivity in terms of systems rice equivalent yield (SREY) was maximum with SSNM (20.7 t ha^{-1}) followed by ISR (18.9 t ha^{-1}), STLR (18.0 t ha^{-1}), SR (17.6 t ha^{-1}) and FFP (14.5 t ha^{-1}). Of the 06 rice based cropping systems studied, productivity variation was in the order of 40.4 t ha^{-1} in rice-garlic, 17.5 t ha^{-1} in rice-potato, 13.7 t ha^{-1} in rice-wheat, 12.5 t ha^{-1} in rice–berseem, 12.0 t ha^{-1} in rice-chickpea and 11.6 t ha^{-1} in rice-mustard system. However, the maximum net return was registered with rice-garlic (Rs. 3,55,764) followed by rice-potato (Rs. 1,20,425), which were distinctly higher than rice-chickpea (Rs. 1,03,301), rice-wheat (Rs. 1,18,373), rice-mustard (Rs. 1,01,774) and rice-berseem (Rs. 1,04,224) cropping systems. The economic profitability with fertilizer application as per SR and STLR were on par but significantly better than farmer's practice of fertilizer. The net return with SR/STLR was less than that of SSNM treatment in all the cropping systems. Averaged across the copping systems SSNM out yielded FFP, SR, STLR and ISR by 50%, 19%, 17% and 10%, respectively.

After completion of two crop cycles, soil pH and EC remained unaffected, whereas Olsen- P, exchangeable K and available S status improved over initial content in 0-15 cm soil profile under SSNM plots. Smaller N and K content in 15- 30 cm soil depth indicated restricted movement of these nutrients with SSNM option. These results immensely reveal that generalized recommendations at state level and recommendations made by soil testing laboratory based on initial soil status (i.e. high, medium and low) do not work for achieving high yield target. On the other hand, recommendation made through SSNM based on indigenous nutrients supplying capacity of soil and targeted yield can be advocated for attaining potential yield of different crops and cropping systems.

PDFSR- IRRI Collaborative project

Site-specific nutrient management (SSNM) for a rice-maize system as affected by crop establishment and residue management

Field experiments were continued at PDFSR farm during 2009-10 for studying the effect of different tillage and crop establishment practices and residues management options on productivity of rice–maize system. Eighteen treatments including nutrient options like NP, NPK+S and Zn, NP+S and Zn under different crop establishment practices were evaluated under split plot design with 04 replications. The target objective of the study was accessing the effect of crop establishment and residue management on potassium and micro nutrient needs of rice and maize crop in the system.

Effect on rice crop

Rice grain yield varied from 6.76 t ha^{-1} to 8.92 t ha^{-1} under different crop establishment practices and nutrient management. Residue recycling under transplanted rice crop had highest yield gain as compared to direct seeded or zero till rice crop (Fig.1). Response to K+ S and Zn application was also modified in the presence of residue and the magnitude was 1.00, 0.90 and 0.53 t ha^{-1}, respectively for K + S and Zn under transplanted rice (TPR), direct seeded rice (DSR) and zero till rice (ZT). Whereas such response under residue removed plots had 1.32, 1.22 and 0.87 t ha^{-1} respectively. Individual response to K and S +Zn application was also more with residue removed plots (ranging from 0.46 to 0.79 t ha^{-1} for K and from 0.41 to 0.43 t ha^{-1} for S +Zn application. These findings clearly indicate that partial requirement of K, S and Zn was supplemented through residue recycling/ retention, which has curtailed the fertilizer nutrients requirement for rice crop. Among different crop establishment practice maximum K response was noticed with TPR followed by DSR and ZTR.

Effect on maize crop

Winter maize productivity varied from 7.19 to 9.4 t ha^{-1} under different crop establishment practices. The effect of residue recycling/retention was more pronounced under zero till-maize, followed by conventional till maize. The recycling of rice residue under different crop establishment options had significant effect on K, S and Zn response, and responses were more in the absence of in situ residue recycling (0.84 to 0.93 t ha^{-1}). Individual response to K was also more under conventional till Maize (0.32 to 0.50 t ha^{-1}) as compared to zero till maize (0.38 to 0.45 t ha^{-1}).

During maize crop season, soil temperature studies indicated a significant effect of retention on soil micro-climate particularly on temperature buffering which ranged between 1.6 to 4.2 ^{0}C during crop growth period. Here, it may be envisaged that, the soil chemical/ microbial processes were stimulated for enhanced nutrient transformations and ultimately more yields. Effect of residue management was also apparent for rice- maize system productivity and individual nutrient response.

Photo 9.6/2: Maize crop under balanced nutrition plot

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

During study period following technological interventions were made for ensuring lively hood security of farming community falling under different canal commands where additional water is being released through Tehri reservoir.

Intervention 1: Site- specific input management for sustained crop productivity and soil health

Green manuring for conserving organic carbon and enhancing rice yield

In general, farmers keep fields vacant during summer after wheat harvest. It was felt for utilizations of these fallow periods for green maunuring for enhanced nutrient use efficiency and sustained soil health. For this 12 farmers in each location were selected for demonstration of dhaincha green manuring and its residual advantages were noticed in succeeding rice crop. Under Agra canal command (ACC), with Farmer's Fertilizer Management practices (FFP) grain yield of rice ranged from 3.59 to 4.29 t ha^{-1}. Rice crop grown after green manuring with Dhaincha yielded 1.05 to 1.34 t ha^{-1} extra rice and also helped to curtail 25% N. Green manuring + FFP had a mean yield improvement of 10.9% over FFP alone.

Use of dhaincha as green manuring before rice crop had an yield gain of 0.85 to 1.16 t ha^{-1} over existing FFP_N (3.29 to 4.02 t ha^{-1}) in East Ganga Canal (EGC) site. Further a saving of 25% N was noticed with green manuring without any detrimental effect on yield and soil health. Higher yield after green manuring was corroborated with better yield attributing characters under green manuring plots.

Reduction of 25% N through GM over FFP_N yielded 0.91 to 1.21 t ha $^{-1}$ more in East Yamuna Canal Command and mean yield increase across the farmer's field due to GM +FFP was of 10.1%. These yield improvements at different sites were attributed due to better crop growth and yield attributes. The yield variation seen under rice crop in different farm demonstrations of dhaincha as green manuring was mainly due to changes in soil management, climatic conditions and age of dhaincha incorporation etc.

Assessing production potential of wheat cultivars

Farmers generally grow wheat cultivars *viz.*, Raj 3765, HD 2687, Kalyan Sona and Lok 1. Most of these cultivars have started showing yield declining due to insect- pest and disease infestations. The productivity of these cultivars was in the range of 3.18 to 4.07 t ha $^{-1}$ with a mean of 3.44 t ha $^{-1}$. Introduction of wheat cv. DBW 16 in place of these cultivars had an edge of 1.18 t ha $^{-1}$. The yield gain due to DBW 16 was mainly attributed to increased number of ears/m^2 (6.1%), number grains/ear (10.1%) and grain weight/ear (12.14%). The other reason assigned for poor yield with farmer's seed was its lower seed replacement rate (4-5 year), poor keeping quality of seed which invites insect-pest and disease infestation, continuous perpetuation of weed seed, and non-availability of quality seed in local market.

In EGC, the wheat cultivars viz., HD 2687, UP 2338, UP 2425 and Kalyan Sona were most common cultivars being used by the farmers. The productivity of these cultivars was in the range of 3.43 to 4.29 t ha $^{-1}$ with a mean yield of 3.85 t ha $^{-1}$. Introduction of wheat cv. PBW 343 in place of existing cultivars had an edge of 1.03 t ha $^{-1}$. The yield gain due to PBW 343 was mainly attributed to increased numbers of ears/m^2 (6.22%), number grains/ear (10.26%) and grain weight/ear (12.2%). Apart from this, highest count for 1000-grain weight was also noticed with PBW 343. The seed replacement rate for existing cultivars with farmers was in the range of 2-4 years. Also the proper storage of seeds and non-use of fungicides at the time of sowing was a major cause for the poor seed quality and its results.

In EYC, wheat cultivars *viz.*, HD 2285, UP2338, UP 2425 and Sonalika were the common varieties. The productivity of these cultivars was in the range of 3.02 to 3.8 t ha $^{-1}$ with a mean of 3.52 t ha $^{-1}$. Introduction of new wheat cv. PBW 343 in place of existing cultivars had an edge of 1.56 t ha^{-1}. Apart from these numbers of ears/m^2 (6.6%), number grains/ear (10.7%) and grain weight/ear (12.4%) were also more with PBW 343. The seed replacement rate of existing cultivars was 3 to 4 year. Apart from these poor storage facilities for wheat seed always invites insect-pest infestation and force for dependency on the local market for purchasing seed every year.

Balanced nutrition for sustaining wheat productivity

Results obtained from on-farm studies conducted in Agra Canal Command (ACC) indicated that under farmer's fertilizer management practices, wheat yield ranged from 3.66 to 3.96 t ha $^{-1}$ at different sites with a mean of 3.66 t ha $^{-1}$. Application of K, S and Zn as per site-specific nutrient management (SSNM) recommendation yielded 3.71 to 4.82 t ha $^{-1}$ with a mean of 4.71 t ha $^{-1}$. Average yield improvement across the farmers' fields yield due to SSNM based recommendation over FFP was of 21%. Effect of balanced nutrition was also visible on yield attributes viz. number of grains/ear, grain weight/ear and number of effective tillers.

In EGC, application of K, S and Zn as per site-specific nutrient management (SSNM) recommendation yielded 3.54 to 4.66 t ha^{-1}. Averaging yield across the farmers' fields yield improvement due to SSNM based recommendation over farmers' fertilizer practice (FFP) was of 20%. Effect of balanced nutrition was also visible on yield attributes of wheat viz. number of grains/ear, grain weight/ear and number effective tillers.

Alike ACC and EGC, application of K, S and Zn as per site-specific nutrient management (SSNM) recommendation yielded 3.50 to 4.61 t ha^{-1}. Averaging yield across the farmers' fields yield improvement due to SSNM based recommendation over farmers' fertilizer practice (FFP) was of 20%. Effect of balanced nutrition was also visible on yield attributes viz. number of grains/ear, grain weight/ear and number of effective tillers.

Scheduling of irrigation water in wheat

On-farm survey indicated that farmers apply 2 to 6 number of irrigations with a water depth of 10 to 13 cm in wheat in each canal command site, which is more because of ease in availability of irrigation water. Flooding is a common practice of irrigation in these region. Under this water management practice farmers wheat yield varies from 3.42 to 4.98 t ha^{-1} with a mean of 4.2 t ha^{-1}. Scheduling of irrigations water with 05 to 07 cm depth at 06 important critical stages viz. CRI, tillering, jointing, flowering, milking and dough stages brought an yield gain of 0.72 to 1.56 t ha^{-1} with a mean of 3.3 t ha^{-1}. On the other hand, application of only 03 irrigation with 05-07 cm depth at 30 days after sowing (DAS), jointing (50-60 DAS) and milking (80-90 DAS) did not show any significant differences over existing farmer's water management practices. During different on-farm trainings farmers were also taught about different techniques of enhancing water productivity and efficient utilization of irrigation water for other crops and cropping.

Scheduling of irrigation water with 05 to 07 cm depth at 06 important critical stages viz. CRI, tillering, jointing, flowering, milking and dough stages in East Ganga Canal command brought an yield gain of 0.41 to 1.45 t ha^{-1} with a mean of 3.4 t ha^{-1}. On the other hand, application of only 03 irrigations with 05-07 cm depth at 30 days after sowing (DAS), tillering (45 DAS) and milking (80-90 DAS) did not also show any significant differences (only 0.3 t ha^{-1} yield gain) over existing farmer's water management practices. Different yield and yield attributes of wheat were also maximum when irrigation was applied at important critical stages.

In East Yamuna canal command site, application of irrigation water (05 to 07 cm depth) at 06 important critical stages viz. CRI, tillering, jointing, flowering, milking and dough stages brought an yield gain of 0.26 to 0.88 t ha^{-1} with a mean of 3.2 t ha^{-1}. Curtailing irrigation up to 04 numbers at CRI, Tillering, jointing (50-60 DAS) and milking (80-90 DAS) were found equally good as existing farmer's water management practices. Excessive irrigation by farmers at tillering and beyond this had adverse effect on wheat like yellowing, crop lodging and more acute N and K deficiencies.

Evaluation of herbicides for efficient weeds management in wheat

Wide spread infestation of noxious weeds like *Phalaris minor* L. and *Avena fatua* L. and broad leaf weeds like *Chenopodium album*, *Anagalis arvensis, Vicia sativa*, *Vicia hirsuta*, *Melilotus alba* and *M. sativa* were noticed in wheat crop. In order to effective control of these weeds farmers use isoproturon for narrow weeds and 2, 4-D for broad leaf weeds. For efficient and cost efective control of these weeds, on-farm demonstrations were conducted with treatments comprising no weeding (control), isoproturon @ 0.75 kg a. i. /ha (farmer practice), isoproturon @ 0.75 kg a.i./ha + 2, 4-D (0.50 kg a.i. /ha), 2, 4- D (0.50 kg a.i./ha) + weed uprooting at maximum tillering stage and Bracket (Sulphosulphuron + Metsulphuron @ 14 g /ha). The results obtained from on-farm trials of ACC indicated that bracket was more effective herbicides among all the options tried in the study. Its application at 35 DAS was effective for controlling all broad and narrow leaf weeds. The weed control efficiency (WCE) was highest (90.4%) with bracket application followed by use of 2, 4-D + uprooting of weed at maximum tillering (85.5%) and use of isoproturon + 2, 4 D (75.3%). The lowest WCE was noticed when only isoproturon was used (67.5%). The highest WCE with brachet application was attributed to lowest weed counts (12/m^2) and weed dry weight (26.1 g/m^2) with grain yield of 5.12 t ha^{-1}. On other weed management options gave 4.75 t ha^{-1} grain yield in 2, 4-D + uprooting of weed at maximum tillering and 4.25 t ha^{-1} with use of isoproturon + 2, 4 –D and lowest being with plots where only isoproturon (3.84 t ha^{-1}) was used.

In EGC, weed control efficiency 89.5% was recorded with bracket followed by use of 2, 4 -D + uprooting of weed at maximum tillering (66.2%) and use of isoproturon + 2, 4 -D (49.0%). The lowest weed control efficiency was noticed when only isoproturon was used (27.8%). It is pertinent to mention here that some of the farmers used bracket along with 5% urea spray and it had very good crop response also. Comparing resultant effect of herbicide on wheat grain yield, maximum yield was obtained with bracket application (4.78 t ha^{-1}) followed by 2, 4 D + weed uprooting (4.42 t ha^{-1}) and isoproturon + 2, 4-D spray (4.1 t ha^{-1}). Such yield gain was 28.5%, 22.6% and 16.6% higher than that of isoproturon (3.42 t ha^{-1}) alone. The minimal crop weed competition facilitated better crop growth, yield and yield attributes i.e. no of ears/m^2, grain weight/ear, no. of grains/ear and 1000 grain-weight. These values were also higher under bracket applied plots than other weed management options.

In East Yamuna Canal command, application of Bracket at 30-35 DAS also had maximum weed control efficiency (88.7%) followed by use of 2, 4-D + uprooting of weed at maximum tillering (75.7%) and use of isoproturon + 2, 4 -D (64.4%), whereas the lowest weed control efficiency was noticed when only isoproturon was used (54.6%). The weed count (13/m^2) and its weight (29.7 g/m^2) was significantly lower under Bracket applied plot which ultimately resulted better crop ecologies for wheat growth and development. As a result the maximum grain yield of wheat was obtained with bracket application (4.95 t ha^{-1}) followed by 2, 4-D + weed uprooting (4.62 t ha^{-1}) and isoproturon + 2, 4-D spray (3.84 t ha^{-1}). Some other reasons assigned for lower weed control efficiency of locally available weedicides in these 03 regions was its poor and fake quality as several unauthorized manufacturers were producing such herbicides, lack of knowledge regarding appropriate weedicides for target weed, its recommended dose of application, right time and method of application, and non-availability of quality herbicides at the critical weed infestation stage.

Assessing sowing techniques for higher productivity of mustard

In general, broad casting of seed is common feature for sowing of mustard crop. This practice requires more seed as well as leads to poor weed management options. To overcome this, on-farm demonstration on line sowing was done. Growing of mustard crop by broadcast method in ACC had yield potential in the range of 1.21 to 1.62 t ha^{-1} with a mean of 1.56 t ha^{-1}. Line sowing in place of existing broad casting had an edge of 20-26%. The grain yield increased under line sowing in mustard due to more number of branches/plant (5.1%), number of siliqua/plant (6.8%), number of grains/siliqua (14.5%) and 1000-grain weight (6.7%). Alike ACC, in EGC, line sowing of mustard had more grain yield (1.01 to 1.42 t ha^{-1} with a mean of 1.39 t ha^{-1}) which had 18.3% higher yield compared with broad casting. These grain yields were positively correlated with the yield contributing characters like more number of branches/plant (4.5%), number of siliqua/plant (6.3%), number of grains/siliqua (14.2%) and 1000-grain weight (6.5%).

Demonstrations conducted under EYC also proved superiority over broad casting in black mustard and such intervention had yield gain of about 20%. All these yield gains were attributed to more number of branches/plant (5.4%), number of siliqua /plant (5.6%), number of grains/siliqua (14.1%) and 1000-grain weight (6.8%). The reason assigned for poor yield with farmer's seeding practice (broad casting) was higher plant population leading more competition for nutrients, light and water, poor management of crop particularly weed, insects and pest management and continuous perpetuation of weed seed. Apart from these, farmers were not aware about the advantages of modern tools and techniques of mustard crop management.

Line sowing of mustard was also demonstrated for yellow sarson in this region and it had pronounced effect on number of branches/plant, number of siliqua /plant, number of grains/siliqua and 1000-grain weight.

Balanced nutrition in mustard for higher yield and profit

In general, farmers apply N and P as nutrient for mustard production in these study domains. In ACC, under farmer's fertilizer management practices (FFP), mustard yield ranged from 1.49 to 1.75 t ha^{-1}. Application of sulphur @ 30 kg/ha over farmers' fertilizer practice (FFP) gave additional mustard grain yield of 13 to 44%. Averaged over the location, sulphur application had 14.4% additional yield advantage. Mean yield improvement across different farmers with SSNM recommendation over FFP was of 20%. Different growth, yield and yield attributing characters of mustard crop were also positively influenced with SSNM nutrient package.

Similar on-farm demonstrations conducted under East Ganga Canal command indicated that with farmer's fertilizer management practices, mustard yield ranged from 1.40 to 1.56 t ha^{-1} (Average 1.48 t ha^{-1}). Use of sulphur over farmers' fertilizer practice (FFP) had 0.48 to 0.72 t ha^{-1} additional yield gain. Mean yield improvement across the farmers' fields due to sulphur application was 30.2%. This yield improvement was positively corroborated with the growth, yield and yield attributing characters under different treatment options.

In East Yamuna Canal command (ECC) site, mustard yield under farmers fertilizer management practices, ranged from 1.29 to 2.52 t ha^{-1} (mean 1.48 t ha^{-1}). Application of sulphur @30 kg/ha over farmers' fertilizer practice (FFP) gave 0.4 to 0.81 t ha^{-1} additional yield and the mean yield gain across the farmers field due to S application was 16.9%.

Applying nutrient as per site- specific nutrient management option (SSNM) had an yield in the range of 1.28-2.52 t ha^{-1} and mean yield improvement over FFP was 16%. The yield gains under these treatments were sizably contributed through various yield attributing characters.

Assessing production potential of rapeseed and mustard cultivars

In the study domain, farmers generally grow mustard cultivars i.e. Varuna, Local toria and Vardan. In AAC, the productivity of these cultivars ranged between 1.29 to 1.75 t ha^{-1} with a mean yield of 1.6 t ha^{-1}. Introduction of yellow sarson in place of existing cultivars had an edge of 23.24% yield. The grain yield increase in yellow Sarson was attributed to more number of siliqua/plant (7.6%), number of grains/siliqua (16.5%) and 1000-grain weight (7.4%).

In EGC, the productivity of existing cultivars was in the range of 1.19 to 1.61 t ha^{-1} with a mean of 1.51 t ha^{-1}. Introduction of yellow sarson in place of existing cultivars had an edge of 21.32%. Such yield increase was mainly attributed due to more number of siliqua /plant (7.1%), number of grains/siliqua (15.3%) and 1000-grain weight (7.6%).

The productivity of available cultivars with farmers was in the range of 1.11 to 1.56 t ha^{-1} with a mean of 1.41 t ha^{-1} in EYC. Introduction of yellow sarson had an edge of 18.42% more grain yield. The grain yield increase in yellow sarson was due to more number of siliqua/plant (5.0%), number of grains/siliqua (13.2%) and 1000-grain weight (6.1%). On the other hand, reasons associated for poor yield with farmers mustard seed was its lower seed replacement rate (5-6 year) and poor keeping quality, which invited more insect-pest and disease infestation. Continuous perpetuation of weed seed, non-availability of quality seed and unawareness about quality seed production were also important constraints.

Assessing production potential of lentil cultivars

In general, farmers attraction towards legumes was very less due to increasing irrigation facilities. A shift in cropping system was noticed from less water requiring crops to more water requiring crops. Rice-wheat cropping system has emerged as a predominant cropping system in these regions. Such continuous mono-cropping induced the problems like weed infestation, nutrient deficiencies, insect-pest severity and over all poor economic benefits. In these circumstances growing a break crop or crop diversification has assumed a great significance. During the course of study, legume intervention (improved lentil seed) was made at all the locations. Some of the farmers of these region were growing lentil and its yield ranged between 1.11 to 1.39 t ha^{-1} with a mean of 1.23 t ha^{-1}. Introduction of improved cultivars of lentil in place of existing cultivars gave 12.5% more grain yield. This improved cultivar also had more number of pods/plant (7.6%), number of grains/pods (50.0%) and 1000-grain weight (2.4%) compared with local once and over all yield increase of 12.21%. was noticed.

Introduction of improved cultivars (PL-2) of lentil in place of existing cultivars had an edge of 14.75% along with more number of branches/plant (6.2%), number of grains/pod (50.0%) and 1000-grain weight (2.67%). Similarly in EYC, farmers yield improved with high yielding cultivars of lentil crop. Farmers of the command area were also taught about quality of seed production and it's processing.

Effect of fodder production influenced through improved cultivars

To ensure green fodder during lean period, production of berseem and oat was demonstrated. For this, improved cultivars of berseem and oat were grown. On average, green fodder production was 64.47 , 66.76 and 62.92 t ha^{-1} in ACC, EGC and in EGC, respectively. With the continuous availability of green fodder for milch animals an increase of 16 to 18% milk production was also noticed.

Alike berseem, multicut oat crop was also grown and over all fodder oat production was 41.9 to 43.8 t ha^{-1} in ACC, 31.6 to 35.8 t ha^{-1} in EGC and 37.2 to 39.7 t ha^{-1} in EYC under different farmer categories. In variably preference for green fodder oat was more in EGC and EYC, whereas in ACC, berseem was the most liked fodder.

Intervention 2: Kitchen gardening for house hold nutritional security

Promotion of kitchen gardening for daily vegetable needs

In general farmers purchase vegetables for their own consumption from out side the village and spent a sizeable amount of their profit on it. To make them self-reliance, promotion of kitcken gardening on the bare land was promoted by giving seeds of bottle gourd, torai, lady's finger, chillies and brinjals as per their choice. With this intervention monthly total vegetable production through different vegetables ranged between 145.1 to 169.2 kg, 102 to 166 kg and 110 to153 kg in villages of Kosikhurd, Nagala Jhinga and Jatav Nagala of ACC.

Similar vegetable production in EGC was with the range of 132 to 171 kg/month in Kumharpura village, 128 to 158 kg in Shahnagar, 130 to 170 kg in Batpura village and 123 to 153 kg in Rehmapur village. Farmers category wise, effect on vegetable production was studied and noticed that small farmers gave more attention for kitchen gardening than that of medium and large farmers. Also the overall production was more with small farmers family.

Economics of vegetables grown under kitchen gardening during *Kharif* season was worked out by multiplying the production of each vegetable (kg) by the present market prices. Over all, total income ranged between Rs. 8764 to 10018 per family in different farmer groups. Variation in vegetable production and net income was also noted in different villages of ACC. Also it varied with the availability of resources like soil, water and other management practices.

In East Ganga Canal Command, net income due to vegetables under kitchen gardening was Rs.7993 to 10114/ family/season in Kumharpura village, Rs.7699 to 9450/ family/season in Shah Nagar, Rs.7835 to 10021/ family/season in Batpura and Rs.7493 to 9134/ family/season in Rehmapur village. The higher income under EGC compared with ACC was noticed due to more vegetables production period in EGC.

Intervention 3: Live stock management

Effect of balance nutrition on milk production of milch animals

Malnutrition among the animals of the study domain was a very common feature which induced several deficiencies on health, milk production and at the same time pregnancy of the these animals are also affected. Normally, farmers do not apply micro-nutrient supplements with their animal feed and also fodders are grown without these nutrients. To avoid such imbalance in animal nutrition mineral mixture and salt brick (A multi-nutrient supplement) was used along with routine feed/fodder in selected villages. Effect on milk productivity was noticed on per day basis.

Data obtained from different villages of ACC, indicated that feeding of mineral mixture to the cows and buffaloes (milch animal) gave 16.3 to19.1% more milk production over control through small to large farmers at Kosikhurd village, followed by Nagala Jhinga and JataavNagala villages. The highest total milk production (4806) per family/ milch animal/ lactation was with large farmers followed by medium farmers (4023) and small farmers (2295). Over all additional milk production 783, 567 and 540 kg/ family, respectively, was noticed per animal with small, medium and large farmers. The corresponding increase in total milk production was 432, 486 and 837 kg/family in Nagala Jhinga village and 324, 459 and 405 kg in Jatav Nagala village. Similar effect of mineral nutrition was noticed in EGC also. The additional milk production of 756, 486 and 270 kg/ year/family, respectively, with mineral mixture use per milch animal/lactation period over control was recorded with small, medium and large farmers.

Economics of mineral mixture use in animal feed

Feeding of mineral mixture to milch animals enhanced the income of farmers by 16.3 to 19.1% over control. The maximum net income (Rs.96,552 /year) per house-hold family/lactation was with large farmers followed by medium farmers (Rs.75,816/ year) and small farmers (Rs. 55,080/ year) with balance nutrition in Kosikhurd village. An additional income of Rs. 18,792/year, Rs. 13,608/year and Rs. 12,960/year, respectively, was obtained due to this intervention under in large, medium and small farmers category. Other villages like Nagala Jhinga and Jataav Nagala also had additional income of Rs. 10,368 to 20,088 and Rs. 7,776 to 9,720 , respectively.

Similar studies on mineral mixture use for balance nutrition was noticed in East Ganga Canal Command site and an enhanced income of 16.3 to 19.1% over control was noticed at Kumharpura village, followed by Shahnagar, Batpura and Rehampur villages. Over all the net income of Rs. 6,480 to 18,144/ family in Kumharpura village, Rs. 7,776 to 13,608/ family in Shah Nagar village, Rs. 6,480 to 14,256 /family in Batpura village and Rs. 5,832 to 17,496 in Rehamepur villages were obtained on annual basis. The maximum gain was with large farmers, followed by medium and small group.

In Mehrampur village of East Yamuna Canal Command feeding of mineral mixture to milch animal enhanced milk production by 10.1 to 13.9%. Alike ACC and EGC, in EYC the milk yield improvement was 10 to 14 % over control under different farmers group. The additional income of Rs. 18,144/year, Rs. 12,312/year and Rs. 9,072/year/house-hold was recorded with the use of mineral mixture and salt brick under large, medium and small farmers. It is pertinent to mention that the large farmers having improved cow or buffalo breed had more advantages of such balance nutrition, whereas the net advantages were of smaller magnitude with small farmers due to their local breeds.

Intervention 4: Fish farming

Fish production and economics of fish farmer as influenced by feeding material and mineral mixture

Fisheries intervention was made for promoting fish farming at Shah Nagar village in EGC site and at Mehrampur village in EYC site. For this natural pond was cleaned and limed and finger lings viz., Silver carp, Rohu and Mrigal were stocked. For better growth these fishes were fed through rice bran, mineral mixture and mustard cake.

At Shah Nagar village of the East Ganga canal command the total expenditure was Rs.6,040 /year. Feeding of mineral mixture and feed materials to fishes increased fish production 10 to 49% over control. Of the total fish production gross cropshared 2,538 kg/year, Silver carp 1,175 kg/year, Rohu

1,138 kg/year and Mrigal 225 kg/year and over all net income due to fish production was Rs. 1,03,218/ house hold.

Fish farming was also promoted at Mehrampur village of EYC site with Silver carp, Rohu and Mrigal. The total cost for this site was Rs.5,960/ year. With feeding of mineral mixture the increase in fish production was 11.1 to 54.6% over control. The total fish production of 2202.15 kg/year per family and net share in total fish production was of 958.0 kg/year through Silver carp, 1049.8 kg/year through Rohu, 194.25 kg/year through Mrigal, respectively. Net income through such technological intervention was Rs. 1,03,218/ family obtained.

4. Technology transfer

In order to improve the existing farming situations of Agra canal command, East-Ganga Canal Command and East Yamuna Canal Command areas, trainings on available enterprises for efficiency improvement were organized at farmers' fields. During these trainings the needful inputs were provided for its demonstration (Table 9.6/3). The different trainings organized and number of beneficiaries during the period is listed as under:

Since milk production per unit milch animal was very smaller in study domain the use of mineral mixture and salt brick for increasing milk production of milch animal was also made during February 2009 to March 2010. Apart from this, distribution of Lemon, Aonla, Papaya and Anar plants and and sowing of vegetables seeds (bottle gourd, lady finger, coriander and taroi) for kitchen gardening were done among the farmers and trained for their establishment at their own. The aim behind such training/orientation was to make them able to produce their daily family need of vegetables and fruits through kitchen gardening. The preparation of vermi-composting was

Table 9.6/3. Technological intervention made under farmers participatory mode in various command areas of THDC project

S. No.	Activities	Number of beneficiaries
	Agra canal command	
1.	Training on efficient water management	33
2.	Training on balanced nutrition	52
3.	Training on weed management	20
4.	Kisan gosthi	312
5.	Use of mineral mixture for milch animals	100
6.	Transplanting of lemon plants in kitchen gardening	50
7.	Use of salt brick for milch animals	12
8.	Transplanting of papaya plants in kitchen gardening	200
9.	Transplanting of aonla for kitchen gardening	30
10.	Transplanting of anar plants in kitchen gardening	25
11.	Sowing of bottle gourd seeds for kitchen gardening	60
12.	Sowing of Taroi seeds for kitchen gardening	60
13.	Sowing of lady's finger seed in kitchen gardening	60
14.	Transplanting of chillies plants for kitchen gardening	110
15.	Transplanting of brinjal plants for kitchen gardening	100
	East Ganga canal command	
1.	Use of mineral mixture for milch animals	30
2.	Transplanting of lemon plants in kitchen gardening	30
3.	Residue management in sugarcane ratoon crop	8
4.	Vermi-composting trials at village level	10
5.	Sowing of Taroi seeds for kitchen gardening	200
6.	Sowing of bottle gourd seeds for kitchen gardening	200
7.	Sowing of coriander seeds for kitchen gardening	200
8.	Sowing of lady's finger seed in kitchen gardening	200
9.	Transplanting of chilly plants in kitchen gardening	80
10.	Transplanting of brinjal plants in kitchen gardening	100

S. No.	Activities	Number of beneficiaries
	East Yamuna canal command	
1.	Use of mineral mixture for milch animals	30
2.	Sowing of Taroi seeds for kitchen gardening	200
3.	Sowing of bottle gourd seeds for kitchen gardening	200
4.	Sowing of coriander seeds for kitchen gardening	200
5.	Sowing of lady's finger seed in kitchen gardening	60
6.	Transplanting of chilly plants for kitchen gardening	50
7.	Transplanting of brinjal plants for kitchen gardening	60

also done in farmers' participatory mode in 03 villages of EGC at 06 locations, 01 village of EYC at 03 locations and 02 villages of ACC at 08 locations for effective recycling of animal feed, dung, urine and crop residue wastes. Residue burning of sugarcane traces was common practice in EGC and EYC, and burning of rice residue was done in ACC. Hence, a training programme on its management was also conducted at field level and trials were initiated.

Photo 9.6/3: Project Director, PDFSR and THDC officials visiting on-farm experiments on balanced nutrition

Photo 9.6/4: A view of kitchen gardening

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

Project Directorate for Farming System Research has well-established linkages and collaborations with reputed International Institutes like IRRI, other ICAR Institutes, State Agricultural Universities and *Tehri* Hydro Development Corporation etc.

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 INTRGRATED FARMING SYSTEMS'

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

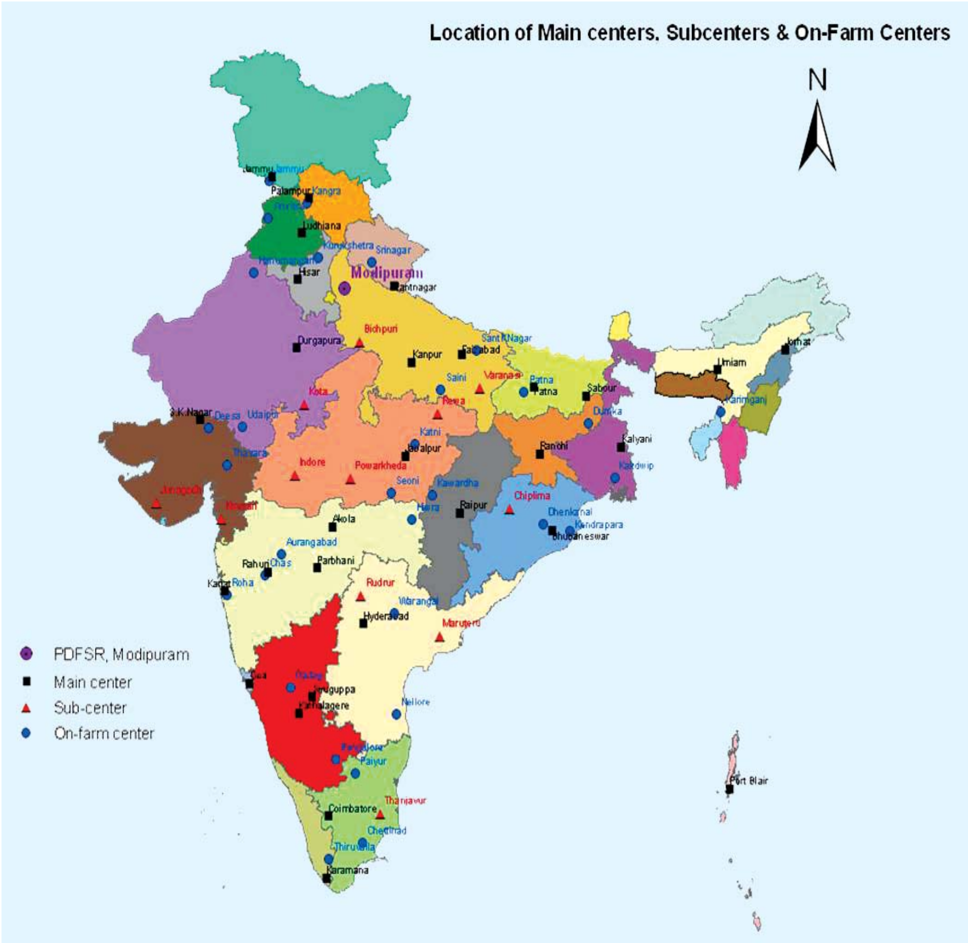
A. ***Main Centres (25) –*** All located in research centres of SAUs and undertaking IFS as well as cropping systems research.

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.



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).

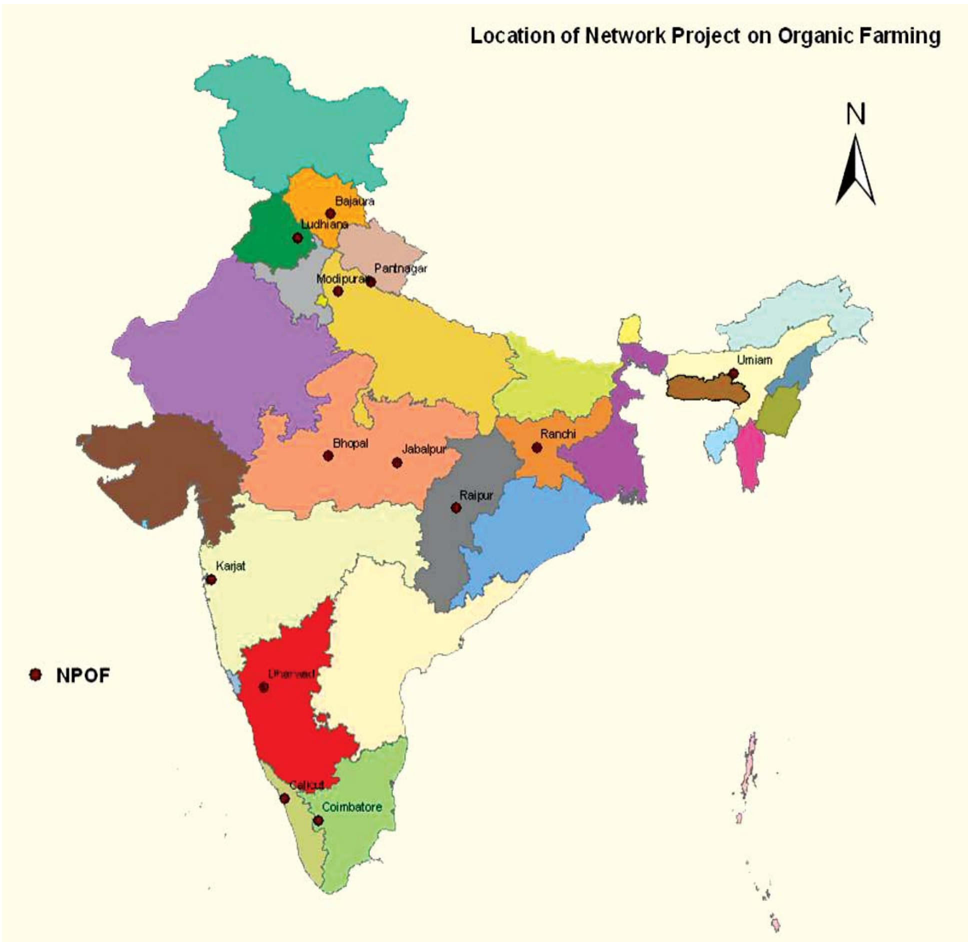
[Centres marked with (*) are sub centres, and marked with ($) are voluntary centres]

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.



Map 2.

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 2].

12. GENERAL/MISCELLANEOUS

12.1 LIST OF PUBLICATIONS

Research papers: (Published/ accepted/ communicated)

Biswas, C., Singh, D. and R. Singh. 2010. Reaction of BT and non B hybrids of upland cotton to major insect pests. *Environment and Ecology* 28 (2A): 1086-88.

Chaudhary, V. P. and K. S. Gangwar. 2010**.** Effect of different machinery on rice crop establishment and their influence on subsequent wheat crop in India. *Agricultural Mechanization in Asia, Africa and Latin America (AMA)* 41(4): 9-16.

Choudhary, S., Soni, A. K. and N. K. Jat. 2010. Effect of organic and inorganic sources of nutrients on growth, yield and quality of sprouting Broccoli (*Brassica oleracia* L. var. *italica* Plenck) cv. C.B.H.-1. *Indian Journal of Horticulture.* (Accepted)

Gangwar, B., Duhoon, S.K. and M.S. Gill. 2010. System based production potential, yield gaps and diversification opportunities in selected zones of India. *Progressive Agriculture (An International Journal)* 10(1): 19-26.

Jat, N. K., Kumar, A. and S. Dhar. 2010. Influence of *Sesbania* green manure with or without wheat residues and N fertilization on Maize-wheat cropping sequence. *Indian Journal of Agronomy* 55(4): 253-258

Kumar, N., Singh, M. and K. K. Singh. 2010. Decadal change in important district indicators and demographic information of Meerut district in post reforms period. *The Geographical Observer*, Vol. 39, 2009, pp. 3-16.

Kumar, N., Singh, M. and K. K. Singh. 2010. Distribution, decadal change and decadal growth rate of land use pattern and cropped and irrigated areas of Meerut district in post reforms period. *The Geographical Observer*, Vol. 40, 2010 (in press).

Shamim. M., Shekh A.M., Pandey V., Patel H.R. and M. M. Lunagaria. 2010. Sensitivity of CERES-Rice model to different environmental parameters on the productivity of aromatic rice in middle Gujarat. *Journal of Agrometeorology* 12 (2): 213-216.

Shukla, N. D. 2010. Impact of Fertilizers in Indian Agriculture and Rural Prosperity, *Indian Journal of Fertilizers*, 6. (7).pp.

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

Singh, D., Kumar, D., Pandey, R., Malik, K. And V. Kumar. 2010. Physiological evaluation of different crop genotypes for the intensification of cotton-wheat system through inclusion of potato in north-western plains. *Indian J. plant physiology (Communicated)*.

Singh, D., Pandey, R. and V. Kumar. 2010. Early maturing cotton genotypes for enhancing the productivity of cotton - wheat system: a physiological analysis. *Indian J. plant physiology (Communicated)*.

Singh, J. P. and M. S. Gill. 2010. Livelihood Security and Resource Conservation through Integrated Farming System. *Indian Farming*, Vol. 60(6) pp: 03-07.

Singh, J.P., Gangwar, K.S., Kumar, B. and D. Pandey. Effect of intercropping systems and planting techniques on yield, economics and quality of autumn sugarcane (Sccharum officinarum L.) in Western Utter Pradesh. *Indian journal of Agricultural Sciences. (Communicated)*.

Singh, J. P., Gill, M. S., Singh, D., Singh, P. and B. Sharma. 2011. Compatibility of winter season crops for simultaneous cropping in autumn sugarcane under different planting techniques. *J. Farming Systems Research and development* 14(2). 308-14.

Singh, J. P., Singh, P. and D. Singh. 2010. Basmati rice- Do not allow lodging your crop. *Indian Farming*, 60 (1) pp. 13-14.

Singh, J. P., Singh, P. and D. Singh. 2010. Basmati rice - Do not allow to lodge your crop. *Indian farming*. 60 (1), April, 2010: 13-14.

Singh, K. K. 2010. Crop residue management for sustainable crop production and soil health. *In:* Compendium of the winter school on "System Based Integrated Nutrient Management for Sustainable Crop Production and Soil Health", held at PDFSR, Modipuram, October 1-21, 2010, pp 362-365.

Singh, K.K. 2010. Laser land leveler for improving nutrient use efficiency. *In:* Compendium of the winter school on "System Based Integrated Nutrient Management for Sustainable Crop Production and Soil Health", held at PDFSR, Modipuram, October 1-21, 2010, pp 185-189.

Singh, K.K. 2010. Resource conservation technologies for improving nutrient use efficiency. *In:* Compendium of the winter school on "System Based Integrated Nutrient Management for Sustainable Crop Production and Soil Health", held at PDFSR, Modipuram, October 1-21, 2010, pp 181-184.

Singh, K. K. 2010. Tillage management and crop establishment strategies for improving yield of pulse crops. *In:* Compendium of the National Workshop cum Group Meeting on "Solving the Crisis in Pulses through Crop Diversification", held at Agricultural research Station, Durgapura, October 25-26, 2010 (communicated).

Singh, S. P. and B. Gangwar. 2010 Economics of crop and livestock production in Uttar Pradesh, *Indian Journal of Animal Sciences* : *80(9): 110-117*

Singh, S. P., and B. Gangwar. 2010. Farming systems diversification in semi arid agriculture of Uttar Pradesh, *Journal of Agricultural Development and policy,* 20 (1):47-54

Singh, S. P., Gangwar, B., Singh, M.P. and S. P. Singh. 2010. Identification and Resource Productivities of Existing Farming System in western Uttar Pradesh, *Progressive Agricultur*e (An International Journal), 10(1) : 8-17

Singh, V. K., Singh, M.P. Gangwar, B., Kumar, R. and K. Majumdar. 2010. Maximizing productivity and profit through site-specific nutrient management in rice-based cropping systems. *Better crops (Accepted).*

Tripathi, K. P. and V. K. Garg. 2010. Impact of grass and legume based pasture on biomass production and soil organic carbon in the inter-dunal soils of Indian arid zone. *Journal of Farming Systems Research and Development Association*. (Accepted)

II. Abstracts/seminar/symposia

Chaudhary V. P., Gangwar, B. and D. K Pandey 2010. Studies on energy of direct seeded and transplanted rice based cropping systems. . In Proc., National Symposium on emerging trends in agricultural research held at PDFSR, Modipuram, Meerut during September 11-12, 2010 (pages 56).

Chaudhary, V. P., Gangwar, B., Singh, M. P. and D. K. Pandey. 2010. Field evaluation of different resource conservation machineries in Western UP. *National symposium on emerging trends in Agricultural Research*; Sept., 11-12, 2010.

Gangwar, B. 2010. Farming system approach for livelihood security of small holder farmers. Invited paper presented in National Conference on "Livelihood Security of Smallholder Farmers" held at NASS Wing, New Delhi on 31st August and 1st September, 2010.

Gangwar, B. 2010. Food security through crop diversification under changing climate. Invited paper presented in National Symposium on "Food Security in Context of Changing Climate" held at CSAUA&T, Kanpur during 31st October and 1st November, 2010.

Gangwar, B. 2010. Farming system approach for livelihood improvement of small farmers. Presented in National Seminar on "Sustainable Challenges and Opportunities and Food Security" held on Bhubaneswar during 30th November to 1st December, 2010.

Gangwar, B. 2010. Diversification of predominant farminf systems for higher productivity and profitability. Invited paper presented in National Symposium on "Integrated Farming Systems" held at Bundelkhand University, Jhansi, 19th-21st February, 2011.

Gangwar, B. and K. K. Singh. 2011. Up scaling water productivity through cropping systems management. Key note lecture presented at the National Seminar on "Improving Water Productivity: Limits and Opportunities", held at Agriculture College, RVS Krishi Vishwa Vidyalay Gwalior, February 25-26, 2011.

Gangwar, B. and V. K. Singh. 2010. Soil sustainability through crop diversification during *National Seminar on "Soil security for sustainable agriculture*" held on 27-28, 2010 at College of Agriculture Nagpur.

Jat, N. K. 2010. Integrated Nutrient Management and Soil Health. *In*: Compendium of Lecures:

Winter School on "System-based Integrated Nutrient Management for Sustained Productivity and Soil Health" 1-21[st] Oct. 2010, PDFSR, Modipurum, Meerut, India pp:130-37

Jat, N. K., Kumar, A., Bana R. S. and S. Kumar. 2010. Substitution of fertilizer N through organic sources in maize–wheat cropping system. Souvenir and Abstracts, *Zonal Seminar on "Plant Stress Physiology in Perspectives of Agri-Horticulture and Climate Change*" held on 25[th], Feb 2011 at Swami Keshwanand Rajasthan Agricultural University, Biknar (Jobner campus) pp: 41

Kochewad, S.A., Singh J.P., Langer, R.K. and D. K. Pandey. 2010. Role of Dairy Animals in Integrated farming Systems. In Souvenir & Abstract –National Symposium on Emerging Trends in Agricultural Research –Organised by Hi-Tech Horticultural Society, Meerut, Sept., 11-12, 2010, pp. 117.

Kumar, A., Sharma, B. K. and B. Gangwar. 2010. On-farm assessment of balanced nutrition in wheat in Meerut district of Uttar Pradesh. In: *Souvenir & Abstracts of National Symposium on Emerging Trends in Agricultural Research*. Organised by Hi-Tech Horticultural Society, Meerut during 11-12 September, 2010. pp 10-11.

Mazumdar, S.P., Nayak, A.K., Gangwar, B., and V. Kumar. 2011. Influence of soil management options on total soil organic carbon in rice-wheat cropping system. In: Abstracts: "*X Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and sustained Agricultural productivity.*" 10-12[th] February, 2011, National Bureau of Fish Genetic Resources, Lucknow.SFH-157

Mishra, R. P. and K. K. Singh. 2010. Evaluation of resource efficient complementary bio-intensive cropping systems for enhancing productivity. Paper presented at National Congress on "Emerging Trends in Agriculture Research", held at PDFSR, Modipuram, September 11-12, 2010.

Mishra R. P. 2010. How to save irrigation water? at Scientist farmer interaction meet at PDFSR Modipuram on 15-04-2010.

Mishra R. P. 2010. Scaling up water productivity in Agriculture for Livelihood through Teaching cum Demonstration on 25.08.2010.

Mishra R. P. 2010. Water management in kharif crop at training programme on production technology for kharif crops July 5-7-2010 at PDFSR.

Shamim M. 2010. Simulation modelling and its applications for INM lecture delivered in winter school on "System based integrated nutrient management for sustained productivity and soil health" during 1[st] to 21[st] October 2010 at PDFSR, Modipuram, Meerut 250 110 (U.P).

Shamim, M. and N. K. Jat. 2011. Impact of climate change on agriculture and its adaptation strategies. Souvenir and Abstracts, *Zonal Seminar on "Plant Stress Physiology in Perspectives of Agri-Horticulture and Climate Change*" held on 25[th], Feb 2011 at Swami Keshwanand Rajasthan Agricultural University, Bikaner (Jobner campus) pp: 36

Sharma, B. K, Kumar, A. and B. Gangwar. 2010. Assessment of balanced nutrition in sugarcane in Meerut district of UP. In: *Souvenir & Abstracts of National Symposium on Emerging Trends in Agricultural Research*. Organised by Hi-Tech Horticultural Society, Meerut during 11-12 September, 2010. pp. 57.

Shukla, N.D., Gangwar, B., Sharma, B. K. and S. Kumar. 2010. Enhancing household income of resource poor farmers through goat farming– A case study of Jalaun district of Bundelkhand region of Uttar Pradesh. In: *Souvenir & Abstracts of National Symposium on Emerging Trends in Agricultural Research*. Organized by Hi-Tech Horticultural Society, Meerut, 11-12 September, 2010. pp. 221.

Singh, D. Shamim, M., Gangwar B. and V. Kumar. 2010. Growth and yield responses of various rice genotypes to changing climatic scenario. In *National Symposium on "Sustainable rice production system under changed climate*" 27-29 November, 2010, ARRW, CRRI, Cuttak, No. 58, pp. 37.

Singh, D. 2010. Nutrient management: effect on plant growth and productivity, *lecture delivered during Winter School on "System-based Integrated Nutrients Management for Sustained Productivity and Soil Health"* during October 1-21, 2010 at PDFSR, Modipuram, Meerut (U.P.).

Singh, D. and V. Kumar 2010. Physiological techniques for the measurement of plant growth, *lecture delivered during Winter School on "System-based Integrated Nutrients Management for Sustained Productivity and Soil Health"* during October 1-21, 2010 at PDFSR, Modipuram, Meerut (U.P.).

Singh, D. and R. Pandey. 2010. Physiological disorders in cotton-causes and effects on productivity. In Zonal Seminar on "*physiological and molecular interventions for yield and quality improvement in crop plants"*, Eds. Kumar, P., Singh, J. and Singh, A.K., September 17-18, 2010, Centre of Excellence in Ag Biotechnology, SVPUAT, Meerut & ISPP, New Delhi, pp 1-6.

Singh, J. P. 2010. Winter school on "System based INM for sustained productivity and Soil health" – Delivered a lecture on the subject entitled, "Nutrient management in farming system perspective".

Singh, J. P., Gangwar. B and D. K. Pandey. 2011. Farming Systems Scenario of small farm holders and measures to diversify On - Farm Farming Systems for sustaining farm productivity and livelihood. – Presented in the National Symposium on Integrated farming Systems for Sustainable Agriculture – Challenges and Opportunities, held at Institute of Agricultural Sciences, Bundelkhand University, Jhansi, 19-21 Feb., 2011.

Singh, J. P., Kochewad, S. A., Langer, R. K. and D. K. Pandey. 2010 . Integrated Farming System – A Multipurpose farming System for sustainable production. In Souvenir & Abstract –*National Symposium on Emerging Trends in Agricultural Research –Organized by Hi-Tech Horticultural Society*, Meerut, Sept., 11-12, 2010, pp. 49.

Singh, K. K. 2010. Crop residue management for sustainable crop production and soil health. Paper presented at the winter school on "System Based Integrated Nutrient Management for Sustainable Crop Production and Soil Health", held at PDFSR, Modipuram, October 1-21, 2010.

Singh, K. K. 2010. Laser land leveler for improving nutrient use efficiency. Paper presented at the winter school on "System Based Integrated Nutrient Management for Sustainable Crop Production and Soil Health", held at PDFSR, Modipuram, October 1-21, 2010.

Singh, K.K. 2010. Laser land leveler for scaling up water productivity and resource use efficiency. Paper presented at the Teachers' Training on "Up scaling water productivity", organized by SVBPUA&T, Modipuram, August 21, 2010.

Singh, K.K. 2010. Resource conservation technologies for improving nutrient use efficiency. Paper presented at the winter school on "System Based Integrated Nutrient Management for Sustainable Crop Production and Soil Health", held at PDFSR, Modipuram, October 1-21, 2010.

Singh, K.K. 2010. Tillage management and crop establishment strategies for improving yield of pulse crops. Paper presented at the group meeting on "Solving the Crisis in Pulses through Crop Diversification", held at Agricultural research Station, Durgapura, October 25-26, 2010.

Singh, K. K. and B. Gangwar. 2010. Laser land leveler for improving resource use efficiency in agriculture. *In:* Book on "Improving Land, Water and Energy Productivity through Cropping Systems Management", P. D. F. S. R. Modipuram (communicated).

Singh, K. K. and R. P. Mishra. 2010. Crop Residue Management for sustainable crop production and soil health. Paper presented at National Congress on "Emerging Trends in Agriculture Research", held at PDFSR, Modipuram, September 11-12, 2010.

Singh, K. K., Mishra, R. P. and B. Gangwar. 2011. Long term effect of resource conservation technologies on productivity and profitability of rice-wheat cropping system. Paper presented at the 45th Annual Convention & Symposium of the Indian Society of Agricultural Engineers, held at P. D. K. V., Akola, Maharashtra, January 17-19, 2011.

Singh, K. K., R. P. Mishra and B. Gangwar. 2010. System Based Tillage and Crop Establishment for Improving Land, Water and Energy Productivity. *In:* Book on "Improving Land, Water and Energy Productivity through Cropping Systems Management", P. D. F. S. R. Modipuram (communicated).

Singh, K. K., V. K. Singh and V. P. Chaudhary. The documentation of technologies developed/ evaluated / promoted by the directorate. Presented in the Zonal Technology Management – Business Planning Development meeting of north zone, IARI, March 17-18, 2011.

Singh, M. P., Singh, V. K., Gangwar, B., Kumar, V. and N. Singh. 2010. Integrated and balance nutrition for sustainable crop productivity and soil health; A farmers participatory approach in Agra canal commend. *National symposium on emerging trends in Agricultural Research.;* Sept., 11-12:98-99.

Singh, S.P., Gangwar, B. and S. P. Singh. 2010. Institutional finance and farming systems diversification Uttar Pradesh. Paper presented in *National Symposium on emerging trends in Agricultural research organized by High –Tech Horticultural Society* Meerut (U. P.), held at PDFSR Modipuram, Meerut 11-12 Sep, 2010, Souvenir and Abstract pp 85.

Singh, V. K., Singh, M. P., Gangwar, B., Kumar, R. and K. Majumdar. 2010. Maximizing productivity and profits through site specific nutrient management under different wheat based cropping systems. *National symposium on emerging trends in Agricultural Research*; Sept., 11-12, 2010.

Singh, V.K., Majumdar, K., Singh, M. P, Kumar, R. and B. Gangwar. 2010. Site-specific nutrient management for attaining maximum productivity and profits during *research cooperators meet cum workshop organized by IPNI-OUAT* Ranchi held at 17-19 August, 2010 at BAU Ranchi.

Tripathi, K. P. and B. Gangwar. 2010. Utilization of Industrial Effluents for crop production and soil health. Presented in *National Congress on Emerging Trends in Agricultural Research*, 11-12 Sept, 2010 at PDFSR, Modipuram, Meerut, pp 59.

Popular /Technical articles

बी. गंगवार, दिनेश कुमार पाण्डेय, के. यस. गंगवार और वेदप्रकाश चौधरी (2010)। धान–गेहूँ फसल प्रणाली विविधीकरण लाभ। ''खेती''। अंक 10; 23–29।

बी. गंगवार, दिनेश कुमार पाण्डेय और वेदप्रकाश चौधरी (2010)। टिकाऊ खेती के लिए फसल विविधीकरण। ''खाद पत्रिका'', दि फर्टिलाइजर एसोसिएशन आफ इण्डिया,नई दिल्ली। 51: 17–23।

चौधरी, वेदप्रकाश, दिनेश कुमार पाण्डेय और बी. गंगवार (2011)। फसल सुरक्षा के लिए विभिन्न आधुनिक यन्त्र। ''खाद पत्रिका'' दि फर्टिलाइजर एसोसिएशन आफ इण्डिया, नई दिल्ली। (52) 01: 18–20।

जाट, एन.के., गंगवार, बी. और कुमार सुनील. 2010. खरीफ फसलों में एकीकृत पोषक तत्व प्रबंधन। खाद पत्रिका।

Jat, N.K., Kumar, Sunil. Majumdar, S.P. and Jat, Gajanand.2010. *Samanvit Paushak Tatva Prabandhan avem Mrida Swasthaya.. Khad Patrika*. (In Hindi) (communicated)

Kochewad, S. A., Langer., R. K and Singh, J. P. 2010. Integrated poultry cum fish farming. *Pashudhan* **36** (**7**), pp. 3-4.

चन्द्रभानु (2010). कृषि क्रियाओं में सुधार: वैश्विक तपन में उतार. *योजना. अप्रैल, 54* (4): 18–22।

Singh, V. K. and Tiwari, R.B. 2010. Ganne Ki Mithas Potash Ke Sath. *Khad Patrika*, December, 2010.

Singh, V. K. and Tiwari, R.B. 2010. Sanrakshit Krish Apnayen, Kheti ka Bhavishya Banayen, *Kheti* (Accepted).

बी. गंगवार, दिनेश कुमार पाण्डेय और वेदप्रकाश चौधरी (2011)। धान–गेहूँ फसल चक्र की समस्याये एवम समाधान। 1–68।

Books / Bulletins

Gangwar, B. 2011. Cropping System Management, Agrotech Publishing Academy, 11-A, Vinayak Complex B, Udaipur, pp. 1-344.

Gangwar, B., Varughese, K., John, J., Vijyan, M. and T. Mathew. 2010. Manual on integrated farming systems, Joint publication Kerala Agricultural University, CSRC Karmanna (Kerala) and PDFSR, Modipuram, Meerut (U.P.), pp. 1-178.

Gangwar, B., Singh, V. K., Singh, Prem, Singh, K. K. and S. S. Pal (Eds), Compendium on Winter School on System – based Integrated Nutrient management for Sustained Productivity and Soil Health (1-21 October, 2010). Organized by the Project Directorate for farming Systems Research (Indian Council of Agricultural Research) Modipuram, Meerut – 250 110 (U.P.) India 365 pp.

Shukla, A. K, Singh V. K., Dwivedi, B.S. and V. Kumar. 2010. Sustainability of rice-wheat system: a means of food security in India. Sustainable Agriculture. (Sengar, R.S. and Sharma, A.K. Eds).Studium Press Pvt Ltd, New Delhi, India.pp. 499-542.

Singh, D. and C. Bhanu. 2010. Annual Report. Project Directorate for Farming Systems Research (ICAR), Modipuram, Meerut – 250 110, India. pp. 113.

Singh, S.P., and B. Gangwar. 2010. Economics of existing farming systems of Uttar Pradesh. (India) ISBN 978-3-8383-8423-8 paperback, 148 pages, Lambart Academic Publishing AG & Co.KG, Dudweiler Landstr. 99, 66123, Saarbrucken, Germany.

Tripathi, K. P. 2011. Soil carbon management for better soil health.

Tripathi, K. P. and B. Gangwar. 2010. PDFSR Newsletter, 17 (1&2)

12.2 MEETINGS OF RAC/IRC/IMC

29th Biennial Workshop of AICRP on IFS

29th biennial workshop of AICRP on IFS was held on 10-13 December 2010 at ANGRAU, Hyderabad (A.P.). The inaugural session was chaired and presided over by Hon'ble Vice Chancellor, ANGRAU, Hyderabad. In his introductory remarks, Dr. B. Gangwar, Project Director, PDFSR, highlighted that presently Indian agriculture is passing through a very critical phase. On one hand, it has onus of providing national as well as household food and nutritional security to its teeming millions. Whereas, on the other hand, wide-spread occurrence of ill-effects of green revolution technologies (GRTs) in all intensively cultivated irrigated areas, a backbone to national food security, is threatening the very sustainability of the agricultural production system and national food security as such. With more intensive agriculture in these areas, there has been a rising stress on natural resources in several parts of the country. He further mentioned that about 84% of our farmers belong to the category of marginal to small landholders. Improving household food security has been an issue of supreme importance to them who constitute 71.2 million marginal (< 1.0 ha) and 21.6 million small (1.0-2.0 ha) farmers. For

Glimpses of the Biennial Workshop at Hyderabad such scenario the farming system approach is considered to be the powerful tool to address these major issues. During workshop, on-going AICRP-IFS programme was reviewed centre-wise to assess the progress made during the year 2009-10. During review several technical and general recommendations emerged out for further improvement of the programme. Technical programme for 2010-11 and 2011-12 was also finalized, in view of the changed mandate.

Group meeting on solving the pulses crisis through crop diversification

During post-green revolution era a phenomenal increase in production and productivity of cereal crops occurred but in the process pulse crops were left behind and practically pushed back to lesser productive areas on account of several constraint. Despite concerted efforts for their genetic improvement, pulses are still not able to compete with main stream cereal-based agriculture in terms of stability in yields and economics. This has lead to a crisis of availability of pulses to a common man in the country for which pulses are the main source of protein. However, wide-spread researches carried out under AICRPs on pulse crops, cropping systems and elsewhere during past few decades are clear indicative of the fact that new varieties of pulse crops combined with better management practices, have a high potential to be included in different cropping systems through crop diversification approach, which may prove to be an efficient tool in alleviating pulse crisis in Indian agriculture. Hence, a need is being felt to deliberate on all such technologies on a common platform to develop future road map and strategies for augmentation of pulse production in the country.

With this backdrop in mind, a 2-days Group Meeting of selected scientists with a theme on 'Solving the crisis in pulses through crop diversification' was organized at SK RAU Agricultural Research Station, Durgapura (Jaipur) on 25-26 October 2010.

The meeting was inaugurated by Shri Murari Lal Meena, Minister of Technical Education, Government of Rajasthan. Prof. S.P. Tiwari, Vice Chancellor of SK RAU presided over the function. Dr. N Nadarajan, Director, IIPR, Kanpur, Dr. B. Gangwar, Project Director, PDFSR, Modipuram, Dr. M. V. Singh, PC, AICRP on Micro & Sec. Nutrients, IISS, Bhopal, Dr. J. G. Varshney, Director, DWSR, Jabalpur, Dr. N.D. Mazumdar, Project Coordinator (Pigeon pea), Dr. B. B. Singh, Project Coordinator (MULLARP), Dr. N. P. Singh, Project Coordinator (Chickpea) and Chief Agronomists of AICRP-IFS centres were the resource persons.

The major issues for discussion during the meeting were; issues, strategies and technological options for doubling pulses production in India. A decline in area of pulses in post-green revolution period in Indo-Gangetic plains (IGP) mainly due to creation of extensive irrigation network, occurrence of epidemic of *Ascochyta* blight in chickpea, government's generous incentives for rice-wheat production and economically less viable than cereals, low genetic yield potential in pulses due to narrow genetic base, inefficient plant type, and self-pollinated nature which leaves little scope for heterosis breeding, relegation of pulses from high productivity zone to low productivity zone, maximum acreage in rain fed areas (87%) and poor crop management, instability in production as being rain fed crop, pulses experience drought at critical growth stages, they are highly sensitive to a biotic stresses (such as temperature extremities, excessive moisture, salinities, etc,), vulnerable to a large number of diseases and insect pests, and poor seed replacement on account of non-conversion of breeder seed to certified seeds, reluctance of central and state seed corporations to take up pulse seed production, lesser participation of private seed companies and high volume crops, especially in chickpea, field pea and rajmash; were the major point of concern in pulse production. The speaker scientists, hailing from different regions of the country, presented the technological options available to increase area under pulses through replacement of varieties, adoption of improved production techniques, introduction of pulses in new niche areas, especially in summer fallows and rice fallows, include them as intercrop with cereals or partial substitution of cereal crops with pulses in view of future irrigation water crisis.

Research Advisory Committee Meeting

The 16th meeting of newly constituted Research Advisory Committee (RAC) of PDFSR was held on 8-9 February 2011 at PDFSR, Modipuram under the chairmanship of Prof. Panjab Singh, former Secretary DARE (GOI) and Director General ICAR. The other members were; Dr. R. P. Singh, Dean, Institute of Agricultural Sciences, BHU, Varanasi; Dr. Suresh Pal, Head, Division of Economics, IARI, New Delhi; Dr. K. K. Vass, Ex-Director, CIFRI (ICAR); Dr. Shyam Singh, Ex-Director, NRC for Citrus (ICAR); Dr. A. K. Yadav, Director, NCOF, Ghaziabad; Dr. B. Gangwar, Project Director, PDFSR, Modipuram; Dr. J. C. Dagar, ADG (Agronomy), ICAR, New Delhi and Dr. Kamta Prasad, Pr Scientist & Member Secretary. In total there were 26 participants, including special invitees. During discussions, Dr. Panjab Singh re-emphasized that cropping systems on farmers' fields are becoming more and more market-driven then who will adopt our recommendations with reference to new cropping systems. He also opined that scientifically it would be more appropriate if cropping systems are compared in terms of energy input-output as monetary returns are totally governed by the market prices for inputs and produce, which remain highly fluctuating over time and location. All the committee members were of the view that PDFSR scientists should concentrate all their efforts on characterization of prevailing farming systems, documentation of IFS research already done and undertaking new IFS research projects. They also suggested that they should consolidate different small research projects into only few projects and think of merging some inter-related experiments so that more information is derived from limited experiments/ projects. The committee, after detailed discussions and visit of the experimental fields, made the following recommendations.

Glimpses of the Research Advisory Committee Meeting

1. In the context of emerging issues related to agricultural resources, namely; land, water, energy, ecology, market and farm enterprises, the Integrated Farming Systems Research and Development (IFSRD) assumes high priority so as to address to the issues of livelihood and ecological security. Therefore, the role of this Directorate becomes much more important. It is recommended that the scientific and technical manpower and infrastructure should be adequately strengthened, particularly in areas of horticulture, animal sciences, fisheries, food processing, plant protection etc. The mandates assigned could be better addressed by strengthening and upgrading the status of the Project Directorate to the level of an Institute and be named as Indian Institute of Farming Systems Research (IIFSR). This will provide support for conducting basic and applied research at the headquarter and will also facilitate monitoring and evaluation of programmes and activities undertaken by various centers in the country.

2. Since the Directorate is in the transition stage from the Cropping Systems Research to the Farming Systems Research involving different enterprises/components namely animal, fishery, horticulture, agro-processing and value addition, a more comprehensive planning of the research programmes in the area of natural resource management, namely; Integrated Nutrient Management, Integrated Water Management, Integrated Pest Management etc. is to be emphasized. The issues of sustainability and resource conservation while optimizing the production and productivity should take into account the inventory and audit aspects of natural resource parameters.

3. The Directorate should prepare a compendium on the state-of-the-art report of existing IFSR technologies in India and outside. It should be taken as a base for assessment, refinement, improvement and multiplication in different agro-climatic zones of the country.

4. Few successful models, which have proven their utility in different regions of the country, should be selected for further refinement and multiplication at selected locations (on-farm and on-station). This will not only provide a lead in farming systems research but will also help in efficiently utilizing resources for improving and strengthening the programme.

5. While planning research programme for the Directorate and the centers in the country, the farmers' resources, their social fabrics, market infrastructure and environmental aspect should be kept in focus. The programme should be developed keeping these important factors in mind so as to make the technology more relevant and acceptable. This aspect is invariably left out.

6. Review and impact analysis of the Cropping Systems Research for last two decades needs to be taken up. This will help to add additional enterprises/ components while framing the programme for farming systems research, which is the mandate now.

7. Climate change is going to impact agriculture. Therefore the Directorate should prepare itself to address the issues of productivity in the changing scenario in different agro-ecological regions through its different on-farm and off-farm research programmes.

8. The Directorate should lay more emphasis on basic and applied research at the headquarter addressing to the issues of Integrated Farming Systems Research and development keeping in view the socioeconomic aspects of different stakeholders.

9. A mega project should be initiated incorporating important components/enterprises like animals, fisheries, horticulture, farm forestry etc and data should be collected on various aspects relating to natural resource conservation, energy use, by-product recycling, productivity gains and economic returns.
10. Survey methodology of farming systems characterization needs to be modified with respect to sample size so as to have wider acceptability and relevance of data.
11. All the projects should have log frame indicating the problem, approach and quantifiable output. This will enable better monitoring and impact analysis of the on-going programmes.
12. Training of a few scientists in IFS in other institutions in India and abroad should be taken-up for capacity building of the scientists, especially in the areas of farming system modeling, monitoring and evaluation, impact analysis and agriculture and climate relationships.
13. The scope of organic farming research should be enlarged in collaboration with practicing farmers and National Centre of Organic Farming of DAC, to develop package of practices for organic farming.
14. The Directorate has been conducting research on conservation agriculture, long term INM and cropping systems for last 3 decades and has generated useful information on various aspects. There is need to take-up further studies on carbon sequestration and other parameters and relate it to the climate change.

Institute Research Committee (IRC) meetings

There were two IRC meetings held during the period of report.

23rd meeting of Institute Research Committee held on April 29-30, 2010

Twenty third meeting of Institute Research Committee of PDFSR, Modipuram was held during April 29-30, 2010 and June 30, 2010. Twenty-seven scientist members attended the meeting. The meeting was chaired by Dr. B. Gangwar, Project Director, PDFSR, Modipuram.

The meeting started with the introduction of new scientists who had joined the Directorate after the last IRC meeting. In his introductory remarks the Chairman, IRC, the Project Director emphasized that with the increase in the strength of the Directorate our responsibility also enhanced to give better out put 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 publications. The art of the state facilities developed at PDFSR should be fully utilized for different research projects by the scientists. He asked the scientists to develop the research projects involving such observations, which needed the use of lab equipments, like atomic absorption spectrophotometer, gas chromatograph and GC-MS. The meeting proceeded as per the agenda items listed below:

1. Presentation of the Action Taken Report on the recommendations of IRC meeting held on October 26-27, and November, 23rd, 2009.
2. Review of the results of on-going research projects
3. New Research Proposals

24th meeting of Institute Research Committee held on September 28-29, 2010

Twenty fourth meeting of Institute Research Committee of PDFSR, Modipuram was held during September 28-29, 2010. Twenty-six scientist members attended the meeting. 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 member, Dr. K. S. Gangwar, Principal Scientist (Agronomy) who left us for heavenly abode on 13-09-2010 due to a road accident on 10-09-2010.

The Project Director emphasized to give better output of research in farming system mode. He urged the scientists to fully dedicate and improve the quality of research. The output should be visible in terms of publications. The meeting proceeded as per the agenda items listed below:

1. Presentation of the action taken report on the recommendations of IRC meeting held on April 29-30, and June 11th, 2010.
2. Review of the results of on-going research projects

At the end of the meeting, the Chairman advised the scientists to improve the quality of their experiments and to pay sincere attention to their projects. Regular monitoring through field visit may be ensured during experimentation. The meeting ended with a vote of thanks to the chairman and the members of IRC by the member secretary.

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

Dr. J. P. Singh, Principal Scientist assisted in organizing an “Orientation workshop for the Nodal officers of the SAUs and Relief commissioners of six northern states (U.P., Punjab, Haryana, H.P., Uttrakhand and J&K)” on 3rd June 2010 at PDFSR, Modipuram, Meerut- 250 110 (U.P).

Dr. B. Gangwar, Project Director presented the status report of the on-going Network Project on Organic farming at One-Day Consultation Meeting on Organic Farming in India on 23rd April 2010 held at NASC Complex, Pusa, New Delhi. This meeting was also attended by Dr. Kamta Prasad, Dr. S. S. Pal and Dr. Prem Singh from the Directorate.

Drs. B. Gangwar, K. Prasad, D. Singh, J. P. Singh, S. S. Pal, K. K. Singh, S. P. Singh and V. K. Singh participated in Binneal Workshop of AICRP on IFS – held at ANGRAU, Rajendernagar, Hyderabad, 10-13 December, 2010.

Dr. J. P. Singh, Principal Scientist participated in Symposium on “sustainable rice production system under changed climate”, organized by ARRW, CRRI, Cuttack and ICAR, held on 27-29 November, 2010 at CRRI, Cuttack,

Dr. J. P. Singh, Principal Scientist participated in Zonal Seminar on “physiological *and molecular interventions for yield and quality improvement in crop plants”*, held on September 17-18, 2010, organised by Centre of Excellence in Ag Biotechnology, SVPUAT, Meerut & ISPP, New Delhi, held at SVPUAT, Meerut.

Drs. B. Gangwar, S. S. Pal, J. P. Singh, K. K. Singh, V. K. Singh, S. P. Singh, M. P. Singh and R. P. Mishra participated in National Symposium on Emerging Trends in Agricultural Research – Organized by Hi-Tech Horticultural Society, Meerut, Sept., 11-12, 2010.

Dr. J. P. Singh, Principal Scientist participated in training on *"IT based DSS for Geographical Information System for Rural Lively hood Assessment"* during March 11-20, 2010 organized by National Institute of Rural Development, Rajendra Nagar, Hyderabad-5000030.

Drs. B. Gangwar, Kamta Prasad, S. S. Pal, K. K. Singh and V. K. Singh participated in Group Meeting on Solving the Pulses Crisis through Crop Diversification organized on 25-26 October 2010, at ARS Durgapura (Jaipur)

Dr. Kamta Prasad, Principal Scientist participated in the Interface Meeting of Directors of Crop Science, Horticulture and NRM Divisions of ICAR, convened by DG ICAR at NASC, New Delhi on 23rd November 2010.

Drs. Kamta Prasad and K. K. Singh participated in workshop on Results Framework Document for Responsibility Centers (RCs) at NASC Complex, New Delhi.

Dr. K. P. Tripathi, Senior Scientist participated in Regional Training Workshop of Resource Persons for National Children's Science Congress organized by NCSTC-DST Government of India during July 18-19, 2010 at FIT, Meerut, Uttar Pradesh.

Drs. S. S. Pal, K. K. Singh, K. P. Tripathi, V. K. Singh and S. P. Mazumdar participated in seminar on The Next Generation Fertilizers on 11 March, 2011 at NASC Complex, PUSA, New Delhi organized by NRM Division, ICAR, New Delhi.

Dr. V. K. Singh, Senior Scientist attended Fifteenth General Body Meeting and Foundation Day Lecture of National Academy of Agricultural Sciences held at NASC Complex New Delhi on 4 -5 June 2010.

Dr. V. K. Singh, Senior Scientist attended group meet cum workshop" Implementing SSNM in rice, wheat and maize held at ARS Durgapura, Jaipur (Rajasthan) during 26-28 October 2010.

Drs. K. K. Singh, V. K. Singh, V. P. Chaudhary and Sh. Shailendra Raj attended ICAR ZTM & BPD Meetings- cum workshops 2009-10 held on 19-20 March, 2010 at ZTM unit, IARI, New Delhi.

Dr. K. K. Singh, Principal Scientist participated in 45th Annual Convention & Symposium of the Indian Society of Agricultural Engineers, held at P. D. K. V., Akola, Maharashtra, January 17-19, 2011.

12.4 HUMAN RESOURCE DEVELOPMENT

Dr. Vipin Kumar Choudhary, Scientist (Senior Scale) attended ISRO-NNMS sponsored training viz, GIS Technologies and advances at IISR, Dehradun from 03-05-2010 to 25-05-2010.

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

Sl. No.	Topic	Duration	Course Director
1.	System based Integrated Nutrient Management for Sustained Productivity and Soil Health	1 to 21 October, 2010	Dr. B. Gangwar

12.6 AWARDS/HONOURS/RECOGNITIONS

Dr. B. Gangwar, Project Director, was honored with Gold Medal 2008 by Indian Society of Agronomy for his significant contribution to "Agronomy". The award was conferred to him in recently held National Symposium at Bangalore on 2nd December, 2010.

Dr. B. Gangwar, Project Director, along with Dr. K. S. Gangwar and Shri P. P. Mishra was awarded the "Sriram Puraskar" for the best article entitled "Rabi ki Dalhani Faslo Ka Fasal Pranaliyon Mein Semavesh, mahatva Evam Unnat Kheti" Published in issue of "Khad patrika" in Hindi during the year 2010. The award conferred to them in the National seminar held at Delhi on November 27, 2010.

Dr. B. Gangwar, Project Director, was designated an expert member on National Strategy on Rice Production in India on 1st June, 2010 at the workshop on National Strategies for Rice Production during 2010-2011 at Krishi Bhawan, New Delhi under the chairmanship of Secretary, Agriculture and Cooperation, Government of India. DDG (Crop Science) of ICAR, Krishi Bhawan, New Delhi will be chairing the committee.

Dr. B. Gangwar, Project Director, sreved as Councilor, Indian Society for Coastal Agricultural Research, Canning, W.B., served as Member, Executive Council, Indian Society of Dry-Land Agriculture, Hyderabad, served as Member Executive "Agriculture Science Digest", served as Chief Editor "Agricultural Reviews", served as President, Modipuram Chapter of Indian Society of Agronomy, served as Member Advisory Board, Indian Farming, ICAR, New Delhi, served as Team Leader, Technical team for framing appropriate policy for cropping pattern in the lands around forest areas in Karnataka to prevent farmers-Elephant Conflict, served as an expert member on National Strategy on "Rice Production in India" for 2010-11.

Dr. K.K. Singh, Principal Scientist, was appointed Director (Membership and Public Relations) of the Indian Society of Agricultural Engineers for the period 2010-2012.

Dr. V. K. Singh, Senior Scientist was selected as ICAR National Fellow.

Sh. S. P. Singh, Technical Officer, awarded certificate and trophy for recognition as Joint coordinator, editor and excellent contribution "National Symposium on Emerging trends in Agricultural Research" by Hi tech Horticultural Society, Meerut, on Sept. 11-12, 2010.

Sh. S. P. Singh receiving appreciation certificate

Mr. Rajesh kumar, Jr. Steno was declared runner up in Chess (men) in the ICAR Zonal tournament (North Zone) during 6-9 April, 2010 at Indian Institute of Pulse research, Kanpur (U.P.)

12.7 DISTINGUISHED VISITORS

A five member delegation from Ethiopian Agricultural Research Institute, Addis Ababa, visited the Directorate on 22nd November 2010. They observed that the research facilities and other allied activities being undertaken at this Directorate should be replicated under Ethiopian conditions.

Sh. Sachin Pilot, Minister of State for Coal and Mines, GOI, New Delhi visited Project Directorate on 11th September, 2010 to inaugurate the National Symposium on Emerging Trends in Agriculture organised at PDFSR, Modipuram

Farmers visiting PDFSR research farms

Extension scientists collecting data

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

Dr. J. P. Singh delivered lecture on livestock management on 11th February, 2011 at Kumarpura distt. Bijnor organized by PDFSR, Modipuram.

Dr. J. P. Singh conducted three days Training/Short course on Integrated farming Systems of SMS of KVKs Zone-1, PAU, Ludhiana during 22-24 July, 2010.

Dr. J. P. Singh conducted three days Farmers' Training on production technologies for kharif crops, July 5-7, 2010.

Dr. J. P. Singh conducted field visit of a group of CBSE school "HERITAGE ACADEMY" representatives on 25th October, 2010 related to the Project on National Childrens' Science Congress.

Dr. J. P. Singh conducted farmers' group (50 farmers) field visit related to Macrofed Plan organised by Ganna Vikas Vibhag and Sugar factories on 29th June, 2010

Dr. V. K. Singh conducted the technological knowledge improvement, sustained lively hood security, promotion of vermi composting, fruit plantation and fish farming following farmers' participatory training were organized:

S. No	Training Organized	Participants
1	Weed management in wheat crop	207 farmers
2	Fish Production	4 farmers
3	Distribution of mineral mixture for milch animals	130 farmers
4	Distribution of lemon plants	90 farmers
5	Residue management in sugarcane ratoon crop	40 farmers
6	Distribution of vegetable seeds for kitchen gardening	550 farmers
7	Conduct of vermin-composting trails at village level	15 unit

Participation in Exhibitions

12.9 हिन्दी पखवाड़े का आयोजन

निदेशालय में कार्यालय से सम्बंधित दैनिक कार्यो में हिन्दी के अधिकाधिक उपयोग को प्रोत्साहित करने के उद्देश्य से दिनांक 14–30 सितम्बर, 2010 के दौरान हिन्दी पखवाड़े का आयोजन किया गया। पखवाड़े के शुभारंभ के अवसर पर परियोजना निदेशक ने अपने संबोधन में निदेशालय के समस्त अधिकारियों/कर्मचारियों को अपने दैनिक कार्यो में हिन्दी के अधिकाधिक प्रयोग करने का आग्रह किया तथा देश की एकता एवं विकास में राजभाषा के योगदान पर प्रकाश डाला। पखवाड़े के दौरान टोली प्रतियोगिताओं जैसे अन्त्याक्षरी एवं हिन्दी सामान्य ज्ञान तथा एकल प्रतियोगिताओं जैसे निबंध लेखन एवं संक्षिप्त भाषण का आयोजन किया गया। इन प्रतियोगिताओं में सभी संवर्ग के अधिकारियों एवं कर्मचारियों ने बढ़–चढ़कर हिस्सा लिया। डा0 बाबूजी गंगवार, परियोजना निदेशक ने प्रतियोगिताओं में प्रथम, द्वितीय एवं तृतीय स्थान प्राप्त करने वाली टोलियों एवं एकल प्रतिभागियों को प्रमाण–पत्र एवं पुरस्कार स्वरूप दैनिक उपयोग की वस्तुएं एवं पुस्तकें वितरित कीं। अन्य समस्त प्रतिभागियों को भी सांत्वना पुरस्कार वितरित किये गये। निबन्ध लेखन एवं संक्षिप्त भाषण प्रतियोगिता में प्रथम पुरस्कार क्रमशः श्री विपिन कुमार एवं डा0 नन्द किशोर जाट ने हासिल किया तथा टोली प्रतियोगिताओं जैसे अन्त्याक्षरी एवं हिन्दी सामान्य ज्ञान प्रश्नोत्तरी मे प्रथम पुरस्कार क्रमशः श्रीमती अन्जू वर्मा, श्रीमती अलका जैन, श्रीमती शीला देवी, श्री नरेश चौहान

हिन्दी पखवाड़े के दौरान आयोजित विभिन्न कार्यक्रम एवं पुरस्कार वितरण

की टोली ने एवं श्री दिनेश चन्द्र मिश्र, श्रीमती अलका जैन, डा0 ब्रजमोहन एवं श्री प्रेमसिंह की टोली ने हासिल किये। विभिन्न प्रतियोगिताओं के आयोजन में निदेशालय की राजभाषा समिति जिनमें डा0 सुधांशु शेखर पाल, डा0 विनोद कुमार सिंह, श्री हम्बीर सिंह चौहान एवं रहस बिहारी तिवारी का सक्रिय योगदान रहा। इस दौरान समय–समय पर विभिन्न कार्यों हेतु श्री परमानन्द, श्री देवेन्द्र पाल सिंह एवं श्री राजेश कुमार ने विशेष सहयोग प्रदान किया।

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
Evaluation of different cropping systems under limited water availability situation	B. Gangwar
Study on water and nitrogen use efficiency of different varieties of rice under aerobic condition	R. P. Mishra
Tillage and planting management in different cropping systems	K. K. Singh
Performance of different cropping system under various tillage management	A. Sarkar
Evaluation of different resource conservation technologies for planting of rice	K. K. Singh
Development of low cost multi tillage - multi crop planter for round grain cereals, legumes and pulses	K. K. Singh
Accelerating the adoption of second-generation machinery for managing the crop residue through RCTs in western U.P.	V. P. Chaudhary M. P. Singh
Resource conservation and sustaining high productivity through cropping system management and land configuration	B. Gangwar K. K. Singh
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
Carbon Sequestration Potential of Rice-Wheat Cropping System under Different Soil Management Options	S. P. Mazumdar
Evaluation of different crop residues management practices in rice-wheat cropping system	K. K. Singh
Resource Conservation Modules for high yield realization of different cropping system	V P Chaudhary K. S. Gangwar
Integrated nutrient management in transplanted rice-wheat system	V.K. Singh R.P. Mishra K. P. Tripathi
Physiological evaluation of rice and wheat genotypes under changing climatic scenario	D. Singh 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

Name of the Project	PI/Co-PI/Contributor (s)
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	Prem Singh
C. Integrated Farming Systems (IFS)	
Field crop based IFS-Models Development of integrated farming system model for small farmers of western Uttar Pradesh	J. P. Singh
Development of Dairy Based Integrated Farming System Model for Marginal Land Holders of Western Plain Zone of Uttar Pradesh under AICRP on IFS.	J. P. Singh
Development of year round production module of mushrooms for small and marginal farmers	J. P. Singh
D. Resource Characterization and System Diagnosis (RCSD)	
Characterization and evaluation of farming system in India	S. P. Singh
Digitization of database of on-station and on-farm experiments of cropping systems under AICRP on IFS	G. C. Sharma
Status of organic farming in eastern Himalayan region	Sunil Kumar
Impact of Ground Water Table on Cropping Systems Economics and Energetic in Bundelkhand region of Utter Pradesh	N. D. Shukla B. K. Sharma
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	
Evaluating production systems for attaining maximum productivity and profits under different cropping systems	V.K. Singh M.P. Singh
Site-specific nutrient management (SSNM) for a rice-maize system as affected by crop establishment and residue management	V.K. Singh
Study of Crop Pattern and Increase in Agricultural Produce due to Release of Water from Tehri Reservoir for Irrigation Purpose	V.K. Singh M.P. Singh B. Gangwar

Annexure - II

LIST OF PERSONNEL

(As on 31.03.2011)
Project Director: Dr. B. Gangwar

A. SCIENTIFIC

1. Dr. B. Gangwar, Project Director (Agronomy)
2. Dr. Kamta Prasad, Principal Scientist (Agronomy)
3. Dr. G.C. Sharma, Principal Scientist (Agri. Statistics)
4. Dr. J.P. Singh, Principal Scientist (Agronomy)
5. Dr. S.S. Pal, Principal Scientist (Soil. Fertility)
6. Dr. K.K. Singh, Principal Scientist (FMP)
7. Dr. M.P. Singh, Principal Scientist (Agril.Exten.)
8. Dr. Prem Singh, Principal Scientist (Agronomy)
9. Dr. Anil Kumar, Principal Scientist (Agril.Exten.)
10. Dr. M.P. Sharma, Principal Scientist (Soil Science)
11. Dr. S.P. Singh, Senior Scientist (Agril. Econ.)
12. Dr. N.D. Shukla, Senior Scientist (Agril. Econ.)
13. Dr. B.K. Sharma, Senior Scientist (Agril. Exten.)
14. Dr. K.P. Tripathi, Senior Scientist (Soil Science)
15. Dr. V. K. Singh, Senior Scientist (Agronomy)
16. Dr. N. Subash, Senior Scientist (Agri. Meteorology)
17. Sh. Vipin Kumar, Scientist (Sr. Scale) (Computer Applications)
18. Dr. R.P. Mishra, Scientist (Sr. Scale) (Agronomy)
19. Dr. V.P. Chaudhary, Scientist (Sr. Scale) (FMP)
20. Shri Chandra Bhanu, Scientist (Plant Pathology)
21. Dr. S.K. Kochewad, Scientist (LPM)
22. Dr. M. Shamim, Scientist (Agro. Met.)
23. Shri Sunil Kumar, Scientist (Statistics & Comp. Appl.)
24. Dr. S. P. Mazumdar, Scientist (Soil Science)
25. Dr. N. K. Jat, Scientist (Agronomy)

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, T5
18. Sh. Brijesh Sharma, T-5
19. Sh. D.K.Pandey, T-5
20. Sh. Krishan Kumar, T-5
21. Sh. Jaipal Singh, T-2
22. Sh. Uma Shankar, T-3
23. Sh. Ashok Kumar, T-2
24. Smt Anju Verma, T-2
25. Sh. Mahendra Prasad, T-1

C. ADMINISTRATIVE

1. Sh. H.S. Chauhan, AAO
2. Sh. Anil Agarwal, FAO
3. Sh. Attar Singh, P.S. to P.D.
4. Smt. Alka Jain, Assistant
5. Sh. S.K. Gupta, Assistant
6. Smt. Sheela Devi, Assistant
7. Sh. Jata Kant, UDC
8. Sh. Ravi Kant Sharma, UDC
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, LDC
15. Sh. Rajendra Kumar, LDC
16. Sh. Parmanand, LDC
17. Sh. D.C. Mishra, LDC

D. SUPPORTING

1. Shri Anand Singh
2. Shri Prem Kumar
3. Shri Rakesh Kumar
4. Shri Rajendra Singh
5. Shri Kripa Shankar Pandey
6. Shri Ayodhya Prasad Dubey
7. Shri Prem Shankar
8. Shri Mahabir Singh
9. Shri Siddh Kumar
10. Shri Harshnath