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कृषि प्रणाली अनुसंधान परियोजना निदेशालय
(भारतीय कृषि अनुसंधान परिषद)
मोदीपुरम, मेरठ–250 110, भारत

Project Directorate for Farming Systems Research
(Indian Council of Agricultural Research)
Modipuram, Meerut - 250 110, India

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PREFACE

With the view to enhance crop yields, a noble scheme started in the name of "Simple Fertilizer trials" during 1952-53 which paved the way for creation of All India Coordinated Agronomic Research Project (AICARP) during 1968-69 to coordinate agronomic research at national level. During mid-eighties it was realized that component approach of crop research is not sufficient to boost and sustain high yield levels, attained during green revolution period. Consequently, AICARP was upgraded to the level of Project Directorate on Cropping Systems Research (PDCSR) with a vision to strengthen all aspects of system based crop research at national level. Further, during the year 2009-10 PDCSR was re-named as **"Project Directorate for Farming Systems Research (PDFSR)".** At present, in addition to campus based basic and strategic research at Modipuram, the Directorate is also operating through All India Coordinated Research Project on Integrated Farming Systems with 25 main centers, 12 sub centers, 32 on-farm IFS units and 5 voluntary research centers spread throughout the country representing 15 agro-climatic zones. The Network Project on Organic Farming also remained operational since 2004-05 with its 13 Cooperating Centers spread over 12 states of the country. During the year under report, major emphasis was given for reorientation of on-going programme from cropping systems to farming system mode. The major research programmes were Cropping Systems and Resource Management, Organic Agricultural Systems, Integrated Farming Systems, Resource Characterization and Systems Diagnosis and Technology Transfer and Refinement. The major research activities are presented in this report.

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. Sikka, Deputy Director General (Natural Resource Management) and Dr. B. Mohan Kumar, Assistant Director General (Agronomy & Agro-forestry), 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 contributions are thankfully acknowledged. The scientific, technical and administrative staff of the Directorate, who has contributed at different levels in preparing this annual report, also deserves appreciation for their hard and sincere work.

Modipuram — **(B. Gangwar)**
25 May, 2013 — **Project Director**

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1. सारांश

फसल प्रणाली एवं संसाधन प्रबन्धन

जैव–सघन प्रणाली से खरीफ में विस्तृत क्यारी पर 1:1 अनुपात में मक्का (भुट्टा) + लोबिया (सब्जी) एवं कूंड़ में ढ़ैंचा और रबी में कूंड़ में सरसों एवं विस्तृत क्यारी पर मसूर की तीन पंक्तियाँ जबकि जायद में क्यारी पर मूंग की तीन पंक्तियाँ उगाया जाना, अन्य फसल प्रणालियों की अपेक्षा उल्लेखनीय रूप से बेहतर पाया गया। इसमें अधिकतम धान समतुल्य उपज 24.6 टन/हे. के साथ 67.4 कि.ग्रा. अनाज/हे./दिन उत्पादकता एवं रु. 518/हे./दिन लाभ प्राप्त हुआ। प्रणाली के पूरक प्रभाव दर्शाते हैं कि अत्यधिक वर्षा की स्थिति में नालियाँ पानी निकालने का कार्य करती हैं जिनमें खरीफ में 35 टन/हे. तक हरी खाद व रबी में 2.02 टन/हे. सरसों पैदा हुई व साथ ही 30% तक सिंचाई का पानी बचाया गया।

एक दूसरी फसल प्रणाली [मक्का + लोबिया (सब्जी)] (विस्तृत क्यारी) + ढ़ैंचा (नाली)–मटर (सब्जी) (वि.क.)+गेहूँ (ना.)–मूँग ने सर्वाधिक धान समतुल्य उपज 14.9 टन/हे. व शुद्ध लाभ रु. 94820 प्रति हे. प्रदान किया।

धान (साकेत–4) की उपज परम्परागत रोपाई (4.68 टन/हे.) की तुलना में मशीन से रोपाई में (14%), हाथ की मशीन से रोपाई (11%), शून्य जुताई (15%), पट्टी जुताई (7%), रोटरी जुताई (9%), उच्च क्यारी बुवाई (8%) और ड्रम सीडर (2%) अधिक जबकि परम्परागत बुवाई में 2% व छिड़कवाँ बुवाई में 4% कम दर्ज की गई। पारम्परिक बुवाई की तुलना में शून्य, पट्टी व रोटरी जुताई तथा उच्च क्यारी बुवाई से समय बचत (75 से 83%), डीजल बचत (65 से 86%), लागत बचत (71 से 82%), ऊर्जा बचत (65 से 86%) एवं सिंचाई जल की बचत (10 से 35%) हुई; गेहूँ की उपज 2 से 12%, शुद्ध लाभ 7 से 18%, लाभ–लागत अनुपात 9 से 14% अधिक; विशिष्ट लागत 4 से 6%, विशिष्ट ऊर्जा 16 से 21%, गुल्ली डंडा 56 से 70% व अन्य खरपतवारों में 66 से 79% की कमी प्राप्त की गई।

गेहूँ के भूसे की रीसाइक्लिंग के बाद बोये धान की उपज (5.39 टन/हे.) भूसा जलाने व निकालने की तुलना में 15 व 11% अधिक प्राप्त की गई। धान की पुवाल की रीसाइक्लिंग के बाद बोये गेहूँ की उपज (6.4 टन/हे.) पुवाल जलाने व निकालने की तुलना में 4 व 8% अधिक प्राप्त की गई।

बासमती धान की अपेक्षा गैर बासमती धान में प्रकाश संश्लेषण, वाष्पोत्सर्जन एवं कार्यिकीय विकिरण उपयोग दक्षता की दर अधिक पायी गयी। पी.बी. डब्ल्यू–226 में पुष्पगुच्छी एवं शीर्षन में सबसे कम दिन दर्ज किए गये जबकि पी.बी. डब्ल्यू–343 में, बुवाई की तारीख व नत्रजन स्तरों के बावजूद पर्णक्षेत्र सूचकांक व ऊष्मा उपयोग दक्षता अधिक पायी गयी।

पिछले 14 वर्षों से लगातार धान–गेहूँ चक्र में धान में एकीकृत उर्वरक प्रबन्धन व गेहूँ में सिफारिशी एन पी के द्वारा सर्वाधिक उपज एवं स्थिरता सूचकांक (धान में 0.83 एवं गेहूँ में 0.81) जबकि रासायनिक

खाद वाले प्रक्षेत्र में न्यूनतम प्राप्त हुआ। मृदा कार्बन व एकत्रीकरण जैविक प्रक्षेत्र में सर्वाधिक व रासायनिक खाद वाले प्रक्षेत्र में न्यूनतम रहे।

भूमि संसोधकों जैसे गोबर की खाद, प्रेसमड, ढ़ैंचा की हरित खाद और जिप्सम के लवणीय मृदा में एकल या संयुक्त उपयोग से मिट्टी की पोटेंशियली मिनरैलाइजेबल नाइट्रोजन (पी.यम.यन.) की मात्रा में बढ़ोतरी अंकित की गयी। पी.यम.यन. की मात्रा मृदा में ढ़ैंचा की हरी खाद का प्रयोग करने से, चाहे अकेले या किसी भूमि संसोधक के साथ, बढ़ती हुई मिली। पी.यम.यन. की मात्रा धान सरसों फसल चक्र में सबसे अधिक (15.9 कि.ग्रा. कि.ग्रा.$^{-1}$) दर्ज कीगयी। 24% अधिक नाइट्रोजन का उपयोग लवणीय मृदा में करने पर फसल पैदावार प्रभावित नहीं होती है।

50% सान्द्रता वाले औद्योगिक तरल उत्प्रवाह से गन्ने की फसल में सिंचाई करने पर फसल के वृद्धि मापदंडों जैसे लम्बाई, मोटाई, वजन उपयोगी तनों की संख्या तथा उपज में काफी वृद्धि हुई। इन वृद्धि मापदंडों में काफी वृद्धि उच्चीकृत क्यारी विधि से सिंचाई करने पर मिली। मिट्टी में डीटीपीए लौह, कापर, जिंक और मैंगनीज की मात्रा में तरल उत्प्रवाह से सिंचाई करने पर, वृद्धि हुई थी। लगभग 50% सान्द्रता के तरल उत्प्रवाह से सिंचित मिट्टी में गन्ने की फसल अवशेष की विघटन प्रक्रिया तीव्र पायी गयी।

जैविक कृषि प्रणाली

सन् 2011–2012 रबी सत्र में गेहूँ की सर्वोत्तम उपज (6.03 टन/हैक्टेयर) ऐसे उपचार से हुई, जिसमें एस.आर.आई. विधि द्वारा धान की फसल लगायी गयी थी। इस उपचार के उपरान्त गेहूँ की पैदावार 26 प्रतिशत अधिक पायी गयी। परन्तु एफ. आई.आर.बी. विधि द्वारा गेहूँ की बुआई करने से पैदावार 4.6 टन प्रति हैक्टेयर पायी गयी जो कि गेहूँ का चिराचित (Conventional) प्रथा से बुआई की तुलना में 35 प्रतिशत अधिक पैदावार मिली। एस.आर.आई. विधि द्वारा सम्पन्न किये गये मूल प्रक्षेत्र में जीवांश तथा सूक्ष्म जीव से उद्यभुत जीवांश (MBC) की मात्रा सर्वोत्तम पायी गयी। परन्तु हैप्पी सीडर विधि द्वारा बुआई किये गये उप–प्रक्षेत्र में इन दोनों जीवांश के प्रारूपों में सर्वोत्तम मात्रा का अवलोकन किया गया। मृदा में सूक्ष्म जीव जीवाणु, कवक तथा एक्टीनोमाइसीट्स आदि की संख्या में वृद्धि पायी गयी।

ग्रीष्म कालीन सत्र 2012 में प्याज का सर्वोत्तम उत्पादन ऐसे उपचार से हुआ जिसमें नीम की खली, केंचुए की खाद तथा गोबर की खाद का सम्मिलित रूप, जो कि पौधे के लिए संस्तुत नाइट्रोजन मात्रा का एक तिहाई हिसाब से दिया गया, साथ ही साथ जैविक विधि से खरपतवार, कीट पतंग एवं रोग आदि का उपचार किया गया था। विभिन्न जैविक विधि से प्याज की पैदावार में रासायनिक विधि की तुलना में चार से साढे बारह प्रतिशत की वृद्धि दर्शायी गयी। मक्का की सर्वोत्तम पैदावार (6.35 टन प्रति हैक्टेयर) खरीफ सत्र में ऐसे उपचार से पायी गयी जहाँ पूर्व वर्णित जैविक वस्तुओं के साथ नाइट्रोजन एवं फास्फोरस वर्ग के जैविक उर्वरक का इस्तेमाल किया गया था। परन्तु सम्पूर्ण फसल प्रणाली में मक्का की समतुल्य उपज (31.04 टन प्रति हैक्टेयर) केवल

जैविक उर्वरकों के सम्मिलित रूप से पायी गयी। जैविक विधि से फसल लेने पर प्रक्षेत्र में जीवांश, सूक्ष्म जीवों से उद्धभुत जीवांश (MBC) तथा अन्य सुलभ पोषक तत्वों की उपलब्धता में वृद्धि पायी गयी है।

एकीकृत कृषि प्रणाली (आई.एफ.एस.)

पिछले छः वर्षों के मूल्यांकन के आधार पर यह निष्कर्ष निकला कि यदि फार्म के सभी बेकार उत्पादों, फसल अवशेषों, पशु गोबर एवं मूत्र आदि के साथ–साथ हरी खाद व जैविक खादों को प्रयोग कर लें तो उर्वरकों के खर्च में 30 प्रतिशत से भी अधिक बचत की जा सकती है; यह भी पाया गया कि समन्वित कृषि प्रणाली विधि अपनाकर खेती उत्पादन खर्च को साठ प्रतिशत तक कम करना भी संभव होता है; समन्वित कृषि प्रणाली विधि में विविधिकरण के फलस्वरूप न केवल परिवार की भोजन व चारे की आवश्यकताओं को पूरा करना संभव हो पाया बल्कि पोषनता में सुधार के साथ–साथ वर्ष के सभी महीनों में लगातार खर्च से अधिक आमदनी सुनिश्चित हो सकी; समन्वित कृषि पद्धति परियोजना मोदीपुरम के वर्तमान वर्ष के परिणामों के अनुसार इस वर्ष के सकल एवं शुद्ध लाभ को देखने से पता चला कि अकेले फसल उत्पादन की अपेक्षा समन्वित खेती जिसमें विविधिकरण प्रक्रिया अपनाई गई, सकल एवं शुद्ध लाभ में 210% एवं 159% क्रमशः वृद्धि हुई; प्रचलित खेती विधि फसलें व पशु पालन की अपेक्षा समन्वित किये गये अतिरिक्त व्यवसायों बागवानी, मछली पालन, मशरुम व वर्मिकम्पोस्ट से प्रति रूपया खर्च से अधिक आमदनी प्राप्त हुई।

इस परियोजना के तहत पश्चिमी उत्तर प्रदेश के छोटे और सीमांत किसानों के पोषण सुरक्षा बढ़ाने हेतु तीन विभिन्न मॉड्यूल यथा फल आधारित (0.3 हे.), सब्जी आधारित फसलों (0.22 हे.) और क्षेत्र फसल आधारित (0.4 हे.) का अध्ययन किया गया। मूल्यांकन से सब्जी आधारित प्रणाली उत्पादकता और लाभप्रदता के मामले में सबसे अधिक प्रभावी साबित (Rs. 249957/हे. सकल वापसी) पायी गयी। फल फसल आधारित प्रणाली से Rs. 80172/हे. सकल वापसी) और फसल आधारित प्रणाली से Rs. 68717/हे. पाया गया।

संसाधन अभिलक्षण एवं प्रणाली निदान

पूर्वी हिमालय क्षेत्र में मिजोरम राज्य का सर्वेक्षण इस क्षेत्र में जैविक खेती की स्थिति के अध्ययन के लिए गया गया। सर्वेक्षण के लिए मामीत, आईजोल एवं कोलासिब जिलों को चुना गया। बहु–स्तरीय स्तरीकृत याद्रच्छिक नमूना पद्धति द्वारा प्रत्येक जिले से 80 किसानों का साक्षात्कार कर निर्धारित प्रोफार्मा से आंकड़े दर्ज किए गए। मामीत, आईजोल एवं कोलासिब जिलों में किसान क्रमशः 80 प्रतिशत जैविक खेती व 20 प्रतिशत अजैविक खेती करते हैं। धान राज्य की मुख्य फसल है जिसकी उत्पादकता मामीत, आईजोल एवं कोलासिब जिलों में लगभग 1.3 टन प्रति हैक्टेयर ऑकी गई। अदरक सभी जिलों में सबसे अधिक लाभकारी फसल है। यहां पर उर्वरकों का प्रयोग मात्रा 27 कि.ग्रा. प्रति हैक्टयर पाया गया है। अधिकांश घरों में फसलोत्पादन के अलावा मूर्गी पालन, सुअर पालन और सब्जी उत्पादन आदि कृषि उद्यम लिए जा रहे हैं। समस्त राज्य में वर्षा

आधारित कृषि का प्रभुत्व है। कुछ किसान बैल, गाय और बकरियाँ मुख्य रूप से दूध और खाद के लिए न रखकर मांस प्रयोजन के लिए रखते हैं।

मध्य प्रदेश में संसाधन अभिलक्षणन व प्रणाली निदान खेती की संभावनाओं की खोज के लिए निदेशालय द्वारा एक सर्वेक्षण वर्ष 2011–12 में कराया गया। इस सर्वेक्षण के परिणामों से यह निष्कर्ष निकाला जा सकता है कि मध्य प्रदेश राज्य में प्रमुख कृषि प्रणाली फसल आधारित प्रणाली है, जो राज्य के विभिन्न क्षेत्रों में 23.6–84.7 प्रतिशत किसानों द्वारा की जा रही है। फसल आधारित प्रणाली से खेती से आय 32.6–75 प्रतिशत तक पाई गई। प्रायः वहां यह भी देखा गया है कि फसल आधारित प्रणाली के बाद पशुधन आधारित प्रणाली किसानों की आय में महत्वपूर्ण योगदान देती है। सामान्य रूप में फसल आधारित खेती प्रणाली जोत के आकार के साथ सहसंबद्ध पाई गई। लेकिन खेत के आकार में वृद्धि होने तथा पशुधन आधारित प्रणाली से प्राप्त आय में व्युत्क्रम संबंध पाया गया।

तकनीकी हस्तान्तरण एवं परिष्करण

जॉची परखी गई सब्जी, अनाज, बायोइनटेसिव कम्पलीमेंन्ट्री एवं दलहन से सम्बंधित 25 फसल प्रणाली तकनीकियों के प्रदर्शन लगाये गये जिसमें कि धान–आलू (कुफरी बहार)–मक्का (उच्चीकृत क्यारी)+लोबिया+ढ़ैंचा (कूंड़) से धान समतुल्य उत्पादन (23.4 टन/हे.) एवं आमदनी (रु. 402/दिन/हे.), धान (यन्त्रिक रोपण, RDF + 20%)–गेहूँ (ST, RDF + 20%)–ढ़ैंचा से धान समतुल्य उत्पादन (12.3 टन/हे.) एवं आदमनी (रु. 179/दिन/हे.), लोबिया (उच्चीकृत क्यारी) + ढ़ैंचा (कूंड़)–मसूर (उच्चीकृत क्यारी) + सरसों (कूंड़) से धान समतुल्य उत्पादन (11.0 टन/हे.) व आदमनी (रु. 222/दिन/हे.) एवं अरहर + मक्का (RB 2:1)–मसूर (RB) + गेहूँ (कूंड़) से धान समतुल्य उत्पादन (10.5 टन/हे.) एवं आमदनी (रु. 195/दिन/हे.) सबसे अधिक प्राप्त हुई।

टिहरी जिले में कृषि प्रणाली के द्वारा सुरक्षा विश्लेषण परियोजना के अन्तर्गत 20 गांव का चयन किया गया जिसके अन्तर्गत प्रत्येक गांव से 10 कृषक परिवारों को चयनित कर परियोजना के अध्ययन हेतु चयन किया गया। प्रत्येक परिवार के अध्ययन हेतु एक अनुसूची विकसित की गई जिसके अन्तर्गत सभी पहलुओं का अध्ययन करके फसल कृषि प्रणाली की कृषि उद्योगिक ईकाइयों से हो रही आमदनी में आने वाली कठिनाईयों के कारण कम उत्पादन का अध्ययन किया। कठिनाईयों के निवारण हेतु कृषि वैज्ञानिकों द्वारा सुझाई गई नवीन तकनीकियों के गेहूँ, धान, मूँग, झंगोरा एवं मडवा में उन्नत बीज, पोषक प्रबन्धन, खरपतवार नियंत्रण एवं पशुपालन के प्रदर्शन लगाये गये जिनके द्वारा कृषकों के उत्पादन में 29, 19, 68, 9, 12 एवं 15 प्रतिशत की वृद्धि हुई तथा साथ ही साथ उन्नत तकनीकियों के प्रसार हेतु तीन कृषक गोष्ठियों का भी आयोजन किया गया।

SUMMARY

Cropping Systems and Resource Management

Bio-intensive system of raising maize for cobs + vegetable cowpea in 1:1 ratio on broad beds (BB) and *sesbania* in furrows during *kharif* and mustard in furrows and 3 rows of lentil on broad beds in *rabi* while 3 rows of green gram on beds in summer produced highest REY of 24.6 t ha^{-1} with productivity of 67.4 kg grain $ha^{-1}day^{-1}$ and profitability of Rs. 518 $ha^{-1}day^{-1}$. This was reported remarkably better than other systems. The complimentary effects were reflected in the system as in broad bed and furrow (BBF) system, the furrows served as drainage channels during heavy rains in *kharif* which were utilized for in-*situ* green manuring with 35 t ha^{-1} green foliage incorporated after 45 days of sowing and timely sown mustard crop in these furrows resulted a good harvest 2.02 t ha^{-1} and a bonus yield of lentil (1.47 t ha^{-1}) could be harvested on one hand and 30% of irrigation water was saved.

Another cropping system [Maize + vegetable Cowpea] (BB) + Sesbania (F) - Veg. pea (BB) + Wheat (F) - Green gram produced maximum REY of 14.98 t ha^{-1} and net return Rs.94820 ha^{-1} which was followed by Maize (RB) + Sesbania (F) – vegetable Pea (RB) + Wheat (F) – Green gram system (13.57 t ha^{-1} and Rs. 83530 ha^{-1}).

Rice (Saket – 4) yield was higher in MT (14.1%), MaT (10.9%), ZT (14.7%), ST (6.8%), RT (8.8%), BP (8.3%) and DS (2.4%); but lower in CS (2.1%) and BS (4.5%), respectively, compared to traditional HT (4.68 t ha^{-1}). The rotary, strip and zero till drilling and bed planting saved time (75 to 83%), labour (70 to78 %), diesel (65 to 86%), cost (71 to 82%), energy (65 to 86%) and irrigation water (10 to 35%); provided higher wheat yields (2-12%), net returns (7-18%), cost effectiveness (9-14%) and energy efficiency (20-29%); required lower specific energy (16-21%) and specific cost (4-6%); and reduced *Phalaris minor* (56-79%), other weeds (66-79%), compared to conventional sowing of wheat.

The *insitu* recycling of wheat straw produced rice yield (5.39 t ha^{-1}) which was 15 and 11 per cent higher than straw retrieval and burning treatments. The net returns under straw recycling were 27 and 19 per cent higher; B: C ratio and energy output: input ratio were 8 and 6% higher, and 0.5 and 3 per cent lower; and specific cost and specific energy 8 and 6 per cent lower, and 0.2 and 3 per cent higher, respectively. The recycling of rice straw produced wheat yield (6.4 t ha^{-1}) that was 8 and 4 per cent higher than straw retrieval and burning treatments. Recycling also increased the wheat yield (8%), net returns (11%) and B: C ratio (3%), but decreased energy output: input ratio (5%) compared to straw retrieval treatment.

Yield trend based on moving average for 14 rice-wheat cycle reveals that integrated nutrient management (IPNS) in rice and recommended NPK to wheat crop had maximum yield and sustainability index (0.83 in rice and 0.81 in wheat) followed by soil test based recommendation (0.79 in rice and 0.78 in wheat) and organic farming (0.76 in rice and 0.76 in wheat). The yield under chemical fertilized plots had lowest sustainability index. Soil organic carbon content was maximum under organic farming plots followed by IPNS and least under chemical fertilized plots (0.64 % and 0.68% respectively). Similar trend was obtained for soil aggregation also.

Use of amendments such as gypsum, FYM, Press mud and green manure either in isolation or in combination led to increase in potentially mineralizable nitrogen over the saline-sodic control plots. Introduction of *Dhaincha* as green manure further increased the nitrogen mineralization potentials in saline sodic soils over and above the other inorganic amendments. Rice- mustard system showed highest potentially mineralizable nitrogen in the soil (15.9 mg kg^{-1} soil) over other cropping systems. Response of 25% excess N application was observed in all treatments as well as cropping systems.

Cane length, Cane girth, Weight per cane, mileable cane number and cane yield were significantly higher with 50% Effluents and declined thereafter under flat bed planting however, this parameter were improved with the raised bed planting over the flat bed planting. There was significant increase in the DTPA extractable Fe, Mn, Cu and Zn under both the planting methods with the use of industrial effluents irrigation. Further decomposition of sugarcane trash residue in the soil was increased up to 50% effluent application

Maximum HUE (on grain yield as well as biomass accumulation basis), was reported in Saket 4 fertilized with 150 kg/ha N transplanted on 3rd week of July, whereas, the lowest HUE and RUE were reported in PS 4 fertilized with 60 kg/ha N transplanted on 3d week of June. Higher LAI (5.7) at flowering stage was reported in PBW 342 sown at 4th week of October and fertilized with 150 kg N/ha. Lower days for phenophases viz., panicle initiation (35 DAS) and 50% flowering (86 DAS) were taken by PBW 226 fertilized with 60 Kg N ha^{-1} and sown on D_3.

Organic Agriculture Systems

Highest grain yield of (6.03 t ha^{-1}) wheat during rabi, 2011-12 was recorded under main plot which was designated for SRI method of rice cultivation compared to (4.77 t ha^{-1}) under conventional method of wheat cultivation (CWS) and the treatment effect was significant . On the contrary, the highest yield among sub-plot was (6.46 t ha^{-1}) under FIRB system which yielded 35.00 % higher than CWS. Organic carbon and MBC were highest (0.62% and 230 µg g^{-1} soil) under SRI among main plots and 0.60 % and 178.00 µg/g under happy seeder seeded wheat. Among main plots, available N was highest (312 kg ha^{-1}) under SRI method of wheat cultivation, Av. P under DSR and Av. K under SRI treatment. Among sub-plots, Av. N, P and K were highest under happy seeder seeded wheat. Highest grain yield (6.52 t ha^{-1}) of rice during *kharif* 2012 was recorded under SRI method of rice cultivation compared to (5.44 t ha^{-1}) under conventional method of rice cultivation (TPR) and the effect of treatments were significant. Organic carbon, available N and K were highest under SRI and available P was highest under DSR method of rice cultivation. Microbial population in terms of heterotrophic bacteria, total bacteria, fungi actinomycetes and N fixing bacteria are also highest under SRI atpanicle initiation stages.

Highest grain yield of onion during summer 2012 was recorded under T_4 (20.50 t ha^{-1}) which received organic nutrient sources each equivalent to 1/3 % recommended and agronomic practices for weed and pest control with 12.58 % yield increase compared to T_7. Highest grain yield of maize (6.35 t ha^{-1}) was achieved under T_6 which received T_2 + bio fertilizers containing N and P carries and 9.11 % yield increase compared to treatment T_7 but the maize equivalent yield (MEY) 31.04 t ha^{-1} was highest under T_2. Organic carbon and microbial biomass carbon were highest under T_6 at 0.66% and 375.5 µg g^{-1} soil. Av. N, P and K were highest under T_3. The total N, P and K uptake in the system was 575.6, 107.2 and 517.6 kg ha^{-1} under T_2 respectively. Irrespective of treatments, microbial population was highest under maize crop compared to onion. Further, important fact is that compared to inorganic and integrated nutrient management packages, organic nutrient management packages harbored higher microbial population in terms of bacteria, fungi, actinomycetes and phosphate solubilizing bacteria and treatment T_6 was superior to all.

Integrated Farming Systems

As per objectives of modified programmes, impact analysis of last six years results were made. Recycling of all the crop residues, farm wastes, cow dung, urine and green manuring (Sesbania and cowpea) could add about 125 kg NPK/ha/annum). Inter-relationship of outputs and inputs of different enterprises within the system indicated that out of total cost of production Rs.1,31,922/ha/annum about 60 % (Rs.79, 337) is met from the inputs (out- put of other enterprises) generated within the system itself. Income expenditure relationship showed that gross income varied from Rs.20413/month in September to Rs.88316/month in April. However, expenditures on various inputs ranged in between Rs. 12435/month in September and Rs.22859/month in July. The net returns were highest (Rs.66, 762/ month) in the month of April with a lowest value in May (Rs.5098/month). The results of the reporting year 2012 indicated that IFS approach increased gross and net returns by 210.6% and 159% as compared to crop alone. Enterprises horticulture, fishery, vermicompost and mushroom were found to give higher input: output ratio as compared to crops and dairy. Highest input: output ratio was in fishery followed by mushroom and vermicompost

Experiments were conducted at PDFSR, Modipuram to develop horticultural crop based model for improving profitability, enhanced productivity and nutritional security of small and marginal farmers particularly of western plain zone of Uttar Pradesh, in which three modules, viz. which are being studied under this project, Fruit based (CS 1, 0.3 ha), vegetable crops based (CS 2, 0.22 ha) and field crop based (CS 3, 0.4 ha) are evaluated. Among the modules, vegetable based system has been found proved most effective in terms of productivity and profitability (Gross return of Rs.249957) followed by fruit crop based system (Gross return of Rs.80172) and crop based system (Gross return of Rs.68717) respectively in the first year with adoption of recommended dose of fertilizers and other cultural practices. The lower gross return from fruit crop based system in the first year can be explained by the fact that fruit plants are in non-bearing stage and will start bearing fruits in next year. Effect of different horticulture based farming systems on soil fertility status was also studied. The results revealed that the intercropping systems were effective in bringing gradual improvement in the soil properties. Among the fruit based systems, banana based cropping systems and turmeric throughout the year followed by mango based cropping system resulted in the most improvement in organic carbon and available N in the soil as compared to other systems. The nutrient status of soil indicated that the system where guava is included in cropping system recorded greatest available potassium (K) content.

Resource Characterization and Systems Diagnosis

Study revealed that on mean data basis 80% farmer are practicing organic agriculture while 20% are following inorganic agriculture in Mizoram. The productivity of rice was recorded 12.8 q/ha for organic cultivators as against 20.8 t/ha for inorganic producers. Declining trend in rice productivity was noted in case of organic growers while increasing yield trend was observed for inorganic farmers. On an average 7.3 animal which includes cow, goat, poultry and pigs was noted to be kept by each sample household. The average use of fertilizer was recorded 27 kg/ha by inorganic producers. The organic materials namely FYM, compost and vermi compost was recorded to use by organic growers. Non availability of sufficient organic manure and non awareness of organic farming was observed among major constraints. The study concluded bright prospect of organic agriculture in the state if the sufficient organic manure is produce by farming community.

The Directorate undertook the farming system characterization work in Madhya Pradesh during 2011-12. In the light of the study results, it can be inferred that the most dominant cropping system in the state of Madhya Pradesh is the cereal-based system which is being practiced by the farmers (23.6% –84.7%) in different zones of the state. The cereal-based system has significant contribution to farm income ranging from 32.65 percent to 75 percent. Crop-based farming systems in general are positively correlated with the size of land holding. Another interesting finding is that there is an inverse relationship between farm size and livestock-based system. As the farm size increase, the share of livestock-based farming and its contribution to farm income declines. The most dominant cropping system in the state of Madhya Pradesh is the cereal-based system Majority of the farmers (23.6% –84.7%) practiced the cereal-based farming system in different zones of the state. The contribution of cereal-based farming system to farm income ranges from 32.65 percent to 75 percent, followed by livestock-based farming system. Another interesting finding is that there is an inverse relationship between farm size and livestock-based system. It implies that livestock-based farming system is major source of income for marginal and small farmers in the state.

Technology Transfer and Refinement

The highest rice equivalent yield (t/ha) as well as highest income per day was obtained from Rice – potato (K. Bahar)-[Maize +Cowpea] (BB) +Sesbania (F) (23.4) whereas, the lowest REY and income per day was reported in Rice – mustard - Maize (FB) (9.8) under vegetable based cropping systems. Among cereal based cropping systems, Rice (MT, RDF+20%)-Wheat (ST,RDF+20%)– Sesbania stood first in terms of REY (12.3 t ha^{-1}) as well as income (Rs.179 day^{-1} ha^{-1}) whereas, the lowest REY (10 t ha^{-1}) and net income (Rs. 122 day^{-1} ha^{-1}) was obtained from Rice (SRI+RDF) – Wheat (Conv.+RDF) – Sesbania. Under pulses based cropping systems, the highest REY (10.5 t ha^{-1}) and 1.3 times higher net income per day over the lowest performer (Pigeon pea single row (raised bed)-Wheat (LS)) was reported in Pigeon pea +Maize(RB) 2:1 - Lentil (RB)+ Wheat (F).

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 constraint analysis under different agro-ecological regions/ farming situations.
- Farming/ cropping systems analysis.
- Efficient sources of fertilizers for different crops and soil types.
- INM in different farming/cropping systems.
- Effect of long term INM and chemical fertilizer use on crop yields and soil fertility.
- Options for introducing legumes in cereal-cereal cropping systems.
- Resource conservation technologies.
- Farm mechanization and crop residue management.
- Climate resilient agriculture.
- Organic farming.
- Precision farming.
- Integrated farming systems.
- On-farm evaluation and refinement of cropping systems technologies.
- Cropping/ farming systems related database management
- Human Resource Development related to Cropping/Farming Systems Research

During 2012-13, 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. ***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.

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 mandate of the PDFSR is given as below:

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

4. LOCATION

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

5. SOILS AND CLIMATE

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

The important weather parameters during 2012-13 are depicted in Figs 1-4. Rainfall recorded at Modipuram during the year under report was almost 3/4th (638.0 mm) of the normal rain. This was

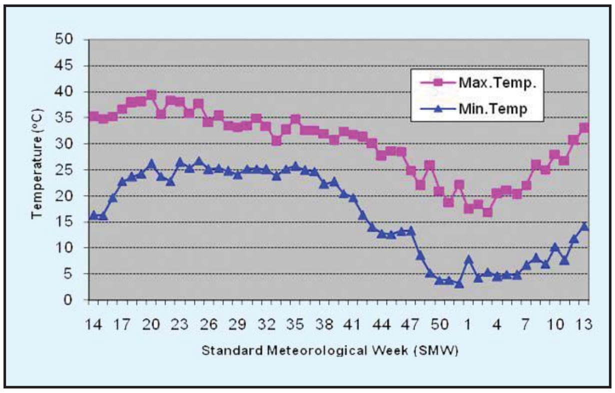


Fig 5/1: Weekly maximum and minimum temperature during crop season

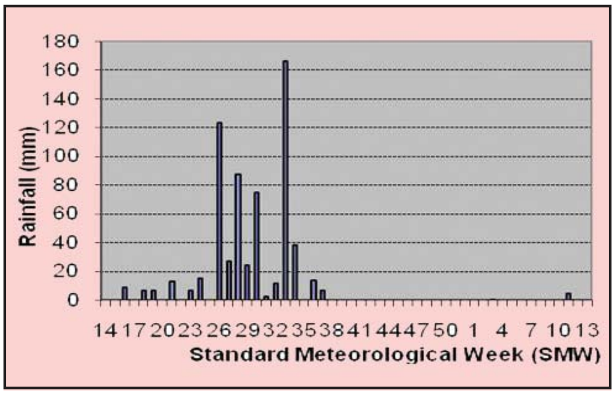


Fig 5/2: Weekly rainfall during crop season

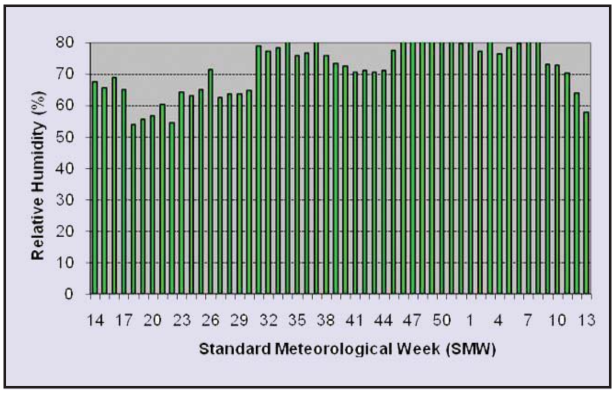


Fig 5/3: Weekly average relative humidity during crop season

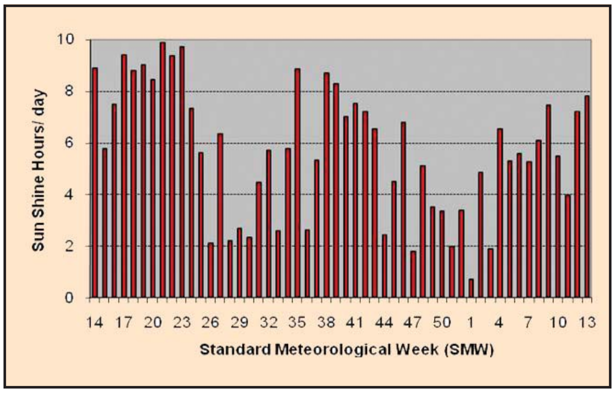


Fig 5/4: Weekly average bright sunshine hours during crop season

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

6. PERSONNEL

6.1 STRENGTH

Table 6.1 : Staff position as on 31-03-2013

Category	Sanctioned	Filled
RMP	01	01
Scientific	38	29
Technical	25	25
Administrative	16	18**
Supportive	10	10
Total	**90**	**83**

**As per new cadre strength after re-struturing of administrative strength, two posts of P.A. are in excess.

6.2 NEW APPOINTMENTS/JOININGS

Mr. Sanjeev Kumar, Scientist (Agronomy) has joined on 09.10.2012.

Mr. Chethan Kumar G., Scientist (Soil Science) has joined on 09.10.2012.

Shri. Sushil Kumar Singh Joined as Sr. A. O. on 14.05.2012.

6.3 PROMOTIONS

Dr. K. P. Tripathi promoted to the post of Principal Scientist (Soil Science) retrospectively from 01.01.2010.

Dr. V. P. Choudhary promoted to Senior Scientist (Farm Machinery & Power) retrospectively from 16-08-2010.

Shri. Umashankar, driver promoted from 29.06.2011

Shri Ashok Kumar, driver promoted from 29.06.2008

Shri. Mahendra Tripathi, driver promoted from 06.11.2011

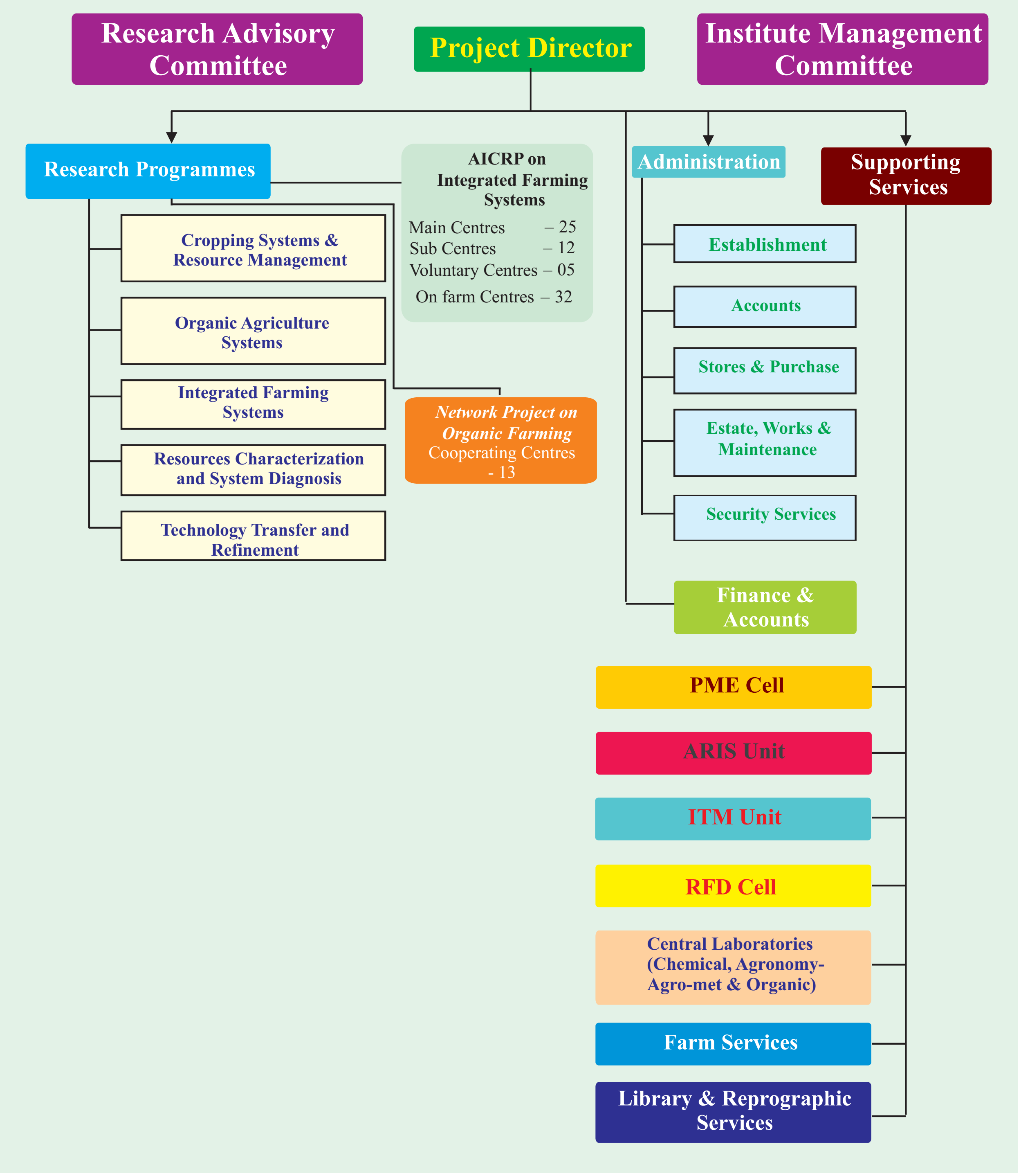
6.4 TRANSFERS

Dr. S. P. Singh, Principal Scientist (Agri. Econ.) relieved on 05.09.2012 to join the post of Director Extension at NDUA&T, Faizabad

Dr. (Mrs.) Sonali Paul Mazumdar, Scientist (Soil Science) transferred to Central Research Institute for Jute and Allied Fibres, Barrackpore on 22.09.2012.

Dr. M. P. Sharma, Principal Scientist (Soil Science) relieved on 05.06.2012.

7. ORGANIZATIONAL STRUCTURE



8. BUDGET

Statement for Review of Expenditure for the period ending 31-Mar-13

Rs. in Lakhs

	Non Plan			Plan		
	Budget	**Remittance**	**Utilization**	**Budget**	**Remittance**	**Utilization**
Grants in Aid - Capital						
Works						
A.1 Land	0.00	0.00	0.00	0.00	0.00	0.00
B.1 Office Buildings	0.00	0.00	0.00	0.00	0.00	0.00
B.2 Residential Buildings	0.00	0.00	0.00	0.00	0.00	0.00
B.3 Other works	0.00	0.00	0.00	0.00	0.00	0.00
Total: Works	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Other Capital Expenditure						
C. Equipments	7.00	7.00	6.98	19.00	19.00	17.41
D, Information Technology	0.00	0.00	0.00	3.00	3.00	2.38
E. Library Books and Journals	0.00	0.00	0.00	32.00	32.00	33.63
F. Vehicles and Vessels	0.00	0.00	0.00	0.00	0.00	0.00
G. Livestock	0.00	0.00	0.00	0.00	0.00	0.00
H. Furniture & fixtures	2.00	2.00	1.99	3.00	3.00	3.00
I. Others	0.00	0.00	0.00	0.00	0.00	0.00
Total: Other Capital Expenditure	**9.00**	**9.00**	**8.97**	**57.00**	**57.00**	**56.41**
Total Grants in Aid - Capital	**9.00**	**9.00**	**8.97**	**57.00**	**57.00**	**56.41**
Grants in Aid - Salaries						
Establishment Expenses						
A.1 Establishment Charges	590.00	586.20	582.85	0.00	0.00	0.00
A.2 Wages	40.00	40.00	38.92	0.00	0.00	0.00
A.3 Overtime Allowance	0.20	0.20	0.20	0.00	0.00	0.00
Total: Establishment Expenses	**630.20**	**626.40**	**621.96**	**0.00**	**0.00**	**0.00**
Loans and Advances						
	0.00	0.00	0.00	0.00	0.00	0.00
Total: Loans and Advances	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Grants in Aid - Salaries	**630.20**	**626.40**	**621.96**	**0.00**	**0.00**	**0.00**
Grants in Aid - General						
Pension and Retirement Benefits						
A. Pension & Other Retirement Benefits	18.00	17.00	16.79	0.00	0.00	0.00
Total: Pension and Retirement Benefits	**18.00**	**17.00**	**16.79**	**0.00**	**0.00**	**0.00**

	Non Plan			Plan		
	Budget	Remittance	Utilization	Budget	Remittance	Utilization
Travelling Allowances						
A. Domestic TA / Transfer TA	4.00	4.00	2.28	8.00	8.00	8.00
B. Foreign TA	0.00	0.00	0.00	0.00	0.00	0.00
Total: Travelling Allowances	**4.00**	**4.00**	**2.28**	**8.00**	**8.00**	**8.00**
Research and Operational Expenses						
A. Research Expenses	7.00	9.00	6.95	5.00	10.00	5.20
B. Operational Expenses	9.00	7.00	9.05	20.00	15.00	19.80
Total: Research and Operational Expenses	**16.00**	**16.00**	**16.00**	**25.00**	**25.00**	**25.00**
Administrative Expenses						
A. Infrastructure	15.80	18.00	15.78	16.00	16.00	14.32
B. Communication	2.70	2.00	2.73	0.00	0.00	0.04
C.1 Repairs/Maintenance - Equipments,Vehicles & Others	4.00	3.00	4.00	3.00	3.00	4.99
C.2 Repairs/Maintenance - Office building	0.00	5.00	0.00	1.00	1.00	1.66
C.3 Repairs/Maintenance - Residential building	0.40	3.00	0.41	0.00	0.00	0.67
C.4 Repairs/Maintenance - Minor Works	0.05	1.00	0.02	0.00	0.00	0.00
D. Others (excluding TA)	15.75	6.00	15.76	17.40	17.40	15.73
Total: Administrative Expenses	**38.70**	**38.00**	**38.70**	**37.40**	**37.40**	**37.40**
Miscellaneous Expenses						
A. HRD	1.70	1.50	1.71	1.60	1.60	1.95
B. Other Items (Fellowships, Scholarships etc.)	0.00	0.00	0.00	0.00	0.00	0.00
C. Publicity & Exhibitions	0.00	0.00	0.00	0.00	0.00	0.00
D. Guest House – Maintenance	0.40	1.00	0.39	0.00	0.00	0.19
E. Other Miscellaneous	0.00	0.30	0.00	1.00	1.00	0.46
Total: Miscellaneous Expenses	**2.10**	**2.80**	**2.10**	**2.60**	**2.60**	**2.60**
Loans and Advances						
	0.00	0.00	0.00	0.00	0.00	0.00
Total: Loans and Advances	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Grants in Aid - General	**78.80**	**77.80**	**75.87**	**73.00**	**73.00**	**73.00**
B. Loans and Advances	0.00	0.00	6.00	0.00	0.00	0.00
Total: Loans and Advances	**0.00**	**0.00**	**6.00**	**0.00**	**0.00**	**0.00**
Total Loans and Advances	**0.00**	**0.00**	**6.00**	**0.00**	**0.00**	**0.00**
Grand Total : Capital + Revenue (Salaries)	**718.00**	**713.20**	**712.80**	**130.00**	**130.00**	**129.41**

9. Research Achievements

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

9.1 CROPPING SYSTEMS AND RESOURCE MANAGEMENT (CSRM)

A. Alternative Cropping Systems

i. Bio-intensive complementary cropping systems for high productivity and profitability

Ten bio-intensive complimentary cropping systems (Table 9.1.1) were evaluated for higher productivity and profitability. The effect of these systems on Rice equivalent productivity, net returns, per day productivity and per day profitability are presented in Figs. 9.1.1 to 9.1.4.

The results revealed that the bio-intensive system of raising maize for cobs + vegetable cowpea in 1:1 ratio on broad beds (BB) and *sesbania* in furrows during *kharif* and mustard in furrows and 3 rows of lentil on broad beds in *rabi* while 3 rows of green gram on beds in summer produced highest REY of 24.6 t ha^{-1} with productivity of 67.4 kg grain $ha^{-1}day^{-1}$ and profitability of Rs. 518 $ha^{-1}day^{-1}$ and was remarkably better than other systems.

The complimentary effects were reflected in the system as in broad bed and furrow (BBF) system, the furrows served as drainage channels during heavy rains in *kharif* which were utilized for in-*situ* green manuring with 35 t ha^{-1} green foliage incorporated after 45 days of sowing and timely sown mustard crop in these furrows resulted a good harvest 2.02 t ha^{-1} and a bonus yield of lentil (1.47 t ha^{-1}) could be harvested on one hand and 30% of irrigation water was saved. In the summer season green gram could yield 1.25 t ha^{-1} as grain while incorporation of green

Table 9.1.1. Bio-intensive complimentary cropping systems and abbreviations used

Bio-intensive complimentary cropping systems	Abbreviations
Rice-Wheat	R-W
Hy. Rice-Lentil (B)+Wheat (FIRB)-COWPEA (V+R)	HY R-L(B)+W(RB)-CP
MAIZE(C) + VEG. COWPEA (BB) + SESBANIA (F) – LENTIL (BB) + MUSTARD (F) - GREEN GRAM (MT) (G+R)	MA(C)+V. CP(BB)+SE(F)-L(BB)+ M(F)-GG
MAIZE (G) + BLACK GRAM (1:1) –MUSTARD + VEG. PEA (FIRB) - GREEN GRAM (G+R)	MA(G)+BG(1:1)-M+V. P(RB)-GG
MAIZE (C) + SESBANIA – TORIA + G. SARSON (TPT) - GREENGRAM (ZT)(G+R)	MA(C)+SE-TO+G. SAR(TPT)-GG
SORGHUM + CLUSTER BEAN (f) –MAIZE (C) + BLACK GRAM (1:1) – METHI- COWPEA (V+R)	SO+C BN (f)-MA(C)+BG(1:1)-METHI - CP
PIGEONPEA + BLACK GRAM (1:1) –WHEAT + MUSTARD (6:1) (ZT) - COWPEA (f) (ZT)	PP+BG(1:1)-W+M(6:1)-CP(f)
PIGEONPEA-WHEAT+METHI (6:1)(ZT)-COWPEA (f)(ZT)	PP-W+METHI(6:1)(ZT)-CP(f)
MAIZE + COWPEA (f) - MAIZE (G) + BLACK GRAM – WHEAT + METHI (6:1) - GREEN GRAM (G + R)	MA+CP(f)-MA(G)+BG- W+METHI(6:1)-GG
SORGHUM (G) + COWPEA (V) - OAT (F) –PEARLMILLET (f) + CLUSTER BEAN (V)	SO(G)+CP(V)-OAT(F)-PM(f)+C BN(V)

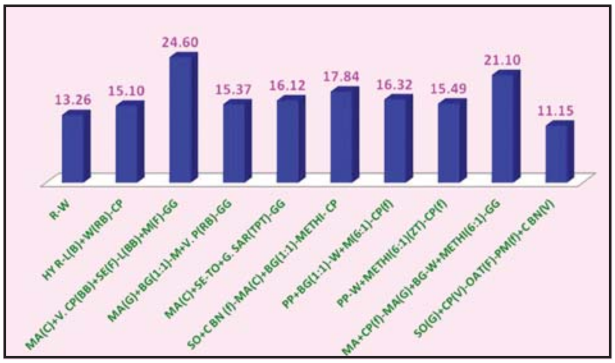


Fig. 9.1.1. Effect of bio-intensive cropping systems on Rice Equivalent Yield (t/ha)

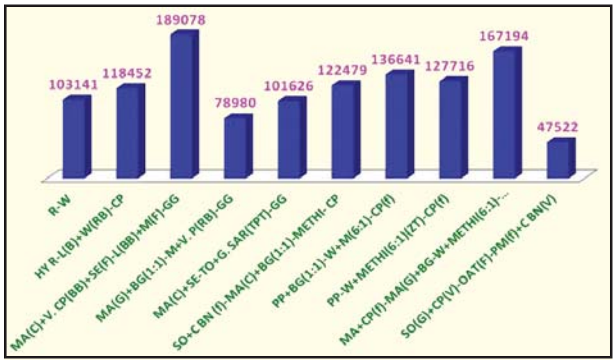


Fig. 9.1.2. Effect of bio-intensive cropping systems on Net returns (Rs/ha)

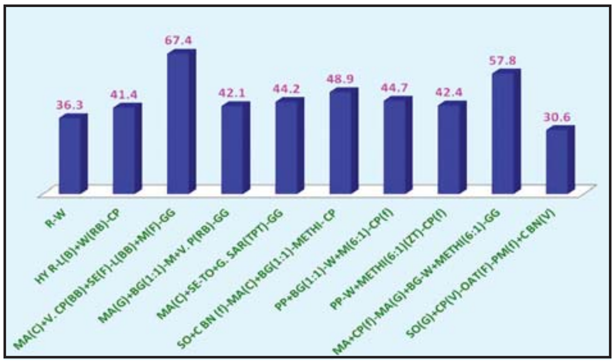


Fig. 9.1.3. Effect of bio-intensive cropping systems on Rice Equivalent Productivity (kg/ha/day)

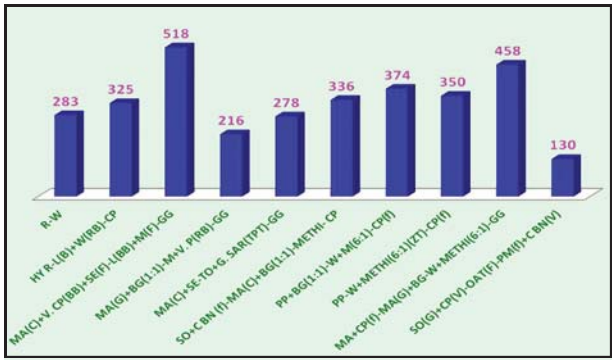


Fig. 9.1.4. Effect of bio-intensive cropping systems on Profitability (Rs/ha/day)

foliage of about 4 t ha^{-1} in the soil further helped the system favourably. Bio-intensive System of raising [Maize + Cowpea] (f) - Maize(C) + Blackgram-Wheat + Methi (6:1) – Green gram (G+R) was second best which resulted in REY of 21.1 t ha^{-1} with productivity of 57.8 kg grain ha^{-1}day^{-1} and profitability of Rs. 458 ha^{-1} day^{-1}.

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

The micro meteorological parameters viz., vertical profile of temperature and relative humidity and PAR at the top of the canopy and its interception by the crops for *rabi* 2011-12 and *kharif* 2012 were monitored during 60 DAS and 90 DAS at 11 am. The bio- intensification modified the micro meteorological parameters significantly.

It was found that 0.4 to 1.2 °C higher in air temperature between at 5 cm and top of the crop canopy during 60 DAS while it was 0.7 to 1.7 °C during 90 DAS. The bio-intensification modified the thermal regime significantly at 5 cm compared to conventional wheat. The Veg Pea(B)+Wheat(F) modified the thermal air regime of the order of 4.2 & 3.3 °C, respectively in Veg Pea(B) and Wheat(F) compared to conventional wheat. The relative humidity profile also modified significantly by the bio-intensification of crops. The relative humidity varied in wheat (F) of the order of 6 to 24 % in different combination of crops compared to conventional wheat at 5 cm. It is found that percentage PAR intercepted by crops under different bio-intensification also varies significantly compared to conventional wheat due to different canopy stature and characteristics. It varies from 24 % in Veg. pea (B) to 74 % in Mustard(F) (Table 9.1.2).

Table 9.1.2.Micro meteorological variations under different bio-intensification combinations during *rabi* 2011-12

Treatments	Crops	Temperature (°C)				Relative Humidity (%)				Photo synthetically active radiation (PAR)(w/m²)			
		60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		90 DAS	
		5 cm	Top	5 cm	Top	5 cm	Top	5 cm	Top	5 cm	Top	5 cm	Top
Wheat	Wheat	18.0	19.0	23.0	23.5	81.5	73.4	54.4	48.3	23.6	58.9	16.5	54.6
Mustard+	Mustard	18.2	19.2	22.0	21.3	88.8	80.3	49.8	50.4	15.6	60.3	25.3	65.6
Lentil(B)+	Lentil	18.2	18.6	22.0	20.3	65.8	56.3	49.8	50.4	15.6	36.6	25.3	45.6
Wheat(F)	Wheat	19.1	19.9	22.0	23.0	76.9	66.8	60.8	54.4	21.6	69.8	23.6	60.2
Barley(B)+	Barley	19.6	20.4	20.4	23.1	77.2	71.2	59.5	40.8	18.5	54.6	12.3	65.3
Mustard(F)	Mustard	19.2	19.9	23.1	24.1	76.1	66.8	57.2	48.4	15.6	60.3	25.3	65.6
Methi(B)+	Methi	20.4	21.0	24.2	25.1	67.2	59.4	38.1	31.4	25.6	48.6	23.6	65.3
Mustard(F)	Mustard	19.5	20.2	23.2	23.9	73.8	64.7	56.6	49.4	25.6	68.6	23.6	79.6
Lentil(B)+	Lentil	20.6	21.5	23.2	24.1	65.8	56.3	40.3	33.2	21.6	45.6	23.6	24.6
Wheat(F)	Wheat	19.2	20.4	23.5	24.3	76.1	63.3	54.9	47.4	21.6	69.8	23.6	60.2
Lentil(B)+	Lentil	20.2	20.8	21.6	22.5	68.6	60.7	48.7	40.6	15.6	36.6	25.3	45.6
Mustard(F)	Mustard	20.6	21.4	21.7	22.0	65.8	56.9	66.0	60.4	15.6	60.3	25.3	65.6
Veg Pea (B)+	Veg Pea	22.2	22.7	20.3	21.0	55.6	49.3	56.4	48.6	35.6	46.8	13.6	35.2
Wheat(F)	Wheat	21.3	22.2	20.4	21.5	61.2	52.1	75.2	63.6	35.6	70.6	13.6	59.6
Chickpea(B)+	Chickpea	20.1	20.6	21.2	22.3	69.3	62.0	51.0	41.6	19.6	35.6	10.3	25.3
Mustard(F)	Mustard	19.1	20.0	22.6	23.0	76.9	66.1	60.2	54.4	19.6	70.2	10.3	60.3
Lentil(B)+	Lentil	20.1	20.8	21.1	22.5	69.3	60.7	51.5	40.6	21.6	45.6	23.6	24.6
Wheat(F)	Wheat	19.1	20.0	22.5	22.9	76.9	60.1	60.8	55.0	21.6	69.8	23.6	60.2

Table 9.1.3.Micro meteorological variations under different bio-intensification combinations during *kharif* 2012

Treatments	Crops	Temperature (°C)				Relative Humidity (%)				Photo synthetically active radiation (PAR)(w/m^2)			
		60 DAS		75 DAS		60 DAS		75 DAS		60 DAS		75 DAS	
		5 cm	Top	5 cm	Top	5 cm	Top	5 cm	Top	5 cm	Top	5 cm	Top
Rice	Rice	32.0	33.0	30.0	31.0	62.0	59.9	48.7	61.3	38.6	85.6	41.3	85.2
Maize(C)+	Maize	36.0	37.0	33.0	34.0	49.5	48.0	80.2	57.9	17.2	105.6	17.2	115.6
Cowpea(BB)	Cowpea	36.0	37.0	33.0	34.0	49.5	48.0	80.2	57.9	17.2	68.9	17.2	95.3
H. Rice	H. Rice	32.0	33.0	31.0	31.5	70.6	68.2	73.2	66.0	25.3	100.4	32.8	102.4
Maize(C)	Maize	33.0	33.8	33.0	34.5	68.2	67.0	80.2	53.2	56.7	109.6	49.4	114.2
Maize(G)+	Maize	34.0	34.9	35.0	36.5	60.5	59.0	69.2	45.3	45.6	99.6	38.9	98.5
B.gram	B.gram	34.0	34.2	35.0	34.7	60.5	59.0	69.2	45.3	45.6	87.6	38.9	66.5
Sorghum+	Sorghum	35.0	36.0	35.5	36.5	53.5	51.9	51.5	40.2	45.8	110.3	35.6	109.5
C.bean(F)	C.bean	35.0	35.7	35.5	35.8	53.5	51.9	51.5	40.2	45.8	89.9	35.6	114.5
Maize +	Maize	33.0	34.0	33.0	34.0	65.4	63.2	52.0	47.8	17.2	105.6	17.2	115.6
C.pea (F)	Cowpea	33.0	34.0	33.0	34.0	65.4	63.2	52.0	47.8	17.2	68.9	17.2	95.3
P.pea +	P.pea	34.5	35.5	34.0	35.0	58.8	56.4	47.8	44.0	35.6	89.5	25.0	68.9
B.Gram	B.Gram	34.5	35.0	34.0	35.9	58.8	56.4	47.8	44.0	45.6	87.6	38.9	66.5
P.pea	P.pea	33.5	34.5	33.0	34.0	62.9	60.8	62.6	47.1	35.6	89.5	25.0	68.9
Sorghum(G)+	Sorghum	35.5	36.5	35.5	36.5	56.4	54.6	51.6	40.3	18.5	105.6	25.0	104.3
C.Pea(V)	C.Pea	35.5	36.5	35.5	36.5	56.4	54.6	51.6	40.3	18.5	68.9	18.9	70.2

There is 0.2 to 1 °C higher in air temperature between 5 cm and top of the crop canopy in 60 DAS while it was 0.3 to 1.9 °C in 90 DAS during *kharif* 2012 under different bio-intensification treatment combinations. The bio-intensification of crops modified the thermal regime at 5 cm height compared sole crop because of the higher LAI of the combined crop. The PAR interception at different combinations showed that there is 48 % to 84 % intercepted in different treatments compared to the top of the canopy.

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

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

1. Flat bed system

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

2. FIRB system

kharif	*rabi*	**summer**
Ma (B) + Se (F)	VP (B) + W (F)	GG (G+R)
GG (B) + R (F)	W (F) + L (B)	GG (G+R)
Sf (B) + Se (F)	L (B) + M (F)	GG (G+R)
PP (B) + Se (F)	W + M (5:1)	Fallow

3. BBF system

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

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

The effect of land configuration and cropping systems on Rice Equivalent Yield, net returns, rice equivalent productivity, profitability, water use and saving in irrigation water, respectively, are presented in Figures 9.1.5 to 9.1.10.

During kharif, [Pigeon pea + Black gram] (BB) + sesbania (F) system produced maximum rice equivalent yield, REY (6.81 t/ha) followed by [Maize + vegetable Cowpea] (BB) + sesbania (F) system (6.35 t/ha) and Pigeon pea (RB) + sesbania (F) system (6.06 t/ha) while Sorghum (f) (FB) produced lowest REY (3.18 t/ha). During rabi, Vegetable pea (BB) + Wheat (F) system produced maximum wheat equivalent yield, REY (7.93 t/ha) followed by Lentil (BB) + Wheat (F) (7.62 t/ha) and Lentil (BB) + Mustard (F) (7.51 t/ha) while vegetable pea (FB) produced lowest REY (5.42 t/ha). During summer, yield of Green gram after Lentil (RB) + Wheat (F) was maximum 1.07 t/ha.

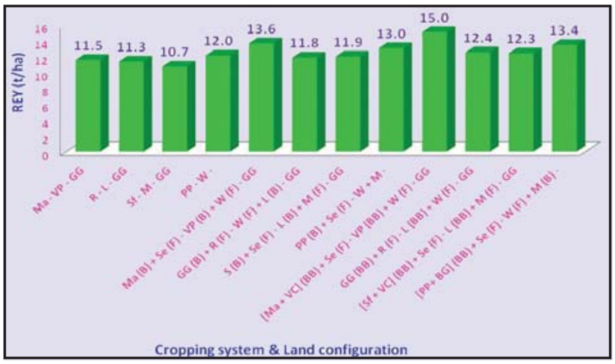


Fig. 9.1.5. Effect of land configuration and cropping systems on Rice Equivalent Yield

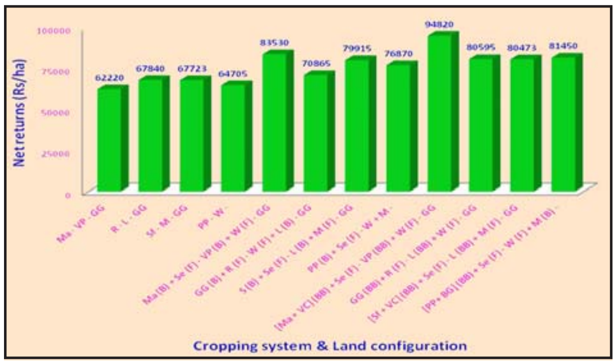


Fig. 9.1.6. Effect of land configuration and cropping systems on Net returns

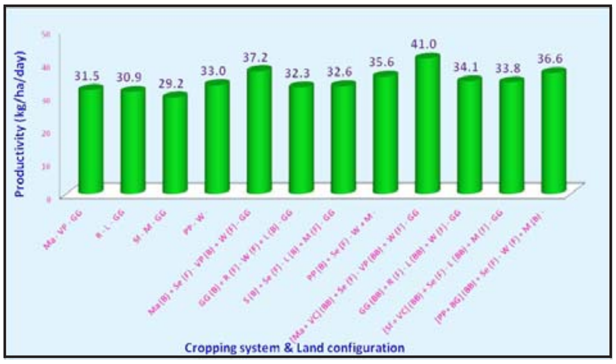


Fig. 9.1.7. Effect of land configuration and cropping systems on Rice Equivalent Productivity

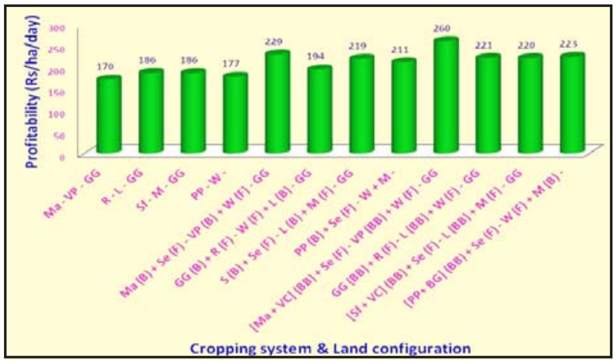


Fig. 9.1.8. Effect of land configuration and cropping systems on Profitability

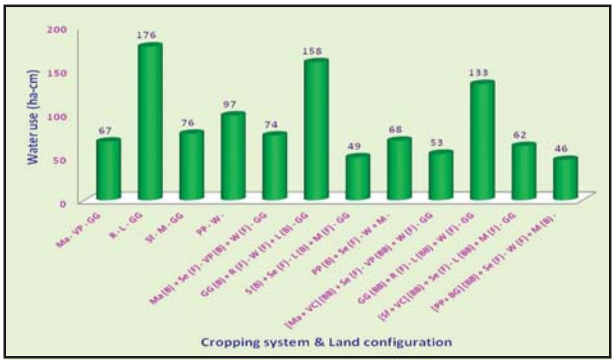


Fig. 9.1.9 . Effect of land configuration and cropping systems on water use

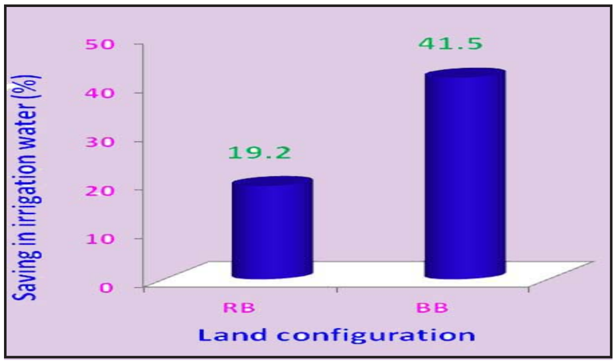


Fig. 9.1.10. Effect of land configuration on saving in irrigation water

The bio-intensive complementary cropping system [Maize + vegetable Cowpea] (BB) + Sesbania (F) - Veg. pea (BB) + Wheat (F) - Green gram produced maximum REY of 14.98 t/ha, which was followed by Maize (RB) + Sesbania (F) – vegetable Pea (RB) + Wheat (F) – Green gram system (13.57 t/ha) and [Pigeon pea + Black gram] (BB) + sesbania (F) – [Wheat + Mustard] (5:1) - system (13.37 t/ha). The system [Maize + vegetable Cowpea] (BB) + Sesbania (F) - Veg. pea (BB) + Wheat (F) - Green gram also provided maximum net return of 94820 Rs/ha, which was followed by Maize (RB) + Sesbania (F) – vegetable Pea (RB) + Wheat (F) – Green gram system (83530 Rs/ha) and [Pigeon pea + Black gram] (BB) + sesbania (F) – [Wheat + Mustard] (5:1) - system (81450 Rs/ha).

The system [Pigeon pea + Black gram] (BB) + sesbania (F) – [Wheat + Mustard] (5:1) provided maximum water productivity of 291 kg/ha-cm, which was followed by [Maize + vegetable Cowpea] (BB) + Sesbania (F) - Veg. pea (BB) + Wheat (F) - Green gram (283 kg/ha-cm) and Sorghum (RB) + Sesbania (F) – Lentil (RB) + Mustard (F) – Green gram system (243 kg/ha-cm). About 19.2 and 41.5 % irrigation water was saved using RB and BB than FB.

iii. Effect of different crop establishment methods and slow release fertilizer management on growth, yield and GHGs in rice- wheat system

The field trial was undertaken at Modipuram to study the effect of different crop establishment methods and slow release fertilizer management on growth, yield and GHGs in rice- wheat system. Four crop establishment method, three slow release fertilizer applications were factorially combined in a split- plot design with three replications, giving total of 36 sub-plots of 5 m length and 4 m width each. In kharif, rice crop establishment methods (main plots) were: SRI-system rice intensification, aerobic rice/ direct seeded-dry bed (AR), drum seeder-wet bed (DS), and conventional method of transplanting (CT) however, *in rabi*, the wheat sown in the main plot treatments were: no tillage (NT), bed planting (BD), no till sowing with 6 t ha^{-1} (NT-CR) and conventional tillage (CT), i.e. 4 harrowing and one patella. The sub-plots were: F_1- Neem coated urea; F_2-Sulpher coated urea; F_3-Normal urea. A recommended fertilizer dose of 120-60-40 kg ha^{-1} was applied in *kharif* (i.e. rice) and *rabi* (i.e wheat) crops. Rice-wheat crops were sown as per recommended package and practices with seed rate 80 kg ha^{-1} and line spacing 20 cm of wheat crop (PBW-343) whereas, in the rice crop (PRH-10) were sown/ transplanting with seed rate 5, 25, 40 and 30 kg ha^{-1} and row spacing were 25, 20, 20 and 20 cm apart in the treatments SRI, MT, DS and CT, respectively.

Significantly higher rice yield (5.7 t ha^{-1}) were found in SRI as compared to other treatments such as direct seeded (4.4 t ha^{-1}), drum seeded (4.6 t ha^{-1}) and transplanted rice (5.3 tha^{-1}). The transplanted rice had significant difference that of direct and drum seeded rice. However, sub plot treatment (fertilizer application: neem, sulphur coated urea) had also significantly higher yield than normal urea application.

Application of fertilizer as sulphur and neem coated urea in rice cultivation produced less methane (CH_4) emission as compared to normal urea application in different rice crop establishment experiments.

iv. Study on water and nitrogen use efficiency of different varieties of rice-wheat under aerobic condition

The experiment was conducted to find out the water and nitrogen use efficiency of rice-wheat cropping system under aerobic condition. Four rice cultivars (Subhangi, PRH 10, Saket 4 and Pro-agro 6444) and four wheat cultivars (PBW-373, PBW-343, Lok-2 and PBW-226) with three types of N application (normal urea, neem coated and sulphur coated) and 3 level of soil moisture tension (0, 20 and 40 kPa during rice and 0.3,0.5 and 0.7atm. during wheat) with three replications were evaluated in split plot design during 2011-12.

Rice productivity varied in accordance with irrigation water scheduling and modified slow release urea used in different cultivars. Rice productivity was maximum (6.02 t/ha) at zero irrigation water tension, which is statistically significant with 40 kPa (Table 9.1.4). Maximum harvest index (39.90 %), panicle length (18.71cm), number of grains/panicles (62.67) and effective tillers/m2 (376.56) were obtained under 0 kPa moisture tension. However, highest test weight (16.64 g) obtained under 20 kPa moisture tension.

Rice productivity was maximum with sulphur coated urea (5.41t/ha), which is higher than neem coated and normal urea. Higher number of grains/ panicle, which are statistically significant may be the reason for higher rice productivity under sulphur coated urea. Among the varieties, Pro-agro 6444 gave maximum rice grain yield of 6.04 t/ha, which

Table 9.1.4. Yield and Yield attributes of rice under different treatments

Treatments	Grain Yield (t/ha)	Straw yield (t/ha)	HI (%)	Length of panicle (cm)	No. of grains /panicle	1000 grain weight (g)	No of effective tillers/m^2
M0	6.02	8.99	39.90	18.71	62.67	16.63	376.56
M1	5.33	8.51	38.45	15.63	62.14	16.64	338.19
M2	3.68	7.92	33.47	12.21	57.58	16.46	294.83
SEm(±)	0.85	1.10	0.59	0.58	0.56	0.14	8.48
CD(5 %)	3.33	4.28	2.29	2.26	2.19		33.10
F0	4.75	8.06	36.56	15.81	59.28	16.62	349.97
F1	4.88	8.34	36.27	15.45	60.72	16.95	340.45
F2	5.41	8.37	38.98	15.29	62.39	16.16	319.16
SEm(±)	1.19	1.44	0.89	0.23	0.57	0.16	7.51
CD(5 %)	3.36				1.62	0.45	21.21
V1	4.08	7.88	33.93	14.42	56.43	19.29	318.26
V2	5.11	8.04	38.33	15.92	61.13	15.80	348.26
V3	4.81	7.74	37.92	15.08	61.70	16.14	341.15
V4	6.04	9.38	38.89	16.64	63.93	15.07	338.44
SEm(±)	1.38	1.66	1.02	0.27	0.66	0.19	12.26
CD(5 %)	3.88	4.70	2.89	0.76	1.87	0.52	8.67

was statistically significant over others. The yield attributes such as length of panicle and number of grains/panicle were more for Pro Agro 6444. PRH 10, Subhangi and Saket 4 gave lower yield by 15, 20 and 32 %, respectively compared to Pro-agro 6444.

However wheat productivity varied in accordance with irrigation water scheduling and modified slow release urea used in different cultivars. Wheat productivity was maximum (5.9 t/ha) at 0.3 atm. irrigation water tension. Maximum harvest index (35.51 %), spike length (11.09 cm), test weight (46.74g) and effective tillers/m2 (545.14) were obtained under 0.3 atm. moisture tension (Table 9.1.5). However, highest number of grains/spike (51.66) obtained under 0.7 atm. moisture tension.

Wheat productivity was almost same with sulphur coated urea (5.48 t/ha) and neem coated urea (5.49t/ha). Higher number of effective tillers/m^2, number of grains/spike and spike length may be the reason for higher wheat productivity under sulphur coated urea. Among the varieties, Lok-2 gave maximum wheat grain yield of (6.28 t/ha), which was statistically significant over PBW-226 and slightly higher than PBW-343, PBW-373. Spike length and number of effective tillers/m^2 may be the reason of higher yield of Lok-2. PBW-343, PBW-373 and PBW-226 gave lower yield by 11, 16 and 23 %, respectively compared to Lok-2.

Maximum water productivity achieved in Proagro-6 444 (33.6 kg/ha-cm), followed by PRH-10 (28.4 kg/ha-cm), Subhangi (26.7 kg/ha-cm) and Saket (22.7 kg/ha-cm).

Table 9.1.5. Yield and Yield attributes of wheat under different treatments

Treatments	Grain Yield (t/ha)	Straw yield (t/ha)	HI (%)	Length of spike (cm)	No. of spike /panicle	1000 grain weight (g)	No of effective tillers/m^2
M0	5.9	11.77	35.51	11.09	47.83	46.74	545.14
M1	5.38	11.82	32.99	10.90	49.24	43.71	507.22
M2	5.12	12.08	31.1	10.74	51.66	44.75	539.5
SEm(±)	0.25	5.53	1.33	0.22	0.73	1.26	13.48
CD(5 %)	0.98				2.83		
F0	5.48	12.81	31.16	10.49	47.48	47.98	531.25
F1	5.49	11.32	33.85	10.86	49.61	46.30	489.08
F2	5.44	11.53	34.54	11.39	51.65	40.92	571.53
SEm(±)	0.22	6.21	1.35	0.12	0.87	0.96	14.34
CD(5 %)				0.35	2.46	2.71	40.49
V1	5.25	10.69	35.06	10.84	50.87	44.72	500.19
V2	5.57	11.51	34.84	10.59	48.93	46.63	528.22
V3	6.28	12.79	33.81	11.36	48.34	44.21	551.29
V4	4.79	12.59	29.02	10.85	50.18	44.71	542.77
SEm(±)	0.26	7.17	1.57	0.14	1.01	1.11	16.56
CD(5 %)	0.73			0.39			

B. Conservation Agriculture and Farm Mechanization

v. Long term effect of RCTs and crop residue management practices on crop productivity, water requirement and soil health in rice-wheat cropping system

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 Figure 9.1.11. The effect of planting methods on rice yield over the years is depicted in Figure 9.1.12. We noted that the rice (Saket – 4) yield was higher in MT (14.1%), MaT (10.9%), ZT (14.7%), ST (6.8%), RT (8.8%), BP (8.3%) and DS (2.4%); but lower in CS (2.1%) and BS (4.5%), respectively, compared to traditional

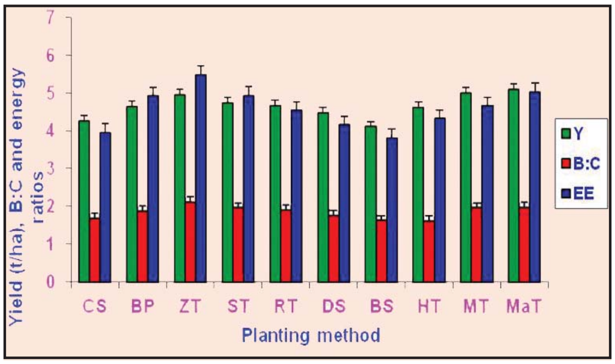


Fig. 9.1.11. Effect of planting methods on rice yield (Y), benefit: cost (B:C) and energy ratios (EE) *(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT _ Transplanting by manual transplanter)*

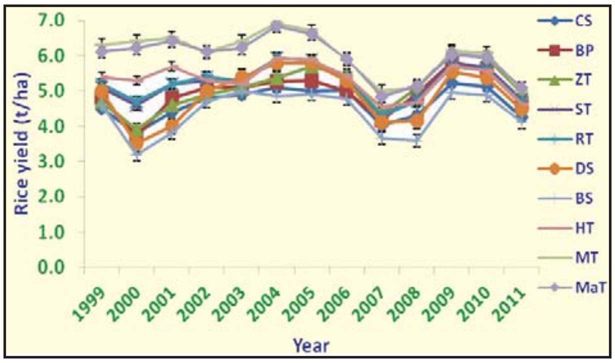


Fig. 9.1.12. Effect of planting methods on rice yield over the years *(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT _ Transplanting by manual transplanter)*

HT (4.68 t ha^{-1}). The net return was 68 higher in ZT, 54% higher in MT; 42 to 47% higher in Mat, RT, BP and ST; 23% higher in DS; and 6 to 12% higher in BS and CS, respectively, compared to HT (Rs 19490 ha^{-1}). The B: C ratio was 36% higher in ZT; 22 to 25 per cent higher in ST, MaT, MT, BP and RT; 7 to 13% higher in BS, CS and DS, respectively, compared to HT (1.58). Energy output: input ratio was 36% higher in ZT, 23 to 2% higher in all the methods except CS and BS, where it was 2 to 4% lower, compared to HT (4.28). The water use was 32% lower in BP; 1 to 7 per cent lower in all other methods except CS, DS and BS, where it was 4 to 7% higher, compared to HT (204 ha-cm). The infiltration rate was maximum in BP (87 mm day^{-1}) and lowest (35 to 39 mm day^{-1}) in the three transplanting methods because of puddling. The weed dry matter was 55 to 200% higher in all the methods but 28 and 37 per cent lower in MaT and MT, compared to HT (67 kg ha^{-1}).

Performance of rice transplanter

The grain yield of rice (Saket - 4) as affected by different levels of puddling and methods of transplanting is given in (Table-9.1.6). The results

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

Puddler passes	Transplanting method	Grain yield (t ha^{-1})
Zero	Manual	4.38
	Mech.	4.92
One	Manual	4.65
	Mech.	5.23
Two	Manual	4.81
	Mech.	5.53
Three	Manual	4.88
	Mech.	5.62

indicated that, the yield increased with puddling operations. The increase in grain yield was highest in one pass of puddler, both under manual (6.2%) and mechanical transplanting (6.3%), over zero pass. This increase in two passes of puddler was 3.4 and 5.7% under manual and mechanical transplanting respectively. The yield increase under three passes was 1.4% in manual and 1.6% in mechanical transplanting over two passes. The average increase in mechanical transplanting was 13.9 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 (80%) and cost of

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

Parameter	Manual transplanting	Mechanical transplanting
Net income, Rs ha^{-1}	19,490	30,090
Benefit: cost ratio	1.58	1.98
Specific cost, Rs kg^{-1}	7.20	5.73
Specific energy, k cal kg^{-1}	701	614
Energy output: input ratio	4.28	5.19

operation (54%); higher yield (14.1%), net returns (54%), benefit: cost ratio (25%), energy output: input ratio (21%); while requiring less specific cost (20%) and specific energy (12%) compared to manual transplanting (Table-9.1.7).

Evaluation of different machines for direct dry seeding of rice

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

The performance parameters of different rice seeding machines showed that ZT, ST, RT and BP of rice saved time (89 to 86%), labour (87 to 83%), diesel (88 to 60%), cost (80 to 60%), energy (88 to 61%) and also irrigation water (7 to 35%) as compared to conventional sowing (table-9.1.8). The rice yield, economics and energy use affected by different methods is given in table-9.1.9. The zero till drilling produced higher rice (17 %), net returns (49 %), B: C ratio (25 %) and energy output: input ratio (39 %) while requiring lesser specific cost (11 %) and specific energy (28 %), compared to conventional sowing. The rotary till drilling produced higher rice (11%), net returns (29%), B: C ratio

Table 9.1.8: 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	0.42	0.38	0.35	0.47
Field Efficiency, %	57	51	51	57	60
Fuel consumption, l ha^{-1}	8.0	10.5	10.0	27.0	68.0
Cost of sowing, Rs. ha^{-1}	1050	1190	1120	2170	5420
Energy requirement, MJ ha^{-1}	465	606	582	1534	3942

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

Parameter	Zero-till drill	Strip-till drill	Bed planter	Roto-till drill	Conventional drill
Grain yield, t ha^{-1}	5.37	5.00	5.07	5.09	4.58
Straw yield, t ha^{-1}	6.3	5.9	6.0	6.2	5.6
Net income, Rs ha^{-1}	32,760	27,670	27,970	28,450	21,960
Benefit: cost ratio	2.16	1.95	1.94	1.97	1.73
Specific energy, k cal kg^{-1}	514	586	568	617	718
Energy output: input ratio	5.84	5.12	5.28	4.87	4.18
Specific cost, Rs kg^{-1}	5.25	5.78	5.83	5.78	6.57

(14%) and energy output: input ratio (16 %) while requiring lesser specific cost (20 %) and specific energy (14 %), compared to conventional sowing. The strip till drilling produced higher rice (9 %), net returns (26 %), B: C ratio (13 %) and energy output: input ratio (22 %) while requiring lesser specific cost (11 %) and specific energy (18 %), compared to conventional sowing. The bed planting produced higher rice (10 %), net returns (27 %), B: C ratio (12 %) and energy output: input ratio (39 %) while requiring lesser specific cost (12 %) and specific energy (20 %), compared to conventional sowing.

Evaluation of different drill machines for planting wheat succeeding rice

The comparative performance of different machines namely; bed planter (BP), zero-till drill (ZT), strip-till drill (ST), rotary-till drill (RT), and conventional drill (CS), in terms of wheat yield (Y), benefit: cost ratio (B: C), energy output: input ratio (EE), water use (WU), infiltration rate (IR), *Phalaris minor* (PM) and other weeds (OWE) was assessed. The effective field capacities of RT, ST, ZT, BP and CS were 0.42, 0.39, 0.52, 0.35 and 0.45 ha h^{-1}, respectively (table-9.1.10). The rotary, strip and zero till drilling and bed planting were time saving (78, 77, 83 and 75%), labour saving (76, 73, 78 and 70%), diesel saving (65, 84, 86 and 86%), cost saving (71, 78, 82 and 77%), energy saving (65, 84, 87 and 86%) and also irrigation water saving (10, 10, 11.0 and 35%) compared to conventional sowing of wheat. Also, there was saving of about 20-25% in seed and fertilizer inputs in bed planting compared to conventional sowing. Zero, strip and rotary till drills and bed planter provided higher wheat yields (2-12%), net returns (7-18%), cost effectiveness (9-14%) and energy efficiency (20-29%); required lower specific energy (16-21%) and specific cost (4-6%); and reduced *Phalaris minor* (56-79%), other weeds (66-79%), compared to conventional sowing of wheat (Fig. 9.1.13). The

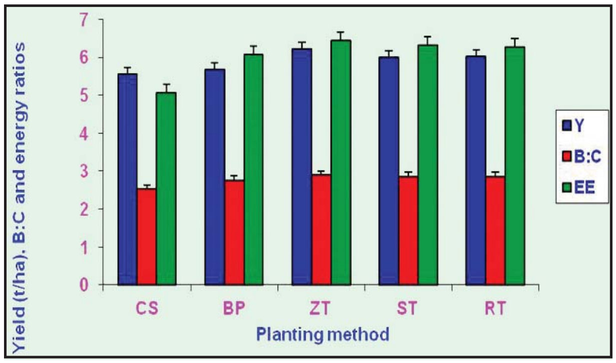


Fig. 9.1.13. Effect of planting methods on wheat yield (Y), benefit: cost (B:C) and energy ratios (EE) *(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)*

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

Parameter	CS	BP	ST	ZT	RT
Fuel consumption, l ha^{-1}	56.3	7.6	8.7	7.5	19.7
Cost of sowing, Rs. ha^{-1}	5881	1332	1292	1058	1697
Energy requirement, MJ ha^{-1}	3190	436	497	428	1112
Grain yield, t ha^{-1}	5.55	5.68	6.23	6.01	6.02
Benefit: cost ratio	2.53	2.76	2.89	2.86	2.86
Specific energy, k cal kg^{-1}	593	495	465	474	478
Energy output: input ratio	5.06	6.07	6.45	6.33	6.28
Specific cost, Rs. kg^{-1}	7.10	6.48	6.07	6.26	6.18

effect of planting methods on wheat yield over the years is depicted in Figure 9.1.14.

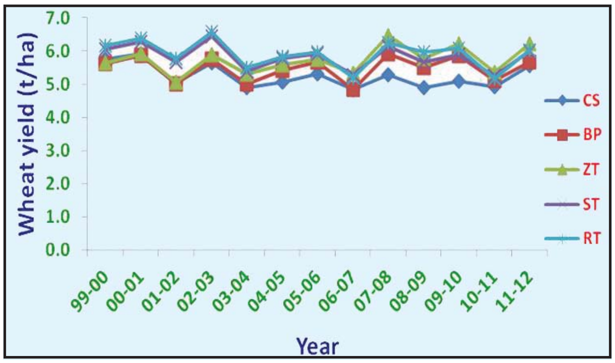


Fig. 9.1.14. Effect of planting methods on wheat yield over the years *(CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)*

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

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

A field experiment is in progress since 1998 to study the energy requirement and cost of recycling of rice-wheat straw after combine harvesting and to evaluate the performance of subsequent crops in straw recycled fields. The recycling was done by rotavator and achieved in shallow layer only (30-70 mm). The action of rotavator was to impart rotation to successive bites of soil so that chopped/ broken straw falls between these bites for uniform mixing with the soil. After harvesting of rice and wheat, three straw management practices (recycling, retrieval and burning) were practiced before the planting of next crop. Self-propelled transplanter was used for transplanting of rice after wheat straw recycling. Zero, strip and conventional drills were used for wheat sowing after rice straw recycling. It was observed that for recycling of rice (5 to 6 t ha^{-1}), as well as wheat straw (8 to 9 t ha^{-1}), the degree of recycling was 81-86% and cost and energy of recycling of Rs 4070 ha^{-1} and 2255 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 45 to 50 days in rice fields.

The effect of different crop residue management practices on yield, benefit: cost ratio (B: C) and energy efficiency (EE) of rice and wheat are given in Figure 9.1.15. The effect of crop residue management

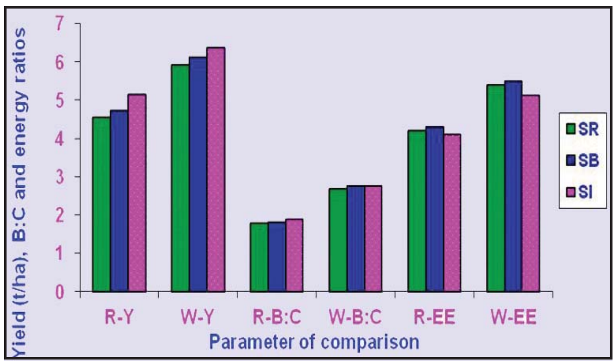


Fig.9.1.15. Effect of crop residue management practices on yield (Y), economics (B:C) and energy efficiency (EE) of rice (R) and wheat (W) *(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)*

practices on the yield of rice and wheat over the years is depicted in Figures 9.1.16 and 9.1.17.The *insitu* recycling of wheat straw produced 15 and 11 per cent higher rice yield than straw retrieval and burning treatments, respectively. The net returns under straw recycling were 27 and 19 per cent higher; B: C ratio and energy output: input ratio were 8 and 6% higher, and 0.5 and 3 per cent lower; and specific

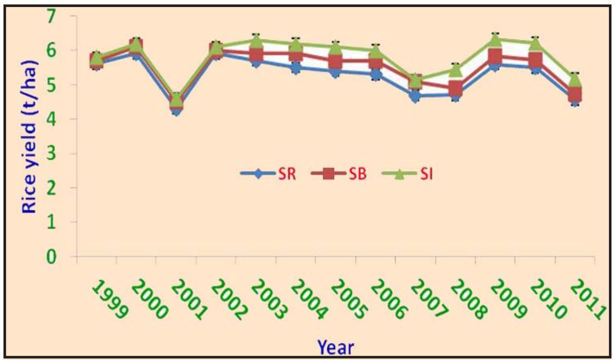


Fig. 9.1.16. Effect of crop residue management practices on rice yield over the years *(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)*

cost and specific energy 8 and 6 per cent lower, and 0.2 and 3 per cent higher, respectively. The recycling of rice straw increased the wheat yield (8%), net returns (11%) and B: C ratio (3%), but decreased energy output: input ratio (5%) compared to straw retrieval treatment. Crop residue recycling and

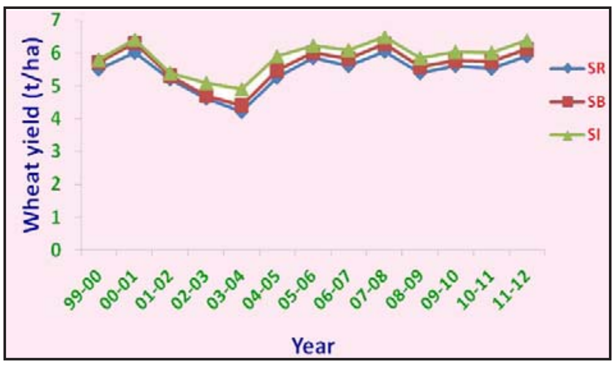


Fig. 9.1.17. Effect of crop residue management practices on wheat yield over the years *(SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)*

burning improved soil organic carbon, SOC (39 and 8%) whereas retrieval decreased SOC (9%) compared to initial values after fourteen 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 fourteen 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 (23%) compared to residue retrieval.

vi. Resource conservation modules for high yield realization of different cropping systems

The field trial was undertaken 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. Two tillage systems, four cropping systems and four crop residue mulching and fertilizer combination were factorially combined in a split-split plot design with three replications, giving total of 96 sub-sub plots of 5 m length and 4 m width each. The tillage systems (main plots) were: no tillage (NT) and conventional tillage (CT), i.e. 4 harrowing and one patella. The cropping systems where in sub-plots:C_1- rice-wheat; C_2- rice-winter maize; C_3-rice-barley and C_4- rice-mustard. The crop residue used as mulching and fertilizer combination treatments (sub-sub-plots) consisted of four M_1 - No mulch + recommended dose of fertilizer (RDF), M_2 - Mulch (6 t/ha) + recommended dose of fertilizer (120:60:40 kg NPK) (RDF), M_3 - Mulch (0) +125% recommended dose of fertilizer (RDF), M_4 - Mulch (6 t/ha) +125 % recommended dose of fertilizer (RDF). A recommended fertilizer dose of 120-60-40 kg ha^{-1} was applied in all *rabi* crops. All the crops were sown as per recommended package and practices with seed rate 100, 25, 100, 6 kg ha^{-1} and line spacing 20, 60, 20 and 45 cm apart of wheat (PBW-343), maize (Naveen), barley (K-508) and mustard (Pusa bold), respectively.

A tillage system significantly affects the SOC and MBC. Significantly higher SOC and MBC were observed in the treatment (M_2 and M_4) where 6 t ha^{-1} crop residues were applied as surface mulch.

The mechanical transplanter has produced higher rice yield (6.88 t ha^{-1}) as compared to direct seeded rice (5.92 t ha^{-1}). Significantly higher rice equivalent yield (REY) was found in ZT as compared to CT. However, sub-sub plot treatment as M_2 (4.6 t ha^{-1}) and M_4 (5.0 t ha^{-1}) has significantly higher REY than M_1 (4.3 t ha^{-1}) and M_4 (4.7 t ha^{-1}) which are at par values.

Tillage significantly affected soil organic carbon (SOC) at 0-15 cm at P= 0.01, but seldom (P=0.05) at 15-30 cm. The SOC was significantly higher value in ZT (5.55 gkg^{-1}) than CT (4.80 g kg^{-1}) at 0-15 cm. However, in 15-30 cm, it was 3.59 g kg^{-1} in ZT and 3.54 g kg^{-1} in CT. The SOC concentration in the upper soil layer (0-15cm) was 15 % higher in ZT than CT. The SOC was not significantly affected by cropping systems. The C_3 (5.35 g kg^{-1}) had higher SOC than C_1 (5.15 g kg^{-1}), C_2 (5.17 g kg^{-1}) and C_4 (5.02 g kg^{-1}) which were at par values in soil depth of 0-15 cm. It was due to higher volume of root in upper soil layer influenced by different crops. However, in 15-30 cm, there was no significant difference in SOC among the crop pattern. The effect of mulching and recommended dose of fertilizer was also significant on each measured parameter. On average, compared to M_1 (control), soil organic carbon (SOC) was 50.5 and 40.75% higher in M_4 and M_2, respectively. The treatments M_2 and M_4 (5.94 and 6.35 g kg^{-1}) as well as M_1 and M_3 (4.33 and 4.42 g kg^{-1}) had significant at par value in CT system and similar pattern were also found in ZT. However, treatments M_2 and M_4 had significant at par values but higher than M_1 and M_3 which were shown non-significant.

The main plot treatments i.e. tillage levels had significant different values of soil MBC which higher in ZT plots than CT plot. However, sub-plot treatments i.e. cropping systems and sub-sub plot treatment i.e. mulching x RDF combination had shown statistically significant (P=0.05 and 0.01). The interaction of tillage levels with mulch x RDF combination was significant. However, the interactions of tillage levels with cropping systems and cropping systems with RDF x mulch combination were found not significant. Whereas, the interaction of cropping systems, tillage levels and RDF x mulch was also found non-significant for MBC in for both depth.

vii. Studies on crop establishment methods, mulching and weed management under rice-wheat cropping system

The field trial was undertaken at Modipuram to study on crop establishment methods, mulching and weed management under rice-wheat cropping system. Two crop established methods, and four weed managements were factorially combined in a split- plot design with three replications, giving total of 24 sub-sub plots of 5 m length and 5 m width each. In *kharif*, rice crop establishment methods (main plots) were: SRI-system rice intensification and mechanical transplanting with self propelled transplanter (MT), however, *in rabi*, the wheat sown in the main plot treatments were: no tillage (NT) and no till sowing with 6-8 t ha^{-1} rice residue (NT-CR). In *kharif* (rice crop), the sub-plots were: W_1-Weedy check; W_2-Weed free; W_3-Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) + one mechanical weeding at 30 DAT; W_4- Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) + Halosulfuron (PoE) at four leaf stages and in

Rice crop in SRI method under slow release fertilizer application

rabi (wheat crop), the sub plot treatments were: W_1- Weedy check; W_2 - Weed free; W_3-Clodinofop + Cleansweep (PoE); W_4- Sulfosulfuron + Metsulfuron (PoE). A recommended fertilizer dose of 120-60-40 kg ha^{-1} was applied in *kharif* (i.e. rice) and *rabi* (i.e wheat) crops. Rice-wheat crops were sown as per recommended package and practices with seed rate 80 kg ha^{-1} and line spacing 20 cm of wheat crop (PBW-343) whereas, in the rice crop (PRH-10) were sown/transplanting with seed rate 5 and 25 kg ha^{-1} and row spacing were 25 and 20 cm apart in the treatments SRI and MT, respectively.

The rice yield in main plot treatments were 5.4 t ha^{-1} in SRI and 4.8 t ha^{-1} in mechanical transplanter, however, the rice yield was recorded in sub plot treatments with ordered W_4 (5.5 t ha^{-1}) > W_3 (5.2 t ha^{-1}) > W_1(5.1 t ha^{-1}) > W_2 (4.6 t ha^{-1}) as a weed management.

Rice crop in SRI method under weed management

C. Nutrient Management

viii. Integrated nutrient management in transplanted rice-wheat system

In order to study the production sustainability and changes in soil physico- chemical as well as microbial population under integrated use of fertilizers and organic manures, 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 19h year during 2011-12. 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 conducted 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). I worked as PI. The salient findings are being given here as under.

Productivity dynamics

A perusal of yield trends during last 19 years suggested that continuous rice-wheat cropping without fertilizer or manure application resulted in yield reduction by 31% in rice and 24% in wheat crop over initial years. Fertilizer applied at recommended dose also could not prevent yield decline in rice, although the extent of reduction was smaller (-7.2 and 6.5%) than unfertilized plots.

Among the organic sources used for substitution of 25% NPK, SPM proved superior over others, and gave 22 and 19% extra rice and wheat yield over its initial. Yield trend over the years based on moving average reveals highest productivity of rice and wheat crop over the years with application of sulphitation press mud for 25% NPK substitution to rice crop followed by 25% NPK substitution with FYM. Among IPNS options GR had lowest annual rice-wheat productivity. Cumulative yield trend for 19 years indicates that use of S alongwith NPK+Zn had pronounced effect over recommended NPK+Zn alone. Use of green gram residue to rice and FYM to wheat had higher rice and wheat productivity over application of crop residue to both rice and wheat crop.

Simulation Modeling

During the study period, simulation modeling based on available observations using DSSAT model for different nutrient management options were made and found that observed value are very well simulated with the model predicted value. Parameterized Agricultural Production Systems sIMulator (APSIM) crop growth simulation model with the observed rice-wheat system data set during 2008-09 and validated with the data set of 2009-10. The different statistical parameters used to quantify the goodness of fit between observed and simulated grain yield of rice and wheat under recommended management practices indicated that the observed and simulated values are statistically within the tolerable range. The RMSE for rice and wheat were 24 and 33 %, respectively, while corresponding CRM was -0.2150 and -0.3133, respectively. The negative values of CRM indicate an over-prediction of the model. It is not surprising that the simulated yields are slightly higher than the observed yields, because the model does not include any biotic stress factors that might be reducing yields.

During the course of study Soil Physical fraction of associated carbon was made with selected treatments. The details of treatment used for the study was as follows:

Carbon input and soil physical fractionation Studies

Tr. No.	Monsoon	Winter
T1.	Control	Control
T2.	NPK+Zn	NPK
T3.	NPK+Zn+S	NPK
T4.	75% NPK+25% N (FYM)	NPK
T5.	75% NPK+25% N (SPM)	NPK
T6.	75% NPK+Greengram Residue	NPK
T7.	75% NPK+Greengram Residue	75% NPK+25% N (FYM)
T8	75% NPK+25% N (WS)	75% NPK+25% N (RS)

FYM: farmyard manure; SPM: sulphitation pressmud; WS: wheat straw; RS: rice straw 100% NPK for rice as well as wheat is 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha.

Carbon input to the system

Carbon input study was made after 18 rice-wheat cycle for different treatments reveals that highest total biomes carbon was under FYM/SPM/ or S applied treatment. Among the different external inputs crop residue of rice or wheat had maximum C input followed by FYM (Table 9.1.11). Summing biomass inputs and C inputs from external sources and FYM had maximum total C inputs. Over all C input was maximum under the plot having incorporation of rice and wheat straw to both the seasons (151.42 t ha^{-1}) followed by Crop residue incorporation to rice and FYM to wheat crop (98.5 tha^{-1}). The lowest C input was recorded in recommended NPK applied plots (38.02 t ha^{-1}).

Properties of soil aggregates

Density, tensile strength and friability of aggregates increase with the depth of soil, and decrease with organic inputs (Table 9.1.12). Treatment T_1 has the highest aggregate densities (1.82-1.95 Mg m^{-3}) and strengths (127.2-171.6

Table.9.1.11. Components of organic inputs (t ha^{-1}) to soil under different treatments of the rice-wheat system

Treatment	Stubble biomass C		Root biomass C		Rhizodeposition biomass C		Total biomass C		External organic C inputs		Total C inputs
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	
Control	0.67	0.33	2.22	1.59	6.63	3.47	9.52	5.39	-	-	14.92
NPK+Zn	1.64	1.07	5.02	6.40	13.53	10.36	20.19	17.83	-	-	38.02
NPKZn+S	2.43	1.53	8.64	10.24	18.18	12.94	29.24	24.71	-	-	53.94
FYM Sub	2.08	1.33	7.71	9.13	16.98	11.82	26.77	22.28	39.06	-	88.11
SPM Sub	2.34	1.56	8.80	10.43	18.12	12.85	29.26	24.84	10.94	-	65.03
GR Sub	1.92	1.29	7.74	8.72	16.29	11.47	25.95	21.48	13.21	-	60.64
GR : FYM	1.93	1.35	7.44	9.07	15.16	11.27	24.53	21.69	13.21	39.06	98.50
RS: WS	1.75	1.17	6.76	8.00	14.38	10.10	22.90	19.26	61.54	47.72	151.42

Table. 9.1.12. **Soil aggregate fractions in 0-7.5, 7.5-15 and 15-30 cm soil layers under the integrated nutrient management practices in a rice-wheat rotation**

Treatment	Density ($Mg\ m^{-3}$)	Tensile strength (k Pa)	Friability	Water retention (%)			
				2-5 mm aggregates		5-8 mm aggregates	
				-33 k Pa	-1500 k Pa	-33 k Pa	-1500 k Pa
0-7.5 cm							
Control	1.82^{A}	127.2^{A}	0.15^{C}	21.0^{C}	9.2^{B}	21.4^{E}	7.2^{A}
NPK+Zn	1.77^{AB}	113.4^{B}	0.18^{C}	22.9^{B}	10.0^{AB}	22.3^{CD}	7.1^{A}
NPKZn+S	1.75^{B}	109.7^{BC}	0.20^{C}	22.7^{B}	9.4^{B}	21.7^{DE}	6.8^{A}
FYM Sub	1.66^{C}	85.6^{D}	0.32^{B}	22.6^{B}	10.1^{AB}	22.3^{CD}	7.9^{A}
SPM Sub	1.74^{B}	102.7^{C}	0.31^{B}	23.0^{AB}	10.1^{AB}	21.6^{E}	6.9^{A}
GR Sub	1.65^{C}	84.2^{D}	0.35^{B}	23.9^{A}	9.8^{AB}	23.0^{B}	7.4^{A}
GR : FYM	1.63^{C}	80.3^{D}	0.44^{A}	23.1^{AB}	10.9^{A}	22.3^{BC}	7.5^{A}
RS: WS	1.60^{C}	79.6^{D}	0.34^{B}	23.2^{AB}	10.2^{AB}	25.2^{A}	8.1^{A}
7.5-15 cm							
Control	1.85^{A}	130.2^{A}	0.14^{D}	19.5^{C}	9.5^{A}	19.9^{C}	9.8^{A}
NPK+Zn	1.81^{AB}	122.1^{AB}	0.15^{D}	19.7^{BC}	8.0^{B}	20.7^{B}	9.9^{A}
NPKZn+S	1.78^{AB}	121.4^{AB}	0.16^{D}	19.6^{BC}	8.0^{B}	20.4^{BC}	8.7^{A}
FYM Sub	1.71^{C}	93.9^{C}	0.29^{BC}	19.9^{BC}	9.1^{A}	20.8^{B}	8.9^{A}
SPM Sub	1.79^{AB}	111.6^{B}	0.24^{C}	19.8^{BC}	8.8^{A}	20.9^{B}	9.2^{A}
GR Sub	1.72^{BC}	98.8^{C}	0.27^{BC}	19.9^{BC}	9.2^{A}	20.7^{B}	9.6^{A}
GR : FYM	1.67^{C}	83.8^{C}	0.36^{A}	21.1^{A}	9.3^{A}	21.0^{B}	8.8^{A}
RS: WS	1.65^{C}	81.2^{C}	0.31^{AB}	20.4^{AB}	8.5^{A}	22.2^{A}	9.3^{A}
15-30 cm							
Control	1.91^{A}	171.6^{A}	0.10^{E}	18.4^{D}	7.1^{C}	18.1^{F}	10.4^{AB}
NPK+Zn	1.89^{A}	163.4^{A}	0.13^{DE}	19.5^{BC}	8.8^{A}	19.8^{DE}	10.1^{AB}
NPKZn+S	1.88^{A}	162.4^{A}	0.15^{D}	18.7^{CD}	8.1^{B}	19.2^{E}	11.3^{A}
FYM Sub	1.77^{AB}	124.0^{B}	0.25^{BC}	20.1^{B}	8.4^{B}	20.6^{BC}	10.3^{AB}
SPM Sub	1.82^{AB}	151.5^{A}	0.22^{C}	20.9^{A}	8.3^{B}	19.6^{DE}	10.1^{AB}
GR Sub	1.76^{AB}	123.3^{B}	0.23^{BC}	19.9^{B}	8.5^{A}	20.9^{B}	11.8^{A}
GR : FYM	1.72^{B}	117.6^{B}	0.30^{A}	19.9^{B}	8.1^{B}	21.8^{A}	8.9^{B}
RS: WS	1.73^{B}	117.2^{B}	0.27^{AB}	19.8^{B}	6.3^{D}	20.0^{CD}	8.3^{B}

kPa), and the lowest friabilities (0.10-0.15). The lowest density is recorded in T_7 and T_8, which is significantly higher than T_1, in all the layers. Treatment T_4 has similar effect as in T_7 and T_8 in 0-7.5 and 7.5-15.0 cm layers. Effect of inorganic fertilizers is not significant except in T_3 at 0-7.5 cm. Tensile strength is the lowest in T_4 (85.6-124.0 kPa), T_6 (84.2-123.3 kPa), T_7 (80.3-117.6 kPa) and T_8 (79.6-117.2 kPa) in the soil layers while effect of inorganic Nutrients is restricted to 0-7.5 cm layer only. Similarly, the effect of SPM in reducing the density and strength of aggregates is found in layer 0-7.5 cm only. Friability of aggregates improved significantly with addition of organic inputs, but the effect was most evident in T_7 (0.44, 0.36 and 0.30 at 0-7.5, 7.5-15.0 and 15-30 cm, respectively). Treatments only with inorganic N only (T_1 and T_2) have no apparent effect of aggregate friability. Substitution of inorganic Nutrients by organic sources improves water retention by aggregates; however, the impact varies among soil layers and size of aggregates. Water retention by 5-8 mm aggregates at field capacity is significantly greater in T_8 in both 0-7.5 (25.2%) and 7.5-15.0 (22.2%) cm layers compared to other organic treatments. T_6 enhances water retention of 2-5 mm aggregates at field capacity in 0-7.5 cm, while T_7 is effective at 7.5-15.0 cm layer. Effect of SPM is only manifested in 15-30 cm layer on field capacity water content of 2-5 mm sized aggregates.

Size distribution of aggregates

Total macraoaggregates (LM+SM) in organic treatments account for 80-90% of the soil with the exception in SPM (T_5) where the amount was comparatively less (Table 9.1.13). Higher large micro-aggregates is recorded in T_7 and T_8 in layers 0-7.5 (34-36%), 7.5-15 (19%) and 15-30 (17%) cm. These treatments also have proportionally less small micro aggregates and significantly lower

Table.9.1.13. Mechanical and hydraulic properties of soil aggregates as influenced by nutrient management practices in a rice-wheat rotation

Treatment	Density ($Mg\ m^{-3}$)	Tensile strength (k Pa)	Friability	Water retention (%)			
				2-5 mm aggregates		5-8 mm aggregates	
				-33 k Pa	-1500 k Pa	-33 k Pa	-1500 k Pa
				0-7.5 cm			
Control	1.82^{A}	127.2^{A}	0.15^{C}	21.0^{C}	9.2^{B}	21.4^{E}	7.2^{A}
NPK+Zn	1.77^{AB}	113.4^{B}	0.18^{C}	22.9^{B}	10.0^{AB}	22.3^{CD}	7.1^{A}
NPKZn+S	1.75^{B}	109.7^{BC}	0.20^{C}	22.7^{B}	9.4^{B}	21.7^{DE}	6.8^{A}
FYM Sub	1.66^{C}	85.6^{D}	0.32^{B}	22.6^{B}	10.1^{AB}	22.3^{CD}	7.9^{A}
SPM Sub	1.74^{B}	102.7^{C}	0.31^{B}	23.0^{AB}	10.1^{AB}	21.6^{E}	6.9^{A}
GR Sub	1.65^{C}	84.2^{D}	0.35^{B}	23.9^{A}	9.8^{AB}	23.0^{B}	7.4^{A}
GR : FYM	1.63^{C}	80.3^{D}	0.44^{A}	23.1^{AB}	10.9^{A}	22.3^{BC}	7.5^{A}
RS: WS	1.60^{C}	79.6^{D}	0.34^{B}	23.2^{AB}	10.2^{AB}	25.2^{A}	8.1^{A}
				7.5-15 cm			
Control	1.85^{A}	130.2^{A}	0.14^{D}	19.5^{C}	9.5^{A}	19.9^{C}	9.8^{A}
NPK+Zn	1.81^{AB}	122.1^{AB}	0.15^{D}	19.7^{BC}	8.0^{B}	20.7^{B}	9.9^{A}
NPKZn+S	1.78^{AB}	121.4^{AB}	0.16^{D}	19.6^{BC}	8.0^{B}	20.4^{BC}	8.7^{A}
FYM Sub	1.71^{C}	93.9^{C}	0.29^{BC}	19.9^{BC}	9.1^{A}	20.8^{B}	8.9^{A}
SPM Sub	1.79^{AB}	111.6^{B}	0.24^{C}	19.8^{BC}	8.8^{A}	20.9^{B}	9.2^{A}
GR Sub	1.72^{BC}	98.8^{C}	0.27^{BC}	19.9^{BC}	9.2^{A}	20.7^{B}	9.6^{A}
GR : FYM	1.67^{C}	83.8^{C}	0.36^{A}	21.1^{A}	9.3^{A}	21.0^{B}	8.8^{A}
RS: WS	1.65^{C}	81.2^{C}	0.31^{AB}	20.4^{AB}	8.5^{A}	22.2^{A}	9.3^{A}
				15-30 cm			
Control	1.91^{A}	171.6^{A}	0.10^{E}	18.4^{D}	7.1^{C}	18.1^{F}	10.4^{AB}
NPK+Zn	1.89^{A}	163.4^{A}	0.13^{DE}	19.5^{BC}	8.8^{A}	19.8^{DE}	10.1^{AB}
NPKZn+S	1.88^{A}	162.4^{A}	0.15^{D}	18.7^{CD}	8.1^{B}	19.2^{E}	11.3^{A}
FYM Sub	1.77^{AB}	124.0^{B}	0.25^{BC}	20.1^{B}	8.4^{B}	20.6^{BC}	10.3^{AB}
SPM Sub	1.82^{AB}	151.5^{A}	0.22^{C}	20.9^{A}	8.3^{B}	19.6^{DE}	10.1^{AB}
GR Sub	1.76^{AB}	123.3^{B}	0.23^{BC}	19.9^{B}	8.5^{A}	20.9^{B}	11.8^{A}
GR : FYM	1.72^{B}	117.6^{B}	0.30^{A}	19.9^{B}	8.1^{B}	21.8^{A}	8.9^{B}
RS: WS	1.73^{B}	117.2^{B}	0.27^{AB}	19.8^{B}	6.3^{D}	20.0^{CD}	8.3^{B}

amounts of mi and sc fractions. The T_5 treatment has significantly higher SM and lower LM in 0-7.5 and 7.5-15 cm layers. Significantly higher values of micro aggregates Mare recorded in T_6, T_7 and T_8 (70.17,74.34 and 74.76 g 100 g^{-1} of soil, respectively) in the layer 0-7.5 cm compared to zero and 100% inorganic N treatments. In rest of the layers, T_8 has larger effects while other organic treatments have nearly similar impacts as in inorganic N application.

Aggregation indices

The mean weight diameter (MWD) of aggregates is 4 times higher in capillary-wetting than in slaking pre-treatments (Fig. 9.1.18). Variation in MWD values of capillary-wetted aggregates is smaller and they range between 3.5 and 4.5 mm. Except T_7, which has a significantly higher values of MWD in all the layers (3.86-4.58 mm), other treatments are neither significantly different among them nor with the zero-N treatment (T_1). However, the MWD of slaked aggregates shows larger variations, and the treatments differences are quite evident. In the layer 0-7.5 cm, treatments T_4, T_6, T_7 and T_8 have significantly higher MWDs of slaked aggregates. At 7.5-15 and 15-30 cm, values are significantly higher in T_7 and T_8. Rests of the treatments arecomparable,

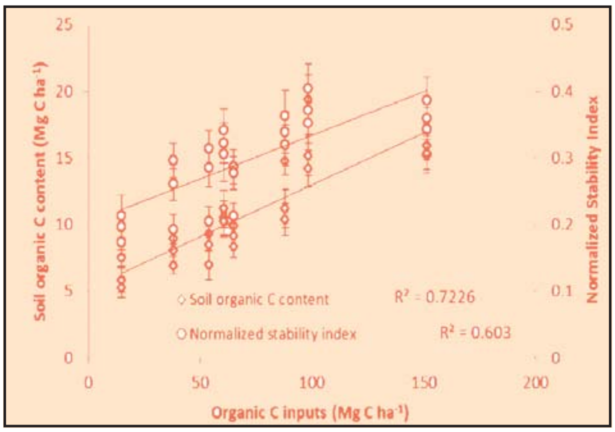


Fig.9.1.18. Stability of soil aggregates and soil organic C content relations with C inputs to the soil

although significantly higher than (7.5-15 cm) or similar to (15-30 cm) T1.

The normalized stability index values are able to distinguish the treatment effects (Fig. 9.1.19). Treatments T_7 and T_8 show greater NSI values in either of the layers (0.34-0.40). Values are significantly higher in all integrated nutrient management practices in both 0-7.5 and 7.5-15 cm layers, while in 15-30 cm, T_4, T_6, T_7 and T_8 has higher values than the rest of the treatments, which are statistically similar.

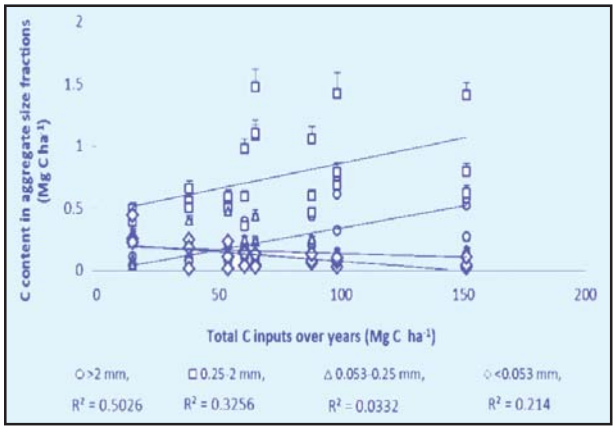


Fig.9.1.19. Accumulation of C in aggregates as influenced by total C inputs to the soil

Carbon in bulk soil and aggregates

The integrated nutrient management has significant effect on bulk soil organic C (Table 9.1.14). It is significantly higher in T_7 and T_8 in all the layers followed by T_4. The inorganic N-fertilizer improves soil C over zero-N, although it has lesser C content than the treatments with partial substitutions of N through organic sources.The C contents are higher in LM and followed the order: LM>SM>sc>mi, although there are substantial variations over the treatments and the soil depths. The C contents in LM and SM fractions are higher in T_7, ranging between 9.51-18.95 g 100 g^{-1} of soil

Table.9.1.14. Carbon in bulk soil and aggregate fractions in 0-7.5, 7.5-15 and 15-30 cm soil layers under the integrated nutrient management practices in a rice-wheat rotation

Treatment	Carbon (g kg^{-1} of soil)							
		Soil aggregate fractions						
	Bulk soil	LM (³2 mm)	SM (0.25-2 mm)	Mi (0.053-0.25mm)	sc (<0.053mm)	cPOM+sand (>0.25 mm)	mM (0.053-0.25mm)	scM (<0.053mm)
0-7.5 cm								
Control	5.87^{H}	7.43^{D}	5.17^{E}	5.66^{C}	7.94^{C}	10.54^{D}	5.68^{C}	8.13^{C}
NPK+Zn	7.25^{G}	10.56^{C}	8.02^{C}	5.68^{C}	8.08^{C}	14.93^{C}	9.62^{B}	8.96^{C}
NPKZn+S	7.85^{F}	10.63^{C}	8.65^{CD}	5.90^{C}	8.36^{C}	14.71^{C}	10.07^{B}	10.31^{B}
FYM Sub	13.77^{C}	13.98^{B}	10.14^{B}	7.51^{B}	9.23^{B}	17.44^{B}	11.75^{B}	12.15^{A}
SPM Sub	8.52^{E}	10.00^{C}	13.74^{A}	9.67^{A}	9.08^{B}	16.95^{B}	10.82^{B}	11.64^{AB}
GR Sub	10.51^{D}	13.36^{B}	9.84^{BD}	6.52^{BC}	9.14^{B}	18.63^{B}	10.35^{B}	11.16^{AB}
GR : FYM	18.40^{A}	18.95^{A}	13.37^{A}	9.27^{A}	11.04^{A}	18.84^{B}	17.37^{A}	13.75^{A}
RS: WS	15.11^{B}	14.58^{B}	12.99^{A}	8.91^{A}	9.94^{AB}	22.36^{A}	12.63^{B}	12.69^{A}
7.5-15 cm								
Control	4.56^{G}	6.84^{D}	6.31^{C}	4.13^{A}	7.24^{B}	6.14^{D}	5.35^{B}	7.02^{B}
NPK+Zn	6.53^{F}	9.02^{C}	7.95^{B}	4.85^{A}	7.35^{B}	6.91^{D}	8.94^{A}	7.93^{B}
NPKZn+S	7.19^{E}	9.16^{C}	7.99^{B}	4.85^{A}	7.78^{B}	6.94^{D}	9.00^{A}	7.98^{B}
FYM Sub	10.46^{B}	11.45^{C}	8.05^{B}	5.08^{A}	8.15^{B}	10.33^{C}	10.34^{A}	11.41^{A}
SPM Sub	7.86^{D}	9.48^{C}	10.82^{A}	6.01^{A}	10.80^{A}	10.95^{C}	11.72^{A}	11.14^{A}
GR Sub	9.87^{C}	10.83^{C}	8.04^{B}	4.91^{A}	8.04^{B}	13.03^{B}	10.26^{A}	10.85^{A}
GR : FYM	14.41^{A}	15.78^{A}	9.87^{A}	5.83^{A}	8.96^{B}	15.16^{B}	10.92^{A}	12.63^{A}
RS: WS	14.36^{A}	13.65^{B}	9.04^{A}	5.52^{A}	8.25^{B}	19.85^{A}	10.66^{A}	12.22^{A}
15-30 cm								
Control	3.97^{E}	4.87^{C}	3.04^{C}	3.92^{C}	4.44^{C}	5.41^{A}	3.43^{B}	4.65^{B}
NPK+Zn	5.43^{D}	5.24^{C}	3.63^{C}	3.99^{C}	4.59^{C}	5.82^{A}	4.33^{B}	5.05^{B}
NPKZn+S	5.48^{D}	5.30^{C}	3.66^{C}	4.74^{BC}	4.63^{C}	5.89^{A}	4.39^{B}	5.33^{B}
FYM Sub	8.57^{B}	8.94^{B}	7.23^{B}	5.08^{B}	5.74^{B}	6.37^{A}	7.65^{A}	7.84^{A}
SPM Sub	6.54^{C}	7.24^{B}	9.93^{A}	5.72^{AB}	7.11^{A}	7.25^{A}	8.24^{A}	8.95^{A}
GR Sub	8.52^{B}	7.14^{B}	6.75^{B}	4.93^{B}	5.65^{B}	6.19^{A}	7.61^{A}	7.37^{A}
GR : FYM	12.42^{A}	15.23^{A}	9.51^{A}	6.22^{A}	6.83^{A}	6.84^{A}	7.95^{A}	8.74^{A}
RS: WS	12.38^{A}	13.24^{A}	8.66^{A}	6.17^{A}	6.37^{AB}	7.27^{A}	7.88^{A}	8.69^{A}

andare closely followed by T_8 (8.66-14.58 g 100 g^{-1} of soil). The C associated with SM in T_5 is similar as in T_7 and T_8, but significantly higher than other treatments in all the layers. Treatments T_5, T_7 and T_8 show higher C contents in mi fraction in 0-7.5 and 7.5-15 cm layers, but no difference among treatments is recorded in 7.5-15 cm layer. No clear trend, however, is observed in C associated with sc fraction of aggregates.

Among various fractions in macroaggregates, cPOM+sand contains higher C, especially in 0-7.5 and 7.5-15 cm layers. Significantly higher C in this fraction is found in T_8 in 0-7.5 and 7.5-15 cm layers; however, all the organic treatments in 0-7.5 cm layer and T_6 and T_7 treatments in 7.5-15 cm layer show higher cPOM-C concentration compared to the inorganic treatments (T_2 and T_3). However, none of the treatments show significant variation in 15-30 cm layer. The organic treatments (T_4 to T_8) increased C contents in mM and scM fractions in all the layers, while effect of inorganic fertilizer is foundin layer 0-7.5 cm only.

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

There is a clear evidence of yield decline or stagnation, deterioration in soil quality, especially soil organic matter in many soils due to intensification of agriculture in India. Soil acts both as source or sink of atmospheric carbon depending on land use, cropping system and management practices. Carbon sequestration in soil through enhanced aggregation is an important approach of judicious soil management to mitigate the increasing concentration of atmospheric CO_2. Aggregate associated organic C is an important reservoir of C, protected from mineralization because it is less subjected to physical, microbial and enzymatic degradation. Soil samples were collected from long term experiment in 2010 to study the effects of different integrated nutrient management practices and tillage practices on soil aggregation, bulk density and associated organic carbon fractions and different C fractions in rice-wheat system. The total water stable aggregates (WSA) at wheat harvest was >50% with different treatments in different locations (Fig. 9.1.20). Application of NPK either through inorganic fertilizers or through combination of inorganic fertilizers and organics such as FYM or crop residue or green manure significantly increased aggregation, mean weight diameter (MWD) (30-72%) and bulk density. The amount of macroaggregates was lowest in the control plot and it was highest in the plots treated with organics. Among the macro aggregates, 0.25-0.50 mm fraction constituted the greatest proportion (15-22% of total WSA). Plots receiving FYM showed the highest MWD and the control plots had

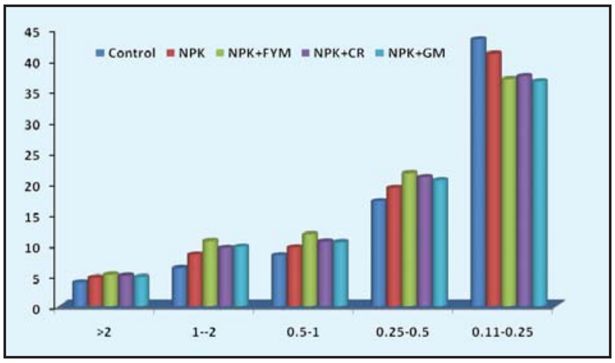
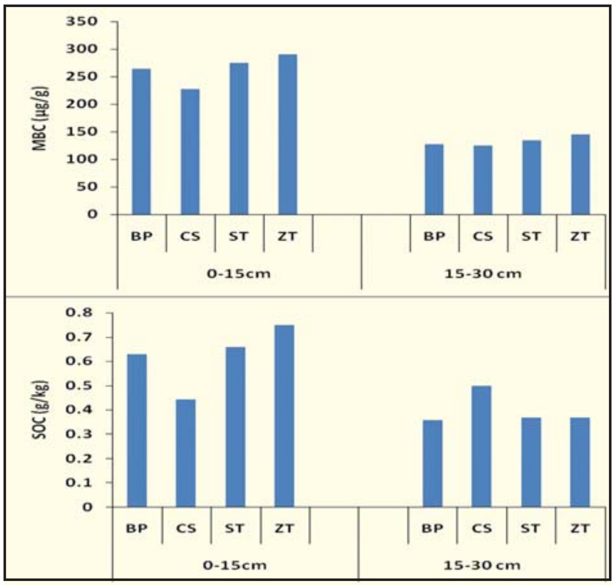


Fig. 9.1.20. Effect of nutrient management on aggregate size distribution

the lowest MWD. This increase in MWD with FYM addition was thus due to higher percentage of soil macroaggregates. acroaggregates had higher C as compared to microaggregates, suggesting that macroaggregates play an important role in C sequestration in soil. Amount of C stabilization in soil depended on the amount of C input through organic sources and these results show that long term application of organics along with inorganics results in C stabilization in macroaggregates. Irrespective of tillage treatments, the fraction of soil macroaggregates was greater than microaggregates. Appreciably higher amount of macroaggregates (>70%) were found at wheat harvest in zero till (ZT) wheat. In ZT system, higher amount of large macroaggregates (>2 mm) aggregates in 0-15 cm depth was recorded, with a proportional decrease in small macroaggregate fractions. Zero tillage increased the bulk density, mean weight diameter and the proportion of macroaggregate fractions and aggregate associated C concentrations, whereas conventional tillage, due to more mechanical disturbances had less aggregation. Different soil C fractions like soil organic carbon, microbial biomass carbon (MBC), particulate organic carbon (POC) (Fig9.1.21), were found to be greater in ZT treatment.



BP- Bed planting; CS- Conventional sowing; ST- Strip tillage; ZT- Zero tillage

Fig. 9.1.21. Distribution of soil organic carbon, MBC under different tillage regimes

SOC content was greatest under ZT (7.5 g kg^{-1}), followed by strip tillage and bed planting and lowest under conventional sowing, i.e., 4.45g kg^{-1}. Beneath 30 cm, the SOC concentrations decreased with increasing depth for all tillage treatments. This indicated a greater potential for C accumulation with ZT. The particulate organic carbon was more in zero tillage as compared to other treatments and this was mainly due to increased yield trend.

It is found that the model estimated the rice-wheat yield at par with the observed yield under recommended dose of fertilizers. DNDC (DeNitrification- Decomposition model) simulated the daily dynamics of soil climate profiles, soil C and N pools, crop growth, N uptake, N leaching and fluxes of CO_2, CH_4, N_2O and NO, N_2 and NH_3. It is found that there is an estimated annual C and N balance of -390 kg C ha^{-1} $year^{-1}$ and 70 kg N ha^{-1} $year^{-1}$, respectively under recommended dose of fertilizers. This simulated annual loss of SOC may be due to lack of organic matter available and also due to high temperature resulting in high decomposition rates of available organic matter in this part of the region. The model also estimated the N uptake by crops, NO_3- leaching and NH_3 volatilization etc. Even though the DNDC model estimated the annual C and N dynamics at par with the reported results by several workers, there is a need for sensitivity analysis of model with different fertilizer levels, irrigation levels and other crop management practices.

D. Soil Amendment and Waste Water Utilization

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

There was reduction in the PMN in the saline sodic soils by 31-37 per cent over the normal soils (16.4 mg kg^{-1}) at the end of the 4 crop cycle. Use of amendments such as gypsum, FYM, Press mud and green manure either in isolation or in combination led to increase in potentially mineralizable nitrogen over the saline-sodic control plots. Introduction of *Dhaincha* as green manure further increased the nitrogen mineralization potentials in saline sodic soils over and above the other inorganic amendments. Impact of cropping systems (Rice-wheat, Rice-mustard and Rice-barley) along with *in situ* residue incorporation of the respective crops also had the similar trend of potentially mineralizable nitrogen in the soil (Table 9.1.15). Rice- mustard system showed highest potentially mineralizable nitrogen in the soil (15.9 mg kg^{-1} soil) over other cropping systems. Highest mineralizable nitrogen could be associated with the mustard residue decomposability in the soil and its impact on soil EC and pH.

Table 9.1.15: **Mean, standard deviation and CV values of potentially mineralizable N (N_0) under different amendments in saline - sodic soils**

Treatments	Mean	SD	CV %
Normal soil	16.4	5.4	11.8
Control (Saline sodic soil)	12.6	5.8	18.4
Gypsum (Gyp)	14.1	2.7	14.6
FYM	14.8	4.3	15.4
Gyp + FYM	15.2	5.8	20.4
Press mud	14.3	6.7	38.0
Press mud + Gyp	16.1	7.8	20.4
Gyp + *Dhaincha* (GM)	15.4	2.5	22.5
Press mud + Gyp + GM	16.1	3.2	19.4
Gyp + FYM +GM	15.4	4.9	24.7
Press mud + Gyp + FYM	15.4	5.8	20.4
Press mud + Gyp + FYM + GM	15.9	6.8	29.4
CD (P =0.05)	0.71	-	-

Higher nitrogen application and System yield

25% higher N application in both rice and wheat gave 17-22 per cent higher system productivity (REY) in all amendments (Table 9.1.16).

Table 9.1.16. **Mean, standard deviation and range of values of potentially mineralizable N (N_0) under different cropping systems (mean of 33 samples)**

Treatments	Mean	SD	CV %
Rice - Wheat	14.8	6.4	15.6
Rice -Barley	14.2	7.9	18.9
Rice - Mustard	15.9	8.2	14.7
CD (P = 0.05)	0.5	-	-

Response of 25% excess N application was observed in all treatments as well as cropping systems. After the 4 crop cycle, the REY increase

Table 9.1.17: **Effect of excess N application on rice equivalent yield in saline- sodic soils under different cropping systems**

Treatments	Rice-wheat		Rice-mustard		Rice- barley	
	RN	25% excess N	RN	25% excess N	RN	25% excess N
Control	9.5	12.6	6.1	7.7	7.0	8.9
Gypsum (Gyp)	9.4	12.1	5.4	7.2	7.1	9.1
FYM	8.4	9.9	4.8	6.2	5.2	6.6
Gyp + FYM	8.4	10.6	4.7	6.0	6.3	7.9
Press mud	9.2	11.1	5.8	7.5	7.4	9.4
Press mud + Gyp	6.8	8.9	5.3	7.0	5.8	7.4
Gyp + *Dhaincha* (GM)	7.4	9.4	5.3	6.4	7.2	9.1
Press mud + Gyp + GM	9.6	13.2	6.3	7.8	6.5	8.6
Gyp + FYM +GM	8.7	10.1	5.6	6.86	5.4	6.9
Press mud + Gyp + FYM	10.9	13.4	5.7	7.5	6.4	8.2
Press mud+Gyp+ FYM + GM	11.2	14.2	6.8	8.8	8.1	10.9

*RN: recommended N applied in individual crops due to 25% excess N application in rice- wheat was 1.0 to 2.9 t ha^{-1} (lowest in press mud to highest in control), in rice- mustard was 1.1 to 1.8 t ha^{-1} (lowest in Gyp + *Dhaincha* to highest in Press mud + Gyp + FYM) and in rice- barley was 1.4 to 2.8 t ha^{-1} (lowest in FYM to highest in Press mud + Gyp + FYM + GM). Higher nitrogen application further enhanced the *in situ* decomposition of residues for all crops as was evident from the CO_2 measurements under field conditions. Higher nitrogen application further enhanced the decomposition of residues for all crops.

xi. Utilization of spent wash effluents for crop production and soil amendment

Cane length, Cane girth, Weight per cane, mileable cane number and cane yield were significantly higher with 50% Effluents and declined thereafter under flat bed planting, however, these parameters were improved with the raised bed planting over the flat bed planting. There was significant increase in the DTPA extractable Fe, Mn, Cu and Zn under both the planting methods with the use of industrial effluents irrigation. Further decomposition of sugarcane trash residue in the soil was increased upto 50% effluent application

Plant characteristics of sugarcane and biomass productivity

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

Cane yield was significantly higher under 50% Effluents irrigation over the normal irrigation water (85.1 and 89.4 t/ ha under flat and raised bed planting, respectively). Dilution of water less than 50% however, declined the yield under both planting methods. Interaction of water and planting method was significant for cane productivity.

Green trash yield was also significantly higher under 50% Effluents irrigation over the normal irrigation water (17.3 and 17.4 t/ha under flat and raised bed planting, respectively). Increasing the concentration of effluents further declined the trash yield. Interaction of effluent water dilution and planting method significantly affected the green trash yield.

Cane recovery was also affected with the dilution of effluents and planting method. Recovery efficiency was significantly increased up to 50% Effluents irrigation (8.6%) over the normal water (6.8%) and declined with the further increasing the concentration of effluents water. Dilution of irrigation water and planting method further improved the recovery efficiency.

Soil characteristics

Effect of effluents with different dilution and planting methods on soil chemical properties showed that soil pH was unaffected with the use of effluents irrigation irrespective of the water dilution and planting method. There was slight increase in the soil EC under the flat bed planting. High presence of Na in the effluents water affected the SAR values in the soil. SAR was slightly but significantly increased with

Table 9.1.18. Soil characteristics after effluent irrigation

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

concentration of effluents water. SAR was maximum with the 100% effluent irrigation as 19.4 and 16.4, respectively with flat bed and raised bed planting. There was significant increase in the DTPA extractable Fe, Mn, Cu and Zn under both the planting methods. Interaction of water and planting method was however was non significant for all soil chemical parameters.

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

Total N in soil was highest with 50% effluents (0.62 and 0.65 g kg^{-1} in flat bed and raised bed, respectively). The C: N ratio of the soil was lowest 6.6 with 50% effluents and highest with 100% effluents in flat bed. In raised bed, it was lowest as 6.5 in normal water and 50% effluents and highest (7.4) in 100% effluents.. The presence of higher C/N ratio in 100% effluent concentration buttresses the presence of higher N content in the effluent. Also, the use of N by microorganisms for metabolic activities did not in any way reduce the C/N ratio below that of control. The change in the C: N ratio of the soil was marginal irrespective of the concentration of the effluents water and planting method.

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

Trash residue decomposition vs effluent irrigation

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

E. Crop Climate Relationship and Modeling

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

Rice during *Kharif*

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

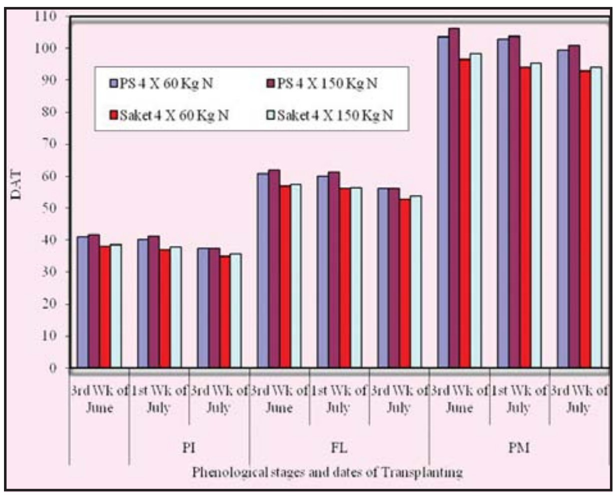


Fig.9.1.22: Effects of date of transplanting and nitrogen levels on phenological stages in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

physiological maturity (PM) were observed among the treatments both in main plots and sub plots (Fig. 9.1.22). Rice transplanted on 3rd week of July reported significantly lower days to reach a particular growth stages and the highest days were taken in D_1 transplanted rice. However, higher dose of nitrogen (150 Kg 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.9.1.23) and declined thereafter in all the treatments. Higher LAI was reported in Saket 4 over the PS 4 in all dates of transplanting. Higher dose of nitrogen (150 Kg/ha) increased the LAI.

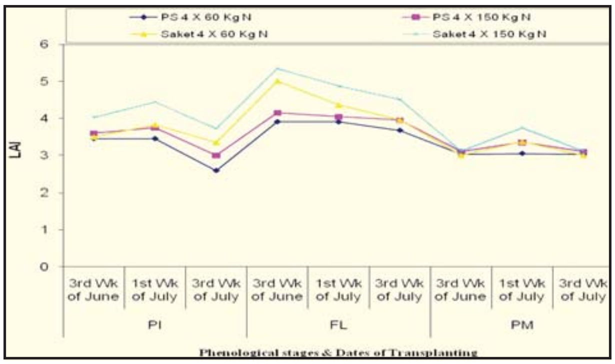


Fig.9.1.23: Effects of date of transplanting and nitrogen levels on Leaf area index (LAI) in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

Effects of date of transplanting and nitrogen levels on grain yield and biomass accumulation

Significantly higher grain yield was reported in 1st Week of July transplanting fertilized with 150Kg N ha^{-1} in both rice genotypes over the other treatments. Significantly lower biomass accumulation was reported in D_3 whereas D_1 and D2 transplanting was statistically at par (Fig.9.1.24).

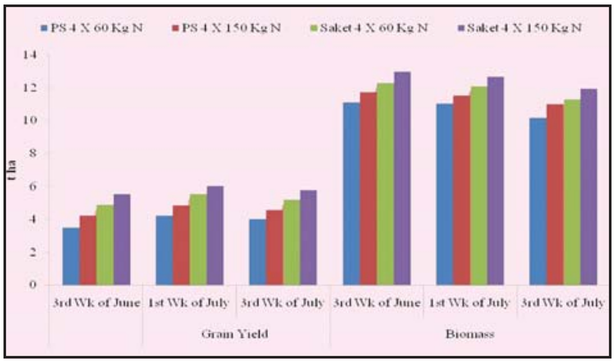


Fig.9.1.24: Effects of date of transplanting and nitrogen levels on grain yield (t ha^{-1}) and biomass accumulation (t ha^{-1}) in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

Effects of date of transplanting and nitrogen levels on growing degree days and Heat use efficiency on grain and accumulation basis

Significantly the highest heat unit was reported in PS 4 fertilized with 150 kg/ha and transplanted on 3rd wk of June and the lowest in Saket 4 fertilized with 60 kg/ha and transplanted on 3rd wk of July. Significantly the highest HUE on grain yield as well as biomass accumulation basis was reported in Saket 4 fertilized with 150 kg/ha transplanted on 3rd wk of July whereas the lowest HUE was reported in PS 4 fertilized with 60 kg/ha transplanted on 3d wk of June. It was reported that higher dose of Nitrogen increased the HUE in general (Fig. 9.1.25).

Fig.9.1.25: Effects of date of transplanting and nitrogen levels on growing degree days and Heat use efficiency on grain and accumulation basis in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

Effects of date of transplanting and nitrogen levels on Radiation use efficiency on grain and accumulation basis

Significantly the highest RUE on grain yield as well as biomass accumulation basis, was reported in Saket 4 fertilized with 150 kg/ha transplanted on 1st wk of July whereas the lowest HUE was reported in PS 4 fertilized with 60 kg/ha transplanted on 3rd wk of June on grain yield basis and PS 4 fertilized with 150 kh/ha transplanted on same date (Fig. 9.1.26).

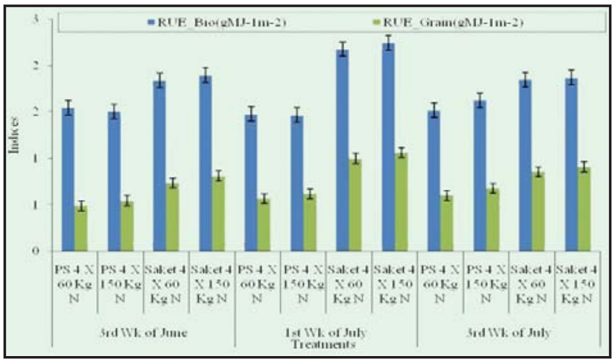


Fig.9.1.26: Effects of date of transplanting and nitrogen levels on grain and accumulation basis in Pusa Sugandha 4 (PS 4) and Saket 4 rice genotypes

Correlation and Regression

Correlation study of grain yield of the cultivars with various meteorological indices and crop growth traits indicated that grain yield was highly significant ($P<0.05$) and positively associated with various parameters (Table 9.1.19). However, it was highly significant but negatively associated with days taken to a particular phenophases and also with total growing degrre days required for physiological maturity of the crop.

Table 9.1.19. Regression Summary

Multiple R	0.9855
R2	0.9712
Adjusted R2	0.9644
F(9,38)	142.5176
P(<0.05)	0.0000
S.E	0.1442

Grain Yield (t/ha) = -11.62 + 0.2796* (RUE_Grain) + 0.1046*(TDM_FL) + 0.3286*(HI) + 0.149* (Bio_PM) + 0.261* (HUE_Grain) + 0.113* (LAI_FL)

Wheat during Rabi

A field experiment was started during rabi 2010-11 with two wheat genotypes *viz,* PBW 343 and PBW 226 with two levels of Nitrogen (60 Kg ha^{-1} and 150 Kg ha^{-1}) were sown on three different dates viz, D_1 (4th week of October), D_2 (4th week of November) and D_3 (4th week of December) with four replications. The major findings are described below.

Effects of sowing date and nitrogen levels on phenology of wheat

Significant variations in phenological events *viz,* panicle initiations (PI), anthesis (AN), heading (HE) and physiological maturity (PM) were observed among the treatments both in main plots and sub plots (Fig. 9.1.27). Wheat cv. PBW 226 required significantly lower days to attain the Pi irrespective

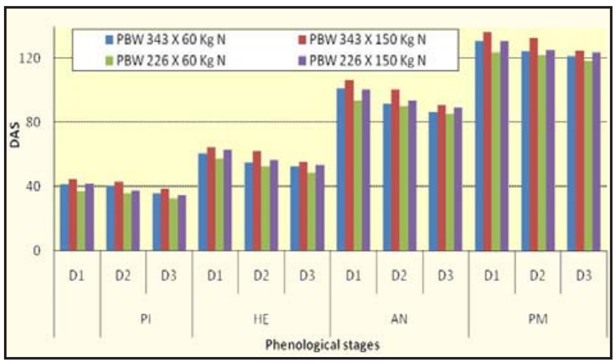


Fig.9.1.27: Effects of sowing date and nitrogen levels on phenological stages in PBW 343 and PBW 226 wheat genotypes

of date of sowing then cv. PBW 343. Panicle initiation was significantly early in PBW 226 fertilized with 60 Kg N ha^{-1} and sown on D_3 (32.0 DAS). Days taken to heading were 64.3 to 48.3 DAS across the treatments. Significantly lower days was taken by PBW 226 fertilized with 60 Kg N ha^{-1} and transplanted on D_3. Anthesis required significantly higher DAS in PBW 343 fertilized with 150 Kg N ha^{-1} and sown on D_1 (106 d) over other treatments whereas, PBW 226 fertilized with 60 Kg N ha^{-1} and sown on D_3 needed lower (85 d) days. Similar trend was observed for attaining the physiological maturity and PBW 343 matured earlier than PBW 343 irrespective of date of transplanting. In general, D_3 required lower days to reach a particular growth stage followed by D_2 and D_1. However, higher dose of nitrogen (150 Kg N ha^{-1}) delayed the maturity of both wheat cultivars in all three dates of transplanting.

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

Linear increase in Leaf Area Index (LAI) was observed in both wheat genotypes up to anthesis (Fig.9.1.28) and declined thereafter in all the treatments. LAI was higher in PBW 343 than PBW 226 genotypes irrespective of date of transplanting and nitrogen level. Significantly lower LAI was recorded in D_3 than D_2 and D_1 at all growth stages

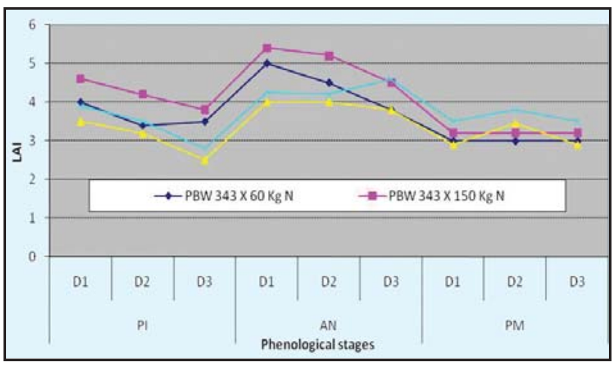


Fig.9.1.28: Effects of sowing date and nitrogen levels on Leaf area index (LAI) in PBW 343 and PBW 226 wheat genotypes

of both genotypes. However, higher dose of nitrogen increased the LAI in both wheat genotypes.

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

Grain yield was higher in D_1 sowing fertilized with 150 Kg N ha^{-1} in both wheat genotypes across the treatments (Fig.3). Higher grain yield (6.03 t ha^{-1}) was recorded in PBW 343 fertilized with 150 Kg N ha^{-1} and sown on D_1 whereas lower grain yield (3.79 t ha^{-1}) was observed in PBW 226 fertilized with 60 Kg N ha^{-1} and sown on D_3 among all the treatments. Heat use efficiency (HUE, Kg/ ^{o}d) was reported relatively higher in PBW 343 than PBW 226 irrespective of treatments (Fig.9.1.29). Mean HUE of all four treatments transplanted on D_2 (2.98 Kg/ ^{o}d) was higher than D_1 (2.86 Kg/ ^{o}d) and D_3

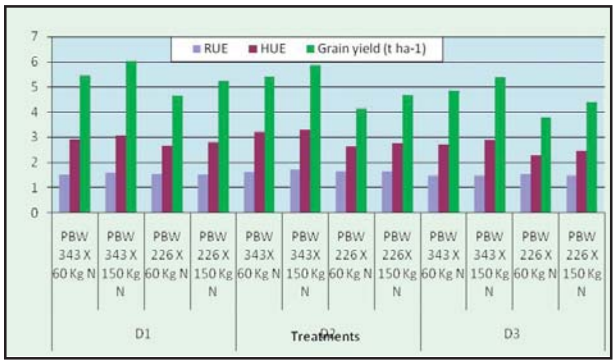


Fig.9.1.29: Effects of date of transplanting and nitrogen levels on grain yield (t ha^{-1}), heat use efficiency (HUE, Kg/ ^{o}d), and radiation use efficiency (RUE, g/Mjm^{-2}) in PBW 343 and PBW 226 wheat genotype

(2.59 Kg/ ^{o}d). 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.9.1.33). However, higher RUE was reported in PBW 343 over PBW 226 genotype irrespective of date of transplanting and dose of nitrogen. Higher dose of nitrogen also increased the radiation use efficiency in both genotypes. HUE was highly associated with grain yield and correlation coefficients (r) were 0.90.

xiii. Development of sustainable production model for rice-wheat system

The field experiment initiated in monsoon 1998 in order to develop a synthesized model of sustainable rice-wheat system was continued for 14th consecutive year (2011-12) at the Directorate's Research Farm. In order to address the major non-sustainability issues of declining soil fertility and increasing weed infestation studies were carried out with following treatment combinations.

Treatments:

T_1= Control i.e., no chemical fertilizer or organic manure

T_2= Recommended fertilizer dose to rice and wheat (SR)

T_3= 75% of recommended NPK as fertilizer+25% N as FYM to rice and complete recommended NPK fertilizer to wheat

T_4= Fertilizer similar to T_3, but substitution of every third wheat crop with berseem

T_5= Fertilizer similar to T_3, but substitution of every third rice crop with forage cowpea

T_6= Soil-test based fertilizer use in rice and wheat (STCR

T_7= Organic farming

The results are presented in Figs. 9.1.30 and 31.

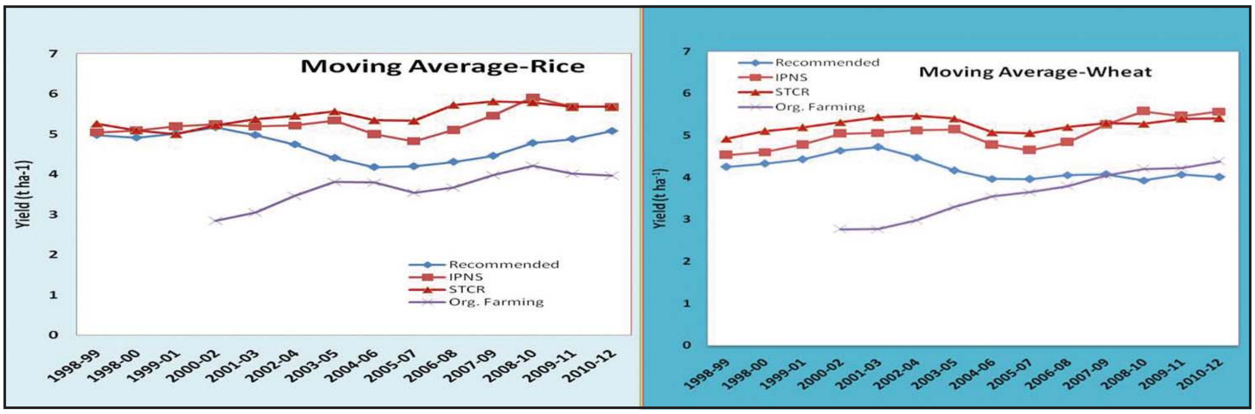


Fig.9.1.30: Yield trend of rice and wheat over the years based on moving average

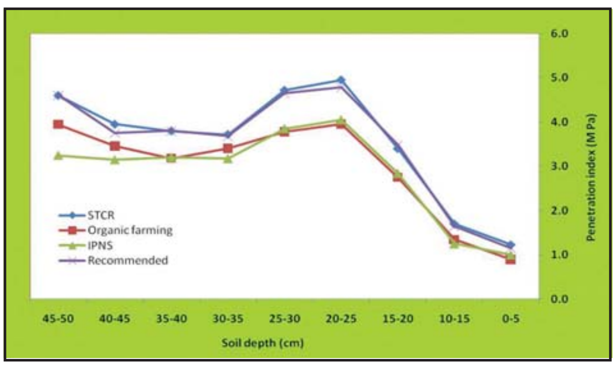


Fig.9.1.31: Soil penetration resistance under Organic vs Chemical farming

F. Database Management

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

Database was structured, architected and designed under Structure Query Language Program for digitizing various observations on different treatments, soil characteristics, plot size, planning details, nutrients applied and yield parameters of on station experiments conducted during 2011-12 in respect of eighteen centres. The experiments covered were ,"Identification of need based cropping systems for different agro-eco systems", "Long range effect of continuous cropping and manuring on soil fertility and yield stability"," Permanent plot experiment on integrated nutrient supply system in cereal based crop sequences"," Resource conservation technologies", Organic farming" and "Sustainable production model in different cropping systems".

Under the On Farm research experiments, "Diversification and Intensification of cropping systems", Response of Nutrients" and Sustainable Production System" conducted at ECF centres of AICRP-IFS during 2010-11, the data was architected, designed , structured and digitized yield wise for different treatments.

xv. Digitization of Database of Network Project on Organic Farming Experiments

Database on Organic Farming Experiments under Network project is being developed in GUI mode (Graphical user interface). Initially Visual basic programming language will be used as front end while SQL server /MS Access as back end. The Relational Database approach will be used to design the database. The fundamentals of Normalization theory have been used to normalize the different tables of the database. Thirteen master tables for the network centres have been created to setup the entity-relation among them. At present system is standalone but in future the system will be a web-based application. It is based on client-server three tier distributed structure technology and can be accessed from any node on the Internet through a web-browser

Password Validation, Main Menu and few data entry forms have been created so far (Snap shots have been attached). Data entry in Excel Sheets for three centers is in progress for testing purpose of the database.

9.2 ORGANIC AGRICULTURE SYSTEMS (OAS)

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

An experiment on "Studies on improvement of soil organic carbon in rice-wheat system under resource conservation technologies" was initiated during the *kharif 2009* 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, different sub-plot treatments like zero till wheat (ZT), bed planting of wheat (FIRB), conventional tilled wheat (CWS), happy seeder planted wheat (HS) were superimposed and wheat was grown during *rabi* (2009-10) season and being continued in cropping seasons 2009-10, 2010-11, 2011-12 and 2012-13 without changing the layout.

In this experiment the agronomic package for SRI method of cultivation involved soil amendment at a rate of 10 t of FYM during final land preparation and 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 harrowing 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 were adopted. Recommended package involved 100% dose of fertilizers (N_{120}, P_{60} K_{40}) for the both the crops. The same was also true for direct seeded rice. No organic manure was applied in direct-seeded rice. Conventional package of rice cultivation involved four passes with tillers followed by planking for impounding of water, which is required for transplanted rice. Twenty one day old seeding was transplanted at 20 x 15 cm spacing.

Highest grain yield of (6.03 t ha^{-1}) wheat during rabi, 2011-12 was recorded under main plot which was designated for SRI method of rice cultivation compared to 4.77 t ha^{-1} under conventional method of wheat cultivation (CWS) and the treatment effect was significant. The yield increase compared to conventional method of wheat cultivation was at the tune of 26.00%. On the contrary, the highest yield

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

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield(t ha^{-1})	Harvest index	Ear head length(cm)	Plant height (cm)	Effective Tillers	1000 grain weight(g)
DSR	5.30	6.77	12.07	2.28	14.76	109.15	413	37.01
SRI	6.03	7.52	13.55	2.25	15.84	117.25	443	41.48
TPR	5.56	7.25	12.81	2.30	14.59	102.91	433	37.53
CONTROL	2.73	5.89	8.62	3.16	12.30	85.24	238	30.04
CD (P = 0.05)	0.03	0.21	1.30	8.00	0.89	2.10	18.0	1.50
Sub Plots								
ZT	5.44	6.70	12.14	2.23	15.00	101.87	421	38.05
HS	5.78	6.95	12.73	2.20	15.90	106.03	438	40.33
FIRB	6.46	7.57	14.03	2.17	16.39	115.20	449	39.71
CWS	4.77	6.48	11.25	2.36	14.48	103.95	417	36.69
CD (P = 0.05)	0.12	0.23	0.92	2.92	1.10	3.50	27.0	0.61

among sub-plot was 6.46 t ha^{-1} under FIRB system which yielded 35.00 % higher than the conventional method of wheat sowing and the effect was significant. The yield attributing characters of wheat followed the same trend as yield under both main and sub-plot treatments (Table 9.2.1).

The root and shoot biomass accumulation of wheat at periodic interval showed a gradual increase up to physiological maturity stage. The highest shoot and root biomass was recorded under main plot which was meant for SRI treatment. Among sub-plot treatments, shoot biomass was highest under FIRB, but the root biomass was higher under HS. Soil properties after harvest of wheat were also determined in terms of O.C. and available N, P, K and MBC. Organic carbon and MBC were highest (0.62% and 230 µg g^{-1} soil) under SRI among main plots and 0.60 % and 178.00 µg g^{-1} under happy seeder seeded wheat. Among main plots, available N was highest (312 kg ha^{-1}) under SRI method of cultivation, Av. P under DSR and Av. K under SRI treatment. Among sub-plots, Av. N, P and K were highest under happy seeder seeded wheat (Table 9.2.3, 5&6).

Rice: Highest grain yield (6.52 t ha^{-1}) of rice during *kharif* 2012 was recorded under SRI method of rice cultivation compared to 5.44 t ha^{-1} under conventional method of rice cultivation (TPR) and the effect of treatments were significant. The percent yield increase under SRI was 11.11%. The straw yield under SRI was 9.0 t ha^{-1}. The yield and yield attributing characters of rice was also highest under SRI method of rice cultivation (Table 9.2.2).

Table 9.2.2. Yield and yield attributing characters of rice under RCT

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest index	Ear head length (cm)	Plant height (cm)	Effective Tillers	1000 grain weight (g)
DSR	4.25	5.94	10.19	2.40	19.48	100.20	278	20.50
SRI	6.52	9.10	15.62	2.40	21.00	112.60	377	24.10
TPR	5.44	8.70	14.14	2.60	19.86	108.20	360	21.60
CONTROL	2.11	2.90	5.01	2.38	14.90	85.90	146	17.20
SEM (±)	0.34	0.57	1.23	0.12	3.56	5.24	21.0	1.14

Table 9.2.3: Soil properties after harvest of wheat under RCT

Treatment	O.C g.kg^{-1} soil	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. (kg ha^{-1})	MBC (µg g^{-1} soil)
DSR	0.54	205	43.85	335	165
SRI	0.62	312	36.30	489	230
TPR	0.54	250	33.15	470	181
CONTROL	0.48	175	23.50	254	105
CD (P = 0.05)	ns	9.8	4.90	23.2	8.4
Sub Plots					
ZT	0.58	256	38.17	360	175
HS	0.60	265	39.10	476	178
FIRB	0.56	259	35.48	461	172
CWS	0.53	234	36.37	240	165
CD (P = 0.05)	ns	21.5	4.5	30.2	8.1

Table 9.2.4: Soil properties after harvest of rice under RCT

Treatment	O.C g.kg^{-1} soil	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. (kg ha^{-1})	MBC (μg g^{-1} soil)
DSR	0.56	195.2	42.2	350	170.2
SRI	0.61	310.4	35.6	480.0	250.1
TPR	0.53	242.0	32.8	465.3	190.2
CONTROL	0.46	175.0	24.2	259.5	110.5
CD (P = 0.05)	NS	15.4	8.2	21.5	15.3

Table 9.2.5: Shoot biomass of wheat (t ha^{-1})

Treatments	20DAS	40DAS	60DAS	80DAS	At harvest
DSR	1.29	2.61	3.10	3.37	6.46
SRI	1.42	2.87	3.39	3.69	7.08
CONVENTIONAL	1.31	2.64	3.11	3.39	6.51
CONTROL	1.05	2.12	2.50	2.72	5.22
ZT	1.33	2.69	3.17	3.45	6.63
HS	1.32	2.67	3.15	3.42	6.57
FIRB	1.49	3.00	3.53	3.85	7.39
CONVENTIONAL	1.23	2.48	2.93	3.19	6.11
CD (P = 0.05)	0.19	0.50	0.52	0.80	1.52

DAS= Days after sowing

Table 9.2.6: Root biomass of wheat (t ha^{-1})

Treatments	20DAS	40DAS	60DAS	80DAS	At harvest
DSR	0.28	0.59	0.97	1.15	1.77
SRI	0.38	0.72	1.08	1.85	2.17
TPR	0.31	0.69	0.86	1.57	2.01
CONTROL	0.21	0.41	0.66	1.07	1.47
ZT	0.23	0.54	0.87	1.03	1.68
HS	0.34	0.67	0.99	1.65	2.07
FIRB	0.28	0.63	0.79	1.40	1.91
CWS	0.19	0.37	0.59	0.96	1.39
CD (P = 0.05)	0.03	0.02	0.08	0.12	0.19

Root and shoot biomass accumulation of rice was recorded at periodic interval and the highest biomass accumulation in terms of root and shoot was recorded under conventional and SRI treatments respectively irrespective of stages of growth (Table 9.2.7&8). Soil properties after crop harvest revealed that organic carbon, available N and K were highest under SRI and available P was highest (42.2 kg ha^{-1}) under DSR method of rice cultivation (Table 9.2.4). Microbial population in terms of heterotrophic bacteria, total bacteria, fungi, actinomycetes and N fixing bacteria are also highest under SRI at panicle initiation stage (Table 9.2.9&10).

Table 9.2.7: Shoot biomass of rice under RCT (t ha^{-1})

Treatments	20DAT	40DAT	60DAT	80DAT	At harvest
DSR	0.97	2.25	3.90	6.54	9.03
SRI	1.66	3.18	4.61	8.39	11.75
TPR	1.55	2.88	4.34	7.16	9.51
CONTROL	0.69	1.22	2.56	3.48	4.45
CD (P = 0.05)	0.16	0.48	0.40	0.76	1.20

DAT= Days after transplanting

Table 9.2.8: Root biomass of rice under RCT

Treatments	20DAT	40DAT	60DAT	80DAT	At harvest
DSR	0.26	0.50	0.82	0.98	1.57
SRI	0.34	0.64	0.96	1.69	1.79
TPR	0.37	0.65	0.76	1.38	1.81
CONTROL	0.17	0.33	0.54	0.88	1.26
CD (P = 0.05)	0.02	0.03	0.09	0.11	0.16

Table 9.2.9: Microbial Population in soil under various cultural practices in rice during panicle stage under RCT (t ha^{-1})

Treatment	Heterotrophic Bacteria	Bacteria	Fungi	Actinomycetes	Nitrogen fixing bacteria		
	$x10^6$	$x10^7$	$x10^4$	$x10^5$	$x10^3$	$x10^4$	$x10^5$
DSR	30.7	109.3	18.0	26.8	128.9	77.9	38.5
SRI	71.3	249.6	23.9	34.0	148.3	95.5	41.7
TPR	43.0	165.5	14.9	26.8	118.8	81.8	37.5
CONTROL	28.9	89.4	8.2	13.9	54.0	37.3	18.7
CD (P = 0.05)	12.6	25.1	4.56	3.90	27.20	22.6	19.5

Table 9.2.10: Microbial Population in soil under various cultural practices in rice during panicle initiation stage under RCT ($t\ ha^{-1}$)

Treatment	Heterotrophic Bacteria	Bacteria	Fungi	Actinomycetes	Nitrogen fixing bacteria		
	$x10^6$	$x10^7$	$x10^4$	$x10^5$	$x10^3$	$x10^4$	$x10^5$
DSR	33.5	127.0	17.6	27.8	134.9	82.3	37.3
SRI	79.8	296.2	23.7	36.6	163.4	100.1	41.9
TPR	48.7	204.2	14.6	25.9	125.6	82.8	37.8
CONTROL	32.6	115.5	7.9	15.8	56.3	39.5	20.0
CD (P = 0.05)	10.6	23.1	4.06	3.80	23.20	20.6	17.5

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

The experiment is being conducted since 2003 and has completed 8 crop cycles. Seven treatments *viz.* 50% recommended NPK + Zn + S as per soil test + 50% N as FYM (T_1); 100% organic nutrient sources (FYM), 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:

Highest grain yield of onion during summer 2012 was recorded under T_4 (20.50 $t\ ha^{-1}$) which received organic nutrient sources each equivalent to 1/3 of recommended N dose and agronomic practices for weed and pest control. Percent yield increase under this treatment was 12.58 % compared to T_7. The yield increase under other organic nutrient management packages varied from 4.34 to 9.88 % (Table 9.2.11).

Highest grain yield of maize (6.35 $t\ ha^{-1}$) was achieved under T_6 which received T_2 + bio fertilizers

Table 9.2.11: Crop yield under various nutrient management packages in maize-potato-onion system

Treatment	Onion	Maize	MEY ($t\ ha^{-1}$)	% increase/decrease in onion yield over T_7		MEY ($t\ ha^{-1}$)
	2011-12	2012	2011-12	Onion	Maize	Av. last 3 years
T_1	18.21	5.8	24.40	1.59	1.37	27.88
T_2	19.50	6.02	31.04	7.08	3.44	31.65
T_3	19.00	5.85	29.43	4.34	0.52	32.21
T_4	20.50	5.95	30.55	12.58	2.23	29.84
T_5	20.01	6.35	30.91	9.88	3.09	30.96
T_6	17.73	4.82	30.37	-2.64	9.11	30.87
T_7	18.21	5.8	22.63	-	-	26.73
SEm$\pm$	0.89	1.02	2.3			

containing N and P carries but the maize equivalent yield (MEY) 31.04 t ha^{-1} was highest under T_2. Maize yield increase in T_6 was 9.11 % as compared to treatment T_7 (Table 9.2.11).

Soil fertility under various organic nutrient management after completion of 8 crop cycles has been presented in Table 9.2.12. Organic carbon and microbial biomass carbon were highest under T_6 at 0.66% and 375.5 µg g^{-1} soil. Av. N, P and K were highest under T_3. The uptake of N,P and K in individual crop and also in the system has been presented in (Fig.9.2.1-4). The total N, P and K uptake in the system was 575.6, 107.2 and 517.6 kg ha^{-1} under T_2 respectively.

Microbial population in terms of bacteria, fungi and actinomycetes after harvest of summer season onion and *kharif* maize is presented in Fig 9.2.5. Irrespective of treatments, microbial population was highest under maize crop compared to onion. Further, important fact is that compared to inorganic and integrated nutrient management packages, organic nutrient management packages harbored higher microbial population in terms of bacteria, fungi, actinomycetes and phosphate solubilizing bacteria and treatment T_6 was superior to all.

Table 9.2.12: Soil fertility under various nutrient management packages in maize-potato-onion system after eight crop cycle

Treatment	O.C g.kg^{-1} soil	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. (kg ha^{-1})	MBC (µg g^{-1} soil)
T_1	0.63	268	31.5	260	342.52
T_2	0.64	248	26.4	217	340.63
T_3	0.66	282	32.3	205	360.32
T_4	0.63	265	31.5	215	344.65
T_5	0.64	227	32.8	241	305.23
T_6	0.66	255	27.2	232	375.54
T_7	0.52	217	21.7	178	207.65
SEM (±)	NS	25.0	4.6	24.5	56.13

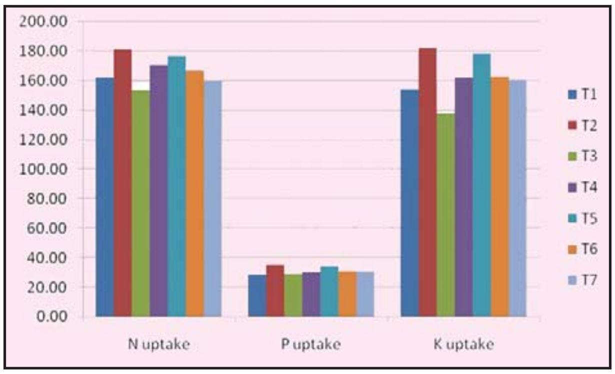


Fig. 9.2.1. Nutrient uptake by maize (2012) under various nutrient management packages in maize-potato-onion system

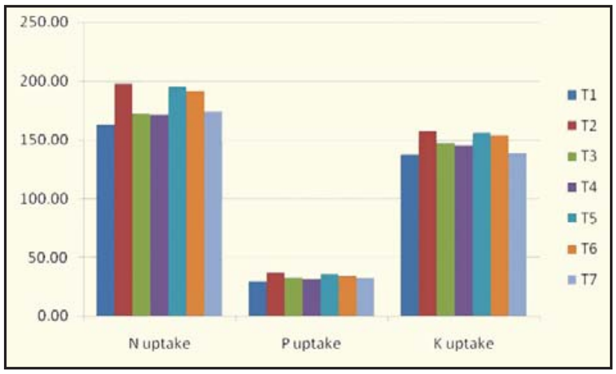


Fig. 9.2.2. Nutrient uptake by Potato (2012) under various nutrient management packages in maize-potato-onion system

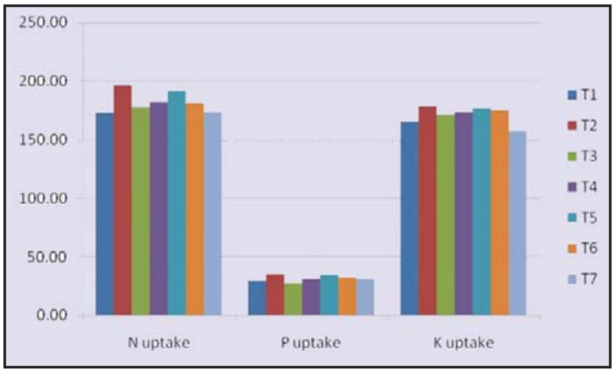


Fig. 9.2.3. Nutrient uptake by onion (2012) under various nutrient management packages in maize-potato-onion system

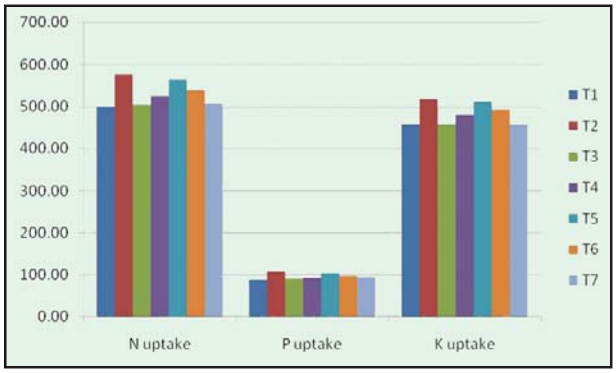


Fig. 9.2.4. Total nutrient uptake under various nutrient management packages in maize-potato-onion system (2012)

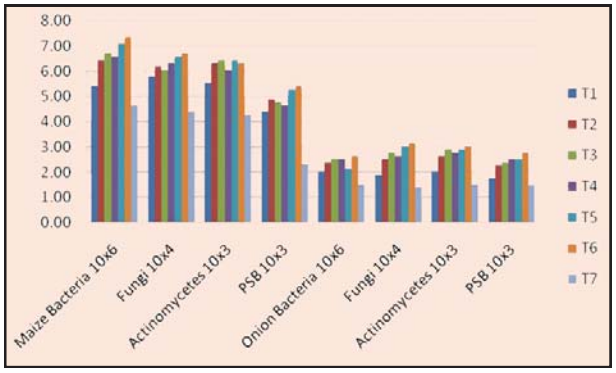


Fig. 9.2.5. Microbial population during 2011-12 in MPO system under various organic nutrient management packages

Onion crop under organic nutrient management package

Potato crop under organic nutrient management package

Yield of potato under organic nutrient management package

Maize crop under organic nutrient management package

iii. Carbon footprint of sugarcane, wheat and rice production in Western Plain Zone, India

An exercise was made to calculate the C footprint of sugarcane, wheat and paddy production by the farmers of Meerut district using the required activity data of a case study 2006. Deficit data were obtained/ derived from the literature and on personal discussion with the farmers of the region. Standard methodology was followed to calculate the C footprint. Results showed that among the crops, sugarcane being C_4 is the highest accumulator of C and hence more C sustainable followed by wheat and paddy. Among different categories of the farmers, C sustainability index of sugarcane, wheat and paddy varied between 27.6 – 32.1, 6.15 – 6.36 and 5.00 – 5.67, respectively. Likewise, mean C footprint per unit production (kg) is lowest for sugarcane (0.065 kg CO_2 equivalent) followed by paddy (0.507 kg CO_2 equivalent) and wheat (0.514 kg CO_2 equivalent).

Among different components of C footprint across crops and categories of farmers, fertilizer production and application is the major component in C emission hot spot requiring decreasing the N doses and increasing its use efficiency by disseminating the available technologies. Averaged across the different categories of farmers, fertilizer production and application contributed 81.7, 80.9 and 60.2 per cent of total CO_2 equivalent emission in production of sugarcane, wheat and paddy production, respectively with corresponding contribution from N fertilizer of 79.8, 78.9 and 55.1 per cent. There were no perceptible differences in CO_2 equivalent emission among different categories of farmers indicating same level of adoption of different crop production and management practices by the different categories of the farmers. However, CO_2 equivalent emission due to farm operations in sugarcane production increased with increasing size of holding.

9.3 INTEGRATED FARMING SYSTEMS (IFS)

i. Development of cost effective and sustainable IFS models for livelihood improvement of small farm holders of western Plain Zone of U.P.

As per decisions of IRC meeting, the technical programme (Action Plan) of exciting IFS model was modified and the area of the model was also reduced from 1.5 hectare to 1.20 hectare Out of total area of IFS model (1.20 hectare), 0.85 ha have been allotted to field crops including green fodders and rest of the area 0.45 hectare have been allotted to nutritionally rich and high income fetching enterprises like horticultural crops fruits & vegetables, fishery, apiary, mushroom and vermicompost etc. In addition to this backyard poultry and kitchen gardening will be put in periphery of dwelling unit. Further, all the farm boundaries and pond dykes are with plantations of fruits, forestry trees and perennial grasses/bushes. Enterprise wise details / progress made during reported year is given here under:

A. Action Plan (Kharif 2012 and onward)

Crop Production (existing area of 1.04 ha)

As per need of a 7 member Indian family, cereals, pulses, oilseeds, vegetables, sugar and green fodder crops will be raised/ undertaken in different crop sequences following the principals of crop rotations and keeping sustainability issues in mind. The important crop sequences are;

1. Sugarcane (Spring) + black gram/cowpea – sugarcane ratoon + menthi –wheat (3200 m^2)
2. Rice – wheat- maize + cowpea (G.F) (1200 m^2)
3. Sorghum (K)-mustard- green gram (1200 m^2)
4. Maize+ pigeon pea – wheat (1200 m^2)
5. Rice- Berseem (850 m^2)
6. Rice- Oats (850 m^2)

Milk Production (2 buffaloes and one cow)

Livestock unit will comprise of two buffaloes (Murrah breed) and one cow (H.F.) and also their young ones. As a policy matter it is decided not to sale female calves and maintains them till they reach to fertility stage and then sale to fetch higher income. The male calves are to be sold at 2-3 years of age for draft purposes on considerably higher prices. To maintain whole the year milk production the milch animals were purchased in phases and not at a time. The cow dung will be composted properly either as vermicompost and/ or farm yard manure and animal urine will be diverted into fish pond as fish feed.

Fruit Production (0.22 ha)

Fruit orchard with mango and guava as main fruit trees, papaya and pear as intercrop fruits and citrus & karonda as border plantations was established and now is in full maturity stage. Considerably good fruit yields were also harvested during 5th' and 6th' years of planting the fruits. In addition to this, several intercrops viz; vegetables brinjal and tomato and fodder crops oats, berseem and even sorghum were taken for more profits during first 3-4th' years of establishment. However, because of dense canopy of fruit trees, the crop planning is to be changed in coming next years and it is considered to grow crops like turmeric, ginger and green chilly etc. better suited in such conditions. The management of fruit trees and intercrops is also to be done on more scientific basis as compared to initial establishment years under the supervision of the scientist (Hort.) associated in the project.

Fish Production (0.10 ha)

Fish production was started in 2005 in a fish pond comprising an area of 0.1 ha land with net volume of 810 cu.m. ponded water . Composite fish culture of Rohu, Mrigal, katla, Nain and grass & common carp was undertaken to get advantage of all the water layers in to the fish pond. Because of loamy sand nature of soil, water loss was high during initial two years but later on deposition of more silt in to the pond minimized the water loss to a great extent. Similar was the trend in fish production. In first three years the production of fish was below 300kg/year which rose to more than 450kg/year in 5th year of production and thereafter. Now it is considered to increase profits from pond area by utilizing whole the dyke area for production of various type of fruits and vegetable species and further increase in production of fishes through adoption of scientific knowledge/scientific man power (Scientist-fishery) available in the project. However, fish production will be restricted to low cost input based enterprise rather than costly market based inputs for wider adaptability and profits. In addition to this scientific data on growth and yield will also be undertaken for meaningful explanation of the results from the study.

Bee keeping (10 bee boxes)

This enterprise was also started in very first year of the establishment of the project. Inspite good yield in first two to three years the apiary unit could not give sufficiently better results thereafter because of heavy attack of **Baravo** insect not only in the unit of IFS but in most of the northern states for consecutively two years. Further, for high yields of honey and proper growth of the bees, regular supply of flowers is a pre-requisite which is not possible at one place and that's why owners of commercial apiary units shift their boxes from one place to another even at far distances which is not feasible and economic with small unit of 10-25 boxes. And hence limited scope of this enterprise at small farm holders. However, with the help of supplementary food (sugar) in lien periods when flowers are not sufficiently available and better crop selection / management, production of honey sufficient for home consumption and little for market may be a better choice. Further this enterprise does not require much land area and labour. Keeping this in mind, it is considered to continue the enterprise for further experimentation and further strengthening with scientific skill and management.

Vermicompost (0.01 ha)

As in past, the unit will continue as such but will be managed with high skill. Various farm wastes and crop residues viz; straw, banana and sugarcane leaves, mushroom spent wash etc. will be added in different ratios with cow dung for increase nutrient levels and composting efficiency. The vermicompost prepared will be analyzed in laboratory and will also be tested in field for production of field and plantation crops.

Boundary plantations

All the field boundaries were planted mainly with fruit and fodder tree/bush species and also start production. The programme will be further strengthened by gap filling of the mortalities in old plantations and new plantation with suitable forestry trees in left out borders/field boundaries. The adverse effect of planted trees/vegetation on field crops (if any) will also be observed, simultaneously.

Mushroom

Mushroom unit with production capacity of 200 to 250 kg per year was established in 2011-12. Mushroom species dhingri button and milky mushroom round the year for more production and profit from the unit will be produced.

Biogas unit

To meet household fuel need a biogas unit of 1.5 Cu.m capacity was also installed. In addition to above, backyard poultry (10 birds) and kitchen gardening (behind dwelling unit) is also planned to be initiated.

B. Results (Kharif 2012):

Crop Production (0.85 ha)

Cropping plan was modified with reduction in area from 1.04 ha to 0.85 ha and crops raised in changed land configuration in ensuing rabi season. The report, however, includes kharif: 2012 crops results only and are summarized in the table-9.3.1 below:

Table-9.3.1: Production and profits from crop unit during kharif season- 2012.

Cropping systems	Crop	Area (m²)	Production (Kg./q/ton)	Produce Value (Rs.)	Cost (Rs.)
Sugarcane (Spring) + black gram/ cowpea–sugarcane ratoon + menthi	Sugarcane ratoon	3200	Cane : 22.0 ton	55,000	18,560
			Green top : 4.4 ton	4,400	
Rice – wheat – maize+ cow pea	Rice	1200	Grain : 6.59 q	7,908	3,840
			Straw : 8.71 q	450	
Sorghum(K)-mustard-green gram	Sorghum	1200	GF : 96q	14,400	1,560
Maize+ pigeonpea – wheat	Maize	1200	Grain : 3.56 q	3,204	2,520
			Stalk : 5.34 q	801	
	Pigeonpea	1200	Grain : 2.7 q	9,450	
			Fuel wood : 7.5 q	900	
Rice- Berseem	Rice	850	Grain : 4.66 q	5,592	2,720
			Straw : 6.17 q	230	
Rice-Oats	Rice	850	Grain : 4.88 q	5,856	2,720
			Straw : 6.34 q	300	
		8500		GR: 1,08,491	CC:31,920
Net return (NR)	GR:Rs.1,08,491 – CC:Rs.31,920 = Rs.76,571 or say Rs.90,083/ha				

CC: Sugarcane - Rs.58,000/ha , Rice - Rs.32,000/ha ,Maize + arhar Rs.21,000/ha, Sorghum 13,000/ha GR: Rs.1,27,636/ha, Net returns Rs.90,083/ha and cost of cultivation Rs.37,552/ha

Milk Production

In running project, the number of animals exceeded that of standards recommended for animal number in small far conditions. Hence, in modified project, the number will be reduced from 11 at present to 6 (2 buffaloes +1Cow and 3 young ones).

Table-9.3.2: Production and profits from dairy unit of the model.

Particulars	Values
Number of animals	11
Productive animals (including young ones)	4+4
Other animals (Proposed for culling)	3
Auction value (Rs.) of culling animals	48,000
Total milk production (liters)	7410
Total value of milk (Rs.)	2,03,584
Production of FYM (quintals)	140
Total value of cow dung (Rs.)	5600
Total expenditure incurred (Rs.) GF+DF+Concentrates+MM+Medicines etc.	1,38,329
Gross income (Rs.)	2,57,184
Net returns (Rs.)	1,18,855

The details of milk production and relative dairy by products in 2012 is given in table-9.3.2.

Horticulture (Fruits and intercrops)

Because of full grown trees canopy cover, the only intercrop turmeric was taken in between the rows of fruit species. The turmeric will be harvested in February, 2013. The production of fruits harvested in the year and income generated from the unit are given in table-9.3.3.

Pisciculture (Fresh water fish production – 0.10ha)

Fresh water fish production initiated in 2005 has start giving considerably good and stable fish production which was recorded 480kg during 2012, sold at nominal price of Rs.50/kg earned a gross and net returns of Rs.24,000 and Rs.20,400 per annum, respectively. In addition to this 18.6 kg N, 6.2 kg P and 4.2 kg K was also recycled and used for crop production by de - silting of nutrient rich soil (pond silt excavated in alternate years). Not only had this, but recycled pond water applied to crops increased crop yields by 12-15% in rice.

Table-9.3.3: Fruit production and income generated from horticultural unit.

Farm produce	Quantity (kg)	Rate/kg(Rs.)	Produce value(Rs.)
Guava	227.5	20	4550
Mango	61	20	1220
Karonda	134.5	20	2690
Citrus	111.25	20-40	3510
Pear,peach , aonla, jackfruit	34.0	16	545
“Beal”	73 pieces	10/piece	730
Gross returns		-	13,245
Expenditure		-	3100
Net returns		-	10,145

Table-9.3.4: Production and profitability of fresh water fish production.

Particulars	Inputs/year	Initial Dose	Dose/Month	In terms of NPK
Area	1000 sq m	-	-	-
Fingerling	1000 nos.	Katla, Rohu, mrigal, silvercarp, common carp, grass carp (2:2:2:1:1:2)		
Cattle Dung	1200 kg	240 kg	96 kg	3.6 N + 2.4 P + 1.2 K
Urea (46% N)	30 kg	-	3 kg	13.8 kg N
SSP (16 % P)	30 kg	-	3 kg	4.8 kg P
MOP (60 % K)	4 kg	-	0.4 kg	2.4 kg K
Liming	15 kg	-	1.5 kg	-

Economics of fish production
Fish production- 480 kg
Costs of production: Inputs =Rs.2600 +Harvesting= Rs.1000=Rs.3600
Gross Returns = Rs.24,000/annum
Net Returns = Rs. 20400/ per annum

Consumed NPK (Kgs):17.4 N,7.2 P,3.6 K
Recycled NPK (Kgs):18.6 N, 6.2P, 4.2 K

Complementary enterprises

Besides supplementary enterprises horticulture and fishery integrated in to the existing farming system crop + dairy of the region as described above, complementary enterprises like mushroom and apiary and value adding activities vermicompost and biogas unit were also added in to the IFS model developed at PDFSR. The performance of these units is given hereunder;

Apiary (Bee Keeping)

Because of heavy pest (Baravo) infestation during last two to three years, the unit suffered a lot and production was badly affected. Because of these factors, a low yield of 70 kg was recorded sold @Rs.120/kg generating total revenue of Rs.8340. All care and maintenance is being undertaken to make improvement in this enterprise.

Vermicompost

Vermicompost unit produced 19 tons of enriched compost which was recycled in production of different field and plantation crops of the unit. To see the effect of different constituents (cow dung and farm by-products/residues) of Vermicompost on the quality and nutritional status of the compost so prepared , an experiment was started by mixing various farm by products viz; rice and wheat straw, farm weeds and subabool leaves mixed with cow dung in different ratios. Treatment with 75% cowdung +25% wheat straw followed by 75% cowdung +25% subabool leaves gave more vermicompost yield whereas minimum was with 75% cowdung +25% grasses &weeds. The nutrient content however, was more in subabool leaves mixed compost followed by cowdung alone.

Mushroom and Biogas

Mushroom and Biogas were added in the existing IFS model during 2011-12. Biogas unit is being used for making food as kitchen gas and is sufficient to meet the fuel needs of a small family except low gas production during winter months. Mushroom unit was started with production of "Dhingary" specie which produced more than 150 kg of mushroom generating additional revenue of

Rs.7,500/-. To raise the income from the unit and quality of produce, simultaneously, production of button mushroom is in progress.

Boundary Plantations

All the farm field boundaries including fruit orchards and pond dykes have been covered under plantations of perennial fruits and fodder species including jackfruit, "bel" (stone fruit), citrus, guava, jamun and Lucenea lucocephala (Subabool) . Most of the planted species have now started given income and this year income worth Rs. 8085/- has been generated.

Economic evaluation of IFS model

The results of the reporting year 2012 indicated that IFS approach increased gross and net returns by 210.6% and 159% as compared to crop alone. Enterprises horticulture, fishery, vermicompost and mushroom were found to give higher input : output ratio as compared to crops and dairy. Highest input : output ratio was in fishery followed by mushroom and vermicompost (Table-9.3.5).

Technologies developed: IFS model for western plain zone of Uttar Pradesh has been developed. A technical bulletin on the results of a six year study on the subject has been published.

ii. Productivity and Economic Evaluation of Horticulture Based Farming Systems

Experiments were conducted at PDFSR, Modipuram to develop horticultural crop based model for improving profitability, enhanced productivity and nutritional security of small and marginal farmers particularly of western plain zone of Uttar Pradesh, in which three modules, viz. which are being studied under this project, Fruit based (CS 1, 0.3 ha), vegetable crops based (CS 2, 0.22 ha) and field crop based (CS 3, 0.4 ha) are evaluated. Among the modules, vegetable based system has been reported to be most effective in terms of productivity and profitability (Gross return of Rs.249957) followed by fruit crop based system (Gross return of Rs.80172) and crop based system (Gross return of Rs.68717) respectively in the first year with adoption of recommended dose of fertilizers

Table 9.3.5: Comparative performance of farm enterprises.

Enterprises/ component of IFS Model	Cost of production (Rs.)	Gross return (Rs.)	Net return (Rs.)	Input:output
Crop production ($8500m^2$) – Kharif crops	31,920 (37,552/ha)	1,08,491 (1,27,636/ha)	76,571 (90,0083/ha)	3.40
Milk production (2B+1C)	1,38,329	2,57,184	1,18,855	1.90
Horticultural crops ($2200m^2$)	3,100	13,245	10,145	4.27
Fish production($1000m^2$)	3,600	24,000	20,400	6.67
Apiary (10 bee boxes)	4,200	8,340	4,140	1.98
Vermicompost ($100m^2$)	13,300	57,000	43,700	4.29
Mushroom production ($200m^2$)	1250	7,500	6,250	6.00
Total ($12000m^2$)	1,95,699 (1,63,082/ha)	4,75,760 (3,96,466/ha)	2,80,061 (2,33,384/ha)	-

Table 9.3.6. Productivity and economic evaluation of different cropping systems

Cropping Systems		Variety	2011 -12	Actual Area (m^2)	Actual yield (kg)	Selling Price/ kg (Rs)	Gross Return
CS-1 (fruit based)							
Mango Intercropping	Onion	N-53	5.14	700	360	5	1800
Guava Intercropping)	Okra	Arka Anamika	6.1	550	335	15	5025
Banana Intercropping	Turmeric			200	120	40	4800
				1450			11625
						Gross return/ha	80172.41
CS- 2 (Vegetables Based)							
Turmeric	Turmeric	Ludhiana selection	5.914	700	414	40	16560
Bottlegourd-Cauliflower -Tomato	Bottle gourd	Sonali	9.342	700	654	10	6540
	Cauliflower	Pusa Aghani	10.24	700	717	5	3585
	Tomato						
Brinjal-Potato	Brinjal	Pusa Purple Long	10.28	700	720	5	3600
	Potato	K. Bahar	20.42	700	1430	40	57200
				3500			**87485**
						Gross return/ha	**249957.14**
CS-3 (Crop Based)							
Rice-Wheat	Rice	Saket4	3.83	1500	575	10.5	6037.5
	Wheat	PBW-343	5.17	1645	850	10.8	9180
Sugarcane-Ratoon-Wheat	Sugarcane	COS-767	40.5	2100	8500	2.45	20825
	Wheat			**5245**			**36042.5**
						Gross return/ha	**68717.82**

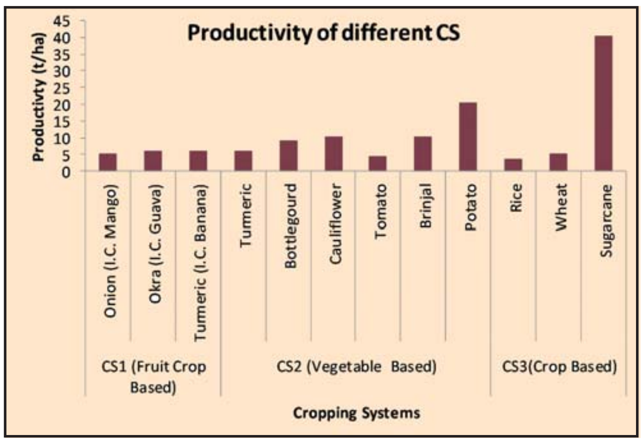


Fig. 9.3.1. Performance of different crops under various cropping systems

and other cultural practices. The lower gross return from fruit crop based system in the first year is because the fruit plants are in non-bearing stage and will start bearing fruits in next year.

Soil fertility status of different cropping systems

Effect of different horticulture based farming systems on soil fertility status was studied at PDFSR, Modipuram. The results revealed that the intercropping systems were effective in bringing gradual improvement in the soil properties (Table 9.3.7). Among the fruit based systems, banana based cropping systems highest followed by mango based cropping system resulted in the most improvement of organic carbon and available N in the soil throughout the year. Where as the maximum increase in available soil potassium (K) was recorded under the guava based cropping system.

In case of vegetable crop based cropping system, growing of turmeric throughout the year proved most effective in increasing the available soil N (167 kg/ha) and K (32.9 kg/ha). Similar trend was recorded for sugarcane- ratoon – wheat based system.

Table 9.3.7: Soil fertility status of different cropping systems

	pH	EC	OC (g/kg)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)
CS-1 (Fruit crop based cropping system)						
Mango (Amrapali)- intercrops	7.81	0.24	4.50	164	33.4	180
Mango (Dasheri)- intercrops	7.85	0.25	4.53	167	33.3	183
Guava (Allahabad Safeda) -intercrops	7.80	0.22	4.47	162	32.5	184
Guava (L-49) -intercrops	7.80	0.22	4.49	165	32.6	192
Lalit -Intercrops	7.80	0.25	4.41	162	32.6	185
Banana- Intercrops	7.80	0.23	4.55	166	33.1	169
CS-2 (Vegetable crop Based)						
Bottleguard-Cauliflower-Dhaincha-Tomato	7.84	0.21	4.40	164	32.6	185
Brinjal-Potato-Beans	7.81	0.24	4.26	160	32.5	177
Turmeric (Through out the year)	7.84	0.25	4.47	167	32.9	174
CS-3 (Cereal crop Based)						
Sugarcane-Ratoon-Wheat	7.77	0.18	4.43	160	31.2	176
Rice-Wheat-Dhaincha	7.83	0.26	4.35	158	31.3	164

9.4 RESOURCE CHARACTERIZATION AND SYSTEM DIAGNOSIS (RCSD)

i. Status of organic agriculture in eastern Himalayan region

Survey of Mizoram was conducted during 2010-11 and 3 districts namely Aizwal, Kolasib and Mamit were selected using multistage stratified random sampling method. Again 2 blocks from each district namely Mamit and Zavylnuam from Mamit, Tlangnuam and Thingsulthlian from Aizwal, Thingdawl and Bulkhawthlir from Kolasib districts were selected using the same sampling procedure. Thus a total of 6 blocks were chosen for the proposed study. Thereafter 4 village from each block and 10 farm families from each village were selected. Finally a total of 240 households were selected for collecting the data. Besides general information, the area under organic, inorganic and organic+ inorganic agriculture of each farm group was collected on the prescribed and well tested questionnaire through interview of the head of the farm families. The productivity of rice, maize, zinger, potato radish carrot, colocasia, cauliflower, beans, broccoli, squash and other such crops were also recorded. The information about other enterprises kept by the farmers, expenditure incurred and income derived from each enterprise was also noted. Similarly the details of inputs and their quantity used in production of each crop commodities along with per unit price were also recorded. Farm animal details and opinion of the farmers about organic and inorganic farming was also noted. The yield of rice for last five years grown with organic manures and mineral fertilizers were also collected to assess the impact of these materials on soil fertility beside grain yield. The constraints facing by the farmers in organic agriculture were also recorded. The name of agencies working in promoting for organic agriculture in the state was also noted. The simple average and percentage were used as analytical tools in processing the data.

Identification of farmer's category

As per data gathered from different districts of Mizoram selected for the study, 80 % farmers were found cultivating traditional organic agriculture while 20 % were noticed utilizing meager amount of mineral fertilizer (27kg/ha) for crop production. However, the organic materials were found to be used mainly for zinger and other vegetables. In the analysis of data table 9.4.1, it was observed that out of the total sample farmers 66.76 per cent were Small while 21.67 and 11.6 was of medium and large category.

Yield trend of rice

As evident from Fig (9.4.1), the yield trend of rice of organic producers was marked decline while it was observed increasing in case of farmers using inorganic fertilizers. The similar trend was observed in case of maize which is next important crop of the state.

As apparent from Table (9.4.2) the traditional organic growers harvested 12.1 and 15.5 q/ha paddy and maize compared to 9.9 and 12.5q/ha by traditional inorganic producers in Aizwal district. The similar variation was noticed with different magnitude in other district as evident from data. The productivity of paddy and maize which is lower than the national average clearly showed that soil fertility status of both group of farmers are very low. However, the higher yield of these crops of inorganic growers indicates that the soil fertility of this farm group is comparatively better than organic producers. As

Table 9.4.1 Socio-personal characteristics of respondents in Mizoram

Particulars	Aizwal		Kolasib		Mamit		Average	
	No.	%	No.	%	No.	%	No.	%
Age								
Young (<25 years)	18	22.50	26	32.5	21	26.25	65	27.08
Middle (25 - 50 years)	45	56.25	38	47.5	44	55.00	127	52.92
Old (> 50 years)	17	21.25	16	20.00	15	18.75	48	20.00
Education								
Llliterate	19	23.75	13	16.25	11	13.75	43	17.92
Primary	9	11.25	17	21.25	13	16.25	39	16.25
High School	37	46.25	29	36.25	29	36.25	95	39.58
Graduate	8	10.00	12	15.00	17	21.25	37	15.42
Post Graduate	7	8.75	9	11.25	10	12.5	26	10.83
Land Farm Size (ha.)								
Small (< 5)	49	61.25	53	66.25	58	72.50	160	66.67
Medium (5 - 10)	23	28.75	16	20.00	13	16.25	52	21.67
Large (>10)	8	10.00	11	13.75	9	11.25	28	11.67
Farm Family Labour								
Male	110	45.83	90	37.50	85	35.42	285	118.75
Female	90	37.50	83	34.58	76	31.67	249	103.75
Type of Occupation								
Agriculture only	32	40.00	43	53.75	39	48.75	114	110.00
Agriculture+ Livestock	15	18.75	11	13.75	15	18.75	41	38.75
Agri + Poultry+ Fish	9	11.25	8	10.00	6	7.50	23	23.75
Agri.+service+Hort.	13	16.25	12	15.00	11	13.75	36	35.83
Agri.+service+Business	11	13.75	6	7.50	9	11.25	26	25.00
Land use pattern								
Organic	58	72.50	71	88.70	63	78.70	192	80.00
Inorganic	22	27.50	9	11.30	17	21.30	48	20.00

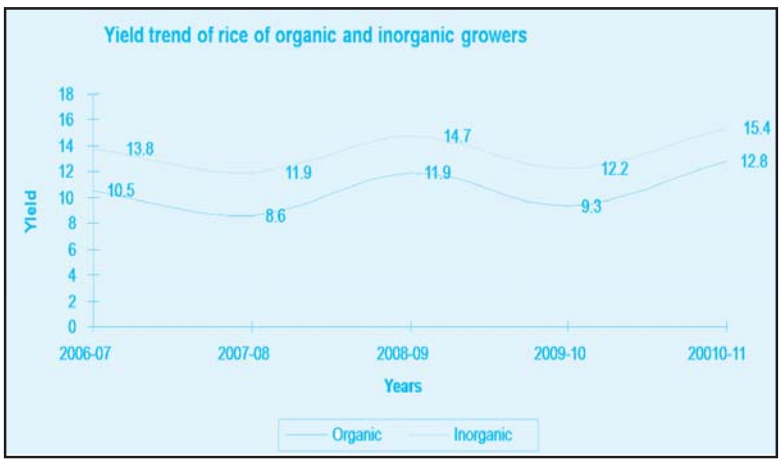


Fig. 9.4.1 Yield trend of rice of organic and inorganic grower

Table 9.4.2. Rice and maize productivity of Organic and Inorganic cultivators in Mizoram (2010-11)

District	Paddy (q/ha)		Maize (q/ha)		(%) increase over organic	
	Organic	inorganic	Organic	Inorganic	Paddy	Maize
Aizwal	12.1	15.5	9.9	12.5	28.10	26.26
Kolasib	13.9	15.8	11.2	13.9	13.67	24.11
Mamit	12.4	14.9	12.3	14.8	20.16	20.33
Average	12.80	15.40	11.13	13.73	20.31	23.35

organic farmers neither use organic manure nor fertilizer, it is obvious that their soil fertility status will never improve. The pooled analysis indicated 12.80 and 11.13 q/ha of paddy and maize productivity of traditional organic farmers while it was 20.9 and 18.0 q/ha in case of traditional inorganic producers.

Organic manures

Consumption of organic manures in study districts during 2009-2010 is presented in Table 9.4.3. Data revealed that slaked lime is the major organic manure used in Mizoram, highest usage being in Kolasib district (1000MT) among 3 districts surveyed followed by Aizwal. Vermicompost is more prevalent in Aizawl district.

Table 9.4.3. District wise consumption of Organic manures during 2009-10

District	Slaked Lime (in MT)	Vermi Compost (in Qtls)
Aizawl	932	500
Kolasib	1000	200
Mamit	150	50

Source: Statistical Abstract book 2009-10

Economics of organic and inorganic produce

The cost and returns of rice and maize grown under organic and inorganic practice is presented in (Table 9.4.4) indicated disparity in net return of these crops. The crop productivity of organic farmers was

Table 9.4.4. Economics of organic and inorganic farming (in ha.)

Expenditure details	Organic	Inorganic	Organic	Inorganic
	Paddy		Maize	
Ploughing and leveling	4000	4000	1900	1900
Seed Cost	1500	1000	900	600
Nursery raising	1200	1200	—	—
Transplanting /sowing	2500	2500	1000	1000
FYM /fertilizers	—	1300	—	450
Irrigation cost	—	—	—	—
Plant protection	—	800	—	—
Weeding	1400	1400	0	0
Harvesting cost	1800	1800	1000	1000

Expenditure details	Organic	Inorganic	Organic	Inorganic
	Paddy		Maize	
Threshing cost	2000	2000	1200	1200
Bagging & Transport	1200	1500	800	900
Cost of cultivation	15600	17500	6800	7050
Interest on capital	936	1050	408	423
Total operational cost	16536	18550	7208	7473
Yield (q/ha)	12.8	15.4	11.5	14.6
Price of grain (Rs/q)	2100	1750	1150	900
Gross return	27300	26950	13225	13140
Net return	10764	8400	6017	5667
BC ratio	1.65	1.45	1.83	1.76

low. Also, the productivity of farmers using inorganic fertilizers was low due to less dose of.

Major Agriculture and allied enterprise of Mizoram

Major and minor farming system and crop rotation systems prevalent in the region as reveled from the survey is agriculture, agriculture + animal husbandry, agriculture+horticulture, agri+ animal husbandry+ horticulture has respectively. Similarly under micro-farming systems agri+fishery, piggery+fishery, poultry+fishery systems were observed from the study. Under crop crops rotation paddy, vegetable & oilseeds were rotated with paddy and maize. Banana and pineapple were intercropped with oil palm and hatkora. In the mixed cropping practices chillies, vegetable and sesamum are cultivated with paddy and maize jhum system. Different agricultural enterprises in practice in Mizoram include crops, horticulture (fruits and vegetables), oilseeds, Piggery, Poultry, Dairying and Fishery.

Horticulture

Mizoram is suitable climatic conditions for cultivation of vegetables and spices, production system has been suffering from the low productivity. The reasons of low production and productivity are use of local verities, improper nutrient management, incidence of insect pests and diseases and inadequate facility for irrigation. The problem could be solved by adopting improved production technology. These include cruciferous (cole crops), Solanaceous, cucurbitaceous, malvaceous are squash, tomato, cabbage, cauliflower, beans, radish, brinjal, broccoli, Chinese mustard, okra, garden pea, palak, carrot, etc. these vegetables may be classified into three categories, namely : underground vegetables, leafy vegetables and fruit vegetables. Farmers economics of vegetable in cost of cultivation along with yield and B: C ratio of Mizoram is given in Table 9.4.5.

Table 9.4.5: Economics of vegetable in cost of cultivation along with yield and B:C ratio of Mizoram

Crops	Cost of cultivation (Rs.)	Yield (t/ha)	Rate (Rs./kg)	Earning (lakhs)	Cost/Benefit ratio
Tomato	65000	19	10	1.9	1:2.9
Brinjal	63000	26	8	2.08	1:3.3
Chilli	68000	9	18	1.62	1:2.4
Cabbage	60000	23	6	1.38	1:2.3
Cauliflower	57000	17	8	1.36	1:2.3
Chow Chow	46000	19	6	1.14	1:2.4
Palak	26000	14	5	0.7	1:2.6
Ginger	61000	15	9	1.35	1:2.2

ii. Characterization and Evaluation of Existing Farming Systems in India

The Directorate undertook the farming system characterization work in Madhya Pradesh during 2011-12 to identify and characterize the existing farming systems across eco-system and size groups, analyze the productivity and viability of farming systems, and determine the factors contributing for farming systems. All Agro-climatic zones of the state form the base for this study. The sample for the study consists of thirty percent districts from each zone having 50 percent representation of high productivity districts and 50 percent representation of low productivity districts. Further, from every district, four representative blocks and three village panchayats from each block were selected by adopting stratified four stage random sampling method. Six farmers from each village panchayat, consisting of two each marginal, small and two farmers from among medium and large size category were interviewed on random basis to fill up the pre-tested schedule and questionnaire. The results are presented below.

Farming Systems in Kymore Plateau of Madhya Pradesh

This area is a vertical strip running down central Madhya Pradesh including Jabalpur Katni and Seoni districts. The region has a relatively high proportion of waste and uncultivated lands (about 21%). About 22 percent of the land is under forest cover. Only 37 percent of the area is cultivated. Irrigation facilities are very poor as only about ten per cent of the cultivated land is irrigated. The cereal-based systems were dominant in the zone and these contribute maximum farm income to the area.

The overall percentage of cereal based farming systems in the zone was 84.72, 75.00 and 79.17 per cent in Jabalpur, Katni and Seoni districts, respectively. While the percentage of households in Jabalpur, Katni and Seoni district under livestock-based farming systems were found to be 12.50, 9.73 and 8.33 percent respectively. The vegetable-based farming systems were also found in Jabalpur (2.78%), Katni (15.27%) and Seoni (12.5%) districts, respectively. Thus it is clear that maximum numbers of households were dependent on the cereal-based farming systems in the study area (Table 9.4.6).

Further the farming systems were identified on the basis of relative income from different enterprizes. A perusal of (Table 9.4.7) revealed that the highest percentages of gross income for all the farms were contributed by the cereal-based farming systems

Table 9.4.6: Farm size wise number of households in different farming systems in Kymore Plateau (Madhya Pradesh)

S. No.	Farming Systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		A. District Jabalpur				
1.	Livestock-based	4(15.38)	2(10.52)	2(11.76)	1(10.00)	9(12.50)
2.	Cereal-based	21(80.77)	16(84.28)	15(88.23)	9(90.00)	61(84.72)
3.	Vegetable-based	1(3.84)	1(5.26)	0(0.00)	0(0.00)	2(2.78)
	Total	26	19	17	10	72
		B. District Katni				
1.	Livestock-based	3(9.37)	2(11.11)	1(6.66)	1(14.28)	7(9.73)
2.	Cereal-based	24(75.00)	13(72.22)	11(73.34)	6(85.71)	54(75.00)
3.	Vegetable-based	5(15.62)	3(16.66)	3(20.00)	0(0.00)	11(15.27)
	Total	32	18	15	7	72
		C. District Seoni				
1.	Livestock-based	4 (12.90)	1(5.26)	1(7.14)	0(0.00)	6(8.33)
2.	Cereal-based	24(77.42)	15(78.95)	11(78.57)	7(87.50)	57(79.17)
3.	Vegetable-based	3(9.68)	3(15.79)	2(14.29)	1(12.50)	9(12.50)
	Total	31	19	14	8	72

The figure in bracket shows the percentage of total.

Table 9.4.7: Farm size-wise percentage share in gross income of different farming systems of districts Jabalpur, Katni and Seoni in (Madhya Pradesh)

S. No.	Farming Systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		A. District Jabalpur				
1.	Size of farm holding (ha.)	0.42	1.41	2.29	4.11	2.05
2.	Livestock based	55.10	50.14	30.49	21.50	39.30
3.	Cereal based	28.59	39.40	62.45	75.29	51.43
4.	Vegetable based	16.31	10.56	7.16	4.21	9.57
	Total	100	100	100	100	100
		B. District Katni				
1.	Size of farm holding (in ha.)	0.38	1.29	2.78	4.41	2.21
2.	Livestock based	60.12	51.72	25.65	17.14	38.65
3.	Cereal based	26.62	39.18	68.82	80.11	53.68
4.	Vegetable based	13.26	9.1	5.53	2.75	7.67
	Total	100	100	100	100	100
		C. District Seoni				
1.	Size of farm holding (in ha.)	0.30	1.18	2.28	4.20	1.99
2.	Livestock based	58.12	55.65	24.60	14.87	38.31
3.	Cereal based	27.52	38.20	69.82	81.38	54.23
4.	Vegetable based	14.36	6.15	5.58	3.75	7.46
	Total	100	100	100	100	100

(51% to 54 %), followed by livestock-based farming systems (about 39%).

Farming Systems in Chhattisgarh Plain Zone of Madhya Pradesh

Balaghat district of Madhya Pradesh comprise Chhattisgarh plain zone. This region is rich in alluvial soils but has a large proportion of ravines. Net sown area is low at about 37% of geographical area. Only 36% of the cultivated area is irrigated. Rainfall is limited to only 670 mm. On the basis of relative income, cereal-based farming systems followed by livestock-based and vegetable-based farming systems are dominant in this area. The overall percentage of households practicing cereal based farming systems in the zone was 55.56 percent. While the percentage of households in livestock and pulse based farming systems were 34.72 and 9.72 percent (Table 9.4.8 & 9).

Farming Systems of Bundelkhand Zone of Madhya Pradesh

The proportion of wastelands in this sub-zone is very high at about 37%. Only about 45% of the land is cultivated. A little over a third of the cultivated area is irrigated. The sub-zone includes the district of Tikamgarh. The area receives relatively low rainfall of around 700 mm annually, the climate is dry sub-humid and the soil type is classified as mixed red and black. There were four

Table 9.4.8: Farm size-wise number of households under different farming systems in district Balaghat (Madhya Pradesh)

S. No.	Farming Systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		District Balaghat				
A	Livestock-based	8(29.63)	8(33.33)	5(20.83)	4(44.44)	25(34.72)
B	Cereal-based	17(62.96)	13(54.17)	5(20.83)	5(55.56)	40(55.56)
C	Pulse-based	2(7.41)	3(30.86)	2(8.33)	0(0.00)	7(9.72)
	Total	27(100)	24(100)	12(100)	9(100)	72(100)

The figure in bracket shows the percentage of total.

Table 9.4.9: Farm size-wise percentage share in gross income of different farming systems in district Balaghat (Madhya Pradesh)

S. No.	Particulars	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		District Balaghat				
1	Size of farm holding (ha.)	0.38	1.21	2.19	4.33	1.45
2	Livestock based	62.11	51.31	29.89	17.22	40.13
3	Cereal based	29.25	36.98	53.45	64.28	45.99
4	Pulse based	8.64	11.71	16.66	18.50	13.88
	Total	100	100	100	100	100

major farming systems followed in the area, viz., livestock-based farming system, cereal-based farming system, oilseed-based farming system, and vegetable-based farming system.

The farming systems were further identified on the basis of relative gross income from different farming systems. The overall percentage of households practicing cereal based farming systems in the zone was 43.06 percent. While the percentage of households in livestock, oilseed and vegetable based farming systems were 36.11, 13.89 and 6.94 percent, respectively in district Tikamgarh. Thus it is clear that maximum numbers of households were dependent on the cereal-based farming systems in the study area (Table 9.4.10).

A perusal of table 9.4.11 revealed that the highest percentage share in grass income among all the farmer come from the cereal based farming systems. On an average, the contribution from the systems was 44.98 percent of their gross income in the district Tikamgarh. While the share of livestock based farming systems in gross income was 33.47 percent. The share of oilseed and vegetable based farming systems were 10.95 and 10.61 percent in district Tikamgarh.

Table 9.4.10: Farm size-wise number of households in different farming systems in the district Tikamgarh (Madhya Pradesh)

S. No.	Farming Systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		District Tikamgarh				
A	Livestock-based	12 (48.0)	8 (34.7)	4(23.5)	2(28.5)	26(36.1)
B	Cereal-based	10(40.0)	7(30.4)	9(52.9)	5(71.4)	31(43.0)
C	Oilseed-based	3(12.0)	4(17.4)	3(17.6)	0(0.0)	10(13.9)
D	Vegetable-based	0(0.0)	4(17.4)	1(5.9)	0(0.0)	5(6.7)
	Total	25(100)	23(100)	17(100)	7(100)	72(100)

The figure in bracket shows the percentage of total.

Table 9.4.11: Farm size-wise percentage share in gross income of different farming systems of district Tikamgarh (Madhya Pradesh)

S. No.	Particulars	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		District Tikamgarh				
1	Size of farm holding (in ha.)	0.35	1.31	2.5	4.67	2.94
2	Livestock-based	54.10	44.46	25.21	10.12	33.47
3	Cereal-based	30.09	35.38	53.15	61.28	44.98
4	Oilseed-based	9.56	11.81	9.36	13.05	10.95
5	Vegetable-based	6.25	8.35	12.28	15.55	10.61
	Total	100	100	100	100	100

Farming Systems of Northern Hills Region of Madhya Pradesh

Northern hills region sub-zone consists of Dindori district. It receives relatively higher rainfall, (about 1,570 mm / annum). Around 42% of the land is cultivated and a little over a third of it is irrigated. Tribal population is high in this zone. The farming systems were identified on the basis of relative gross income from the cereal-based, livestock-based, oilseed based and pulse-based farming systems. The overall percentage of households in cereal based farming systems in the zone was 34.72 per cent. While the percentage of households in livestock, oilseed and pulse based farming systems were 22.22, 22.22 and 20.83 percent, respectively in district Dindori. Thus it is clear that maximum numbers of households were dependent on the cereal-based farming systems in the study area (Table 9.4.12).

The table 9.4.13 revealed that the highest percentage share in gross income for all farms was contributed by the cereal-based farming system (40.26%). It was followed by livestock-based farming systems (28.01%) in the district Dindori. While, the share of pulse-based and oilseed-based

Table 9.4.12: Farm size-wise number of households in different farming systems in the district Dindori (Madhya Pradesh)

S. No.	Farming systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		District Dindori				
A	Livestock-based	5(38.4)	6(25.0)	4(16.6)	1(9.1)	16(22.2)
B	Cereal-based	2(15.4)	9(37.5)	10(41.7)	4(36.3)	25(34.7)
C	Pulse-based	2(15.4)	5(20.8)	5(20.8)	3(27.3)	15(20.8)
D	Oilseed-based	4(30.7)	4(16.6)	5(20.8)	3(27.3)	16(22.2)
	Total	13(100)	24(100)	24(100)	11(100)	72(100)

The figure in bracket shows the percentage of total.

Table 9.4.13: Farm size-wise percentage share in gross income of different farming systems of district Dindori (Madhya Pradesh)

S. No.	Particulars	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		District Dindori				
	Size of farm holding (in ha.)	0.73	1.62	2.77	4.83	2.49
1	Livestock based	42.11	37.20	20.19	12.52	28.01
2	Cereal based	29.65	32.14	46.15	53.10	40.26
3	Pulse based	16.84	17.49	19.06	19.14	18.13
4	Oilseed based	11.40	13.17	14.60	15.24	13.60
	Total	100.00	100.00	100.00	100.00	100.00

farming systems in gross income was minimum i.e.18.13 and 13.60 percent only in the district.

Farming Systems of Satpura Plateau Zone of Madhya Pradesh

The district of southern Madhya Pradesh, Chhindwara with a combined area of about two million hectares form the Satpura Plateau sub-zone. The area receives about 1,120 mm of rains annually and about 36% of the area is under forest cover. Around 52% of the geographical area is tilled, but only about 13% of this is under developed irrigation facilities. The area has a high proportion of tribal population. There were four major types of farming systems followed in the area, viz., livestock-based farming system, cereal-based farming system, vegetable-based farming system, and cotton-based farming system.

The farming systems were identified on the basis of relative income from the cotton-based farming systems followed by livestock-based, cereal based and vegetable -based farming systems. The overall percentage of households in cotton based farming systems in the zone was 33.33 per cent. While the percentage of households in livestock, cereal and vegetable based farming systems were 31.94, 23.61 and 11.11 percent, respectively in district Chhindwara. Thus it is clear that maximum numbers of households were dependent on the cotton-based farming systems in the study area (Table 9.4.14).

The table 9.4.15 revealed that the percentage share in gross income among the farms was comparatively high for the cotton based and cereal based farming system. On an average their contribution to gross income was 32.65 and 28.09 percent, respectively. The minimum share was found in case of livestock based and vegetable based farming system i. e. 25.70 and 13.57 percent in district Chhindwara.

Farming Systems of Vindhyachal Plateau Zone of Madhya Pradesh

This is a cluster of two districts Sagar and Damoh—located in central Madhya Pradesh. This region is more urbanised and has a higher share of its area under cultivation as compared to the rest of the zone. About 53 percent of the area is cultivated; however, only 11 percent of this is irrigated. The region receives about 1,130 mm of rains annually.

Table 9.4.14: Farm size-wise number of households in different farming systems in the district Chhindwara (Madhya Pradesh)

S. No.	Farming systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
		Chhindwara				
A	Livestock-based	8(34.8)	8 (36.3)	5(31.2)	2(20.0)	23(31.9)
B	Cereal-based	5(21.7)	5(22.7)	4(25.0)	3(27.2)	17(23.6)
C	Vegetable-based	3(13.0)	2(9.0)	2(12.5)	1(10.0)	8(11.1)
D	Cotton-based	7(30.4)	7(31.8)	5(31.2)	4(45.4)	24(33.3)
	Total	23(100)	22(100)	16(100)	11(100)	72(100)

The figure in bracket shows the percentage of total

Table 9.4.15: **Farm size-wise percentage share in gross income of different farming systems of district Chhindwara (Madhya Pradesh)**

S. No.	Particulars	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
	Chhindwara					
	Size of farm holding (ha.)	0.58	1.69	2.88	4.75	2.48
1	Livestock-based	38.31	27.80	21.79	14.88	25.70
2	Cereal-based	20.45	25.90	34.45	49.78	32.65
3	Vegetable-based	15.64	16.00	12.06	10.59	13.57
4	Cotton-based	25.60	30.30	31.70	24.75	28.09
	Total	100	100	100	100	100

The farming systems were identified on the basis of relative income from the cereal-based farming systems followed by livestock-based and vegetable-based farming systems. The overall percentage of cereal based farming systems in the zone were 43.06 and 41.67 percent in Damoh and Sagar districts, respectively. While the percentage of households in Damoh and Sagar districts under livestock-based farming systems were found 41.67 and 44.44 percent respectively. The vegetable-based farming systems were also prevalent (15.28 and 13.89%) in Damoh and Sagar districts, respectively. Thus it is clear that maximum numbers of households were dependent on the cereal-based farming systems in the study area (Table 9.4.16).

The table 9.4.17 revealed that on the basis of the percentage share in gross income majority of

Table 9.4.16: **Farm size-wise number of households in different farming systems in the district Damoh and Sagar (Madhya Pradesh)**

S. No.	Farming systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
	District Damoh					
A	Livestock-based	11(47.8)	11(50.0)	6(37.5)	2(18.2)	30(41.6)
B	Cereal-based	8(34.7)	8(36.3)	7(43.7)	8(72.7)	31(43.1)
C	Vegetable-based	4(17.4)	3(13.6)	3(18.7)	1(9.1)	11(15.3)
	Total	23(100)	22(100)	16(100)	11(100)	72(100)
	District Sagar					
A	Livestock-based	12(54.5)	10(43.4)	8(44.4)	2(22.2)	32(44.4)
B	Cereal-based	6(27.2)	9(39.1)	9(50.0)	6(66.6)	30(41.6)
C	Vegetable-based	4(18.1)	4(17.3)	1(5.5)	1(11.1)	10(13.8)
	Total	22(100)	23(100)	18(100)	9(100)	72(100)

The figure in bracket shows the percentage of total.

Table 9.4.17: **Farm size-wise percentage share in gross income of different farming systems of district Damoh and Sagar**

S. No.	Particulars	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
	A. District Damoh					
	Size of farm holding (ha.)	0.37	1.26	2.78	4.71	2.28
1	Livestock-based	52.31	46.12	30.09	18.08	36.65
2	Cereal-based	23.45	32.19	54.45	67.78	44.47
3	Vegetable-based	24.64	21.60	15.06	14.59	18.97
	Total	100	100	100	100	100
	B. District Sagar					
	Size of farm holding (ha.)	0.41	1.45	2.76	4.35	2.24
1	Livestock-based	59.31	40.80	20.79	15.88	34.20
2	Cereal-based	19.47	32.90	60.45	65.70	44.63
3	Vegetable-based	21.60	26.00	19.06	18.60	21.32
	Total	100	100	100	100	100

farms was dependent on the cereal based farming systems. On an average, the contribution from the system was 44.47 and 44.63 percent respectively in the district Damoh and Sagar. While, the share of livestock based farming systems in gross income was found 36.65 and 34.20 per cent and vegetable based farming system was 18.97 and 21.32 percent in the Damoh and Sagar districts, respectively.

Farming Systems of Central Narmada Valley Zone of Madhya Pradesh

This zone covers Narsinghpur district lying between the Vindhya and Satpura plateau. It has average rainfall of about 1,300 mm annually and the soil is deep black, 45 percent of the geographical area is cultivated. Irrigation facilities are limited to around 39 percent of the cultivated area. The farming systems were identified on the basis of relative income from the sugarcane-based farming systems followed by cereal -based, pulse-based, livestock-based and oilseed -based farming systems in all. The overall percentage of households dependant on sugarcane based farming systems in the zone was 30.56 percent. While the percentage of households in cereal -based, pulse-based, livestock-based and oilseed -based farming systems were 25.00, 19.44, 13.89 and 11.11 percent, respectively in district Narsinghpur. Thus it is clear that maximum numbers of households were dependent on the sugarcane-based farming systems in the study area (Table 9.4.18).

The table 9.4.19 revealed that the highest percentage share in gross income of farms was contributed by the sugarcane-based farming system i.e (26.04%). While, on an average the contribution from the cereal-based, pulse-based and livestock-based farming systems were 23.92, 21.44 and 20.76 percent, respectively in the district Narsinghpur of

Table 9.4.18: **Farm size-wise number of households under different farming systems in district Narsinghpur (Madhya Pradesh)**

S. No.	Farming systems	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
	District Narsinghpur					
A	Livestock-based	4.00(16.67)	3.00(16.67)	2.00(11.76)	1.00(7.69)	10.00(13.89)
B	Cereal-based	6.00(25.00)	5.00(27.78)	4.00(23.53)	3.00(23.08)	18.00(25.00)
C	Sugarcane-based	7.00(29.17)	4.00(22.22)	6.00(35.29)	5.00(38.46)	22.00(30.56)
D	Pulse-based	4.00(16.67)	4.00(22.22)	3.00(17.65)	3.00(23.08)	14.00(19.44)
E	Oilseed-based	3.00(12.50)	2.00(11.11)	2.00(11.76)	1.00(7.69)	8.00(11.11)
	Total	24(100)	18(100)	17(100)	13(100)	72(100)

The figure in bracket shows the percentage of total.

Table 9.4.19. **Farm size-wise percentage share in gross income of different farming systems of district Narsinghpur (Madhya Pradesh)**

S. No.	Particulars	Size of Farm holdings				Overall
		Marginal	Small	Medium	Large	Avearge
	District Narsinghpur					
1	Size of farm holding (in ha.)	0.85	1.61	2.83	4.97	3.42
2	Livestock-based	47.10	27.46	6.21	2.28	20.76
3	Cereal-based	20.09	28.30	30.10	17.18	23.92
4	Sugarcane-based	13.56	23.18	24.16	43.25	26.04
5	Pulse-based	19.25	21.15	22.20	23.17	21.44
6	Oilseed-based	13.44	15.12	17.22	14.12	14.98
	Total	100	100	100	100	100.00

Madhya Pradesh. The share of oilseed-based farming system in gross income was found 14.98 percent only in the study area.

Therefore, the most dominant cropping system in the state of Madhya Pradesh is the cereal-based system. Majority of the farmers (23.6% –84.7%) practiced the cereal-based farming system in different zones of the state. The contribution of cereal-based farming system to farm income ranges from 32.65 percent to 75 percent, followed by livestock-based farming system. Another interesting finding is that there is an inverse relationship between farm size and livestock-based system. It implies that livestock-based farming system is major source of income for marginal and small farmers in the state.

9.5 TECHNOLOGY TRANSFER AND REFINEMENT (TTR)

i. Proven systems based technologies under demonstration

Twenty six proven cropping systems based technologies i.e. vegetable based(7), cereal based (7), bio-intensive complementary (8) and pulse based cropping systems (4) were demonstrated in technology park which covered many aspects of improved technology (improved verities, relay cropping, system for rice intensification(SRI), mechanical transplanting of rice, nutrient management, green manuring (GM), raise bed planting(RB), broad bed furrow system(BBF), zero tillage technology in wheat, mustard and lentil, crop residue management in wheat). Farmers practice was also demonstrated to compare the technology. To evaluate the above cropping systems rice equivalent yield (REY t ha^{-1}) and net returns per day ha^{-1} were calculated by considering the cost of cultivation and income.

In vegetable based cropping systems maximum rice equivalent yield (23.4 t ha^{-1}) was obtained in rice –potato (K.Bahar)-maize +cowpea (BB) +sesbania(F) followed by rice-potato (K.Pukhraj)-moong(BB)+ sesbania(F) (22.5 t ha^{-1}), and rice – potato (K.Chipsona-1) – onion(22.9 t ha^{-1}), However, lowest rice equivalent yield (9.8 t ha^{-1}) was obtained in rice – mustard - maize (FB). The maximum increase in income per day ha^{-1}(268.8%) was found in rice –potato (K.Bahar)-maize +cowpea (BB) +sesbania (F) system whereas lowest increase in income was observed in relay cropping system of rice - cauliflower – radish (RB)+wheat (F) - bottle gourd(156.8%).

Rice equivalent yield (t ha^{-1}) in cereal based cropping systems were to the tune of 12.3,12,11.9,11.5,11.0 and 10.2 t ha^{-1} in rice (MT, RDF+20%) - wheat (ST,RDF+20%)– sesbania, rice (RDF) -garlic - sesbania , rice (SRI, RDF+20%) - wheat (ZT +RDF) – sesbania, rice (MT+RDF) - wheat (ST,RDF)–sesbania, , rice (RDF) - wheat (RB)– sesbania, rice (RDF) –wheat +mustard 5:1 (FB) – sesbania respectively, as compared to lowest rice equivalent yield (10 t ha^{-1}) in rice (SRI+RDF) – wheat (Con.+RDF) – sesbania. The maximum higher returns per day ha^{-1} (Rs.179) was recorded from rice (MT, RDF+20%) - wheat (ST, RDF+20%)– sesbania as compared to lowest

returns from rice (SRI+RDF) – wheat (Con.+RDF) – sesbania(Rs.122) .

Bio-intensive complementary cropping systems were also demonstrated for conservation of resources. The maximum yield (11.2t/ha) and net return per day was found in rice (RDF) – mustard (BB)+wheat(F)– sesbania, followed by rice (RDF+20%) – lentil (BB) + wheat (F) – sesbania. The maximum increase in return per day ha^{-1} (29.5%) were recorded from rice (RDF) – mustard (BB)+wheat(F)– sesbania in comparison to rice (FP) – lentil (ZT) - sesbania .

Comparing pulses based cropping systems maximum rice equivalent yield (10.5 t/ha) was obtained from pigeonpea +maize(RB) 2:1 - lentil(RB)+ wheat (F) followed by pigeonpea +maize (RB) 1:1 - wheat(RB)+lentil(F) and pigeonpea (FB) +maize(FB)1:1 - wheat (CT). The maximum return per day ha^{-1} (133%) were recorded from pigeonpea +maize(RB) 2:1 - lentil(RB)+ Wheat (F) as compared to pigeonpea single row (raised bed) -wheat (LS).

ii. Response of Rice and wheat varieties to different levels of FYM under organic conditions

Rice Pusa basamati 1, Pusa Sugandha 4, Pusa Sugandha 5, Pusa Sugandha 15 and Vallabh 21) and wheat varieties (HI 1544, Raj 4037, Lok 1, PBW 550 and HD 2781) were evaluated at five different levels of FYM (Control, 0 t/ha, 10t/ha, 20 t/ha, 30 t/ha and 40 t/ha under organic conditions. Non significant differences were observed in grain and straw yields of rice varieties. However among the varieties Pusa Sungandha-5 recorded highest yield of (4269 kg/ha) followed by Vallabh 21 (4259 kg/ha). Among the FYM levels significant increase in rice grain yield was observed up to 30 t/ha (4502 kg/ha).

Table 9.5.1. Response of rice and wheat varieties to different levels of FYM under organic conditions

Treatments	Rice			Wheat				
	Grain yield (kg/ha)	Straw yield (kg/ha)	HI (%)	Grain yield (kg/ha)	Straw yield (kg/ha)	HI (%)	REY (kg/ha)	S'REY (kg/ha)
FYM doses								
Control	3635	5784	39.1	2588	5342	48.5	1454.0	4042
10 t/ha	3943	5983	40.2	2879	6211	46.4	1577.0	4456
20 t/ha	4114	6090	40.8	3235	6963	46.5	1645.6	4881
30 t/ha	4502	6487	41.4	3623	7984	45.5	1800.8	5424
40 t/ha	4623	6847	40.5	3913	8605	45.6	1849.3	5762
CD (0.05 P)	439	764	N.S.					
Rice - Wheat varieties								
PB 1 –HI 1544	4111	6889	37.9	3426	7368	47.7	1644.4	5070
PS 4 – Raj 4037	3926	6744	37.0	3145	6632	47.5	1570.3	4716
PS 5 – Lok 1	4269	5550	43.6	3053	6816	44.8	1707.5	4760
PS 15 – PBW 550	4252	5785	42.4	3000	6500	46.2	1700.7	4701
Vallabh 21 – HD 2781	4259	6222	41.1	3615	7789	46.4	1703.7	5318
CD (0.05 P)	N.S.	N.S.	2.9					

Among the wheat varieties HD-2781 recorded maximum grain yield (3615 kg/ha) followed by HI-1544 (3426 kg/ha). Response of FYM levels was observed up to 40 t/ha (3913 kg/ha) though the differences were significant only up to 30 t/ha. Considering the systems rice equivalent yield, FYM levels responded up to 40 t/ha whereas among the varieties Pant Sugandha-15, vallabh-21 of rice and HD-2781 and HI-1544 of wheat were proved better than all other varieties.

iii. Effect of Phosgold on yield and yield attributes of Wheat

Non significant differences in plant height due to various treatments were noted, however maximum plant height (95.2 cm) was observed when 50% phosphorus was applied through DAP and remaining dose of P_2O_5 through Phosgold followed by application of recommended dose of phosphorus along with 200 kg Phosgold acre^{-1}. Maximum number of tillers m^{-2} was noted due to the application of recommended dose of phosphorus along with 200 kg Phosgold acre^{-1} followed by the application of 50% phosphorus through DAP and remaining dose of P_2O_5 through Phosgold. Differences in ear length due to various treatments were also non significant, however maximum ear length (8.6 cm) was noted with the application of phosphorus with 200 kg Phosgold acre^{-1}. Highest test weight (49.8 g) was noted with (application of phosphorus with 200 kg Phosgold acre^{-1}) followed by (application of 50% phosphorus through DAP and remaining dose of P_2O_5 through Phosgold). Maximum grain yield (5593 kg/ha) was noted with (application of phosphorus along with 200 kg Phosgold acre^{-1}) followed by (application of phosphorus along with 150 kg Phosgold acre^{-1}). However maximum straw yield (7187kg/ha) was noted with the application of 25% of recommended dose of phosphorus through DAP and remaining 75% P_2O_5 through Phosgold. Maximum root dry weight (642.2 g m^{-2}) was occurred due to the application of recommended dose of phosphorus along with 200 kg Phosgold acre^{-1}. Whereas it was lowest (514.4 g m^{-2}) with application of 75% of recommended dose of phosphorus through DAP and remaining 25% P_2O_5 through Phosgold.

Table 9.5.2: Effect of Phosgold on yield and yield attributes of Wheat (PBW 343).

Treatments	Germination count /m^2	Plant height at harvest (cm)	Tillers / m^{-2}	Ear length (cm)	Test wt. (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Root dry weight (g/m^2)
T1 100% RD of P (Control)	124	89.5	442	7.8	47.7	5015	5911	564.5
T2 100% RD of P + 100 kg Phosgold / Acre	130	91.4	449	8.1	48.2	5333	6185	572.8
T3 100% RD of P + 150 kg Phosgold / Acre	154	92.7	460	8.0	48.7	5556	6526	587.8
T4 100% RD of P + 200 kg Phosgold / Acre	155	94.6	472	8.6	49.8	5593	5852	642.2
T5 75% RD of P by DAP + 25% P by Phosgold	120	89.9	454	8.3	45.4	5059	6238	514.4
T6 50% RD of P by DAP + 50% P by Phosgold	116	95.2	464	8.5	45.4	5074	6741	497.8
T725% RD of P by DAP + 75% P by Phosgold	114	93.9	461	8.5	46.2	5185	7187	533.9
T8 0% RD of P by DAP + 100% P by Phosgold	111	93.8	457	7.9	48.6	5222	7000	537.2
SEm±	6.0	2.3	17.7	0.3	0.8	218.7	493.2	62.0
CD	18.2	N.S.	N.S.	N.S.	2.5	N.S.	N.S.	N.S.

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

Under the project, survey was conducted in Meerut district of Uttar Pradesh using pre-tested interview schedule and covering 40 farmers from 4 villages and two blocks of the district. The survey revealed that Crop+Dairy was the predominant farming system in the district and adopted by 43 per cent of the respondents (Table 9.5.3). Sugarcane (plant)-Sugarcane (ratoon)-Wheat was found as the major cropping system adopted by 70 per cent of the respondents followed by Rice-wheat adopted by 25 per cent respondents (Table 9.5.4). Sugarcane occupied highest acreage per farmer (0.82 ha) followed by Wheat (0.43 ha) and Rice (0.38 ha). Wheat was adopted by maximum farmers (95 per cent) followed by Sugarcane (75 per cent) and Rice (58 per cent). The yield gap analysis revealed that the highest yield gap was in case of sugarcane to the extent of 50 per cent due to heavy infestation of insect-pests in the crop.

Table 9.5.3: Farming systems prevalent in the study area

Sl. No.	Farming system components	% Respondent farmers
1.	Crop + Dairy	43
2.	Crop + Dairy + Agro-forestry	30
3.	Crop + Dairy + Horticulture	5
4.	Crop + Dairy + Horticulture + Agro-forestry	22

Table 9.5.4. Major Cropping systems prevalent in the study area

Sl. No.	Cropping system components	% Respondent farmers
1.	Sugarcane (plant) – Sugarcane (ratoon) - Wheat	70
2.	Rice – Wheat	25
3.	Wheat - Jowar - Dhaincha - Potato	20
4.	Paddy - Mustard - Sugarcane - Sugarcane (ratoon)	12
5.	Sugarcane (plant) – Sugarcane (ratoon) - Potato	10
6.	Paddy - Potato – Marigold	10

Study on changes in the trends of crop and animal husbandry revealed that over the last 10 years, the per farmer average area under sugarcane increased from 0.66 ha to 0.82 ha, that of wheat increased from 0.35 ha to 0.43 ha, that of rice decreased from 0.47 ha to 0.38 ha, that of mustard decreased from 0.30 ha to 0.18 ha, that of jowar decreased from 0.14 ha to 0.10 ha, and that of potato increased marginally from 0.05 ha to 0.07 ha (Table 9.5.5). The per farmer average number of milch animals (cows and buffaloes) decreased from 5 to 2 and that of draught animals (bullock and he buffaloes) decreased from 3 to 1.

The net return per hectare from different crops as reported by the farmers revealed that sugarcane (Rs.78000/- per ha) was the most profitable crop followed by potato (Rs.64000/- per ha), rice (Rs.48000/- per ha), wheat (Rs.27600/-) and mustard (Rs.24000/-). As far as recycling of farm products is concerned, each farmer used on an average 1.0 kg of wheat grains, 1.0 kg of mustard cake, 0.5 kg of Gur, and 20.0 kg of green fodder per day for each dairy animal. As regards recycling of farm by-products, each farmer used on an average of 20.0 kg of wheat straw/ sugarcane leaves per day for each dairy animal. They also used about 8.4 t of FYM per hectare as by-product of livestock for the agriculture enterprise once in every 3 years out of which 50 per cent is met through their own farm resources and the remaining is purchased by them. Crop and Dairy enterprises were found to be highly integrated with each other.

Table 9.5.5: Changes and Trends in area under different crops and no. of animals

Sl. No.	Name of enterprise	Area (hectare) or Nos.		% Change
		10 years before	Present	
1.	Sugarcane	0.66	0.82	24.2
2.	Wheat	0.35	0.43	22.8
3.	Rice	0.47	0.38	-19.1
4.	Mustard	0.30	0.18	-40.0
5.	Jowar	0.14	0.10	-28.6
6.	Potato	0.05	0.07	40.0
7.	Milch animals	5	2	-60.0
8.	Draught animals	3	1	-66.7

Farming system of the study area

The majority of the farmers perceived crop enterprise as most suitable, having high productivity but also high cost of production, medium profitability and high risk involved. The dairy enterprise was perceived as having medium suitability and medium profitability associated with higher cost of production and high risk involved. None of the enterprise was perceived as threat to the environment. Crop+Dairy was found the most sustainable farming system in the study area.

A total of 92 per cent of the farmers reported high cost of agricultural inputs and 87 per cent reported increase in input requirement of the crops as major constraints for agricultural enterprise (Table 9.5.6). Besides, the investigators observed that the use of rotavator for land preparation has increased the prevalence of soil pests due to absence of turning up of deeper layer of soil by rotavator. The land is not given rest for nutrient replenishment, and there is overuse of nitrogenous and phosphatic fertilisers and underuse of potassic fertilizers.

Table 9.5.6: Major Constraints felt by the respondent farmers in the study area

Sl. No.	Constraints	% Respondent farmers
1.	High cost of agricultural inputs	92
2.	Increase in input requirement of crops	87
3.	Lodging problem in wheat and rice	68
4.	Crop damage by wild animals	56
5.	Low conception rate of milch animals	26
6.	Non-availability of veterinary doctors for treating animals	18
7.	Lack of electricity for irrigation in rice during summer	15
8.	Non-availability of labour during peak season	12
9.	Spurious fertilizers and pesticides	10
10.	Decline in soil fertillity	8

v. On-farm Integrated Farming Systems Management

i) Demonstrations on recommended seed rate and use of quality seed in wheat

A total of thirteen demonstrations on recommended seed rate and use of quality seed in wheat varieties PBW-550, PBW-343, PBW-373 and PBW-226 were laid out in Alipur and Madarpur villages of Sardhana block, Meerut district during *rabi*, 2011-12. The comparison of improved practice (use of recommended varieties and optimization of plant population) and farmers' practice was made. The improved practice resulted in increase in yield of wheat by 3.34%, 3.96%, 4.26% and 4.09% over the farmers' practice in case of varieties PBW-550, PBW-343, PBW-373 and PBW-226, respectively.

ii) On-farm trials (OFTs) on balanced use of fertilizers and micronutrients in wheat

Twelve farmers were selected randomly from the abovementioned two villages for conducting on-farm trials (OFTs) during *rabi,* 2011-12. Two treatments were taken under each OFT and each of these treatments was laid on an area of 600 sq. m. The two treatments were- T_1: Farmers' Practice (FP), T_2: farmers' fertilizer + recommended K. The results revealed that the improved practice resulted in increase in yield by 3.76% over the farmers' practice.

iii) On-farm trials (OFTs) on recommended doses of pesticides in sugarcane

Twenty-three farmers were selected randomly from the abovementioned two villages for conducting on-farm trials (OFTs) on sugarcane plant crop during 2012-13. Three treatments were taken under each OFT and each of these treatments was laid on an area of 800 sq. m. The three treatments were- T_1: Farmers' Practice (FP), T_2: Recommended doses of chemical pesticides, $T_{3:}$ Recommended doses of bio-control agents (Beauvaria bassiana, Metarhizium and Trichogramma). The trials are in progress.

iv) On-farm trials (OFTs) on balanced use of fertilizers (MOP) and zinc in sugarcane

Twenty-four farmers were selected randomly from the two villages for conducting on-farm trials (OFTs) on sugarcane plant crop during 2012-13. Three treatments were taken under each OFT and each of these treatments was laid on an area of 800 sq. m. The three treatments were- T_1: Farmers' Practice (FP), T_2: FP + recommended doses of Potash (MOP), $T_{3:}$ FP + recommended doses of Potash + Zinc sulphate. The trials are in progress.

v) On-farm trials (OFTs) on recommended doses of pesticides in Rice

Twenty farmers were selected randomly from Alipur and Madarpur villages for conducting on-farm trials (OFTs) on two varieties of rice PB-1 & Sugandha-4 (1121) during 2012-13 (Table 9.5.7). Three treatments were taken under each OFT and each of these treatments was laid on an area of 400 sq. m. The three treatments were- T_1: Farmers' Practice (FP), T_2: Recommended doses of chemical pesticides, $T_{3:}$ Recommended doses of bio-control agents (Beauvaria bassiana, Metarhizium and Trichogramma).

The results revealed that in case of variety PB-1, treatment T_3 provided highest yield (29.85 q/ha) followed by T_2 (29.58 q/ha) and T_1 (26.93 q/ha). In case of variety Sugandha-4, treatment T_3 provided highest yield (32.53 q/ha) followed by T_2 (32.46 q/ha) and T_1 (29.12 q/ha). The pest control in rice through chemical pesticides and bio-control agents resulted in increase in yield by 9.82% and 10.82 %, respectively in case of variety PB-1, and by 11.45% and 11.67%, respectively in case of variety Sugandha-4 over the farmers' practice.

Table 9.5.7: OFT on use of quality seed, chemical pesticides and bio-control agents in rice

Variety	No of OFTs	Yield q/ha			% Yield increased in IP-1 over FP	% Yield increased in IP-2 over FP
		Seed+FP	Seed+chemical pesticides (IP-1)	Seed+Bio-control agents (IP-2)		
PB-1	10	26.93	29.58	29.85	9.82	10.82
Sugandha-4	10	29.12	32.46	32.53	11.45	11.67

vi) On-farm trials (OFTs) on balanced use of fertilizers (MOP) and zinc in Rice

Eighteen farmers were selected randomly from the two villages for conducting on-farm trials (OFTs) on two varieties of rice (PB-1 & Sugandha-4) during 2012-13 (Table 9.5.8). Three treatments were taken under each OFT and each of these treatments was laid on an area of 400 sq. m. The three treatments were- T_1: Farmers' Practice (FP), T_2: FP + recommended doses of Potash (MOP), $T_{3:}$ FP + recommended doses of Potash + Zinc sulphate.

The result revealed that in case of variety PB-1, treatment T_3 provided highest yield (29.16 q/ha) followed by T_2 (28.58 q/ha) and T_1 (26.63 q/ha).In case of variety Sugandha-4, treatment T_3 provided highest yield (32.23 q/ha) followed by T_2 (31.53 q/ha) and T_1 (29.15 q/ha). The application of potash and potash + zinc in rice resulted in increase in yield by 7.39 and 9.57, respectively in case of variety PB-1, and by 8.18% and 10.55%, respectively in case of variety Sugandha-4 over the farmers' practice.

vii) On-Farm Trials on Wheat

Eighteen on-farm trials on use of recommended quality seed rate and use of balanced fertilizers were conducted during the *rabi* season of 2012-13 in Alipur and Madarpur villages of Sardhana block in Meerut district. Each of the treatments was laid out on an area of 1000 sq. m. The adopted farmers were provided certified seed of wheat and MOP fertilizer for conducting the trials which are in progress.

viii) De-worming in calves

High incidence of worm infestation in young calves, poor feeding management, and unhygienic management conditions cause heavy mortality in calves. To address this problem a total of 70 calves in the adopted villages were administered Albendazole/ Levamisole Hcl Oral suspension (broad spectrum dewormer) to make calves free from stomach problems. The calves which were dewormed showed improved growth rate, body conditions and lower incidence of diarrhea.

Table 9.5.8: OFT on use of quality seed, potash and potash +zinc in rice

Variety	No of OFTs	Yield q/ha			% Yield increased in IP-1 over FP	% Yield increased in IP-2 over FP
		Seed+FP	Seed+Potash (IP-1)	Seed+Potash + Zinc (IP-2)		
PB-1	8	26.63	28.58	29.16	7.39	9.57
Sugandha-4	10	29.15	31.53	32.23	8.18	10.55

Use of Trichocard in sugarcane

Deworming of calves

ix) Feeding mineral mixture to milch animals

A total of 20 dairy animals (cows & buffaloes) were fed with mineral mixture @ 40 gms/day/ animal in adopted villages to improve the milk yield and conception rate. It resulted in increase in milk yield of lactating cows and buffaloes in the range of 0.25-0.50 lit./day/animal.

x) Food support through kitchen gardening

A total of 40 farmers of Alipur and Madarpur villages were provided seeds of vegetables like Bottle gourd, Sponge gourd, Chilli and Brinjal for kitchen gardening to cater the daily needs of vegetable for the households.

xi) On-farm trial on improved composite fish culture

An on-farm trial on improved composite carp culture at Alipur having water spread area of approx. 5000 sq m was started. Stocking of fish pond was done with fingerlings of Indian Major carps (Catla, Rohu and Mrigal) @ 10000 fingerlings/ha. Farmer was advised about the feeding and fertilization schedule along with maintenance of pond water quality through water replenishment and lime treatment. Final harvesting is yet to be done.

In Madarpur village another farmer having a newly constructed pond (approx. 2200 sq m) has shown interest for fish culture. He was advised to go for poultry manure based fertilization for fish culture as he is having sufficient quantity of poultry manure from his poultry rearing in his backyard. Water filling and pre-stocking management for fish pond will be started in the month of April after the winter period is over.

vi. Front-line demonstrations (FLD) on mustard

Thirteen Front-line demonstrations on oilseed (Mustard Var. Pusa bold) were laid out in Alipur, Madarpur, Shyampur, Beeta, Khardauni and Mahal villages of Sardhana and Daurala block of Meerut district during *rabi,* 2011-12. The comparison of improved practice (quality seed, optimization of the plant population, balanced/ recommended dose of NPK @ 120:60:60 and plant protection) and farmers' practice (use of local variety and NPK @ 80:60:0) has been made. Under the improved practice, observations related to different crop yield parameters were collected. The improved practice resulted in increase in yield by 20.2 percent over the farmers' practice (Table 9.5.9).

Table 9.5.9: Performance of demonstration on mustard

Practice	Variety	No. of Demonstrations	Yield (q/ha)	% increase in yield over FP
Farmer's Practice	Local	13	16.8	-
Improved Practice	Pusa Bold	13	20.2	20.2

The plant height of mustard crop varied from 195.6 to 212.4 with an average of 203.62 meters, no. of spikes/ plant varied from 24 to 31 with an average of 28 nos., no of pods /spike varied from 27 to 39 with an average of 33 nos. and grains per pod varied from 10 to 13 nos. with an average of 12 nos. Wherein farmers' practice, the plant height of mustard crop varied from 160 to 190 with an average of 175 meters, no. of spikes/ plant varied from 16 to 27 with an average of 22 nos., no of pods /spike varied from 18 to 26 with an average of 22 nos. and grains per pod varied from 10 to 12.

The economics of both improved practice (IP) and farmers' practice (FP) of mustard variety Pusa bold was worked out. The results revealed that by making an additional expenditure of Rs. 1716/- in the form of fertilizer and quality seed of high yielding variety, the increase in net return under IP was Rs. 6784/- per hectare over FP. As regards benefit cost ratio, it was 1.76 in IP as compared to 1.56 in FP (Table 9.5.10).

Ten Front-line demonstrations on oilseed (Mustard Var. Pusa bold) were laid out in Shyampur,

Top dressing of urea in mustard

Observation of mustard crop

Table 9.5.10: Cost and return per hectare of FLD on mustard during 2011-12

Items	IP qt/ha (A)	FP qt/ha (B)	Difference (B-A)
Cost of cultivation (Rs.)	28633	26917	1716.00
Yield q/ha	20.2	16.8	3.40
Gross return (Rs.)	50500	42000	8500.00
Net return (Rs.)	21867	15083	6784.00
BC ratio	1.76	1.56	-

IP – Improved practice FP – Farmers' practice

Beeta and Khardauni villages of Daurala block of Meerut district during *rabi,* 2012-13. These demonstrations covered a total area of about 5 acres which comprised all the categories of farmers. The comparison of improved practice (use of quality seed, optimization of the plant population, balanced dose of NPK @ 120:60:60 and plant protection) and farmers' practice (use of local variety and NPK @ 80:60:0) will be made.

9.6 EXTERNALLY FUNDED PROJECTS

i. Ensuring livelihood security through farming system approach in Tehri district of Uttarakhand

In order to accomplish the objectives of the study, bench mark survey was done. For collecting the detailed information about the existing cropping/ farming systems and different management practices followed in the study area, participatory rural appraisal (PRA) methodologies were used. Only those villages were selected for characterization in which at least more than one farming system is prevalent. The various categories of farmers belonging to marginal (<1 ha), small (1-2 ha), medium (2-4 ha) group were selected for this purpose. Detailed information on fertilizer and manure use pattern, the productivity levels, varieties used, market availability etc were collected with the help of questionnaires. At the start of study, village profile proforma consisting information at village level was prepared and used for obtaining the basic information's related to village. Information on major cropping systems/ farming systems and their performance, viability and constraints to higher productivity was collected on this Proforma.

Preliminary information revealed prevalence of disease in some vegetable crops in Kandi Soud area. It was found from the survey that there is good scope for horticultural plants like mango and peach etc. In this area vegetable/fruits/crops and livestock farming systems is predominat. In some villages it was observed that people do not use any hybrid variety of rice rather they use local varieties and composting of cow dung is also not practiced. Only raw cow dung is applied resulting in lesser productivity. Very few people use inorganic fertilizer like Urea. Study revealed scope for livestock based farming system in Chinyali Soud cluster.

Based on the preliminary survey constraints and available opportunities were identified (table 9.6.1).

After identification of constraints and opportunities the following technological interventions were proposed for the study area.

- Promotion of kitchen gardening.
- Promotion of organic farming/vermi-composting/ green manuring / biofertilizer.

Table 9.6.1: List of the different constraints and available opportunities in the study area

S. No.	Constraints	Opportunities
1.	Scarce water availability	Water harvesting structures
2.	No use of improved varieties of cereals, fruits and vegetables	Introduction of improved seed varieties
3.	Imbalanced/no use of fertilizers	Balance fertilizer use
4.	Lack of plant protection measures	Awareness of integrated plant protection (IPP) measures
5.	Market accessibility	Linking with local suppliers and market
6.	Poor soil health	Introduction of composting pit/ vermicompossting
7.	No technical knowledge	Capacity building by organizing kishan gosthi

- Fruit plantation for quality food and medicinal importance
- Promotion of mineral mixture/ salt brick in livestock diet.
- Crop diversification
- Balance nutrition in crop, horticultural plants, vegetables and animals
- Development of fishponds
- Quality seed production
- Introduction of improved/hybrid varieties of cereals, crops and fruits/vegetables.
- Residue recycling

I. Demonstration of improved variety of wheat (VLW-829)

Two hundred demonstrations of cultivation of improved varieties of wheat (VLW 829) were carried out in farmers field covering 20 villages in 2 clusters (Koteshwar and Kandisoud). Each farmer was supplied with 20 kg quality seed of wheat (VLW 829) as input material for demonstration trial. Farmers were provided with technical inputs regarding proper methods of sowing and management practices. Results obtained from the demonstration trial in terms of yield and yield attributes were compared with that of local varieties (control) which showed better performance of the wheat variety VLW 829.

Farmers showing comparison of wheat crops (Traditional Vs Improved variety)

In Koteshwar cluster, the yield attributes (Table 9.6.2) as effective tillers, length of ear head, plant height and numbers of grains/ear was reported as 260, 10, 95 and 54, respectively, in improved variety. The increases in percentage were 4.0, 33, 9 and 31 in effective tillers/m^2, length of ear head, plant height and numbers of grains/ear, respectively, as compared to local variety. The yield (Table 9.6.3) was 3.6 t/ha in the local/traditional variety however, it was 4.65 t/ha in improved variety (VLW 829). The increase in yield was about 29.16 % over the local variety.

Table 9.6.2: Comparative performance (Yield attributes) of traditional var (control) with improved variety (VLW 829) of wheat in Koteshwar cluster

Yield attributes	Traditional/Control	Improved var. (VLW 829)	Increase (%)
No. of plants/m^2	263	278	+5.7
No. of effective tillers/m^2	250	260	+4.0
Length of ear head (cm)	7.5	10	+33
Plant height (cm)	87	95	+9
No. of grains/ ear head	41	54	+31

Table 9.6.3: Comparative performance (Yield) of traditional var (control) with improved variety (VLW 829) of wheat in Koteshwar cluster

Yield attributes	Traditional/Control	Improved var. (VLW 829)	Increase (%)
Grain (t/ha)	3.60	4.65	29.16
Straw (t/ha)	3.70	5.00	35.14

In Kandi soud cluster, the yield attributes (Table 9.6.4) as effective tillers, length of ear head, plant height and numbers of grains/ear was reported as 270, 10.6, 96 and 51, respectively, in improved variety. The increases in percentage were 5.8, 36, 7.9 and 31 of effective tillers/m^2, length of ear head, plant height and numbers of grains/ear, respectively, as compared to local variety. The grain yield (Table 9.6.3) was 4.15 t/ha in the local/traditional variety however, it was 3.20 t/ha in improved variety (VLW 829). The increase in yield was about 29.70 % over the local variety. However, straw yield also increased about 27.90 % as compared to local variety.

II. Demonstration of weed management in wheat

Unwanted weeds are a menace in the wheat cultivation causing economic loss to the farmers. About 100 number of demonstrations of weed management in wheat was carried out in farmers field covering 20 villages in 2 clusters (Koteshwar and Kandisoud). Each farmer was supplied with weedicide (TOTAL - Sulpho sulphuron + Met sulphuron) as input material for demonstration trial. Farmers were provided with technical inputs regarding proper methods of spraying. Each village was provided with a Knapsack sprayer to be used for weedicide application. Significant results in controlling the menace of weeds in wheat were recorded by the farmers.

The number of weeds/m^2 and dry weight (g / m^2) were 268 and 263 in weedicidies applied trial as TOTAL (Sulpho sulphuron + Met sulphuron) whereas it was 12 and 20.1 in control /traditional method (Table 9.6.6). Grain yield increased 41% over the local variety.

Table 9.6.4: Comparative performance (Yield attributes) of traditional var (control) with improved variety (VLW 829) of wheat in Kandisoud cluster

Yield attributes	Traditional/Control	Improved var. (VLW 829)	Increase (%)
No. of plants/m^2	260	288	+10.7
No. of effective tillers/m^2	255	270	+5.8
Length of ear head (cm)	7.8	10.6	+36
Plant height	89	96	+7.9
No. of grains/ ear head	39	51	+31

Table 9.6.5: Comparative performance (Yield) of traditional var (control) with improved variety (VLW 829) of wheat in Kandisoud cluster

Yield attributes	Traditional/Control	Improved var. (VLW 829)	Increase (%)
Grain (t/ha)	3.20	4.15	29.70
Straw (t/ha)	3.40	4.35	27.90

Table 9.6.6: Comparative performance of traditional var (control) and improved variety (VLW 829) of wheat in terms of weed control

Treatments	Weed counts /m^2	Dry weight g /m^2	WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)	No. of ears/m^2	No. of grain/ ear	Grain weight/ ear (g)	1000 grain weight (g)
Control	268	263.3	0.0	2.51	3.80	201	31	1.20	28.00
TOTAL (Sulpho sulphuron + Met sulphuron	12	20.1	89.0	4.29	4.90	308	58	1.30	30.20

III. Demonstration of trial on fertilizer application in wheat

About 200 numbers of demonstrations of fertilizer application in wheat were carried out in farmers field covering 20 villages in both the clusters (Koteshwar and Kandisoud). Each farmer was supplied with Urea and balanced fertilizers as NPK mixture as input material for demonstration trial. Farmers were provided with technical inputs regarding proper doses and methods of fertilizer application. It was reported that the yield with application of recommended dose of fertilizer (RDF) increased yield about 19% in comparison to farmers practice.

IV. Insect pest/ Disease control in fruit plants

In both the study clusters (Koteshwar and Kandi soud), for control of insect pest and disease in fruit plants like mango, banana, guava, citrus etc., fungicide/pesticide namely Indofil M-45, Bavistin, Malathion, Monocrotophos, Cypermethrin etc. were distributed to farmers along with information on their application and proper dosage. The yield of different fruits crops were reported by farmers significantly as compared to previous crops. The yield of different fruits crops were reported by farmers 10-15% more as compared to previous crops

V. Nutrient management in fruit plants

To overcome the problem of nutrient deficiency related problems in fruit plants micro-nutrient mixture were supplied in the study clusters. This provided essential micronutrients at critical stages to the plant and helped in preventing nutrient deficiency disorders in fruit plants. The yield of different fruits crops as reported by farmers was 60% more as compared to previous crops as a result of nutrient management.

VI. On farm trials on Kharif crop

On farm trials (200) on improved varieties of paddy (Vl-62&154), Jhangoora (PRJ-1), Madua (VL-149) and Urd (PV-35) each conducted at farmers field on seed replacement basis. The yield of different crops was reported by farmers 15-20% as compared to farmers crops.

VII. Kitchen gardening for providing livelihood security

For promoting kitchen gardening vegetable kit containing following improved varieties of Spinach

Distribution of vegetable kit for kitchen gardening

(All green), vegetable pea (Arkel), fenugreek (PEB), radish (JW and Minong), rye (Hathi Kant), horse gram, chickpea, coriander (Tarang and Mongiano) and sarson (Yellow) have been distributed to the farmers. An investment Rs 100-150 in vegetable seeds returned about Rs 1000 -1500 through kitchen gardening

VII. Animal husbandry

Following interventions were carried out for animal husbandry in study villages.

VIII. Demonstration of weed management in wheat

- Mineral mixture for balanced nutrition of milching animals for improved milk productivity.
- De-worming of calves
- Medicine for heat induction of cattles and buffaloes
- Fodder nutrient analysis for proximate composition
- Vermi-composting using cow dung to be used as fertilizer

Villagers were supplied with Dosmin forte (Mineral mixture) for improving milk productivity. It was observed that 0.5- 0.75 liter/day more milk was obtained in mineral mixture fed animals as compared to animals not fed with mineral mixture. Medicines were provided for control of external parasite infestation in milching animals. Significant improvement in health of milching animals was observed after our intervention.

IX. HRD activities and trainings/krishak gosthi/ mela

Trainings and visits were made for creating awareness regarding proper use of fertilizers, use of improved variety of crops and vegetables, use of mineral mixture supplements for improved milk productivity, preparation of vermicompost from raw cow dung. Farmers were educated about improved agricultural practices through farming system approach by conducting krishak gosthi in study villages.

Krishak Gosthi cum training programmes were organized on kharif crop and rabi crops regarding farming systems components such as animal husbandry, horticulture and apiary on 28th June 2012 at Koteshwar ,on 29th June 2012 at Kandisoud. Emphasis was given on growing horticulture crops

Training of farm women

such as amla, pomogranate, gauva, mango and citrus. mineral mixture and deworming bolus were also distributed to the beneficiary farmers. Face to face interaction was carried out during krishak gosthi at Koteshwar and Kandisoud. Feedback of farmers was taken regarding different activities conducted. On these occasion 455 farmers and farm women were participated. The participant were reported that positive impact of interventions in both the study clusters, such as introduction of improved variety of wheat, mandua ,jhangora rice and vegetable in the study area which gave 15 to 20 % more yield as compared to conventional varieties. The milk productivity (0.5- 0.75 liter) was also increased due to mineral mixture supplements to milching animals, improved health status of milching animals and calf due to deworming and additional farm income through adoption of kitchen gardening of improved vegetable varieties. Farmers were given valuable information in advance on kharif crop cultivation and other farming system components such as animal husbandry and horticulture.

Krishak Gosthi at Koteshwar. Dr. B. Gangwar (Project Director, PDFSR) and Mr. Rakesh Khare, GM, Sewa, THDC distributing mineral mixture and other inputs to farmers

Scientists from PDFSR and Mr. Rakesh Khare, GM, Sewa, THDC discussing with farmers at Krishak Gosthi at Kandisoud

Dr. B. Gangwar (Project Director, PDFSR) and Mr. Rakesh Khare, GM, Sewa, THDC discussing with farmers at Choupra village

Scientist from PDFSR discussing with beneficiaries in Koteshwar and Kandi soud cluster

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

In order to assess the spatial variability of physicochemical properties and native nutrient pools in agricultural soils across selected soil types and cropping systems farmers' participatory survey and collection of soil, plant and water samples from Bhabar and Terai Zone (BTZ), Mid-Western Plain Zone (MWPZ) and South Western Plain Zone (SWPZ) were done during 2012-13. During 2012-13, 07 districts each in South Western Plain Zone and Mid-western Plain Zone and 03 district of Bhabar and Tarai Zone were surveyed and also soil water and plant residue samples were collected using "Proportionate Area Method". During survey predominant crops/ cropping systems of BTZ, MWPZ and SWPZ were characterized for following parameters:

- Biophysical features (Geographical situation, agro-climate, soil, irrigation, crops and cropping systems, fertilizer and organic manure use, residue management and productivity level etc.).
- Socio-economic profile (Demographic features, literacy rate, operational holding, mechanization and livestock population etc.)

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

In the view of developing precision nutrient management zone for different cropping system domain in these NRP Zones using soil fertility parameters (N, P and K), surface maps were generated. In order to generate these homogenous fertility management zones, different fertility parameters were classified into low, medium and high categories using the user defined ranges. The ranges used for classification of N, P and K in low, medium and high classes were < 120, 120-160 and > 160 for N, <10, 10-25 and > 16 for P and <150, 150-

Table 9.5.7: Predicted area (%) under different fertility management zones

Fertility management zones	South-Western Plain Zone	Mid-Western Plain Zone	Bhabar and Tarai Zone
Low N_Med P_Med K	56.29	67.70	62.86
Low N_Med P_Low K	4.13	8.60	1.54
Low N_Med P_High K	22.80	5.43	4.57
Low N_Low P_Med K	6.70	0.24	1.81
Low N_Low P_Low K	0.03	0.03	-
Low N_Low P_High K	6.34	16.08	-
Low N_High P_Med K	1.89	-	-
Low N_High P_Low K	0.20	0.02	22.63
Low N_High P_High K	1.61	1.89	6.59
Total area (km^2)	22457.56	20379.64	16590.87

250 and > 250 for K, respectively. The per cent area falls under different management zone are given in Table 9.5.7 and depicted in Fig 9.6.1. Based on the developed homogenous fertility zones, the fertilizer recommendations can be developed for its practical significance for farmers and policy makers in the recommendation domain.

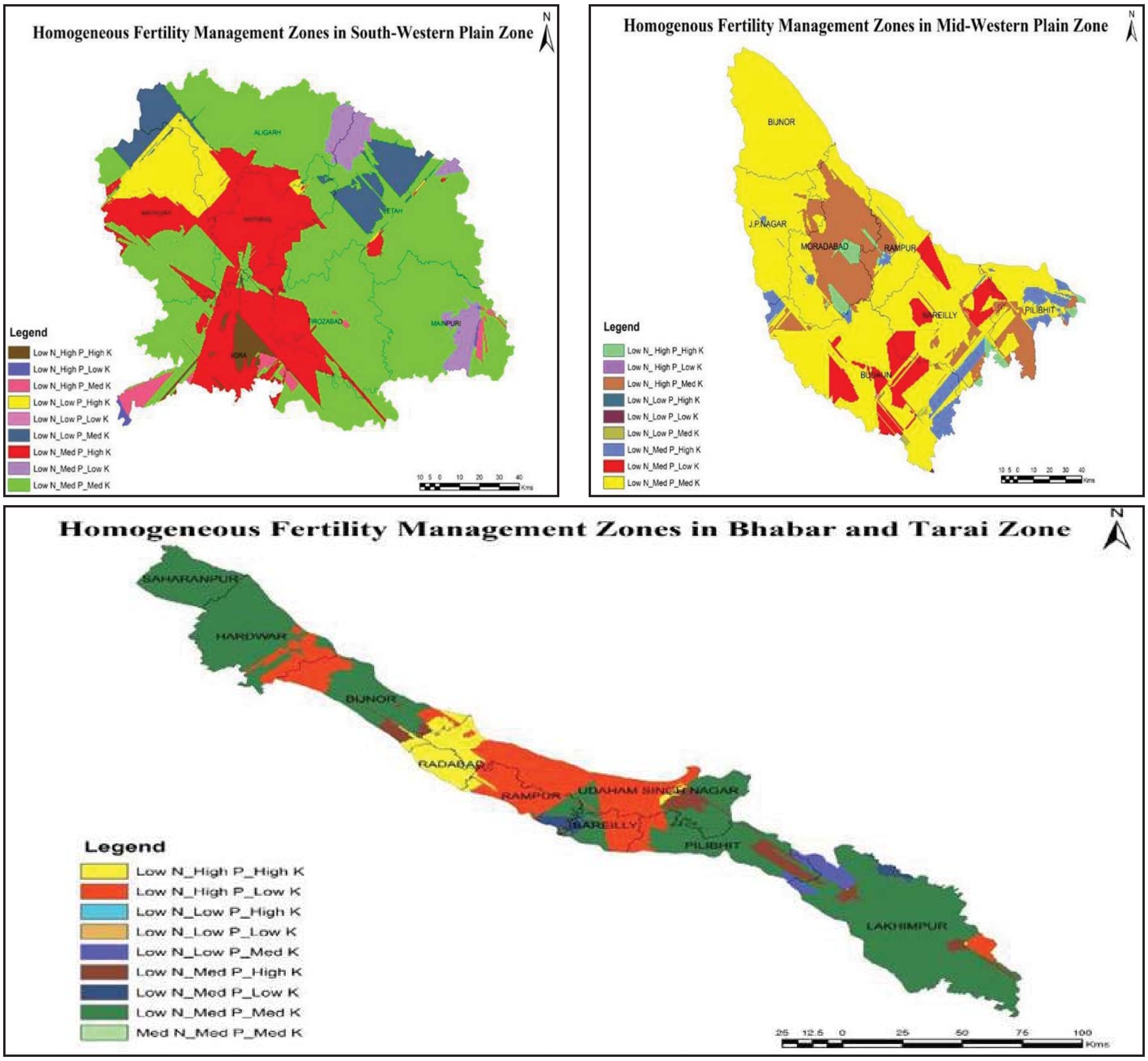


Fig 9.6.1: Homogeneous Fertility Management Zones in South-Western Plian Zone, Mid-Western Plain Zone and Bhabar and Tarai Zone

iii. Early Estimation of Sugarcane Acreage at State Level using remote sensing data Under Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL)

During 2012, 27 districts (Fig 9.6.2a and 2b) in Uttar Pradesh were taken up to develop the procedure for estimation of sugarcane acreage for crop monitoring under FASAL project**.** A total of 27 districts having greater than 10 thousand ha of sugarcane growing areas in the UP state were selected based on statistics of Department of Agriculture. Remote Sensing multi-date data of Resourcesat-2 AWIFS from Mar. 2012 – May/June 2012 and of October was used for analysis. The collateral data of crop statistics, weather data and yield information was collected from various sources. The ground truth was collected during July to August and October.

Spectral profile based on NDVI of sugarcane and rice crop grown during the season in eastern and western UP is given in Fig 9.6.3a and 3b. Using data upto May 2012**,** area estimation based on complete enumeration was 18.1 lakh ha. Area estimation using AWiFS data upto Nov. 3, 2012, the sugarcane acreage was 26.1 lakh ha. Therefore, early estimation in May 2012 showed under estimation of 30 percent compared to final estimate in November 2012. Similar result was obtained using stratification approach also. Classification accuracy was computed using confusion matrix of sugarcane class and classes of competing features. Early estimate of sugarcane acreage in June can be made possible by using multi-date AWiFS data upto May in all the three states studied. UP contributes more than 40 percent of national crop acreage. Early estimate could be possible which contribute about 70 percent of the final acreage obtained in November. This was verified by comparing the RS estimate made in May and November 2012.

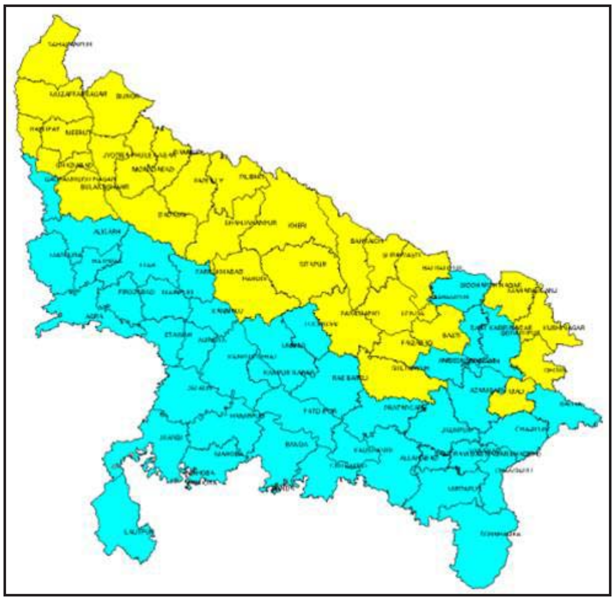


Fig. 9.6.2a. Selected Sugarcane districts (yellow) in UP

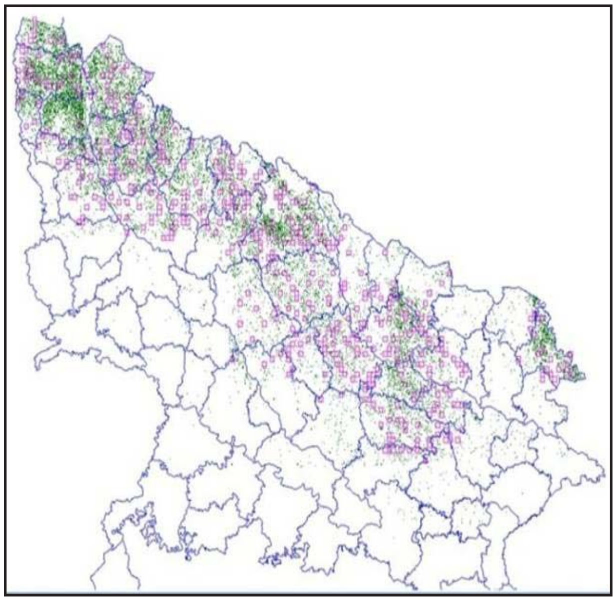


Fig. 9.6.2b. Selected sample segments in seleceted districts UP

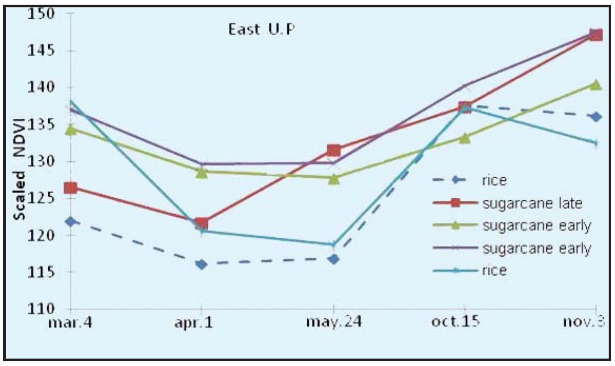


Fig. 9.6.3a. Spectral profile based on NDVI of sugarcane and rice crop grown during the season in eastern UP

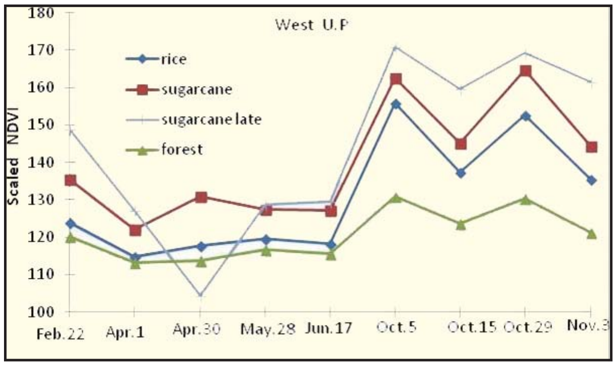


Fig. 9.6.3b. Spectral profile based on NDVI of sugarcane and rice crop grown during the season in western UP

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

In order to characterize and identify production constraints of various cropping systems in different agro-climatic zones of Indo Gangetic Plain, a diagnostic survey jointly by the Project Directorate for Farming Systems Research (PDFSR) and Space Applications Centre (SAC), Ahmedabad was undertaken. The objectives of this collaborative project were to evaluate and characterize current cropping systems through various parameters/ indicators and suggest required diversification/ intensification and to analyze long term changes in cropping system using historical agricultural information. During the year of reporting 2012-13, we have synthesized the surveyed information and analysed the spatial variations of rice based cropping systems productivity over Haryana in relation to spatial variability of fertilizer use, fertilizer availability pattern, pH, electrical conductivity(EC) and organic carbon(OC) of soil.

Rice based cropping system is the predominant cropping system, which occupies around 54.3 % of the total agricultural area followed by 16.7 % under cotton based cropping system. Rice-wheat rotation is the dominant rice based cropping system, which occupies 96 % area. The rice-sugarcane and rice-onion are the minor rice based cropping system followed in Haryana. As the Haryana has well developed irrigation facility (tubewell and canals), it has enormous potential of fertilizer use in the region. The most commonly used fertilizers were nitrogeneous, phosphastic and potassic and some micro-nutrients like Zn. The district-wise fertilizer use (NPK) per cropped area showed that there exist a large spatial variation of N @ 120 kgha^{-1} in Ambala to 198 kgha^{-1} in Sonepat during kharif season while during rabi season, it vary from 125 kgha^{-1} in Yamuna nagar to 210 kgha^{-1} in Sonepat under rice-wheat system (Fig.9.6.4-6). During rabi season, consumption of K is zero in all the districts, except Yamunanagar (Table 9.6.8 & 9).

The total fertilizer use also showed that per cropped area use of N was maximum (@408 kg ha^{-1}) over Sonipat (Table 9.6.9).

Spatial variation of EC, pH and OC

The district wise average EC, pH and OC showed there exists a vide spatial variability under rice based cropping system of Haryana (Fig. 9.6.7) EC showed a higher value of 0.97 dS m^{-1} at Sirsa to 0.32 dSm^{-1} at Yamunanagar. The organic carbon showed a higher value of 0.66 % at Karnal to 0.48

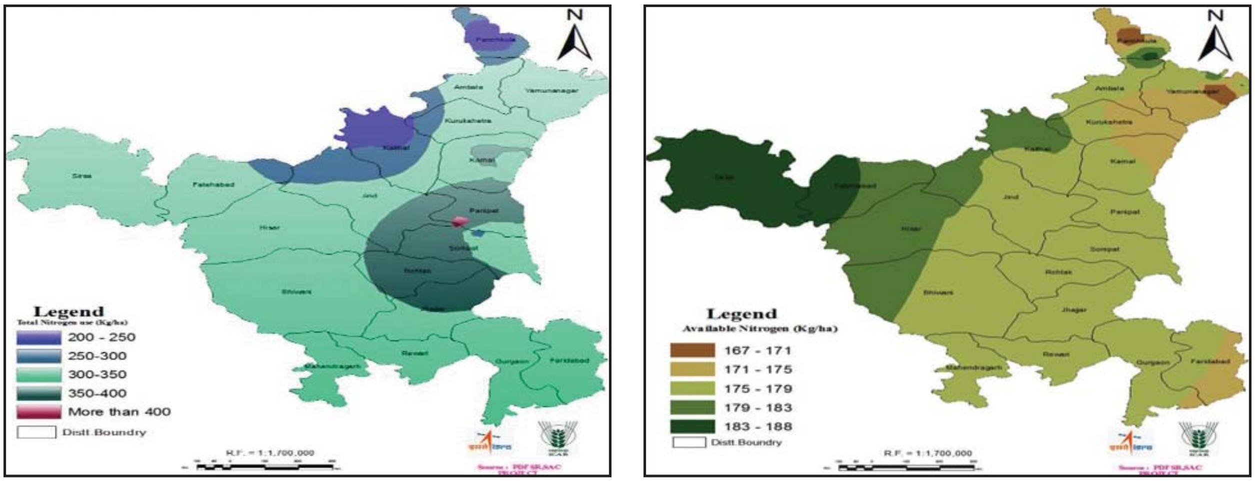


Fig. 9.6.4. Spatial variability of N use and availability over Haryana in rice based cropping system

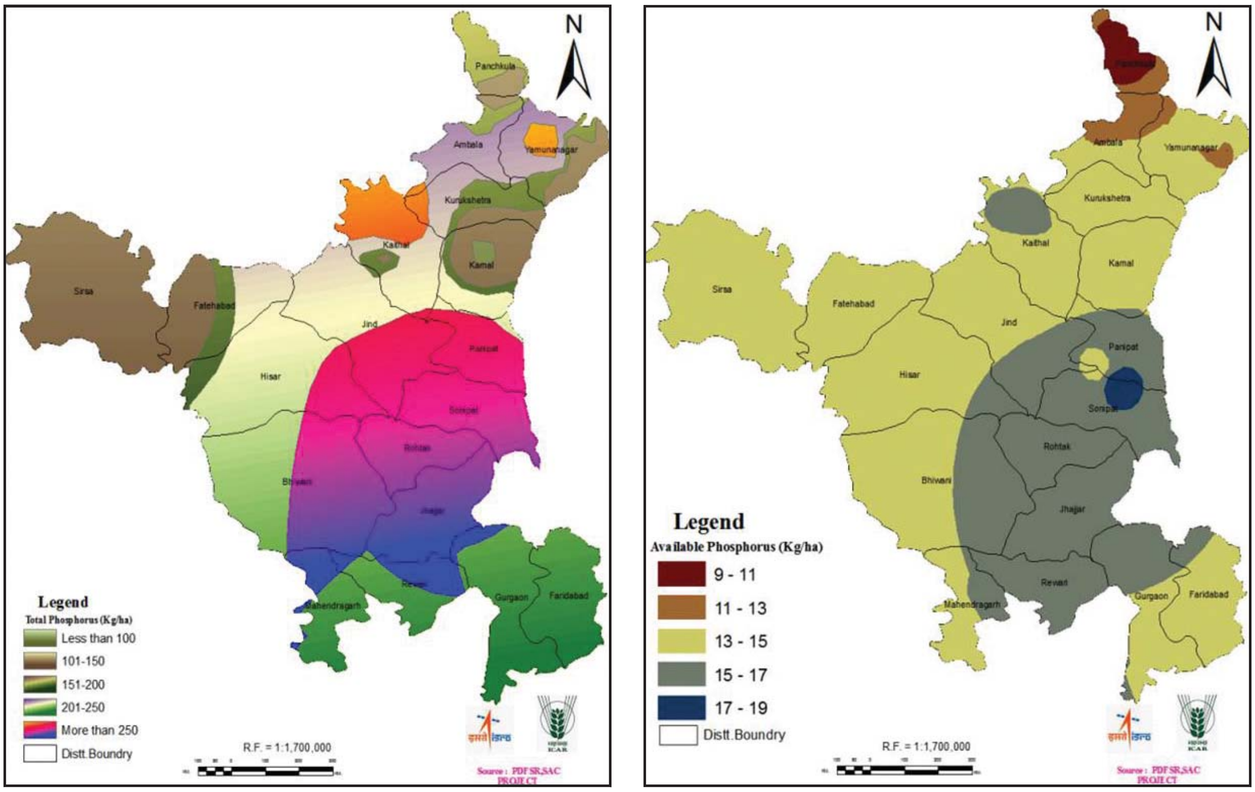


Fig. 9.6.5. Spatial variability of P use and availability over Haryana in rice based cropping System

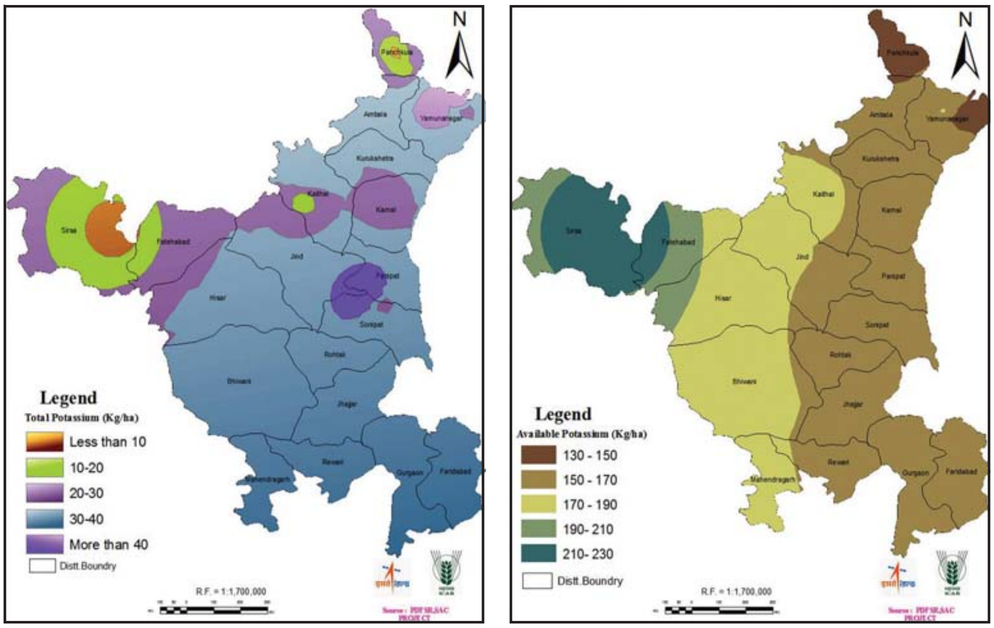


Fig. 9.6.6. Spatial variability of K use and availability over Haryana in rice based cropping system

Table 9.6.8. Fertilizer use during kharif and rabi in rice-based cropping system

Districts	Cropping System	Fertilizer Use kgha^{-1}					
		Kharif			Rabi		
		N	P	K	N	P	K
Ambala	Rice- Wheat	120	53	0	153	56	0
Kaithal	Rice- Wheat	153	89	63	162	73	0
Karnal	Rice- Wheat	166	36	0	154	56	0
Sirsa	Rice- Wheat	161	44	0	141	54	0
Sonepat	Rice- Wheat	198	103	96	210	88	0
Y. Nagar	Rice- Wheat	146	67	77	125	68	88
Y. Nagar	Rice- Sugarcane	175	17	0	230	58	0
Ambala	Rice-Onion	100	0	0	280	100	0

Table 9.6.9. Total fertilizer use and availability in rice-based cropping system

Districts	Cropping System	Fertilizer						REY(tha^{-1})
		Use kgha^{-1}			Available kgha^{-1}			
		N	P	K	N	P	K	
Ambala	Rice- Wheat	273	109	0	169	9	142	9
Kaithal	Rice- Wheat	315	162	63	169	15	157	12
Karnal	Rice- Wheat	320	92	0	177	14	180	10
Sirsa	Rice- Wheat	302	98	0	188	14	237	10
Sonepat	Rice- Wheat	408	191	96	178	16	163	9
Y. Nagar	Rice- Wheat	271	135	165	179	14	157	11
Y. nagar	Rice-Sugarcane	405	75	0	176	16	151	14
Ambala	Rice-Onion	380	100	0	176	11	139	9

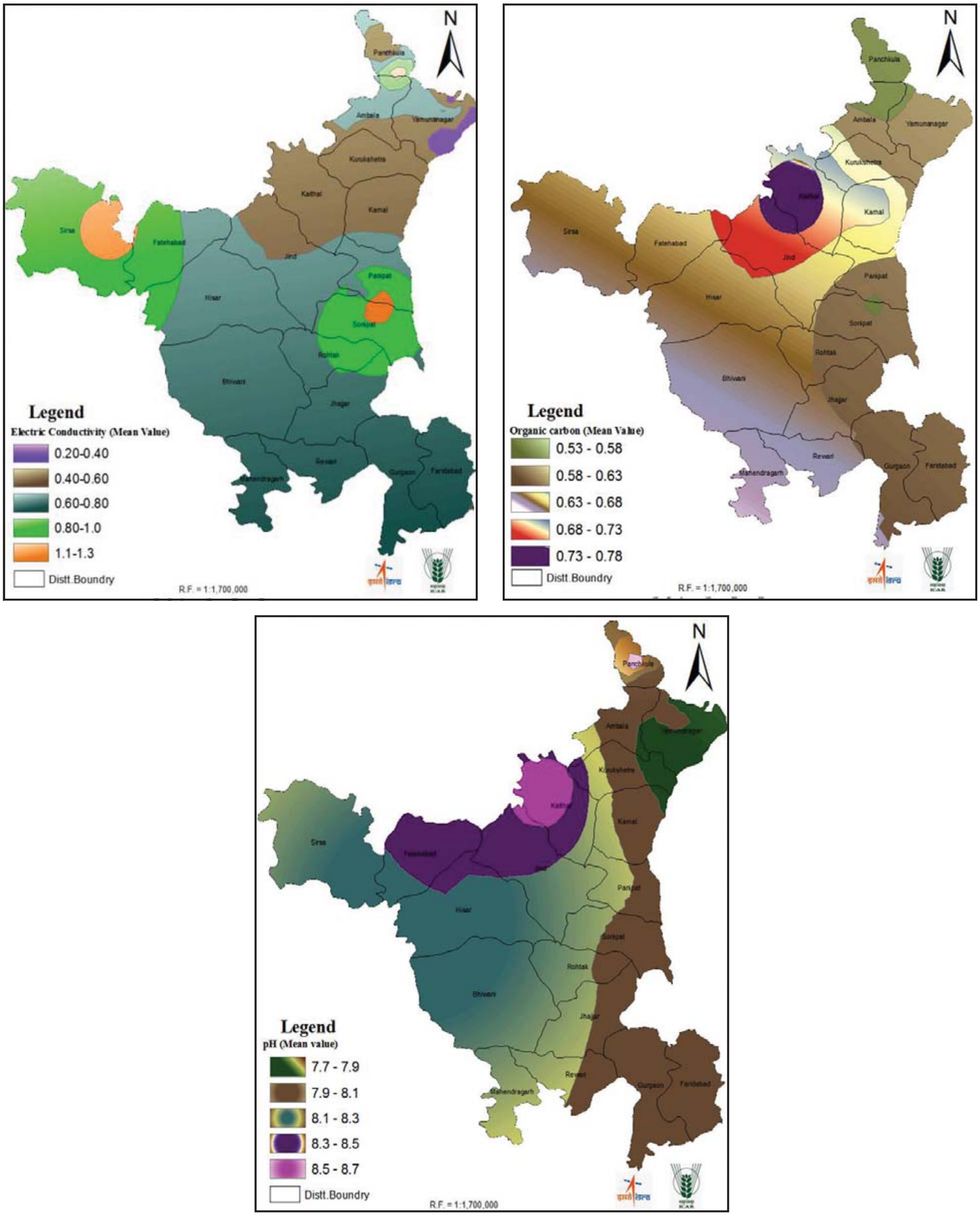


Fig. 9.6.7. Spatial variability of EC, OC and pH under rice-based cropping systems of Haryana

Table 9.6.10. District-wise EC, pH, OC and REY (t/ha) of rice based cropping systems of Haryana

Districts	Cropping System	EC(dSm^{-1})	pH	OC%	REY (tha^{-1})
Ambala	Rice- Wheat	0.43	8.2	0.48	9
Kaithal	Rice- Wheat	0.44	7.5	0.55	12
Karnal	Rice- Wheat	0.41	8.1	0.66	10
Sirsa	Rice- Wheat	0.97	8.1	0.60	10
Sonepat	Rice- Wheat	0.80	8.1	0.54	9
Y. Nagar	Rice- Wheat	0.32	7.6	0.59	11
Y.Nagar	Rice-Sugarcane	1.1	8.0	0.54	14
Ambala	Rice-Onion	0.20	8.0	0.54	9

% at Ambala under rice- wheat cropping system (Table 9.6.10).

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

To know the empirical relationship of yield variability and total N,P,K use, available N,P,K, EC, pH, OC and the yields were grouped into three categories based on the standard deviation (Group I (high) - < 13.0 t/ha, Group II (normal) - 9 – 13.0 t/ha and Group III(low) - > 9 t/ha). It is found that higher rice equivalent yield of rice based cropping system may be due to higher use of N and also with the available P and K (Table 9.6.11). REY falls under lower side when the OC less than 0.56.

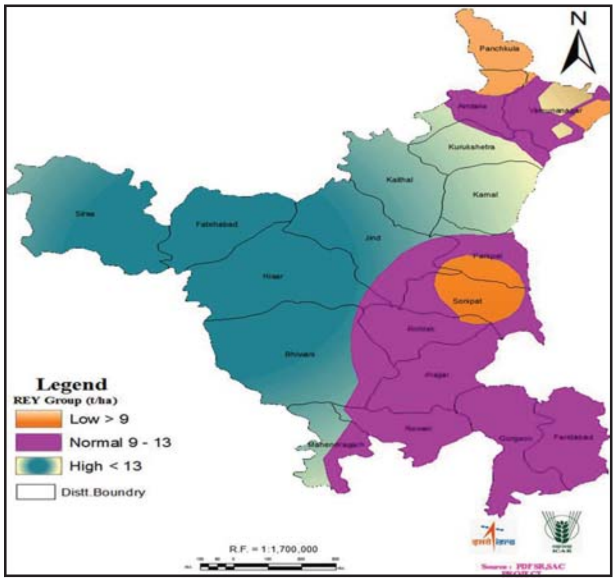


Fig. 9.6.8. Spatial variability of rice equivalent yield (t ha^{-1}) under different groups in rice based cropping system

Table 9.6.11. Relation between REY under rice based cropping system and fertilizer use, fertilizer availability, EC, pH and OC of the soil

REY Group	Avg.	Fertilizer						EC	pH	OC %
		Use kg ha^{-1}			Available kg ha^{-1} (dSm^{-1})					
		N	P	K	N	P	K			
<13	14	357	128	76	185	14	188	0.57	8.0	0.61
9-13	11	302	119	56	181	14	167	0.42	7.9	0.59
>9	8	302	113	146	173	15	165	0.72	8.2	0.56

v. AICRP on Integrated Farming Systems

All India Coordinated Research Project on Integrated farming Systems (AICRP-IFS) is an integral part of PDFSR with 31 on-station IFSR centres, 11 on-station CSR centres and 32 on-farm research centres spread throughout the country in all the agro-climatic regions to develop location specific farming system technologies. Under the aegis of AICRP-IFS, the experiments of Identification of needbased cropping systems for different agro-ecosystems, Tillage and plantingmanagement in different cropping systems, Long range effect ofcontinuous cropping and manuring on soil fertilityand yield stability, Development of organicfarming packages for system-based high valuecrops, To identify the key non-sustainabilityissues in important cropping systems and toenlarge agro-technologies capable of combiningthose issues and development of region specific integrated farming system models were taken up in on-station while 3 experiments viz., On-Farm crop responseto application of major plant nutrients inpredominant cropping systems, On-Farm evaluation of newdiversified cropping systems under irrigated/rainfed conditions and On- Farm evaluation of farming system modules for Improving profitability and livelihood of Small and Marginal Farmers were taken up under on-farm research besides conducting of 96 FLD's on cropping systems involving oilseeds.

The characterization of existing farming systems work has been completed and documented for Uttar Pradesh, while the survey work has been completed in the states of Maharashtra and Tamil Nadu. The quick survey conducted as a part of characterization throughout the country indicates existence of 19 pre-dominant farming systems with majority as crop + livestock (85%). Model IFS evaluated at Modipuram enables to fulfil household's annual food, fodder and, fuel needs of a seven member family. In addition, a sizable amount of cash ranging from Rs.46,700 in first four years to as much as Rs.68,800 /year in sixth year, could be spared to meet other liabilities of the family including education, health and other social obligations. Critical analysis on inter-relationship of different enterprises within the farming system revealed that out of total cost incurred (Rs.1, 97,883 per annum) about 57% (Rs.1, 14,146) is met from the inputs (out-put of other enterprise/ enterprises) generated within the system itself. Bio-intensive system of raising various crops through land configuration technique was found remarkably better as it recorded the highest yield of 18.32 t ha^{-1} as rice equivalent with productivity of 50.2 kg grain $ha^{-1}day^{-1}$ and profitability of Rs.363 $ha^{-1}day^{-1}$. Continuous rice-wheat cropping without fertilizer or manure application resulted in yield reduction by 28% in rice. 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.

On-farm research results revealed that existence of higher yield difference between farmers' and recommended practice of nutrient application in rice, wheat, maize, pearlmillet, sorghum, greengram and chickpea in selected locations.Application of micronutrient based on soil test is highly beneficial for rice, maize ragi, pearlmillet, groundnut and sorghum in many places. The response of wheat to micronutrient application was low compared to other crops. In all the NARP zones, the prevalent cropping systems have recorded higher grain yield witheither 100% NPK alone or NPK +micronutrients. Suboptimal application intermsof number of nutrients led to lower yield in allthe systems. Across the locations and systems, the diversified system registered net returns and total calories of Rs.1,17,156 ha^{-1} and 29158 x1000 kcal ha^{-1} compared to the existing system (Rs.60634 ha^{-1} and 24498 x1000 kcal ha^{-1}). On an average, it was found that, the net return and total calories can be increased by 93.2 and 19 % through diversification of existing cropping systems with location specific identified alternative systems.Farming system modules tested across the locations was found to increase the profitability by 97.8 % within one year of interventions and found to give additional farm employment of 30 to 55 man days.Expenditure pattern analysis of farm family before intervention indicates marginal and small households are incurring 42 and 35 % of their total expenditure towards purchasing of their food related items.Demonstration of improved package in cropping systems involving oilseeds resulted in 32.3 % (n=96) increase in yield of oilseeds across the locations and systems.

vi. Network Project on Organic Farming

Network Project on Organic Farming has 13 co-operating centres representing 9 agro-climatic regions, 13 NARP zones and 12 states. Analysis of 7 years yield data from various locations indicates, the relative yield of organic over inorganic was found to be higher in many crops such as basmati rice, rice, maize, sorghum, berseem, greengram, chickpea, soybean, groundnut, ginger, turmeric and vegetables such as okra, pea, chilli, onion, tomato, cabbage, garlic and cauliflower. The relative yield of wheat (102, n=55), cotton (113, n=17), sunflower (120, n=8) and potato (117, n=32) was found to be higher under integrated over inorganic production system as organic over inorganic registered less than 100 % inferring sustainable yield under integrated production system for these crops. Sustainable Yield Index (SYI) was higher under organic production system for basmati rice (0.75), rice (0.54), cotton (0.71), sunflower (0.61), groundnut (0.62), lentil (0.71), cabbage (0.60), French bean (0.61) and Isabgol (0.68) while maize (0.25), greengram (0.68), potato (0.64), okra (0.48), onion (0.66), Garlic (0.68), cauliflower (0.70), tomato (0.64), ginger (0.62) and turmeric (0.62) recorded higher SYI under integrated management production system. Across the locations, net returns was found to be 16.9 % higher (at 20 % premium price) while the cost of cultivation was found to be 12.7 % higher under organic production system compared to inorganic production system. SOC increased by 22.3 % under organic production over inorganic in 6 years. Increase in soil microbes (Fungi, bacteria, actinomycetes) was observed in all locations. Not much variation in quality parameters of many crops due to organic production. No significant variation in yield was observed between NS1 (two sources) and NS4 (three sources) as both recorded 112.7 % higher yield over control. Net returns were found to 52 and 57 % higher in NS 1 and NS 4 respectively over control. The results of organic input management clearly establish that use of either panchgavya or bidynamic parctice alone reduces the yield significantly. Combination of organic inputs such as vermicompost, FYM, neem cake was found to be better compared to application of single source.

a. Comparative efficiency of organic, inorganic and integrated nutrient management practices on soil health and crop productivity under various cropping systems

The highest yield of the *rabi* crops *viz*., wheat, barley + mustard (4:1), potato and mustard + radish of different cropping systems was recorded under INM. The INM recorded 20.9., 18.7 (21.8) and 23.3% higher grain yield and 16.2, 8.86 (14.5) and 16.6% higher biological yield of wheat, barley + mustard and mustard, respectively over inorganic nutrient management. The same treatment (INM) also recorded 17.1 and 25.4% higher tuber and root yield of potato and radish, respectively over inorganic nutrient management. Whilst summer green gram under CS_2 (rice – barley + mustard - green gram) and okra under CS_3 (maize-potato-okra) yielded highest under organic nutrient management and recorded 25.5; and 21.1% higher grain and pod yield, respectively over inorganic nutrient management practice.

Irrespective of cropping systems and soil depth, the highest mean organic carbon, available P, available K, dehydrogenase, alkaline phosphatase and acidic phosphatase activity in soil was recorded under organic nutrient management and were higher by 10.1, 12.6, 9.9, 9.9, 30.4 and 10.6 % compared to INM with corresponding increase by 77.1, 36.5, 43.2, 43.2, 49.4 and 42.8 % over inorganic nutrient management, respectively. Further, there was decrease in soil pH by 0.16 and 0.18 units under organic nutrient management compared to respective integrated and inorganic nutrient management.

b. Disease and pest management in rice-mustard and rice-chickpea cropping systems

The significantly higher grain and biological yield of chickpea and mustard grown following the *kharif* rice was recorded under the residual effect of green manuring than summer ploughing practiced during preceding *kharif* and under 'treated' (organic pest management practices). Under the residual effect of green manure the chickpea recorded 29.0 and 15.2%; and mustard recorded 22.8 and 16.6% higher grain and biological yield, respectively over summer ploughing. Similarly the treated plots of chickpea and mustard yielded 39.9 and 24.1% higher grain and 18.5 and 23.6% higher biological yield, respectively over untreated plots.

Irrespective of summer ploughing, green manuring and soil depth (0-45 cm), soil under cropping sequence of basmati rice-chickpea tends to build more mean organic carbon which is marginally higher by 1.2 % compared to cropping sequence of basmati rice-mustard. Further, under the same cropping sequence, soil pH was lower by 0.16 units and alkaline phosphatase activity was higher by 19.4%. However, there were no perceptible changes in EC, dehydrogenase and acidic phosphatase activity in the soil under both cropping sequences. Irrespective of cropping sequence and soil depth, green manuring resulted into higher soil organic carbon (5.4%), dehydrogenase (3.8%), alkaline phosphatase (16.1%) and acidic phosphatase activity (16.6%) and decrease in soil pH in comparison to summer ploughing. Mean organic carbon and enzymatic activity in soil decreased with increase in soil depth, while soil pH increased with increase in soil depth. Further, no perceptible change was observed in soil EC.

c. Agronomic evaluation of biodynamic (BD) practices and Panchgavya for organic cultivation of important cropping systems

Among various nutrient management practices treatment T_6 (FYM + Vermicompost +BD + *Panchgavya*) recorded the significantly higher grain (53.2%) and biological yield (31.1%) of wheat grown under basmati rice-wheat cropping system and grain and biological yield of wheat (56.6 and 26.3%) and mustard (69.3 and 52.6%) grown under maize+cowpea-wheat + mustard cropping system respectively, over control. The corresponding yield improvement under T_6 over BD preparation alone was 15.2 and 8.2% higher grain and biological yield of wheat under basmati rice-wheat cropping system and 12.1 and 8.3; and 27.9 and 23..0% higher grain and biological yield of wheat and mustard, respectively under maize+cowpea-wheat + mustard cropping system cropping system.

Irrespective of cropping sequence and soil depth (0-45 cm), incorporation of FYM with vermicompost resulted into improvement in soil organic carbon and enhanced dehydrogenase, alkaline phosphatase and acidic phosphatase activity in soil than to application of BD preparation alone and control. Irrespective of nutrient management practices and soil depth, mean organic carbon, dehydrogenase and alkaline phosphatase activity in soil was found to be higher by 7.3, 33.3 and 3.2%, respectively under cropping sequence of maize + cowpea – wheat + mustard than to basmati rice-wheat, whilst soil pH was lower by 0.11 units. Further, application of T_6 (FYM + vermicompost + BD preparation + *Panchgavya*) in both cropping sequences resulted into higher alkaline phosphatase activity compared to other practices. Across cropping sequences and nutrient management practices, there was definite decreasing trend in mean organic carbon and enzymatic activity in soil with increase in soil depth.

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

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

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

b. *National institutes and agricultural universities*

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

c. *International institutes*

There is research collaboration with IRRI, Philippines; CYMMIT, Mexico; USAID, USA; SAARC Agriculture Center Dhaka; PPIC, Canada; CSIRO, Australia; Independent Science and Partnership Council of the CGIAR, University of Nebraska, Lincoln; and ICRISAT, Hyderabad.

d. *Extension and development agencies*

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

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

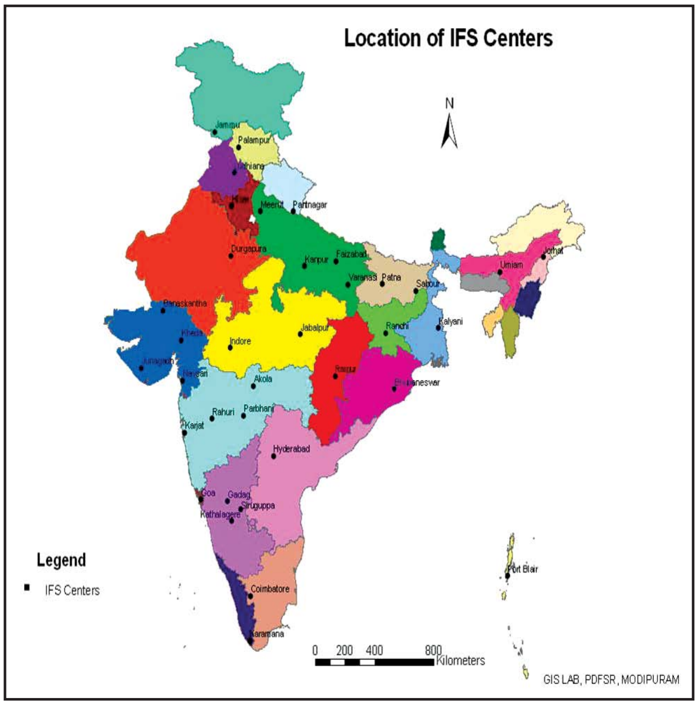
Under the aegis of '*AICRP on Integrated Farming Systems'* on-station research is going on at 31 main canters and 11 sub centers. These centers are engaged in basic an applied research and are located at SAUs or their Regional Research Stations or agriculture colleges of those general universities, or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

Centres of 'AICRP on Integrated Farming Systems'

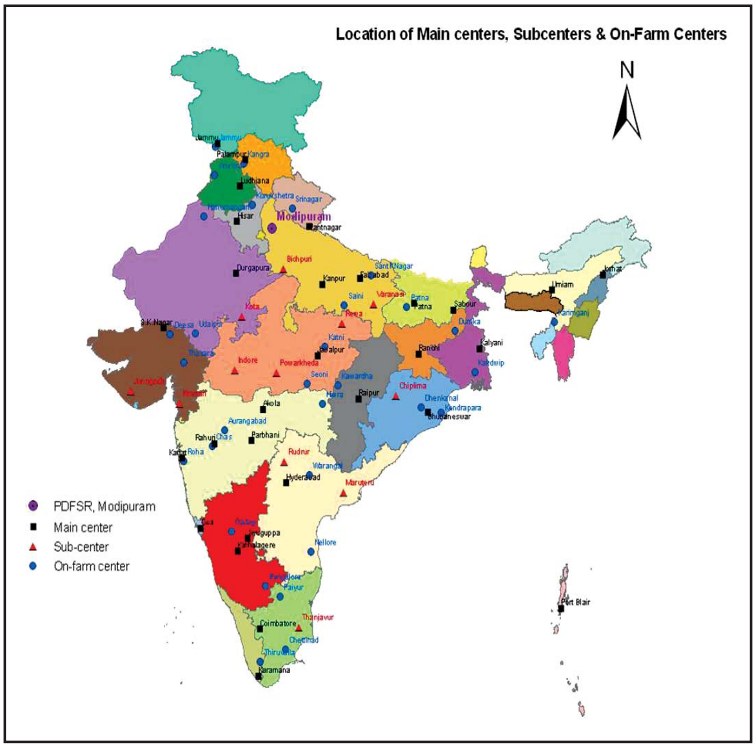
During the year 2012-13 research under the aegis of AICRP-IFS was going on at following centres:

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.



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



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

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

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

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

I. On-Station Research Centres

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

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

II. On-Farm Research Centers

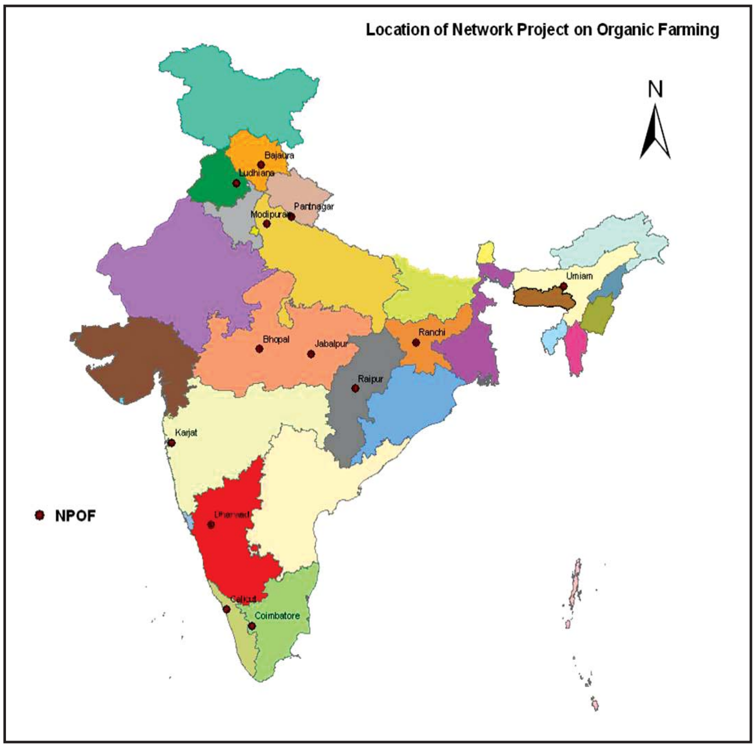
- ***Arid ecosystem*:** Hanumangarh (Rajasthan), Deesa Dist. Banaskantha (Gujarat), Gadag (Karnataka)
- ***Semi-arid ecosystem*:** Warangal (A.P.), Thasara Dist. Kheda (Gujarat), Kurukshetra (Haryana), Bengaluru (Karnataka), Aurangabad (Maharashtra), Chas Dist. Ahmednagar (Maharashtra), Amritsar (Punjab),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

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

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

B. Network Project on Organic Farming

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



Map. 11.3. Location of Network Project on Organic Farming

12. GENERAL/MISCELLANEOUS

12.1 LIST OF PUBLICATIONS

I. Research / Review Papers

Dwivedi, B. S., Singh, V. K., Shukla, A. K. and Meena, M. C. 2012. Optimizing dry and wet tillage for rice on a Gangetic alluvial soil: effect on soil characteristics, water use efficiency and productivity of the rice-wheat system. *European Journal of Agronomy,* **43:** 155-165.

Gangwar, B., Singh, V. K., Ravi-Shankar N. 2013. Fertilizer best management practices in important cropping systems. *Indian Journal of Fertilizer,* **9**(4): 34- 51.

Gangwar, K. S., Chaudhary, V. P., Pandey, D. K., Gangwar, B. and K. K. Singh. 2012. Mechanization Practices in Rice – Wheat Cropping Systems in Upper Gangetic Plains of India. *Agricultural Mechanization in Asia, Africa and Latin America*, **43**(2):66-74.

Gupta, S. K., Pal, A. K., Sahu, N. P., Saharan, N., Mandal, S. C., Prakash, C., Akhtar, M.S. and A. K. Prusty. 2012. Dietary microbial levan ameliorates stress and augments immunity in Cyprinus carpio fry (Linnaeus, 1758) exposed to sub-lethal toxicity of fipronil. *Aquaculture Research*.

Jat, M. L., Kumar, D., Majumdar, K., Kumar, A., Sahi, V., Satyanarayana, T., Pampolino M., Gupta, N., Singh, V., Dwivedi, B. S., Singh, V. K., Singh, V., Kamboj, B.R., Sidhu, H.S and Johnston, A. 2012. Crop response and economics of phosphorus fertilizer application in rice, wheat and maize in the Indo-Gangetic Plains. *Indian Journal of Fertilizer,* **8**(7): 62-72.

Kochewad, S. A., Singh, J. P., Patil, V. M., Kumar, V and Bhokre, S. M. 2013. Calfmortality – causes and control measures. *Indian Farming,* **62**(10):23-26

Kumar, A., Kumar, R. and Choudhary, V.K. 2012. Estimation and Nutrient Response Ratio of Various Cropping Systems under All India Coordinated Research Project on Integrated Farming Systems. *International Journal of Agricultural and Statistical Sciences,* **8(2)**, 645-649.

Kumar, R., Singh, V. K., Sharma, R. P., Kumar, A., and Singh G. 2012. Impact of Nitrogen, Phosphorus, Potash and Sulphur on Productivity of Rice-Wheat System in Sub-humid Region. *Journal of Agricultural Physics,* **12**(1): 84-88.

Majumdar, K., Kumar, A., Sahi, V., Satyanarayana, T., Jat, M. L., Kumar, D., Pampolino, M., Gupta, N., Singh, V., Dwivedi, B.S., Meena, M.C., Singh, V. K., Kamboj, B. R., Sidhu, H.S . and Johnston, A. 2012. Economics of potassium fertilizer application in rice, wheat and maize grown in the Indo-Gangetic Plains. *Indian Journal of Fertilizer,* **8** (5): 44-53.

Meena, D. K., Das, P., Kumar, S., Mandal, S. C., Prusty, A. K., Singh, S. K., Akhtar, M.S., Behera, B. K., Kumar, K., Pal, A. K. and S. C. Mukherjee. 2012. Beta Glucan: An ideal Immunostimulant in Aquaculture (A Review). *Fish Physiol. Biochem*.

Pal, S. S. and B.Gangwar. 2012. Balancing soil organic carbon pool-key to conservation agriculture and environment. *Indian Journal of Fertilizers,* pp. 100-107.

Pal, S. S. 2012. Soil management for improving crop yield and soil fertility under maize-wheat cropping system in an Haplustept of arid and semiarid region in India. *J. Indian Society of Soil Science*, **60** (4): 321-325.

Panwar, S., Kumar, A., Choudhary, V.K. and Rathore, A. 2013. Modeling of Potato Yield in India: An Empirical Approach using ARCH/ GARCH Model *International Journal of Agricultural and Statistical Sciences*, **8(2):** 597-601.

Satyanarayana, T., Majumdar, K., Shahi, V., Kumar, A., Pampolino, M., Jat, M. L., Singh V. K., Gupta, N., Singh, V., Dwivedi, B. S., Kumar, D., Malik, R. K., Singh V., Sidhu, H. S. and Johnston, A..2012. Economics of nitrogen fertilizer application in rice, wheat and maize grown in the Indo-Gangetic Plains. *Indian Journal of Fertilisers,* **8** (8): 62-71.

Sharma, G. C. 2012. Trend estimation of yield under rice-rice cropping system in different nutrient management under long term experiments. *Journal of Farming Systems Research & Development* (In press).

Sharma, G. C., Singh, K. K. and S. K. Duhoon. 2012. Dry and wet spell probabilities by Markov chain model for its application to crop planning in Navsari. *Journal of Farming Systems Research & Development* (In press).

Singh, J. P., Gangwar, B., Kochewad, S. K. and Pandey, D. K. 2012. Integrated farming system for improving livelihood of small farmers of western plain zone of Uttar Pradesh, India. *SAARC J Agri*., **10**(1): 45-53.

Singh, K. K., Lohan, S. K., Jat, A. S. and T. Rani. New Technologies of Planting Rice for Higher Production. Research on Crops, **7**(2): 369-371.

Singh, K., Singh, H., Singh, S., Kumar, V., Sharma, G. C. and P. Singh. 2012. Effect of zinc fertilization on growth yield of rice-wheat cropping system. *Journal of Farming Systems Research & Development* (In press)

Singh, V. K., Dwivedi, B. S, Shukla, A. K., and Mishra, R. P. 2012.Effect of pre-puddling tillage and puddling intensities on growth and yield of rice under rice-wheat system in western Indo-Gangetic Plains. Journal of Farming Systems Research and Development (In Press).

Singh, V. K., Dwivedi, B. S., Buresh, R. J., Jat, M. L., Majumdar, K., Gangwar, B., Govil, V. and Singh, S. K. 2012. Potassium fertilization in rice-wheat system on farmer's fields in India: crop performance and soil nutrients. *Agronomy Journal*, **105** (2): 471-81.

Singh, V. K., Govil, V., Singh, S. K., Dwivedi, B. S., Meena, M. C., Gupta, V. K., Majumdar, K. and Gangwar, B. 2012. Precision Nutrient Management Strategies using GIS-based Mapping in Western Uttar Pradesh. *Better Crops, South Asia,* **6** (1): 15-18.

Singh, V. K., Kumar, V. and Govil,V. 2013. Assessing sulphur deficiencies in soils and on-farm yield response to sulphur under rice wheat system in Garhwal region. *Indian Journal of Agronomy,* **58** (1): 9-16.

II. Abstracts / Seminar / Symposium

Chaudhary, V. P., B. Gangwar and M. Parmanik. 2012. Studies on energetic and productivity of direct seeded and transplanted rice based cropping systems. In Proc.,"Understanding Water-Energy-GHG nexus for future water and food security" held during September 27-28, 2012 at New Delhi, 13.

Chaudhary, V. P., B. Gangwar, N. Subash, R. Kumar, S. Gangwar and R. Kishore. 2012. Study of soil organic carbon, microbial biomass carbon under long term conservation tillage experiment under rice-wheat cropping systems. In Proc., International conference on climate change, Sustainable Agriculture & Public Leadership "(Eds: Dagar and Arunachalam) organized by NCCSD and ICAR during 7-9 February, 2012 at NASC Complex, New Delhi, pp. 82.

Chaudhary, V. P., B. Gangwar, S. Gangwar and R. Kumar. 2012. Study on the effect of tillage and crop residue mulching on soil organic carbon and microbial biomass carbon under rice based cropping system. Third International congress, Nov. 26-30, 2012 at New Delhi.

Jat, N.K., Yadav, R.S., Singh, P., Gangwar, B., Prasad, K. and Kumar, L.. 2012. Agronomic evaluation of biodynamic practices for organic cultivation of cereal-based cropping systems, *In*: Extended Summaries Vol.-3, Third International Agronomy Congress held at IARI, New Delhi during Nov. 26-30, pp. 115.

Kochewad, S. A., Gangwar, B., Singh, M. P., Chaudary, V. P., Prusty, A. K and P. Kashyap. 2012. Grewia optiva-A multipurpose fodder tree in Tehri region of Uttarakhand. National Symposium on Sustainable production of forages from arable and Non-arable land and its utilization. Nov 2-3, 2012 organized by RMSI and IGFRI Jhansi. pp.107.

Kumar, S., Gangwar, B. and N. K. Jat. 2012. Purvottar bharat mein jaivik krishi ki sambhavanaye, National Seminar on Krishi and Environment: Opportunity and Challenges to be held on March 13-14, 2013 at CSSRI, Karnal, Haryana.

Kumar, S., Gangwar, B., Sharma, B. K., Kumar, S., Pursty, A. K. and S. P. Singh. 2012. Depletion of groundwater table and its impact on crop productivity – A case study of Mahoba district of Bundelkhand region, International Conference on Impact of Technological Tools on food Security under Global Warming Scenario (ITTFS-2012) to be held on December 1-3 2012 at Babasaheb Bhimrao Ambedkar University, Lucknow.

Kumar, S., Gangwar, B., Singh, H., Choudhary, V. P. and N. K. Jat. 2012. Impact of Farming Systems on Household Income of Meghalaya Farmers, International Conference on Impact of Technological Tools on food Security under Global Warming Scenario (ITTFS-2012), December 1-3 2012 at Babasaheb Bhimrao Ambedkar University, Lucknow.

Mishra, R. P., Gangwar, B., Singh V. K. and Singh, K. K .2012. Effect of irrigation scheduling and slow release urea on rice productivity paper presented at Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods" IARI, New Delhi, November 26–30, 2012. Extended Summaries, Vol. 2. pp. 150-51.

Pal, S. S., Rai, P. K. and P. Kumar. 2012. Temperature sensitivity of soil respiration under resource conservation techniques in rice - wheat system in Indo Gangetic plain in India. National seminar on Sustainable Agriculture and Food Security: Challenges in Climate Change held March 27-28, 2012, Directorate of Research CCSHAU, Hissar. pp.229.

Pal, S. S., Rai, P. K. and P. Kumar. 2012. Methane emission from soil under resource conservation techniques in rice -wheat system of Indo Gangetic plain in India. National seminar on Sustainable Agriculture and Food Security: Challenges in Climate Change to held March 27-28, 2012, Directorate of Research CCSHAU, Hissar. pp. 226.

Pal, S. S., Rai, P. K., Kumar, P. and K. Singh. 2012. Effect of resource conservation techniques on crop yield, CO_2 efflux and soil fertility in rice - wheat system in an Ustochrept of Indo Gangetic Plain in India. Third International Agronomy congress, Agriculture Diversification, Climate Change Management and Livelihoods held IARI, New Delhi on November 26-30, 2012. pp.778-780.

Pal, S. S., Singh, K., Rai, P. K. and P. Kumar. 2012. Yield, water and nitrogen use efficiency in rice-wheat system under sprinkler irrigation system in an Ustochrept of IGP. National seminar on Indian agriculture: Preparedness for climate change held on March 24-25, 2012, I.A.R.I. New Delhi. pp.155-57.

Pramanik, M, Garg, N. K, Tripathi, S. K. and Singh, R. 2012. Comparison of non stressed baseline for wheat in sub humid sub tropical climate. In Proceeding of "Understanding Water-Energy-GHG nexus for future water and food security", September 27-28, 2012, New Delhi, pp. 13.

Shamim, M., Singh, D., Gangwar, B., Singh, K. K. and V. Kumar, 2012. Agrometeorological standardization of wheat genotypes under timely sown irrigated condition in Western Plain Zone of Uttar Pradesh. Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods" IARI, New Delhi, November 26–30, 2012. Extended Summaries, Vol. 3. pp. 1179-80.

Shamim, M., Singh, D., Gangwar, B., Singh, K. K. and V. Kumar, 2013. Agrometeorological standardization of rice genotypes under Western Plain zone of Uttar Pradesh. Paper presented at the National Symposium on Climate Change and Agriculture: Slicing Down Uncertainties, CRIDA, January, 22-23, 2013. Abstract. p40.

Shamim, M., Singh, D., Gangwar, B., Singh, K. K. and V. Kumar. 2013. Agrometeorological standardization of rice genotypes under Western Plain zone of Uttar Pradesh. Oral Presentation under the theme crop weather relationships and crop modeling in National Symposium on Climate Change and Agriculture: Slicing Down Uncertainties at CRIDA, during 22-23rd January.

Singh, K. K. and Gangwar, B. 2012. Resource conservation and high productivity through cropping system management and land configuration. Paper presented at Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods" IARI, New Delhi, November 26–30, 2012. Extended Summaries, Vol. 3. pp. 1189-90.

Singh, K. K., Mishra, R. P. and Gangwar, B. 2013. Conservation Agriculture Technologies in Rice-Wheat Cropping System for improving Productivity and Profitability. Paper presented at the 47th Annual Convention & Symposium of the Indian Society of Agricultural Engineers, held at DRR, Hyderabad, January 28-30, 2013.

Singh, K., Rai, P. K., Kumar, P. and S. S. Pal. 2012. Optical sensor based nitrogen application in rice-wheat cropping system on an Ustochrept of Indo Gangetic Plain in India on crop yield and nitrogen use efficiency. Third International Agronomy congress, Agriculture Diversification, Climate Change Management and Livelihoods, IARI, New Delhi, November 26-30, 2012. pp. 839-841.

Singh, V. K. 2012. Site- specific nutrient management using GIS during National Seminar on "Advances in Agricultural Research towards Food Security and Environmental Sustenance", September 01-03, 2012 at Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan.

Singh, V. K. 2012. Strategies for potassium management in rice-based cropping system in Indo-Gangetic plain", 19-20 December 2013 at IISS, Bhopal.

Singh, V. K. 2013. Phosphorus management under rice-wheat cropping system for enhancing P use efficiency and soil health" Phosphorus management under rice-wheat cropping system for enhancing P use efficiency and soil health organized by Indian Nitrigen group, 17-18 January, 2013 at NASC complex, New Delhi.

Singh, V. K. 2013. Precision nutrient management strategies using GIS National workshop on GIS applications in Natural resource Management, 20- 23 February, 2013 at NAARM Hyderabad.

Singh, V. K., Govil, V., Singh, S. K. and K. Majumdar. 2012.On-farm nutrient management strategies using GIS during National Seminar on "Advances in Agricultural Research towards Food Security and Environmental Sustenance", September 01-03, 2012, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan.

Singh, V.K., Govil, V., Singh, S.K., Dwivedi, B.S., Meena, M. C., Gupta, V. K., Gangwar, B. and K. Majumdar .2012. Site- specific nutrient management using GIS based mapping Presented during IPNI Co-operators meet on 21 May, 2012 at NASC complex New Delhi

III. Popular Articles

बी. गंगवार, जगपाल सिंह, दिनेश कुमार पाण्ड्ेय एंव आशीष कुमार प्रूष्टि 2012. कृषि प्रणाली मॉडल अपनाना फायदेमंद। खेती दिसम्बर 2012 पेज 3–6।

बेदप्रकाश चौधरी, बी. गंगवार, पूनम कश्यप एंव आशीष कुमार प्रूष्टि 2012. रेज्ड बेड पर मटर का उत्पादन। खेती, मई (2012), पेज 11–14

मौहम्मद शमीम, कंचन कुमार सिंह एंव बी0 गंगवार 2013. पश्चिमी विक्षोम एंव भारतीय कृषि, कृषि जागरण। **18**(3): 26।

मौहम्मद शमीम, के.के. सिंह एंव बी0 गंगवार 2013. गंगा के उत्तरी पश्चिमी मैदानी क्षेत्र में चरम मौसम एवं टिकाऊ कृषि हेतू आकस्मिक रणनीतियाँ, फार्म एंड फूड (Accepted).

Kumar, S. 2012. कृषि में औषधीय पौधों का बढ़ता महत्वए कृषि प्रणाली आलोक पत्रिका, pp. 48. 55।

Kumar, S. and Gangwar, B. सूक्ष्म पोषक तत्व : उर्वरक उपयोग क्षमता फसलोत्पादन वृद्वि की कुंजी 2012, राष्ट्रीय कृषि पत्रिका हिन्दी। (Accepted)

Kumar, S., Gangwar, B. and Jat, N. K. 2012. Prospects and determinates of fertilizer consumption in southern India. *FAI* (Accepted)

Kumar, S., Gangwar, B. and Jat, N. K. 2012. Purvottar bharat mein jaivik kheti ki sambhavanaye, *Bharitya Krishi Anusandhan Patrika*. **27** (4): 231-34.

Kumar, S., Gangwar, B., Mishra, P. P., Singh, S. P. and Kumar, S. 2012 पीली हल्दी की उत्पादन तकनीक, *Fhal Phool Patrika* : 19-23,

Kumar, S., Jat, N. K. and Kumar, S. जैविक खेती–एक दृष्टि, कृषि प्रणाली आलोक पत्रिका, 2012 pp. 23-27, PDFSR, Modipuram, Meerut.

Kumar, S., Kashyap, P., Pursty, A. K. and Choudhary, U. 2012. पूर्वी हिमालय क्षेत्र मेधालय में सब्जी उत्पादन – लधु किसानों की प्रमुख आय का साधन, खेती पत्रिका। (Accepted)

Kumar, V., Singh V. K. and Tyagi, S. 2012. Agro-Technology for direct seeded rice in northern India. *Indian Farmer Digest*, **45**(8): 5-16.

Meena, D., Meena, K. K., Das, P., Prusty, A. K. and M. S. Akhtar. 2012. Probiotics: Present status and future prospects in aquaculture. *Fishing Chimes*, **32**(1): 135-138.

वेद प्रकाश चौधरी, बी. गंगवार, मोनालिशा प्रमाणिक तथा विमल प्रताप पाण्डेय 2012. विभिन्न धान उत्पादन तकनीकियों में फसल उत्पादकता एवं जल संरक्षण – एक अवलोकन। राष्ट्रीय संगोष्ठी ''कृषि क्षेत्र में नवाचारः युवाओं के लिये अवसर'' विषय पर दिनांक 14 सितम्बर 2012 इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर (छत्तीसगढ)।

वेद प्रकाश चौधरी, बी. गंगवार, राकेश कुमार तथा रूप किशोर 2012. विभिन्न धान–गेहूँ के स्थापित विधियो में खरपतवार प्रबंन्धन – एक अध्ययन। राष्ट्रीय संगोष्ठी ''कृषि क्षेत्र में नवाचारः युवाओं के लिये अवसर'' विषय पर दिनांक 14 सितम्बर 2012 इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर (छत्तीसगढ)।

चौधरी, बेद प्रकाश, राकेश कुमार, दिनेश कुमार पाडेण्य तथा शिखा गंगवार 2012. धान – गेहूँ फसल उत्पादन एवं खरपतवार प्रबन्धन" ।खेती। अंक **11**: 3-7।

Shamim, M., Singh, K. K. and B. Gangwar. 2012. Effect of climate change on productivity of rice- wheat cropping system. In: PDFSR Newsletter, **19**(2): 12.

Shamim, M., Singh, K. K. and B. Gangwar. 2013. Extreme weather and contingency strategies for sustainable farming systems under western plain zone of Upper Gangetic plains agro climatic region. *Indian Farming*. (Under Review).

Shamim, M., Singh, K.K. and B. Gangwar. 2012. Effect of climate change on productivity of rice wheat cropping system. PDFSR Newsletter, **19** (2): 12.

Sharma, G. C. 2012. Sankhya i Ki Mahatta, *Krishi Pranali Alok*, **1:** 62-63.

Singh, J. P. and Gangwar, B. 2012. छोटे किसानों के लिए समन्वित कृषि प्रणाली मौडल *Kheti* August, pp3-8.

जगपाल सिंह, बाबूजी गंगवार, दिनेश कुमार पाण्ड़ेय, संजीव कुमार कोचेवाड एंव आशीष कुमार प्रूष्टि। समन्वित कृषि प्रणाली – लाये कृषकों में खुशहाली। सुरभि 2012। गोपशु परियोजना निदेशालय, मेरठ, पेज 115–121।

आशीष कुमार प्रूष्टि एवं पूनम कश्यप. ''रंगीन मछलियों का आशियानाः फिश एक्वेरियम'' कृषि प्रणाली आलोक प्रथम अंक (2012) पेज 4–6।

IV. Training / Compendium / Leaflet

Jat, N. K. 2012. Good Agricultural Practices: with respect to irrigation, including water quality and fertigation, *In*: Compendium of Lectures: Model Training Course on "Good Agricultural Practices" 4-11 March, 2013, PDFSR, Modipurum, Meerut, pp: 43-52.

Jat, N. K. 2012. Status and prospects of weed management in conservation agriculture based rice-wheat cropping system *In*: Compendium of Lectures: Winter School on "*System-based Conservation Agriculture for Sustained Productivity and Soil Health*" 3-23rd Oct. 2012, PDFSR, Modipurum, Meerut, India pp: 269-282

Sharma, G. C. 2012. Models for Fertilizer Response Surfaces. Compendium of lecture notes on System based Conservation Agriculture for sustained productivity and soil health. pp. 199-208.

Sharma, G. C. 2012. Optimum Resource Allocation in Agriculture. Compendium of lecture notes on System based Conservation Agriculture for sustained productivity and soil health. pp.189-198.

Singh, H. 2012. Conservation Agriculture–Economic and Policy Issues, In: Compendium for Winter School on Conservation Agriculture, PDFSR, Modipuram.

Singh, H. 2012. Seed Policy in India: Issues and Concerns, In: Compendium for Model Training Course on Integrated Farming System, PDFSR, Modipuram.

Singh, K. K. 2012. Conservation Agriculture – Concepts, Practices and Prospects. In: Compendium of Winter School on "System Based Conservation Agriculture for Sustained Productivity and Soil Health" Oct. 3 to 23, 2012. pp. 29-33.

Singh, K. K. 2012. Conservation Agriculture machinery and tools. In: Compendium of Winter School on "System Based Conservation Agriculture for Sustained Productivity and Soil Health" Oct. 3 to 23, 2012. pp. 104-108.

Singh, K. K. 2012. Conservation Agriculture Technologies for Integrated Farming Systems. In: Compendium of Model Training Course on "Integrated Farming System", PDFSR, Modipuram, September 3-10, 2012.

Singh, K. K. 2012. Crop Residue Management for Sustained Productivity and Soil Health. In: Compendium of Winter School on "System Based Conservation Agriculture for Sustained Productivity and Soil Health" Oct. 3 to 23, 2012. pp. 384-388.

Singh, K. K. 2012. Micro- Irrigation for Conservation Agriculture. In: Compendium of Winter School on "System Based Conservation Agriculture for Sustained Productivity and Soil Health" Oct. 3 to 23, 2012. pp. 389-392.

Singh, K. K. 2013. Cost Effective and Energy Efficient Conservation Agriculture Machinery for Good Agricultural Practices. In: Compendium of Model Training Course on Good Agricultural Practices", March 4-11, 2013.

Subash, N., Gangwar, B., Chaudhary, V. P. and S. Singh. 2012. Long term trends of productivity in relation to variability in rainfall, temperature and nutrient management practices under rice-rice cropping system. In Proc., International conference on climate change, Sustainable Agriculture & Public Leadership held at New Delhi during February 7-9, 2012 (15 pages).

Tripathi, K. P. and B. Gangwar. 2012. Nitrogen use efficiency in aerobic rice grown under saline sodic conditions. IPUAC Sponsored Second International Conference on Agrochemicals Protecting Crops, Health and Natural Environment, IARI, New Delhi, 14-18 February, 2012. pp. 200.

V. Lecture Delivered

Singh, J. P. 2012. Latest Technologies on Agricultural Production in U.P. and Integrated farming System Approach. Agricultural Research – Development Conclave for U.P. and U.P. Kisan Vigyan, IISR, Lucknow, 23-24 Nov.

Singh, K. K. 2013. Scenario and Multiple Uses of Water. Presented at World Water Day celebrations of Meerut center of the Institution of Engineers (India).

Singh, V. K. 2013. More Crop Per Drop: Through cropping systems management" at CCS university Meerut.

VI. Books / Bulletins

Gangwar, B. and Singh, V. K. (Eds). (2012). System based integrated nutrient management. 378p. New India Publishing Agency, New Delhi. [Edited book].

Gangwar, B., Singh, K. K. and M. Shamim. 2012. PDFSR at a Glance. Yugantar Prakashan, New Delhi, pp. 1-16.

Gangwar, B., Singh, K. K., Singh, V. K., Ravisankar, N. and R. P. Mishra. 2012. System Based Conservation Agriculture for Sustained Productivity and Soil Health (Compendium, mimeographed), PDFSR, Modipuram, pp. 1-410.

Pal, S. S., Kumar, P. and P. K. Rai. 2013. System rice intensification in rice-wheat system for improved resource use and environmental security. PDFSR Bulletin No. 09, pp 1-28.

Singh, V. K., Singh, K. K., Gangwar, B. and P. P. Mishra. 2012. Sanrakshan Krishi Apnayen, Kheti Ka Bhavishya Banayen. Yugantar Prakashan, New Delhi, pp. 1-58.

VII. Book Chapters

Gangwar, B. and J.P. Singh. "Nutrient Economy through Integrated Farming System Approach. In: System Based INM, 2012. B.Gangwar and V.K.Singh(eds.)New India Publishing Agency, New Delhi, India; pp79-91.

Gupta, S. K., Saharan, N., Gupta, A., Sharma, K. K. and A. K. Prusty . 2012. Impact of Fipronil on the Aquatic Environment. In: Biodiversity of Aquatic Ecosystem (Ed. Bharti Pawan K.). Discovery Publishing House, New Delhi, pp.118-137.

Kumar, S. and Jat, N. K. Bhartiya Krishi me Suchana Prodiyogiki - srota avem sambhavnaye. समन्वित कृषि प्रणाली प्रबन्धन, 2012 pp. 132-137, PDFSR, Modipuram, Meerut.

Pal, S. S. 2012. Microbial diversity – key to sustainable agriculture and soil health: In: System Based Integrated Nutrient Management. B. Gangwar and V. K. Singh (Eds.). New India Publishing Agency, New Delhi. pp. 275-286

Pal, S. S. 2012. Pulse production in organic system. In solving the pulse crises. (Ed. A. K. Singh and B. Gangwar).

Pal, S.S. 2012. Microbial diversity: a component of sustainable Agriculture. In: Cropping System

Management. (Ed. B. Gangwar). Agrotech Publishing Academy, Udaipur. pp. 119-136.

Panikkar, P., Khan, M. F., Sharma, A.P., Jha, B. C and A. K. Prusty. 2012. Assessment of ecosystem properties for management of reservoir fishery resources". In: Aquatic Environment and Toxicology (Ed. Bharti Pawan K.) Discovery Publishing House, New Delhi , ISBN- 93-5056-236-7, pp.216-225

Phulia, V., Jamwal, A., Saxena, N., Chadha, N. K., Muralidhar, A. P. and A. K. Prusty. 2012. Technologies in Aquatic Bioremediation. In: Freshwater Ecosystem and Xenobiotics (Eds. Bharti Pawan K et al.), Discovery Publishing House, New Delhi ISBN- 93-5056-299-5, pp.65-90.

S. K. Gupta, Saharan, N., Mandal, S. C., Akhtar, M. S., Kumar, K. and A. K. Prusty. 2012. Ultra-microscopical changes of gill of Cyprinus carpio (Linnaeus, 1758) fry exposed to sub lethal concentration of fipronil. In: Aquatic Environment and Toxicology (Ed. Bharti Pawan K.). Discovery Publishing House, New Delhi ISBN- 93-5056-236-7, pp.195-209.

Singh, A. K., Gangwar, B. and Harbir Singh**.** 2013. Solving the Pulses Crisis: A Road Map, In: Anil Kumar Singh and B. Gangwar (eds.), *Solving the Pulses Crisis*, pp: 1-14, New India Publishing Agency, New Delhi, xvi+364p.

Singh, H. and B. Gangwar. 2013. Pulse Trade in India: Problems, Opportunities and Policy Issues, In: Anil Kumar Singh and B. Gangwar (eds.), *Solving the Pulses Crisis*, pp: 203-217, New India Publishing Agency, New Delhi, xvi+364p.

Singh, J. P., Gangwar, B. and Pandey, D. K. 2012. Uttar Pradesh ke pashcimi maidani chhetron men laghu jot vale krishkon hetu krishi pranali maudal. In: Samanvit Krishi Pranali Pravandhan (Hindi) by J. P. Singh et al. (Eds.). PDFSR Publication, pp. 9-28.

Singh, K. K. 2012. Resource Conservation Technologies for Improving Nutrient Use Efficiency. In: "System Based Integrated Nutrient Management", eds. (B. Gangwar and V. K. Singh), New India Publishing Agency, New Delhi, pp. 259-274.

Singh, K. K. 2012. Sansadhan Sanrakshan Yantra Evam Takniken. In: Krishi Pranali Aalok, Rajbhasha Patrika, **1:** 19-22.

Singh, K. K. 2013. Tillage Management and Crop Establishment Strategies. In: "Solving the Pulses Crisis", eds. (Anil Kumar Singh and B Gangwar), New India Publishing Agency, New Delhi, pp. 107-117.

Singh, K. K. and B. Gangwar. 2012. Laser Land Leveler for Improving Resource Use Efficiency in Agriculture. In: Cropping Systems Management", B. Gangwar (ed.), Agrotech Publishing Academy, Udaipur. pp. 85-100.

Singh, K. K. and B. Gangwar. 2012. System based Tillage and Crop Establishment for Improving Land, Water and Energy Productivity. In:

Cropping Systems Management", B. Gangwar (ed.), Agrotech Publishing Academy, Udaipur. pp. 65-84.

Singh, V. K. 2012. Legume inclusion/substitution in cropping system. pp.91-105. In: Solving the pulse crisis (A.K. Singh, and B. Gangwar, Eds).

Singh, V. K. and B. Gangwar, 2012. Crop Diversification through Pulses: Issues and Strategies. Pp 53-71. In: Solving the pulse crisis (A.K. Singh, and B. Gangwar, Eds).

Tripathi, K. P. 2012. Soil carbon management for better soil health. *In* System Based Integrated Nutrient Management. B. Gangwar and V. K. Singh (Eds). New India Publishing Agency, New Delhi (India), pp. 297-301.

जगपाल सिंह, बी. गंगवार, दिनेश कुमार पाण्ड़ेय, कामता प्रसाद एंव आशीष कुमार प्रूष्टि. 2012. समन्वित कृषि प्रणाली प्रबन्धन पेज 1–142, कृषि प्रणाली अनुसंधान निदेशालय, मोदीपुरम, मेरठ, प्रकाशन।

बी. गंगवार, जगपाल सिंह, दिनेश कुमार पाण्ड़ेय एंव आशीष कुमार प्रूष्टि. 2012. कृषि प्रणाली प्रबन्धन। In: समन्वित कृषि प्रणाली प्रबन्धन (बी. गंगवार, जगपाल सिंह, दिनेश कुमार पाण्ड़ेय एंव आशीष कुमार प्रूष्टि)। कृषि प्रणाली अनुसंधान निदेशालय, मोदीपुरम, मेरठ, प्रकाशन, पेज 1–8।

पूनम कश्यप, आशीष कुमार प्रूष्टि एंव जगपाल सिंह 2012. एकीकृत फसल प्रणाली में बागबानी का समन्वयन। In: समन्वित कृषि प्रणाली प्रबन्धन (बी. गंगवार, जगपाल सिंह, दिनेश कुमार पाण्ड़ेय एंव आशीष कुमार प्रूष्टि)। कृषि प्रणाली अनुसंधान निदेशालय, मोदीपुरम, मेरठ, प्रकाशन, पेज 62–67।

आशीष कुमार प्रूष्टि, जगपाल सिंह, पूनम कश्यप, दिनेश कुमार पाण्डेय, संजीव कुमार कोचेवाड़ 2012. मीठे पानी में मछली पालन। In: समन्वित कृषि प्रणाली प्रबन्धन (बी. गंगवार, जगपाल सिंह, दिनेश कुमार पाण्ड़ेय एंव आशीष कुमार प्रूष्टि)। कृषि प्रणाली अनुसंधान निदेशालय, मोदीपुरम, मेरठ, प्रकाशन, पेज –67।

VIII. Television / Radio Talks

Prusty, A. K. delivered TV talk on Door Darshan regarding Integrated Fish farming broadcasted on 26th November, 2012 at 6.30 PM in Krishi Darshan Programme.

Kumar, S. Radio talk on 26 June 2012 at 7.10 PM to 7.30 PM, खेती में सूचना प्रौद्योगिकी का महत्व organized at Aakaswani, New Delhi

Singh, J. P. delivered TV talk on Door Darshan regarding Integrated farming system broadcasted on 26th November, 2012 at 6.30 PM in Krishi Darshan Programme.

12.2 MEETINGS OF RAC/IRC/IMC

Research Advisory Committee

The 2nd meeting the 6th Research Advisory Committe was held under the chairmanship of Prof. Panjab Singh, Ex-Secretary DARE and DG ICAR during 9-10 April 2012. Dr K.K. Vass, Ex-Director, CIFRI, Barrackpore, Dr Shyam Singh, Ex-Director, NRC Citrus, Nagpur and Dr A.K. Yadav, Director, National Centre on Organic Farming, Ghaziabad attended as members. Dr B. Gangwar, Project Director welcomed the Chairman and members and presented the highlights in terms of research, infrastructure, human resource development and publications of the directorate during 2011-12. He informed to the team that based on the information generated over the years, the zone-wise efficient alternative cropping systems, along with their package of practices, have been documented in the form of a book entitled, "Efficient Alternative Cropping Systems". The action taken report of the previous meeting was presented by Dr Kamta Prasad, Principal Scientist and Member Secretary of RAC. The research project wise achievements were presented before the committee by respective Programme Facilitators.

The committee also visited all the experiments. All the scientists of the directorate participated in the meeting. The Chairman and members have expressed their overall satisfaction about the progress of research at the Directorate. Chairman remarked that farming systems are difficult to manage, but once managed; this approach may give answer to many issues being talked to be managed through agriculture development, such as resource conservation and sustainability, sustainable productivity, climate change, employment, nutritional security, increasing farmers income etc. Tagging the system with on-farm value addition/ processing is very important to achieve the goals of production-consumption chain. The meeting ended with vote of thanks proposed by member secretary.

Quinquennial Review Team

The report finalization meeting of fourth Quinquennial Review Team (QRT) of the directorate including AICRP on Integrated Farming Systems was held at the Directorate during 11-12 August 2012. The QRT team led by Prof. Panjab Singh, Ex-Secretary DARE & DG, ICAR as Chairman with Dr K. Pradhan, Ex-Vice Chancellor, OUAT Bhubaneswar, Dr Gyanendra Singh, Ex-Vice Chancellor MGGU Chitrakoot, Dr CL Acharya, Former Director, IISS, Bhopal, Dr D.M. Hegde, Ex-Project Director, DOR, Dr W.S. Dhillon, Director, Post harvest technology centre, PAU, Ludhiana and Dr Anjani Kumar, Pr. Scientist, NCAP, New Delhi as members and Dr. Kamta Prasad, Pr. Scientist (Agronomy) as Member Secretary have finalized the report for the period of 2007-2012. The committee felt that in-spite of scientific staff limitations; the directorate has significantly contributed to the knowledge and science of cropping/ farming systems research for the larger benefit of farming community and the performance of the directorate was rated as **"VERY GOOD".** The directorate has enabled and empowered the coordinated and network centres of farming systems/ organic farming for development of location specific technologies. The PDFSR has potential to further improve its performance provided the limitations given in the report are overcome with adequate support.

Institute Management Committee

The 30th meeting of Institute Management Committee (IMC) was held on 12 Septmber, 2012 under the chairmanship of Dr B. Gangwar, Project Director. Dr. A.K. Bakshi, Vice Chancellor, SVBPUA&T, Modipuram, Shri K.K. Sharma, Ex-President District Board, Bulandshahar (UP), Dr. P.C. Bhatia, EX- ADG- ICAR, Dr S.S. Pal, Principal Scientist, PDFSR have attended the meeting as members of IMC while Dr Panjab Singh, Ex- Director General, ICAR and Chairman, QRT of PDFSR, Dr. Kamta Prasad Principal Scientist and Sh. Anil Kumar Agrawal, F&AO and Shri H.S. Chauhan, AAO attended the meeting as special invitees. At the outset, Dr. B. Gangwar, Project Director and Chairman of the Committee welcomed Hon'ble chairman of QRT, special invitees and all the respected members on behalf of the Directorate. The Action take report of 29th meeting presented by Shri Sushil K. Singh, SAO and Member Secretary, IMC and it was accepted in toto. Shri Anil K. Agarwal, F & AO presented the budget and utilization under the head Plan and Non Plan along with other projects for the current financial year of the directorate. The chairman presented the progress and achievements since last IMC meeting which included infrastructure development, human resource development, publications besides research accomplishments. The members of the committee appreciated the efforts and progress made. Dr Panjab Singh, Chairman, QRT briefed the members about the report of five yearly assessment of the directorate by the committee. He emphasized that HRD and capacity building in IFS needs special focus at national level. The issues related to purchase of lab equipments, furniture and fixtures for the financial year 2012-13 are discussed and necessary recommendations were given. Shri Sushil K. Singh, SAO and Member Secretary proposed the vote of thanks.

12.3 SCIENTIFIC MEETINGS, WORKSHOPS, CONFERENCES, WINTER/SUMMER SCHOOL, MTC ORGANIZED

XXX Biennial Workshop

The Biennial Workshop of AICRP on Integrated Farming Systems was held at ICAR Research Complex, Goa during 16-19 November 2012. A pre-work shop interaction meeting was organized on 16 November 2012 in which progress was reviewed in two separate sessions for on-station and on-farm programmes.

The workshop was inaugurated by Chief Guest Shri Shripada Yesso Naik, Hon'ble Member of Parliament (North Goa) on 17th November, 2012 in the presence of Dr N.P. Singh, Director, ICAR RC, Goa and Dr B. Gangwar, Project Director, PDFSR.

At the outset, Dr. N. P. Singh, Director, ICAR-RC, Goa welcomed all the participants from different parts of country and highlighted the glory of Goa,

the land of 3'S, Sea, Sun and Scenic beauty which enthralls all. He briefed about the farming system scenario of Goa which is mainly horticulture based. Cashew and Arecanut occupy the major portion of horticulture based systems. He emphasized that sensitization is needed for ensuring livelihood security of the farming community through farming system approach. Dr. B. Gangwar, Project Director, PDFSR, Modipuram in his introductory remark briefed about the journey of PDFSR and highlighted about the predominance and prevalence of farming system research and stressed that future of farming system research is bright as we have to meet the demands of households from shrinking land holdings. He also briefed about the future work plans of PDFSR through farming system approach.

On this occasion 4 publications of PDFSR, viz. '**PDFSR at a Glance (English)**', '**Samanvit Krishi Pranali Pravandhan (Hindi)**', '**Sarankshan Krishi Apnaye, Kheti Ka Bhabishya Banaye '(Hindi)** and '**Annual Report of AICRP on IFS**' were released by Chief Guest.

Hon'ble Chief Guest, Shri Shripada Yesoo Naik, gave his inspiring speech explaining the needs and usefulness of farming system for livelihood security of households and emphasized that findings of research should reach to the farmers specially the poor.

Dr. B. L. Manjunath, Senior Scientist of ICAR-RC, Goa proposed the vote of thanks. All the AICRP centres participated in the workshop.

Action taken report of the previous workshop was presented by Dr Kamta Prasad. The research highlights of programmes were presented by Dr Kamta Prasad, Dr J.P. Singh, Dr S.S.Pal, Dr K.K. Singh, Dr Harbir Singh and Dr N. Ravisankar from the Directorate. In the special session, Dr. J.C. Bhatt, Director, VPKAS, Almora spoke on "Integrated horticulture in the farming systems of rainfed hill agriculture- Possibilities and priorities" in which he explained the physiographical and climatological aspects of the hill agriculture. He said that agriculture in plain and valley areas is highly productive whereas the situations are reverse in case of hilly and sloppy areas. Detailed discussions held to transform the on-going experiments in to farming system perspective. Finally, few experiments were concluded or partially modified besides finalizing new experiments with technical programme and sampling protocols. All the experiments of on-farm programme stands transformed to farming systems perspective. The plenary session was held on 19 November 2012 in which session wise recommendations were discussed and finalized. The workshop ended with vote of thanks proposed by Dr Kamta Prasad, Programme Facilitator, Co ordination Unit.

Winter School on "System based Conservation Agriculture for Sustained Productivity and Soil Health"

Winter School on "System based Conservation Agriculture for Sustained Productivity and Soil Health" was organized during 03-23 October, 2012. There were 26 participants from various disciplines belonging to 12 states. The winter school covered the energy and cost effecticient system based conservation agriculture technologies for improving system productivity, profitability, soil health and environmental quality; with efficient use of irrigation water; besides improving work efficiency and welfare of labours. In total, there were 73 lectures/ practical/ group discussions delivered to the participants. DDG (NRM), ADG (SA&AF), two representatives of international organizations, four Directors of ICAR Institutes, one head of division, two retired Professors / Principal Scientists and seven guest lecturers from other organizations addressed the participants with reference to the latest knowledge about Conservation Agriculture in different crops/ cropping systems. The exposure about GCMS, Gas chromatography, Atomic Absorption Spectrophotometer, Root Image Analyzer, CHNS analyzer, different laboratories (soil chemical, physiology, microbiology, and Agril. Meteorology) was given. The participants were also given the demonstration about the use of second-generation machinery for making efficient management of crop residue, to conserve the natural resources and soil nutrients, to reduce the cost of production and making the system eco-friendly.

Sitting 1st row (Left to right): Sh. Pravin Namdeo Gajbhiye, Dr. Tejeswara Rao Kottana, Dr. Arjun Singh Jat, Dr. Ram Lal Choudhary, Mr. Hardev Ram, Dr. Jacob D.

Sitting 2nd row (Left to right): Dr. R.P. Mishra, Dr. N. Ravisankar, Dr. K.K. Singh, **Dr. B. Gangwar (Course Director)**, Dr. V.K. Singh, Dr. S.S. Pal, Dr. Samrath Lal Meena

Standing (Left to right): Er. Shiv Kumar Lohan, Dr. Sanjeev Tripathi, Dr. Mukesh Kumar, Dr. Ram Nagina Singh, Mr. Akhilesh Sah, Dr. Dibakar Mahanta, Mr. Dharminder, Dr. Arvind Kumar, Dr. Arvind Kumar Girdharbhai Patel, Dr. Meharban Singh Kahlon, Dr. Bhikhabhai Jivanbhai Patel, Mr. Bhagvanbhai Valjibhai Hirpara, Dr. Vijay Khajuria, Mr. Subhash Aswal, Dr. Prashant Shivdas Solunke, Dr. Pramod Bhimrao Jagtap, Dr. Surendra Kumar, Er. Anil Saroha, Dr. Baldev Ram

During the school period, trainees were exposed to practical field demonstrations at PDFSR, Modipuram; SVBP University of Agriculture & Technology, Modipuram; CPRI Campus, Modipuram and few selected farmers fields. Overall, the conduct, knowledge passed on the trainee, skill development about the use of sophisticated instruments/ appliances/ machinery proved excellent and this winter school came up to the expectation of the trainees. All the participants were very much satisfied with the winter school which would prove of immense help in their research / extension programme as well as in teaching the undergraduate and post graduate students. The trainees were fully contented with the out-come which they explained in the valedictory function. Every day, one new word/ concept was explained by scientists of the Directorate for improving their knowledge and skill.

Model training course on "Good Agricultural Practices

A model training course on "Good Agricultural Practices" was organized during 4-11 march 2013 at Project Directorate on Farming Systems Research, Modipuram, Meerut-250 110, U. P. The training was sponsored by Directorate of Extension, Ministry of Agriculture, Government of India, New Delhi. The objective of training was to introduce and popularize the concept of good agricultural practices (modern as well as ITK-based) which are environment-friendly, energy-efficient, cost effective and help in improving crop yields and sustainability of agricultural resources and result in safe and quality food and non-food agricultural products; among extension personnel/ managers. There were 21 participants, primarily from state department of agriculture of six states (A.P., Jharkhand, Maharashtra, Odisha, Punjab and U.P.). The participants were exposed to the concept and relevance of "Good Agricultural Practices (GAPs)" in modern day agriculture, GAPs in respect of seed and planting materials, tillage practices, crop nutrition, fertilizer and manures, crop protection, irrigation and other crop production techniques, second generation farm machinery for conservation agriculture, concept and approach of integrated farming systems development, concept of bio-intensive complementary cropping systems, concepts and practices in organic crop production, concept of nature farming and post-harvesting processing and value addition.

The lectures on almost all the aspects of Good Agricultural Practices (GAPs) were delivered by experienced scientists/ professors from the Project Directorate for Farming Systems Research and also from sister organizations including ICAR institute like Central Potato Research Institute Campus, Modipuram, SVPUA&T, Modipuram and Professor from CCR PG college, Muzaffarnagar (CCS University, Meerut). Moreover, field exposures and practical trainings were also imparted on selected aspects. The trainee participants were taken for field exposure/ study tour to Medicinal Crops Research Farm of Patanjali Yogpeeth, Haridwar along with adopted villages of KVK, Hastinapur. Participants were also taken to On-Farm Research Programme of PDFSR and labs/ experimental fields of Central Potato Research Institute Campus. The trainees were also appraised with Farming System Research Programme being carried out at PDFSR, Research Farm, including On-Station IFS Model developed at PDFSR, experimentation under Organic Farming, Resource Conservation and Diversification of crops and cropping systems. The participants were also shown technologies developed by the Project Directorate and being displayed in Technology Park of the Directorate. Participants were also given hands on training on second generation farm machineries and were exposed to laboratory facilities of PDFSR.

Training on Web enabled information system

A training on "Web enabled information system for On-Farm Research experiment 1" was conducted for OFR Agronomists during 20-21 April 2012 at IASRI, New Delhi. Dr V.K. Bhatia, Director, IASRI, New Delhi and Dr B. Gangwar, Project Director graced the inaugural programme. Dr V.K. Bhatia informed the participants that the information system developed for online data submission is the first of its kind in the history of IASRI for on-farm experiments and this initiative should be taken forward for other experiments also. Dr B. Gangwar informed the house that he is very happy to see the laptops brought by OFR Agronomists for the training. He also mentioned, in order facilitate the real time data processing, all the centres have been provided with laptops, internet connection and printers.

The facilities given should be utilized optimally for the specific purpose and requested the participants to learn the data submission process completely with due attention as the data of 2011-12 have to be compulsorily submitted through online system.

In the valedictory, Dr A.K. Singh, DDG (NRM) was the Chief Guest along with Dr V.K. Bhatia, Director, IASRI and Dr B. Gangwar, Project Director. After taking the feedback from the participants, Dr A.K. Singh, DDG (NRM) congratulated the IASRI and PDFSR for this new initiative and asked to continue this effort for other experiments of the AICRP on IFS in a shortest possible time. He also informed that "Integrated Farming Systems" is one of the important programme of the council as this will serve as a mitigation tool for climate related risks. Dr B. Gangwar, Project Director asked the OFR Agronomists to devote themselves to the cause of on-farm farming systems research.

Multi-skilled training for temporary status staff

A multi-skilled training was organized in the directorate during 01-15 June, 2012 for temporary status/ casual labour staff of PDFSR who do not possess the requisite matriculate qualification to enable the office to grant them the Grade Pay of Rs.1800/- in the pay band of Rs.5200-20200. The training programme consisted of lectures/practicals on various skills which were supposed to be acquired by the participants to be able to perform higher level of assignments in the directorate. The training was attended by 8 supporting staff namely Sh. Gajendra Singh, Sh. Devendra Kumar, Sh. Vijay Shankar, Sh. Rakesh Kumar Sharma, Sh. Kripa Shankar Tiwari, Sh. Narendra Pal Singh, Sh. Subhash Chand Sharma and Sh. Sunil Kumar Sharma. On successful completion of the training, the Project Director, Dr. B. Gangwar distributed certificates to all the participants.

12.4 EVENTS ORGANIZED

Agricultural Education Day

The Agricultural Education Day was celebrated on 25 July 2012 in order to make awareness about scope of agriculture among the students of local schools and colleges, and to sensitize them about the prospects of agricultural education in India. In his introductory address Dr. B. Gangwar, Project Director stressed the need to spread the agricultural education among the masses, particularly the youth.

Dr. Arvind Kumar, DDG (Education), ICAR was the Chief Guest of the day. In his address, Dr. Arvind Kumar called upon the students to choose the field of agricultural education as it is the need of the hour to serve more than 60 per cent of our population who are dependent on agriculture. He also highlighted the need to conserve the natural resources through judicious use of inputs for ensuring sustainable agricultural production. The inaugural session was followed by Debate competition in which 11 students from 4 colleges/universities of Meerut participated.

There were two topics for debate and the participants were asked to speak in for or against the topic entitled "Agricultural education in India has failed to cater to the needs of the farmers" and "Farming system approach is the only solution for livelihood security to small farmers". The debate was followed by Quiz competition for school students. A team of 2 students of 9-12 standards were invited to participate in the quiz competition which covered questions on agriculture, environment and current affairs. There were 16 students from 8 schools of Meerut who participated in the quiz competition.

These competitions were followed by valedictory session in which prizes were distributed to the winners of different events. The Chief Guest distributed the prizes and certificates to the winners of debate and quiz competitions. A total of 12 prizes were given, 6 each in the debate and quiz competitions.

Independence Day Celebration

The directorate celebrated 66th Independence Day on 15 August 2012. Dr B. Gangwar, Project Director hosted the national flag. In his address to the staff of directorate, he narrated the achievements of past one year and called upon the staff to pursue the research and development in farming systems perspective which is considered to be the way forward for the future of Indian agriculture. The event

was attended by the children's, family members, and staff of the directorate and media persons.

The occasion was marked by afforestration programme in the campus of directorate. All the staff of directorate has actively participated in the planting of saplings in farm road side.

Parthenium awareness week

Parthenium awareness week was celebrated during 16-22 August 2012 by the Directorate through lectures and awareness to staff of directorate on 18 August 2012 in which problems caused by the weeds, its effect on future generations and health hazards were explained. Dr B. Gangwar, Project Director inaugurated the week by leading the staff to uproot the grass in the campus. All the staff of directorate was involved in removing the parthenium grass in the entire campus of the directorate with a view to minimize the menace in the campus.

Scientists of the directorate have also demonstrated the ill effects of parthenium in the nearby villages with the involvement of farmers, self help organizations etc. A Kisan gosthi was also arranged in which open discussion with farmers were held on the topic of "Losses and control of parthenium in crops". Kisan gosthi was followed by removal of parthenium grasses by farmers in their field. Control of parthenium by application of Glyphosate was also demonstrated to farmers.

Biological control of parthenium using *Trichogramma* (Tricho cards) insect pathogen has also been demonstrated and sufficient quantity of tricho cards were also distributed to farmers. The directorate is organizing the event continuously for the past three years which led to the awareness of people about the congress grass and its hazardous effect on crops, animals and human.

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

- Dr. B. Gangwar, Dr. K. Prasad, Dr. S. S. Pal, Dr. J. P. Singh, Dr. K. K. Singh, Dr. V. K. Singh, Dr. H. Singh, Dr. N. Ravisankar, Dr. A. K. Prusty, Sh. D. Tripathi and Sh. Rajesh Kumar participated in XXXth Biennial Workshop of AICRP on IFS at Goa during 15-20 November, 2012.

- Dr. B. Gangwar, Dr. S. S. Pal, Dr. K. K. Singh, Dr. M. P. Singh, Dr. Prem Singh, Dr. V. K. Singh, Dr. N. Ravisankar, Dr. R. S. Yadav, Dr. R. P. Mishra, M. Shamim and Dr. N. K. Jat participated in Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods", at IARI, New Delhi during 26-30 November, 2012.

- Dr. K. K. Singh, Dr. V. P. Chaudhary and Ms. M. Pramanik participated in 47th Annual Convention & Symposium of the Indian Society of Agricultural Engineers, held at DRR, Hyderabad, January 28-30, 2013.

- Dr. J. P. Singh participated in Agricultural Research – Development Conclave for U. P. at IISR, Lucknow during 23-24 November, 2012.

- Dr. J. P. Singh participated in National Seminar on Emerging Trends in Input Management for Higher Agricultural productivity, Etawah, U.P. during February 26-27, 2012.

- Dr. K. K. Singh participated in Management Development Programme on "PME of Agricultural Research" at NARRM, Hyderabad during 21-25 January 2013.

- Dr. Harbir Singh participated in Management Development Programme organized by NARRM, Hyderabad during 9-20 April 2012.

- Dr. Harbir Singh participated in 20th Annual Conference of Agricultural Economics Research Association at New Delhi during 9-11 October 2012.

- Dr. B. Gangwar, Dr. H. Singh and Dr. N. Subash participated in AgMIP South Asia Kickoff Workshop at Colombo, Sri Lanka during 12-16 November 20012.

- Sh. Sunil Kumar, Scientist attended Senior Certificate Course at IASRI, New Delhi during 18 June to 17 August 2012.

- Dr. N. Subash and Dr. M. Shamim participated in National Symposium on Climate Change and Agriculture: Slicing Down Uncertainties at CRIDA, during 22-23 January, 2013.

- Dr. M. Shamim, Scientist attended the Summer School on "Forecast modelling in crops" at IASRI, New Delhi during 17 July to 06 August, 2012.

- Dr Brij Mohan, Technical Officer, attended the training on Agricultural Research Prioritization and Impact Assessment at IARI, New Delhi during 17 August to 6 September 2012.

- Sh. Chetan Kumar G., Scientist attended attachment training at IISS, Bhopal for 3 months from 9 November 2012.

- Sh. Sanjeev Kumar, Scientist attended attachment training at CRIDA, Hyderabad from 14 November 2012 for 3 months.

- Dr N.K. Jat, Scientist attended the National training on "Project formulation, risk assessment, scientific report writing and presentation" at IARI, New Delhi during 11-15 December 2012.

- Ms. M. Pramanik, Scientist, attended three months attachment training at CSWCRTI, Dehradun.

12.6 HUMAN RESOURCE DEVELOPMENT

Dr N. Subhash, Senior Scientist and Dr Mohammad Shamim, Scientist attended the AgMIP South Asia Regional workshop organized by AGMIP during 20-24th February 2012 at ICRISAT, Patancheru, Hyderabad.

Dr N. Subhash, Senior Scientist and Dr Mohammad Shamim, Scientist attended the second training workshop and mid-term review meeting of SAARC-Australia Project on "Developing capacity in cropping systems modelling to promote food security and the sustainable use of water resources in South Asia" during 25 May- 1 June, 2012 at Kandy, Sri Lanka organized by University of Peradeniya-Sri Lanka, SAARC, CSIRO- Australia, IRRI-Philippines and Australian Centre for International Agricultural Research-Australian Government.

Dr. B. Gangwar, Project Director, Dr. N. Subash, Senior Scientist and Dr. Harbir Singh, Principal Scientist attended the AgMIP South Asia projects kick-off Workshop held at Cinnamon Lakeside Hotel, Colombo, Sri Lanka during 12-16th November, 2012.

12.7 AWARDS/HONOURS/RECOGNITIONS

Dr. A. K. Prusty, Secured **1st** Position in Hindi Debate competition organized during "Hindi Pakhwada" held at PDFSR, Modipuram on 26th September, 2012.

Er. Monalisa Parmanikh got first prize in the anatakshari game in Hindi pakhwada held at PDFSR, Modipuram on 26th September, 2012.

Sh. Rajesh Kumar was Runner-up (Men) in chess in inter- institutional staff sports tournament (North Zone)-2012 of Indian Council of Agricultural Research held at National Dairy Research Institute, Karnal (Haryana) during 25th to 28th April, 2012. Smt. Sheela Devi bagged bronze medal in Javelin throw event.

12.8 DISTINGUISHED VISITORS

Visiting DDG (NRM) field of residue condition for ready for sowing by happy turbo seeder

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

Participation in exhibitions

Dr J. P. Singh, PS and PF (IFS) along with Dr A. K. Prusty (Scientist) at Fish Festival organized by CIFE, Rohtak Centre

Kisan Gosthi at Kandiosaud, Tehri under THDC sponsored project

Kisan Gosthi at Koteshwar , Tehri under THDC sponsored project

12.10 हिन्दी पखवाड़े का आयोजन

निदेशालय में दैनिक कार्यों में हिन्दी के अधिकाधिक प्रयोग को प्रोत्साहित करने एवं कर्मियों के मध्य राजभाषा के उपयोग के प्रति अभिरूचि पैदा करने के उद्देश्य से दिनॉक 14–27 सितम्बर 2012 तक हिन्दी चेतना पखवाड़े का आयोजन किया गया। पखवाड़े के दौरान हिन्दी से संबंधित विभिन्न कार्यक्रम/प्रतियोगिताओं जैसे – अन्त्याक्षरी, निबन्ध, आशुभाषण, टिप्पणी/प्रारूप लेखन, इमला एवं प्रश्नोत्तरी प्रतियोगिता का आयोजना किया गया। इन सभी प्रतियोगिताओं में निदेशालय कर्मियों ने रूचि पूर्वक भाग लिया तथा प्रथम, द्वितीय एवं तृतीय स्थान प्राप्त करने वाले एकल/टोली प्रतिभागियों को पुरस्कार स्वरूप नकद धनराशि प्रदान की गयी। इस अवसर पर निदेशालय द्वारा प्रकाशित राजभाषा पत्रिका ''कृषि प्रणाली आलोक'' के प्रथम अंक का विमोचन भी परियोजना निदेशक डा0 बाबूजी गंगवार के करकमलों द्वारा किया गया। पखवाड़े के सफल आयोजन के उपरान्त, समापन के अवसर पर सभी ने कार्यालय में यथासंभव अधिकाधिक हिन्दी का उपयोग करने का संकल्प लिया।

Annexure - I

LIST OF CONTRIBUTORS

Name of the Project	PI/Co-PI/Contributor (s)
Cropping Systems and Resource Management (CSRM)	
Identification of bio-intensive complementary cropping systems for high productivity and efficient resource use	B. Gangwar, K. K. Singh, N. Subash and S. Kumar
Resource conservation and sustaining high productivity through cropping system management and land configuration	B. Gangwar, K. K. Singh and S. Kumar
Effect of different crop establishment methods and slow release fertilizer management on growth, yield and GHGs in rice- wheat system	V. P. Chaudhary
Study on water and nitrogen use efficiency of different varieties of rice under aerobic condition	R. P. Mishra
Long term effect of resource conservation technologies and crop residue management practices on crop productivity, water requirement and soil health in rice-wheat cropping system	K. K. Singh
Resource conservation modules for high yield realization of different cropping systems	V. P Chaudhary
Studies on crop establishment methods, mulching and weed management under rice-wheat cropping system	V. P. Chaudhary
Integrated nutrient management in transplanted rice-wheat system	V. K. Singh, R.P. Mishra, K.P Tripathi and R.S Yadav
Carbon Sequestration Potential of Rice-Wheat Cropping System under Different Soil Management Options	S. P. Mazumdar
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 and V. K. Singh
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
Development of sustainable production model for rice-wheat system	V. K. Singh and R. P. Mishra
Digitization of database of on-station and on-farm experiments of cropping systems under AICRP on IFS	G. C. Sharma and Vipin Kumar
Digitization of Database of Network Project on Organic Farming Experiments	V. Kumar and G. C. Sharma
Organic Agriculture Systems	
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
Carbon footprint of sugarcane, wheat and rice production in Western Plain Zone, India	R. S. Yadav, A. Kumar and N. K. Jat

Name of the Project	PI/Co-PI/Contributor (s)
Integrated Farming Systems	
Development of cost effective and sustainable IFS models for livelihood improvement of small farm holders of western Plain Zone of U.P.	J. P. Singh, B. Gangwar, S. Kochewad, P. Kashyap and A. K. Prusty.
Productivity and Economic Evaluation of Horticulture Based Farming Systems	P. Kashyap and K. Prasad
Resource Characterization and System Diagnosis	
Status of organic agriculture in eastern Himalayan region	S. Kumar, N. D. Shukla, B. K. Sharma, N. K. Jat and B. Gangwar
Characterization and evaluation of farming system in India	H. Singh, S. Kumar and B. Gangwar
Technology Transfer and Refinement (TTR)	
Proven systems based technologies under demonstration	M. P. Singh and B. Gangwar
Response of Rice and wheat varieties to different levels of FYM under organic conditions	P. Singh
Effect of Phosgold on yield and yield attributes of Wheat	P. Singh
Adoption behaviour of different farming system components by farmers of UGP & TGP Zones	A. Kumar, B. K Sharma and R. P. Mishra
On-farm Integrated Farming Systems Management	B. K. Sharma, A. Kumar, S. Kochewad, P. Kashyap, A. K. Prusty and J. P. Singh
Front-line demonstrations (FLD) on mustard	B. K. Sharma and A. Kumar
Externally Funded Projects	
Ensuring lively hood security through farming systems approach in Tehari District Uttara Khand.	M.P. Singh and B. Gangwar
Precision nutrient management using GIS-based spatial variability mapping under Upper and Middle Gangetic Plain Zones of India	V. K. Singh
Early Estimation of Sugarcane Acreage at State Level using remote sensing data Under Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL)	N. Ravisankar, N. Subash and B. Gangwar
Cropping System Analysis of India Using Remote Sensing, Geographical Information System and Ground based data	N. Subash
AICRP on Integrated Farming Systems	K. Prasad and N. Ravishankar
Network Project on Organic Farming	N. Ravishankar, R. S. Yadav and N. K. Jat

LIST OF PERSONNEL

(As on 31.03.2013)
Project Director: Dr. B. Gangwar

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

S.N.	Name and Designation	Discipline
27.	Ms. Monalisha Pramanik, Scientist	SWC Engineering
28.	Mr. Sanjeev Kumar, Scientist	Agronomy
29.	Mr. Chetan Kumar G, Scientist	Soil Science
B.TECHNICAL (Group wise)		
1	Sh. Chet Ram (T-9)	A
2	Sh. Jagpal Singh (T-7/8)	A
3	Sh. Yogendra Singh(T-7/8)	A
4	Sh. D. Tripathi (T-6)	A
5	Sh. S.K. Duhoon (T-6)	A
6	Sh R.B. Tewari (T-6)	A
7	Sh K.V.Anand (T-6)	A
8	Sh Vipin Kumar (T-6)	A
9	Sh. D. K.Pandey (T-5)	A
10	Sh. D.P. Singh (T-6)	A
11	Sh. Naval Singh (T-6)	A
12	Sh Vinod Kumar (T-6)	A
13	Sh. Brij Mohan (T-6)	A
14	Sh Krishan Pal (T-7/8)	A
15	Sh S.P. Singh (T-6)	A
16	Sh. P.P. Mishra (T-6)	A
17	Sh Om Kumar Tomar (T-6)	A
18	Sh. A.P. Dwivedi(T5)	B
19	Sh. Brijesh Sharma (T-5)	B
20	Sh. Krishan Pal (T-5)	B
21	Smt Anju Verma (T-2)	C
22	Sh. Uma Shankar	C
23	Sh. Ashok Kumar	C
24	Sh. Mahendra Prasad	C
25	Sh. Raj Kumar	C
C. ADMINISTRATIVE:		
1	Sh. Sushil Kumar Singh	SAO
2	Sh. H.S. Chauhan	AAO

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

*As per new cadre strength after re-struturing of administrative strength, two posts of P.A. are in excess.

NOTES