



वार्षिक रिपोर्ट Annual Report 2009-10

PRELIMINARY



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

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

वार्षिक रिपोर्ट

Annual Report

2009-10



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

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



Citation:

ANNUAL REPORT 2009-10
Project Directorate for Farming Systems Research
(Indian Council of Agricultural Research)
Modipuram, Meerut - 250 110, India

Compiled & Edited by: Dr. Devendra Singh, Principal Scientist
Mr. Chandra Bhanu, Scientist

Technical Assistance: Mr. Brijesh Sharma, Technical Officer

Published by:

Dr. B. Gangwar
Project Director
Project Directorate for Farming Systems Research
Modipuram, Meerut - 250 110 (U.P.), India
Ph. No.: 0121-288 8571, 295 6309
Fax No.: 0121-288 8546
E-mail: director@pdfsr.ernet.in, directorpdfsr@yahoo.com
Website: www.pdfsr.ernet.in

Printed at: Yugantar Prakashan Pvt. Ltd.
WH-23, Mayapuri Industrial Area Phase-I, New Delhi-64
Ph.: 011-28115949, 28116018, 9811349619, 9953134595
E-mail: yugpress01@gmail.com, yugpress@rediffmail.com

PREFACE

Project Directorate for Farming Systems Research was established as Project Directorate for Cropping Systems Research by Indian Council of Agricultural Research, New Delhi in April 1989 at Modipuram, Meerut (Uttar Pradesh). Earlier, the project was operating as All India Coordinated Agronomic Research Project (AICARP) since 1968-69 to coordinate agronomic research at national level. During mid-eighties it was realized that component approach of crop research is not sufficient to boost and sustain high yield levels attained during green revolution period. Consequently, AICARP was upgraded to the level of Project Directorate with a vision to strengthen all aspects of system based crop research at national level. Further, during the 11th five year plan PDCSR was re-named as '**Project Directorate for Farming Systems Research (PDFSR)**' with its revised mandate which became operative in second half of 2009-10. In addition to campus based research at Modipuram, the component of AICRP on CS remained operational during the year through its 37 on-station and 32 on-farm centres. However, to focus the research in farming system perspective, the AICRP on CS has also been renamed as AICRP on IFS with 31 main centres (on-station) and 11 CSR centres (sub-centres) and 32 on-farm centres spread throughout the country in five major ecosystems, i.e., arid, semi-arid, sub-humid, humid and coastal; to develop location specific farming system models and component technologies. Network Project on Organic Farming which remained operational since 2004-05 with its 13 Cooperating Centres spread over 12 states of the country. During the year under report, major emphasis was given to reorientation of on-going programme in to farming system mode. The major research programmes identified were cropping systems and resource management, organic agriculture system, integrated farming systems, resource characterization and systems diagnosis and technology transfer and refinement.

I take this opportunity to express my sincere gratitude to Dr. S. Ayyappan, Director General, ICAR and Secretary (DARE), Govt. of India, Dr. A. K. Singh, Deputy Director General (Natural Resource Management) and Dr. P. D. Sharma, In-charge, Assistant Director General (Agronomy), Indian Council of Agricultural Research for their keen interest in growth and development of this Directorate.

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

Modipuram
30 June, 2010



(B. Gangwar)
Project Director

TABLE OF CONTENTS

1. सारांश / Summary	1
2. Introduction	10
3. Mandate	12
4. Location	12
5. Soil and climate	12
6. Personnel	14
7. Organizational structure	15
8. Budget	16
9. Research Achievements	17
9.1 Cropping Systems and Resource Management	19
9.2 Organic Agriculture System	57
9.3 Integrated Farming Systems	62
9.4 Resource Characterization and Systems Diagnosis	70
9.5 Technology Transfer and Refinement	78
9.6 Externally Funded Projects	82
10. Linkages and Collaboration in India and Abroad Including Externally Funded Projects	90
11. Centres of AICRP on Cropping Systems and Network Project on Organic Farming	90
12. General/Miscellaneous	92
12.1 List of Publications	92
12.2 Meetings of RAC/IRC/IMC	97
12.3 Participation of Scientists in Conferences, Workshops, Seminar, Symposia etc.	100
12.4 Human Resource Development	101
12.5 Scientific Meetings, Workshops, Conferences, Winter/Summer School Organized	102
12.6 Awards/Honours/Recognitions	103
12.7 Distinguished Visitors	105
12.8 Kisan Goshtis/Farmers Trainings/Field Visits/Exhibitions organised by PDFSR	106
12.9 हिन्दी पखवाड़े का आयोजन	108
Annexure I (List of Contributors)	110
Annexure II (List of Personnel)	112

1. सारांश / SUMMARY

भारतीय कृषि अनुसंधान परिषद् द्वारा कृषि प्रणाली अनुसंधान परियोजना निदेशालय (पूर्व नाम फसल प्रणाली अनुसंधान परियोजना निदेशालय) की स्थापना सन् १९८६ में मोदीपुरम्, मेरठ में की गयी थी। ग्यारहवीं पंचवर्षीय योजना के दौरान फसल प्रणाली अनुसंधान परियोजना निदेशालय का नाम बदल कर वर्ष २००६-२०१० से निम्न संशोधित लक्ष्यों की प्राप्ति हेतु **कृषि प्रणाली अनुसंधान परियोजना निदेशालय** कर दिया गया :

- विभिन्न कृषि प्रणालियों की उत्पादकता, जीवन-क्षमता एवं समस्यायें जानने हेतु, उनका अभिलक्षण करना।
- विविध कृषि परिस्थितियों के लिए संसाधन कुशल, आर्थिक रूप से जीवंत एवं टिकाऊँ 'समेकित कृषि प्रणालियों' के प्रमाप एवं प्रतिरूप विकसित करना।
- कृषि प्रणालियों के संदर्भ में, संसाधनों की उपयोग दक्षता में सुधार हेतु, उत्पादन तकनीकों पर आधारभूत एवं रणनीतिक शोध करना।
- सस्य एवं कृषि उत्पादन की नवोदित संकल्पनाओं हेतु, उत्पादन प्रक्रियाओं के पैकेज का विकास एवं मानकीकरण तथा उनके दीर्घवधि-टिकाऊँपन का मूल्यांकन करना।
- उपयुक्त डाटाबेस के सृजन द्वारा, कृषि प्रणाली के सभी पहलुओं पर सूचना-कोष के रूप में कार्य करना।
- कृषक प्रक्षेत्र पर, कृषि आय एवं उत्पाद-गुणवत्ता में वृद्धि हेतु, सस्य-प्रसंस्करण एवं मूल्य-संवर्धन तकनीकों का विकास करना।
- प्रणाली आधारित कृषि उत्पादन तकनीकों का कृषक प्रक्षेत्र पर परीक्षण, सत्यापन एवं परिष्करण।

- प्रशिक्षण के माध्यम से, समेकित कृषि प्रणालियों के लाभार्थियों की कार्यकुशलता को बढ़ाना।

वर्ष २००६-२०१० की विभिन्न योजनाओं के अंतर्गत प्रमुख शोध उपलब्धियों का सारांश निम्नवत है :

फसल प्रणाली एवं संसाधन प्रबंध

वर्ष २००६-१० में ६ जैव सघन सहपूरक फसल प्रणालियों के मूल्यांकन के पश्चात यह ज्ञात हुआ कि, गर्मी में ज्वार + लोबिया (चारा) - अगस्त में मक्का (भुट्टा) + उड़द - मेथी एवं पश्चात में प्याज + धनिया फसल क्रमों से अधिकतम् धान समतुल्य उपज (२८.८५ टन/हे.), उत्पादकता (७६.०८ किग्रा./हे०/दिन) एवं लाभ (रु०१८६.३०/दिन/हे०) प्राप्त हुआ।

संसाधन कुशल पूरक जैव सघन फसल प्रणालियों के मूल्यांकन के पश्चात पाया गया कि मूंग + सोयाबीन + अरहर फसल क्रम से पारम्परिक धान की तुलना में अधिकतम् धान समतुल्य उपज (७७ कु०/हे०) एवं शुद्ध लाभ (रु०१,१०,४००/हे०) प्राप्त हुआ।

शरदकालीन गन्ने में अन्तः फसलों के प्रभाव के अध्ययन में पाया गया कि, गहरी नालियों में गन्ने की दो पंक्तियों में बुवाई व रबी में उनके उच्चिकृत क्यारियों पर अन्तः फसलों की बुवाई करने पर प्रणाली की सकल उत्पादकता व लाभ में वृद्धि एवं गन्ने की गुणवत्ता में सुधार पाया गया। पालक व लहसुन सर्वोत्तम अन्तः फसल सिद्ध हुए।

धान आधारित फसल प्रणालियों में दलहन व चारे की फसलों के समावेश के अध्ययन के दौरान पाया गया कि, धान - सब्जी मटर - मूंग (परम्परागत कर्षण) से अधिकतम् धान समतुल्य उपज पायी गई।

धान रोपाई मशीन के लिए मैट नर्सरी तैयार करने की तकनीक के अध्ययन में पाया गया कि ५ मी० x १.२ मी० के आकार की क्यारी जिसमें ३० किलो प्रति हे. की बीज दर के साथ १६-२० दिन व १०५-१२० मिमी० लम्बाई की पौध उत्तम पाई गई।

कम्बाइन से कटाई के पश्चात धान व गेहूँ के भूषे के पुनर्चक्रण की लागत पर किये गये अध्ययन में पाया गया कि, धान व गेहूँ के भूषे/पुवाल को यथास्थान खेत में मिलाने से एक दूसरे की उपज व शुद्ध लाभ पर अनुकूल प्रभाव पाया गया।

औद्योगिक तरल उत्प्लावक को सामान्य सिंचाई युक्त जल में विभिन्न अनुपातों में मिलाकर धान व गेहूँ की फसलों में प्रयोग करने पर पाया गया कि तरल उत्प्लावक की मात्रा ५० प्रतिशत तक तो उपज पर अनुकूल प्रभाव डालती है, परन्तु ५० प्रतिशत से अधिक प्रयोग करने पर फसलों की उपज पर विपरीत प्रभाव पड़ता है।

ऊसर-भूमि सुधार पर किये गये प्रयोगों में पाया गया कि, सरसों का अवशेष का प्रयोग ऊसर भूमि में अन्य सुधारकों के साथ करने पर द्वितीय वर्ष में धान की उपज पर अनुकूल प्रभाव पाया गया।

धान-पुवाल प्रबंधन की विभिन्न विधियों पर किये गये एक अध्ययन में पाया गया कि, धान की सीधी बुवाई के पश्चात रबी में २५ प्रतिशत अतिरिक्त नत्रजन के साथ अवशेष के सम्मिश्रण द्वारा गेहूँ की उपज में वृद्धि के साथ-साथ सिंचाई जल की उत्पादकता में भी वृद्धि पायी गयी।

धान रोपण की विभिन्न विधियों के तुलनात्मक अध्ययन में यह पाया गया कि, स्वचालित धान रोपाई मशीन से परम्परागत विधि द्वारा रोपित धान की तुलना में ७.३ प्रतिशत अधिक उपज पाई गई।

धान उत्पादन की विभिन्न विधियों द्वारा मृदा जैविक कार्बन की मात्रा में सुधार पर किये गये अध्ययन में पाया गया कि, एस. आर. आई. विधि के अन्तर्गत उगाये गये धान से अधिकतम उपज (५.२१ टन/हे०) प्राप्त हुई।

विभिन्न फसल प्रणालियों में संसाधन संरक्षण माड्यूल के अध्ययन से पाया गया कि, मशीन द्वारा रोपित संकर-धान से शून्य-कर्षण द्वारा बोये गये धान की तुलना में २५ प्रतिशत अधिक उपज प्राप्त हुई।

टिकाऊ धान-गेहूँ पद्धति हेतु मॉडल विकसित करने के क्रम में किये गये अध्ययन के अन्तर्गत पाया गया कि मृदा-परीक्षण आधारित उर्वरक उपयोग द्वारा धान की अधिकतम उपज (६.२१ टन/हे०) पायी गई।

परिवर्तनशील जलवायवीय दशाओं में धान व गेहूँ के २० विभिन्न प्रजातियों के शारीरिकी मूल्यांकन के अन्तर्गत यह पाया गया कि, धान की अधिकतर प्रजातियों में 'लीफ एरिया इण्डेक्स' में ६वें सप्ताह तक रेखीय वृद्धि दर्ज की गयी, जबकि 'आनन्द' व 'पी. आर. १११' में अधिकतम वृद्धि केवल ६वें सप्ताह तक पायी गयी। "कुल उष्मा आवश्यकता", शीघ्र पकने वाली प्रजातियों में विलम्ब से पकने वाली प्रजातियों की तुलना में कम पायी गयी। गेहूँ की विभिन्न प्रजातियों की लम्बाई, फसल शारीरिकी, पुष्पन, परिपक्वन व अकारिकी-शारीरिकी गुणों में अंतर पाया गया जो कि अन्ततः उपज कारकों व उपज के लिए उत्तरदायी होते हैं।

कृषक प्रक्षेत्र पर किये गये प्रदर्शनों से ज्ञात हुआ कि शून्य कर्षण द्वारा बोये गये गेहूँ की उपज परम्परागत कर्षण जैसी ही थी, परन्तु शून्य कर्षण में उत्पादन खर्च कम होने से लाभ अधिक पाया गया।

कृषक प्रक्षेत्र पर मैट नर्सरी व मशीन से रोपाई पर किये गये प्रदर्शनों के फलस्वरूप, संसाधनों जैसे : श्रमिक व उर्जा खर्च में क्रमशः ८० व ६० प्रतिशत की बचत

पायी गयी तथा लाभांश में रु०२५००/- हे० की वृद्धि पायी गई।

जैविक कृषि पद्धति

मक्का-आलू-प्याज फसल क्रम हेतु जैविक कृषि पैकेज के विकास हेतु किये गये प्रयोग में जैविक श्रोतों द्वारा प्रदान किये गये पोषक तत्वों से मक्का एवं आलू की सर्वाधिक उपज प्राप्त हुई, जबकि, उत्पाद गुणवत्ता भी रासायनिक उर्वरकों की अपेक्षा उन्नत पायी गई।

जैविक, रासायनिक व समेकित पोषक तत्व प्रबन्धन में चार फसल चक्रों पर किये गये अध्ययन में मक्का-आलू-भिण्डी फसल चक्र से अधिकतम् उपज (८६५६ किग्रा०/हे०) प्राप्त हुई।

जैविक कृषि के अन्तर्गत धान की १६ व गेहूँ की ३० प्रजातियों के मूल्यांकन के दौरान धान की पी० डी०-१० (४७५२ किग्रा/हे०) व गेहूँ की HI १५४४ (४६५० किग्रा/हे०) प्रजातियों में अधिकतम् उपज प्राप्त हुई।

समेकित कृषि प्रणाली

पश्चिमी उत्तर प्रदेश के सिंचित क्षेत्रों के छोटे व सीमांत कृषकों हेतु प्रक्षेत्र उत्पादकता व लाभ में वृद्धि एवं जीवनयापन सुनिश्चित करने हेतु विकासशील मॉडल पर अध्ययन के दौरान पाया गया कि, फसलों के साथ-साथ अन्य उद्यमों जैसे डेरी, उद्यानिकी, मछली पालन व मधुमक्खी पालन को शामिल करने से प्रक्षेत्र की उत्पादकता व लाभ में आशातीत वृद्धि दर्ज की गयी।

संसाधन अभिलक्षणन व प्रणाली निदान

संसाधन संरक्षण तकनीकों जैसे फसल विविधीकरण, एस. एस. एन. एम., शून्य कर्षण एवं लेजर लेवलिंग इत्यादि के आर्थिक प्रभावों के अध्ययन हेतु किए गये सर्वेक्षण में पाया गया कि, कमोवेश अधिकतम् किसानों ने शून्य कर्षण तकनीक को अपनाया है क्योंकि इससे खेत

तैयार करने की लागत मात्र रु०५००/हे० औसतन पायी गयी। इनके अलावा श्रमिक व सिंचाई जल के खर्च में भी बचत देखी गयी।

उत्तर प्रदेश के बुन्देलखण्ड सम्भाग के जनपदों में भूमि जल स्तर की स्थिति एवं उसके फसल उत्पादन व खर्च पर प्रभावों पर किये गये सर्वेक्षण में वर्ष २००६-१० में यहाँ का भूमि जल स्तर ८२.८० फीट पाया गया जो कि पिछले पाँच व दस वर्षों में क्रमशः ६८.१० और ५३.७० फीट था। जिले के अलग-अलग विकास खण्डों के भूमि जल स्तर में भी व्यापक अन्तर पाया गया। डीजल की खपत वर्ष २००६-१० में २.०२ लीटर/घंटा, की तुलना में पिछले पाँच व दश वर्षों के दौरान क्रमशः २.३६ ली०/घंटा व १.५४ ली०/घंटा थी।

तकनीकी हस्तान्तरण एवं परिष्करण

तकनीकी पार्क पर विभिन्न सिद्ध फसल पद्यतियों व प्रबन्धन तकनीकों के मूल्यांकन के दौरान धान-गेहूँ पद्यति में एस. एस. एन. एम. तकनीक से पोषण प्रबन्धन से अधिकतम् धान तुल्य उपज (११.३ टन/हे०) प्राप्त हुई।

कृषक प्रक्षेत्रों पर विभिन्न उन्नत कृषि तकनीकों के प्रदर्शन के दौरान हरी खाद के साथ पोटाश के प्रयोग से परीक्षणाधीन धान की प्रजातियों की उपज में कृषक विधि की तुलना में १२-१६ प्रतिशत की वृद्धि पायी गयी। गन्ने की विभिन्न प्रजातियों में पोटाश के प्रयोग से ७.६-६.३ प्रतिशत तक की वृद्धि पायी गयी।

तिलहन आधारित फसल पद्यतियों में उन्नत कृषि तकनीकों के समावेश के परिणामस्वरूप, कृषक विधि की तुलना में १५-१६ प्रतिशत तक की वृद्धि दर्ज की गयी।

वास्थ्य वित्तपोषित परियोजनायें

धान व गेहूँ आधारित फसल पद्यतियों में उन्नत उर्वरक प्रबन्धन के अन्तर्गत, एस. एस. एन. एम. द्वारा

धान, मक्का, अरहर, तिल, मूँगफली व ज्वार में क्रमशः ३५.४ प्रतिशत, ३७.६ प्रतिशत, ५४.४ प्रतिशत, ३९.० प्रतिशत, २८.६ प्रतिशत व ५९.० प्रतिशत की वृद्धि दर्ज की गयी।

धान-मक्का फसल पद्धति में विभिन्न कर्षण क्रियाओं व अवशेष प्रबन्धन पर किये गये अध्ययन में रोपित धान के अन्तर्गत अवशेष को खेत में मिलाने से सीधी व शून्य कर्षण द्वारा बोये गये धान की तुलना में अधिकतम उपज वृद्धि दर्ज की गयी। मक्का में शून्य कर्षण के अन्तर्गत, अवशेषों का खेत में सम्मिश्रण, परम्परागत कर्षण की तुलना में अधिक प्रभावी पाया गया।

Project Directorate for Farming Systems Research (PDFSR), (Formerly Project Directorate for Cropping Systems Research) was established in March, 1989 with its headquarters at Modipuram, Meerut, U.P. Further, during 11th five year plan PDCSR has been re-named as **Project Directorate for Farming Systems Research (PDFSR)** with its revised mandate which are as follows:

- 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.

The summary of major research findings during 2009-10 under various programmes are given as below:

CROPPING SYSTEMS AND RESOURCE MANAGEMENT

Nine bio-intensive complementary cropping systems along with land configurations were evaluated during 2009-10 for efficient resource use, high productivity and profitability. Sorghum + cowpea (for fodder) during early summer - maize (cobs) + black gram as late (August) sown-*methi* and onion + coriander in summer produced significantly higher rice equivalent yield (28.85 t ha⁻¹), productivity (79.05 kg/ha/day) and profitability (Rs.186.30/day/ha). 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*, and 3 rows of green gram on beds in summer was found the second best in the order of merit.

Twelve different resource efficient complimentary bio-intensive cropping systems were evaluated for enhancing system productivity. Green gram + soybean + pigeon pea gave maximum rice equivalent yield and net return (77 q/ha and Rs.1, 10,400/ha) followed by maize + pigeon pea (72 q/ha and Rs.1, 00,600/ha) as compared to traditional rice crop (34 q/ha and Rs.30, 700/ha), respectively.

A field experiment was conducted for three crop cycles (2006 to 2010) to study the effect of intercropping in autumn planted sugarcane. Twenty-two treatments comprising two methods of sugarcane

planting (37.5 cm bed and one sugarcane row in furrow of 30 cm and 50 cm bed and two rows of sugarcane in trench having 60 cm width) and eleven crops were evaluated. Planting of two rows of sugarcane in trench and raising of *rabi* crops on broad beds helped to enhanced the productivity and profitability of the autumn sugarcane based intercropping systems and even a number of quality parameters of sugarcane were improved. Spinach and garlic followed by radish- onion and pea -moong were found as best intercrops to be considered for simultaneous cropping with autumn planted cane.

The inclusion of legume and fodder crops in rice based cropping systems and its effect on soil and cropping system productivity and profitability under different tillage options was studied. Conventional tillage adopted in previous *rabi* and summer season crops produced 5.25 t ha⁻¹ rice that was, respectively, 6 and 19% more than bed planting and zero tillage. Rice-vegetable pea-green gram (CT) cropping system produced maximum rice equivalent yield (5.38 t ha⁻¹). The wheat yield under bed planting (ZT) was higher (5.82 t ha⁻¹) than conventional tillage (CT) and bed planting (BP). Rice-Wheat-Green gram (ZT) cropping system produced maximum wheat (5.88 t ha⁻¹) yield.

Studies were made to see the effect of different tillage and planting management techniques in different cropping system to improve crop productivity and soil health at various locations in the Country. The results of different treatments varied with place to place and system to system.

During a study on mat type nursery raising technique for transplanter, under on-station as well as on-farm situations, it was found that the best combination for nursery raising was a size of 5.0 m x 1.2 m nursery bed, sown at 30 kg ha⁻¹ seed (Var. Saket 4) rate and transplanting 16 to 20 days old seedlings with height of 105–120 mm, root length (40-50 mm), trunk diameter (3.3-4.4 mm), thickness of seedling at the base of root (3.8-4.6 mm), leaf stage (3-5) and about 20 thousand seedlings m⁻².

The optimum puddling requirement for rice transplanter was one operation of puddler with corresponding puddling index of 39.7 per cent, depth of puddle profile of 57.4 mm, bulk density of 1.55 t m⁻³, water content of 47.4 per cent and penetration resistance of 1475 k Pa.

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 *in situ* recycling of wheat straw produced 13 and 8 per cent higher rice yield than straw retrieval and burning treatments, respectively. The net returns under straw recycling were 17 and 11 per cent higher; B: C ratio and energy output: input ratio were 5 and 3% higher, and 3 and 6 per cent lower; and specific cost and specific energy 4 and 3 per cent lower, and 3 and 7 per cent higher, respectively. The recycling of rice straw increased the wheat yield (8%) and net returns (8%) but decreased B: C ratio (0.6%), energy output: input ratio (10%); and increased specific energy (12%) and specific cost (0.9%) compared to straw retrieval treatment.

A field experiment using industrial effluents for irrigation (normal water, 25, 50, 75 and 100% industrial effluents) highlighted the increase in grain yield of rice and wheat with the application of industrial effluent up to 50 percent, but it declined with subsequent increase in effluent concentration. Sugarcane yield, in contrast to rice and wheat improved with the intensity of effluents. The cane quality parameters analyzed during the harvest were also improved with the use of industrial effluent as well as its intensity.

The result of the field experiment on the reclamation of saline-sodic soils for crop production and soil health revealed that rice- barley system gave highest rice equivalent yield, but in the second year the residual effect of mustard residue was highest on the productivity of rice for all the amendments. During decomposition of mustard residues in the field there

is marginal change in soil pH, which could be related with the better performance of rice under such system. Combination of gypsum with FYM and/or press mud together with green manure, in general, proved effective for increasing REY for all cropping systems. Application of 25% excess N over recommended NPK gave significantly higher REY than the recommended NPK.

A field experiment was conducted at PDFSR, Modipuram during 2007 -2009 with objectives to assess the effect of different methods of rice residue management on crop productivity; water and nutrient use efficiency, weed dynamics and soil organic carbon fractions in rice –wheat cropping system. The system involving direct seeded rice followed by residue incorporation along with application of 25% extra dose of nitrogen in conventional sown wheat crop was found to be better with highest rice equivalent yield of about 12.48 t/ha/year, productivity of 34.20 kg/ha/day and irrigation water use productivity of 61.01 kg grain/ha cm of water.

The comparative performance of different methods of rice planting with respect to rice yield, benefit: cost ratio, energy output: input ratio, water use, infiltration rate and weed infestation was evaluated. The rice yield was highest in self-propelled transplanter (by 7.3%) as compared to traditional hand transplanting (5.72 t ha⁻¹). The net return was 33% higher in zero till drilling followed by self-propelled transplanter (27 % higher).

An experiment on the ‘studies on improvement of soil organic carbon in rice-wheat system under resource conservation technologies’ was started in *kharif* 2008 season in which the main plot treatments were direct seeded rice (DSR), SRI method of rice cultivation (SRI) and conventional rice cultivation. The highest grain yield of rice (5.21 tons/ha) was recorded under SRI method of cultivation as compared to direct seeded with conventional method of its cultivation. The yield attributing characters of rice were also best under this treatment.

A field experiment was conducted during 2009-10 with the objective to study the resource conservation modules for high yield of different cropping systems and to find out the high value cropping system based on productivity, resource conservation and climate change. Mechanical transplanted hybrid rice produced the highest mean yield of 6.44 t/ha which was 25% higher than zero till direct seeded rice (5.13 t/ha). The grain and rice equivalent yields were affected significantly due to different resource conservation practices.

A long-term study initiated in *kharif* 1993 to study the effect of integrated nutrient management in transplanted rice-wheat system and was continued consecutively for the 17th year during 2009-10. Fertilizer NPK applied at recommended rate, resulted in significant increase in rice yield over unfertilized control that recorded lowest yields amongst the treatments (1.72 t ha⁻¹).

A field experiment was initiated in *kharif* 1998 in order to develop a synthesized model of sustainable rice-wheat system was continued for twelfth consecutive year (2009-10). The grain yield of rice ranged between 1.78 and 6.21 t ha⁻¹, being lowest in control and the highest with soil-test based fertilizer use.

Twenty genotypes of rice and wheat were evaluated in 2009 to know their phenological growth in relation to climatic conditions and to monitor different morpho-physiological parameters in relation to productivity. Phenological variations were observed in panicle emergence (PE), 50 % PE and maturity in different rice genotypes. Linear increase in LAI was observed in all the genotypes up to 9th week after transplanting (ATP) except in Ananda and PR 111 where maximum LAI reached at 6th week ATP, and Naveen, where it was linearly increased up to 12th week ATP. In all the genotypes, LAI started declining from 9th week ATP. Tillers number m⁻² was linearly increased up to 40 days after transplanting (DAT), thereafter it started declining in all the genotypes. Photosynthesis (μ mole

CO₂ m⁻² s⁻¹), in general, was higher in early basmati (22.9-23.6) and non basmati type (19.1-22.7) than the longer duration in both the groups, except in PS 4 and IR 74. Total heat unit requirement i.e. growing degree days (GDD) was relatively low in the early type genotypes (1700-2000 °C) than the late maturing genotypes (2030-2500 °C). Heat use efficiency (HUE, Kg/GDD) in basmati genotypes was more in early (2.33-2.75) than the late maturing (0.87-2.08). Genotypic variations in wheat were observed in stature (88-98 cm), crop phenology i.e. spike initiation (83-100 days after sowing, DAS), 50 % flowering (92-108 DAS) and physiological maturity (129-140 DAS), and different morpho-physiological parameters (biomass, leaf area, photosynthesis and water use efficiency) which resulted in accountable variation in grain yield and yield components

On-farm demonstrations in farmer's participatory mode were conducted to accelerate the second-generation machineries for managing the crop residue through RCTs in western UP. Results indicate that though across sites and farmers, the wheat yield under no-till is likely similar only (1.09) to conventional till, but the profitability was higher under no-till and reduced till due to reduced cost of production about Rs.3000 per hectare. In case of bed planting of wheat, the advantage is saving in irrigation water about more than 20 percent. The wheat yield was increased by about 14 % when rice residue was retained @ 5.0 to 6.0 t ha⁻¹ and sowing of wheat was done with using the Happy and Turbo seeder.

Seven farmers' participatory mode trials on mat type nursery raising and transplanting by self propelled rice transplanter resulted in the saving of resources as labour (80%), energy (60%) and monetary gain of about Rs.2500/ha.

ORGANIC AGRICULTURE SYSTEMS

After 7th cycle of the experiment on Development of organic farming package for maize-

potato-onion, highest grain yield of maize (6.75 t/ha) was recorded during *kharif* 2009 when the organic sources of nutrients were added and maize was intercropped with cowpea. This also gave an additional yield of vegetable cowpea (0.25 t/ha). However, highest potato yield was recorded under total organic nutrient supply during *rabi* season. The yield and yield attributing characters of maize and potato also showed superiority of various organic nutrient management packages over chemical fertilizers.

During studies on comparative efficiency of organic, inorganic and integrated nutrient management practices on yield potential and returns under 4 cropping systems, maize- potato-okra produced maximum rice equivalent yield (8659kg/ha). However, maximum net return was obtained with basmati rice-wheat system (Rs.51961/ha).

Two cropping systems *i.e.* basmati rice-chickpea and basmati rice-mustard were evaluated under two organic management practices, summer ploughing and green manuring. The rice-chick pea system proved more productive (34.4 per cent higher rice equivalent yield) and also gave higher returns as compared to rice-mustard system. Summer ploughing proved better from yield as well as returns point of view as compared to green manuring in rice-chick pea system.

An observational trial was conducted to find out the maximum production and profit from the cropping systems involving spices and high value crops. Maximum rice equivalent yield was obtained from maize (cob)-potato-onion system (7284kg/ha) followed by turmeric- green manuring (6900 kg/ha). However, highest returns to the tune of Rs.94000/ha were obtained from turmeric- green manuring followed by maize (cob)-potato-onion (Rs.65074/ha).

Sixteen varieties of rice and thirty varieties of wheat were evaluated for their yield potential under organic conditions. Among the rice varieties, PD 10



recorded highest yield of 4752 kg/ha, and among wheat HI 1544 (4650kg/ha) attained the highest yields as compared to others.

INTEGRATED FARMING SYSTEMS

A study was conducted to develop an IFS model for maximizing the productivity, profitability and ascertaining the livelihood security of marginal and small farmers under irrigated ecosystem of Western Uttar Pradesh. The model was developed on 1.5 hectare area comprising of crops (0.72 ha), dairy (0.32 ha), horticulture (0.22 ha), fishery (0.10 ha) and miscellaneous (0.14 ha). The relative contribution from the dairy, horticulture, fishery and apiary towards net return was 52, 14, 3 and 6 per cent where crops were taken as 100 per cent. It was observed that among contributions of different enterprises the crop component showed a margin of Rs.39498/ha/annum and their contribution rated about 35 per cent. During fifth year (2008-09) a net saving of Rs.12101 was achieved after fulfilling all the family requirements of 7 family members. The IFS approach was also able to fulfill about 36% of the total nutritional (NPK) requirement from the system itself.

RESOURCES CHARACTERIZATION AND SYSTEM DIAGNOSIS

The survey was conducted to assess the economic impact of the resource conservation technologies viz. crop diversification, crop intensification, SSNM, zero tillage, laser leveling, bed planting, leaves colour chart in Indo-Gangetic plains.

The majority of the sample households invariably adopted zero tillage in various degrees and shades, in sole or in combination with other resource conservation technologies like residue management, green manuring, and laser leveling. The percentage area under zero tillage decreases as farm size increases. However, the average farm size in adopters was marked 9.89 hectare compared to 18.59 in case

of non-adopters. The wheat yield was observed to be higher by about 1.30q/ha in case of adopters over non-adopters of zero-tillage. The cost of land preparation was lower for adopters (Rs.500/ha) of zero tillage as compared to non adopters (Rs.3000/ha). Reduced cost of cultivation, suitability for problem soils and shallow water table areas, savings in fuel (diesel) bill and irrigation water, facilitating timely sowing, overcoming labour shortage, facilitation of line sowing and better germination, less weed intensity, minimized machinery wear, tear and the maintenance and repairing costs were found as main reasons for adoption of zero tillage. However, non suitability to light soils, lack of timely availability of zero till machine and skilled labour, and improper calibration leading to less seed rate and poor yield were raised as main reasons for discontinuing the zero tillage.

To develop yield prediction model by including climatic parameters, digitized time series data of different years' climatic factors was analyzed with yield. Under rice-rice cropping sequence, significant effect of year, relative humidity and wind speed was observed at Bhubaneswar in most of the treatments. Under rice-wheat cropping sequence, at Pusa, rice crop had significant effect of rainfall, whereas, wheat crop had effect of year only. Under maize-wheat cropping sequence, maize crop had positive significant effect of temperature only. The models fitted were adequate as these could explain more than 75% variation in respect of all the treatments.

Survey was conducted in Bundelkhand (U.P.) region to study the ground water profile over time and space and to work out the comparative economics of crop production influenced by groundwater depth and motive for its lifting. The average ground water table in the Jalaun was 82.80 feet during the survey period (2009-10) while it was 89.10 and 53.70 feet before past five and ten years taking into account the base year 2009-10. Data further showed wide disparity in water table depth within the district. The average consumption of diesel

during study period was 2.02 liter/hour as against 2.39 and 1.54 liter during past five and ten years. The total cost incurred for irrigation for wheat cultivation was Rs.782, Rs.2366 and 1857/ha during these years in case of Jalaun District.

TECHNOLOGY TRANSFER AND REFINEMENT

Various proven cropping systems were demonstrated and tested with superimposition of proven crop management technologies in the Technology Park of PDFSR. The maximum wheat equivalent yield was recorded in rice – wheat cropping system with SSNM (11.3 t/ha).

Out of total of 69 on-farm trials/ field demonstrations at farmers' field on green manuring + potash in various crops, band placement of FYM + potash in different varieties of sugarcane, effect of potash on the yield of different varieties of sugarcane and cultivation of napier grass, the improved practice (green manure + potash) resulted in increase in yield by 16 % in 'Sugandha-5', 14.7 % in 'Saket-4', 13.8 % in 'PB-1' and 12 % in 'Basmati-370' varieties of rice over the farmers' practice. The improved practice (band placement of FYM + potash) resulted in the increased yield by 13.5 % in 'COS-767', 11.4 % in 'COS-8436', and 9.9 % in 'COS-8432' varieties of sugarcane as compared to farmers' practice. The improved practice (potash application), resulted in increased yield by 9.3 % in 'COS-8436', 8.9 % in 'COS-767', and 7.9 % in 'COS-8432' varieties of sugarcane as compared to farmers' practice.

During OFD on oil seed-based cropping system, there was increase in oilseed production with improved practice (IP) as compared to farmer's practice (FP) to the extent of 15 % in castor + green gram and 19% in ground nut-mustard at Bachau and 17% at Junagarh in sesame-wheat cropping systems. Similarly, improved practice showed superiority to the farmers' practice in pulse-based cropping systems at Srinagar (Uttarakhand).

EXTERNALLY FUNDED PROJECTS

In order to increase system's productivity and farmer profits through fertilizer best management practices, a field experiment was conducted during 2008-09 to evaluate the performance of five nutrient management options in rice and wheat based cropping systems. The productivity gain under SSNM treatment over FFP was of 35.4% 37.9%, 54.4% 31.0% 28.6% and 51.0%, respectively for rice, maize, pigeon pea, sesame groundnut and sorghum dry fodder in case of wheat based cropping systems. In rice based cropping systems, the highest rice equivalent yield (REY), was recorded in rice-garlic (40.34 t/ha) system. However, SSNM was found as best nutrient management option.

Field experiments on the effect of different tillage crop establishment practices and residues management options on productivity of rice-maize system revealed that residue recycling under transplanted rice crop had highest yield gain as compared to direct seeded or zero till rice crop and the responses to K+ S and Zn application was also modified in the presence of residues in case of rice crop. Winter maize productivity varies from 7.64 to 9.0 t/ha under different crop establishment practices. The effect of residue recycling/retention was more pronounced under zero till-maize, followed by conventional till.

In a study to know the cost and returns of factors of production from crop and live stock farming on different categories of farmers in Uttar Pradesh, it was found that, the large farmers of mid plain had higher disposable income because of considerably higher income from crop production. The source wise income revealed that highest proportion of the income was provided by crop production in mid plain and from live stock in southwest semi arid plain. The farmers in general and marginal and small farmers in particular were able to get positive returns due to engagement of family labour, otherwise if return to management or net return were considered, they realized negative return particularly in crop production.

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 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 renamed as ‘**Project Directorate for Farming Systems Research (PDFSR)**’ with revised mandate as given in the next section. Practically this has come into effect during second half of 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.

- 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 2009-10, PDFSR was operating through following three plan schemes:

1. PDFSR -- Strengthening and continuation of PDFSR headquarters at Modipuram.

2. AICRP on Integrated Farming Systems (IFS):

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

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

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

3. MANDATE

The revised mandate of the PDFSR is given as below:

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

4. LOCATION

The PDFSR and its research farms are located in the Modipuram suburb of Meerut City, situated on Delhi-Haridwar National Highway no. 58, adjacent to 220 KV sub-station of Pashchimanchal Vidyut Vitaran Nigam Ltd. The distance from

Meerut city (Begum Bridge) is about 10 km. Modipuram is situated at an elevation of 237 meters above mean sea level, 29° 4' N latitude and 77° 46' E longitude.

5. SOIL 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 monsoons during July to September.

The important weather parameters during 2009-10 are depicted in Figs 5/1-4. The year 2009-10 received near about 1/4 of normal rainfall i.e. 250 mm. However, the onset of monsoon occurred in the 26th standard meteorological weeks (SMW) which are the normal week of onset at this center. The distribution of rainfall during the *kharif* season was fairly good where as only one week i.e. 35th

SMW received rainfall more than 50 mm. The rainfall almost ceased after 37th SMW but withdrawal of monsoon occurred after 40th SMW. The *rabi* season received 19.0 mm of rainfall. Summer season was moderate with most of the weeks experiencing maximum temperature less than 40 °C. Highest maximum temperature of 42.8 °C recorded in 1st week of June 2009 and lowest maximum temperature of 16.4 °C was recorded in 1st week of January 2010. The 1st and 2nd weeks of June 2009 exposed to highest minimum temperature of 27.4°C and lowest (1.2 °C) during 1st week of January 2010. The lowest average relative humidity of 25.7% was recorded in 4th week of April and highest average RH of 88.9% was recorded in 1st week of September. Number of bright sunshine hours was highest (10.0 hrs) in 3rd week of May and lowest (0.7 hrs) in 1st week of January. Most of the weeks in the *kharif* season (28th to 40th SMW) received less than 6 hours of bright sunshine.

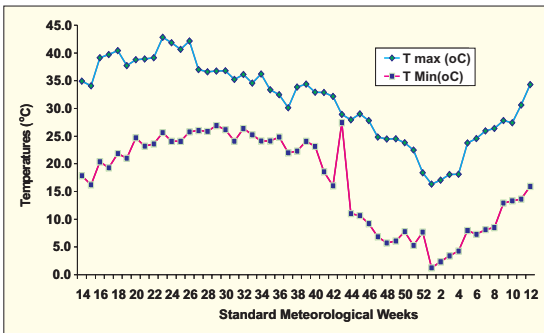


Fig.5/1: Weekly maximum and minimum temperature during crop season (2009-10)

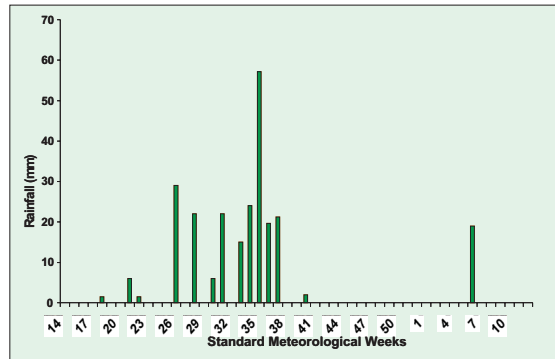


Fig.5/2: Weekly rainfall during the season (2009-10)

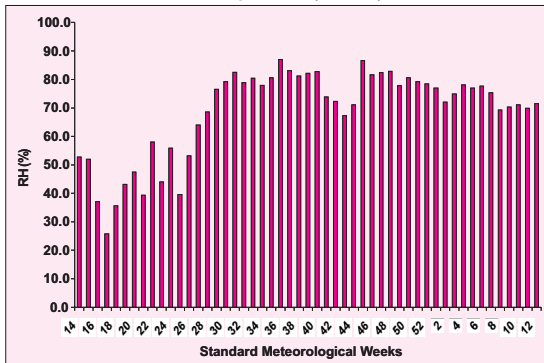


Fig.5/3: Average Relative Humidity (2009-10)

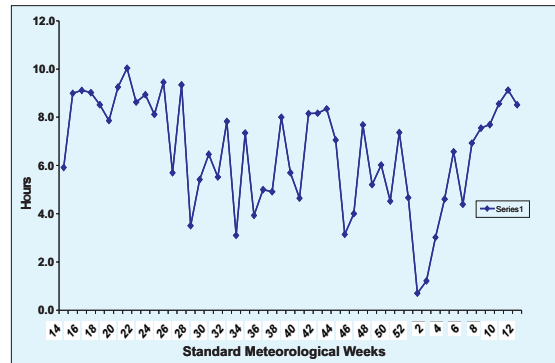


Fig.5/4: Bright Sunshine hours (2009-10)

6. PERSONNEL

6.1 STRENGTH

Table 6.1 : Staff position as on 31-03-2010

Category	Sanctioned	Filled
RMP	01	01
Scientific	38	26
Technical	25	26*
Administrative	20	18
Supportive	09	09
Total	93	80

*one excess adjusted as per court/ICAR order

6.2 NEW APPOINTMENTS/JOININGS

1. Dr. B. Gangwar (P.S.) has been appointed/ selected as Project Director against RMP post of PDFSR w.e.f. 22.02.10.
2. Shri Vipin Kumar Chaudhary, Scientist (Sr. Scale) (Computer Application) has joined this Directorate on 01-08-2009 on inter Institutional transfer from PDC- Cattle, Meerut.
3. Dr. Anil Kumar has been selected as Principal Scientist through ASRB and has joined at PDFSR on 18.8.09 as Principal Scientist in the discipline of Agric. Extension.
4. Dr. A.K. Nayak has been selected as Principal Scientist through ASRB and has joined at PDFSR on 25.8.09 as Principal Scientist in the discipline of Soil Fertility .
4. Dr .Md .Shamim, Scientist (Agric. Meteorology) has joined on 30-10-2009.
5. Dr. Sanjeev Kumar Kochewad, Scientist (LPM) has joined on 30-10-2009.

6. Dr. Akath Singh, Scientist (Sr. Scale- Horticulture) has joined on 2-11-2009 on transfer from NEH region.
7. Shri Sunil Kumar, Scientist (Statistics) has joined on 30-10-2009 after attending the training programme for ARS at NAARM, Hyderabad.

6.3 PROMOTIONS

1. Dr. V. P. Chaudhary promoted to next scale of Scientist (Sr. Scale) from grade of Scientist.
2. Sh. Prem Singh, Jr. Clerk was granted next higher scale under ACP Scheme.

6.4 TRANSFERS

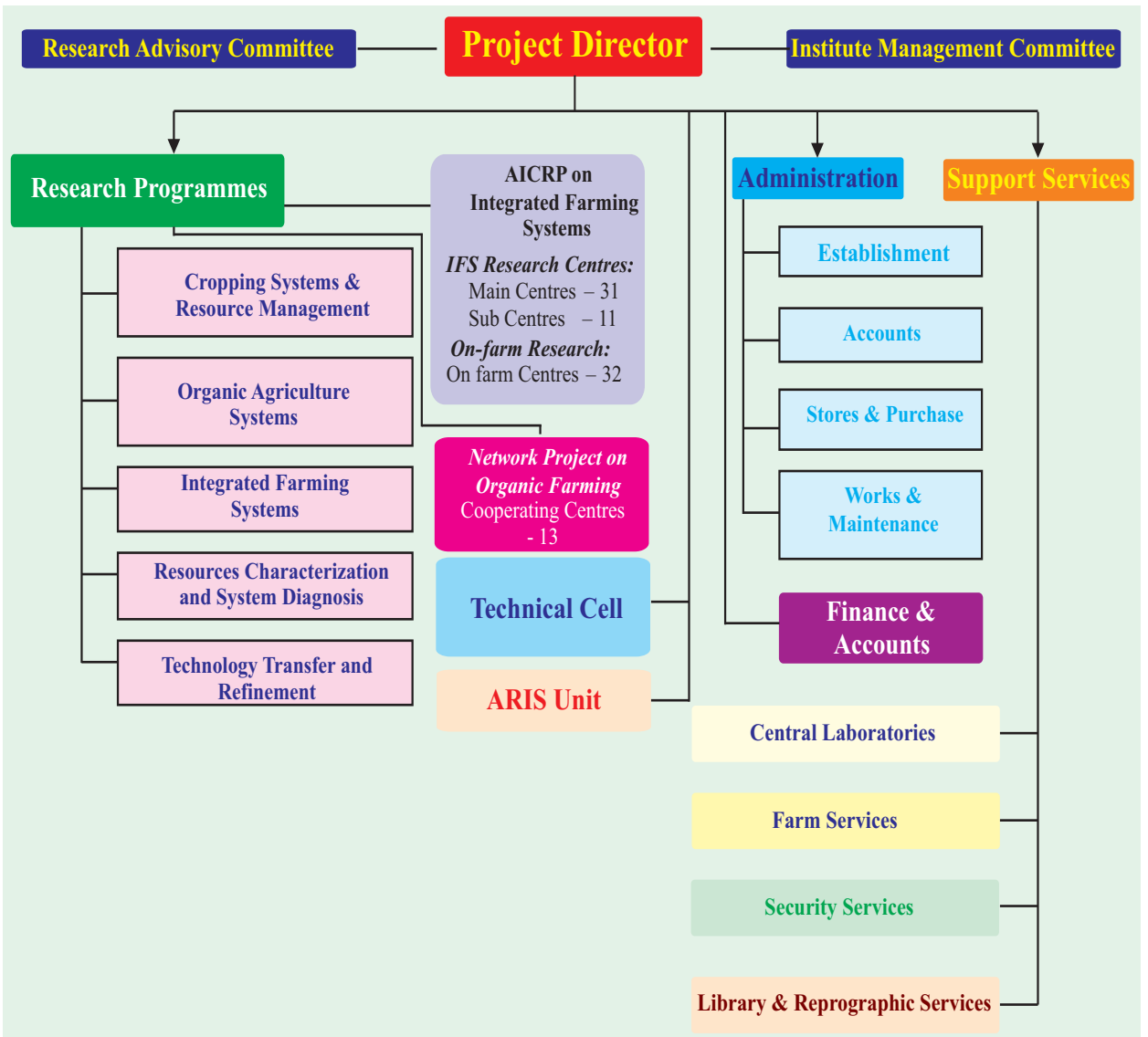
- 1) Dr. M. S. Gill, Ex-project Director has been relieved from PDFSR on 31-08-2009 on his selection to the post of Director, Extension Education at PAU, Ludhiana
- 2) Dr. P. Vijay Kumar, Sr. Scientist (Agro-Meteorology) has been transferred relieved from this Directorate on 02-Sept'2009 to join at CRIDA on transfer basis.

3) Dr. P. Ramasundaram, Principal Scientist (Agric. Eco.) has been relieved from the Directorate on 21-10-2009 to join ENCAEP, New Delhi on transfer basis.

6.5 RETIREMENTS

Dr. Mahender Singh, Principal Scientist has been retired on Superannuation on 31-07-2009.

7. ORGANIZATIONAL STRUCTURE



8. BUDGET

The head-wise budget allocation and actual expenditure (Rs. in lakhs) for the year 2009-10 is given as below:

Head/ Sub-head	PLAN						NON-PLAN	
	PDFSR		AICRP-IFS		NPOF		PDFSR	
	Allocation	Expenditure	Allocation	Expenditure	Allocation	Expenditure	Allocation	Expenditure
(a) Recurring								
Pay & Allowances	Nil	Nil	664.00	664.00	Nil	Nil	565.00	565.00
Wages	Nil	Nil	Nil	Nil	Nil	Nil	29.30	29.11
OTA	Nil	Nil	Nil	Nil	Nil	Nil	0.07	0.07
T.A	6.00	5.99	23.45	23.45	3.40	3.40	2.57	2.57
Other contingency charges	89.97	89.97	162.55	162.55	80.60	80.60	33.67	32.49
Information Technology	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sub-Total (a)	95.97	95.96	850.00	850.00	84.00	84.00	630.61	629.24
(b) Non-Recurring								
Equipment	5.95	5.94	Nil	Nil	1.00	1.00	Nil	Nil
Works (Major)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Annual repair & maint.	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Livestock	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Furniture/Fixtures	6.08	6.07	Nil	Nil	Nil	Nil	Nil	Nil
Lib Books & Periodicals	17.00	17.00	Nil	Nil	Nil	Nil	Nil	Nil
Vehicles	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sub-total (b)	29.03	29.01	Nil	Nil	1.00	1.00	Nil	Nil
Total (a+b)	125.00	124.97	850.00	850.00	85.00	85.00	630.61	629.24

Research Achievements

- ☞ **Cropping Systems and Resource Management**
- ☞ **Organic Agriculture Systems**
- ☞ **Integrated Farming Systems**
- ☞ **Resource Characterization and System Diagnosis**
- ☞ **Technology Transfer and Refinement**
- ☞ **Externally Funded Projects**

9.1 CROPPING SYSTEMS AND RESOURCE MANAGEMENT (CSRM)

A. ALTERNATIVE CROPPING SYSTEMS

Bio-intensive complementary cropping systems for high productivity and profitability

The studies were made to explore the possibilities of evaluating bio-intensive complementary cropping systems so as to ensure efficient resource use with high productivity and profitability. Nine cropping systems along with land configurations, *in situ* green manuring, residue incorporation, zero/minimum tillage and inter cropping approaches were evaluated during 2009-10. Results revealed that Bio-intensive system of raising maize for cobs + vegetable

cowpea in 1:1 ratio on broad beds (BB) and *Sesbania* in furrows during *kharif* and mustard in furrows and 3 rows of lentil on broad beds in *rabi* while 3 rows of green gram on beds in summer was found remarkably better than others which produced highest yield of 25.25 t ha⁻¹ as rice equivalent with productivity of 69.19 kg grain ha⁻¹ day⁻¹ and profitability of Rs.184.58 ha⁻¹ day⁻¹. The complimentary effects could be reflected in the system as in broad bed and furrow (BBF) system. The furrows served as drainage channels during heavy rains in *kharif* which were utilized for *in-situ* green manuring with

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

Treatments	REY** (t ha ⁻¹)	Productivity (kg ha ⁻¹ day ⁻¹)	Net Return (Rs. year ⁻¹)	Profitability (Rs. ha ⁻¹ day ⁻¹)	B:C Ratio	WUE* (kg grain/ha cm water)
Rice- Wheat	10.39	28.46	30560	83.73	1.88	55.84
Hy.Rice -Lentil+Wheat - Cowpea (V+R)	19.79	54.22	61098	167.39	1.88	99.96
Maize(C) +V.Cowpea +Sesbania (F)-Lentil + Mustard - Greengram(G+R)	25.25	69.19	67370	184.58	1.66	290.28
Maize(G)+Blackgram - V. Pea+ Mustard—Greengram(G+R)	22.50	61.63	53828	147.47	1.53	258.78
Maize(C)+Sesbania- Toria+G. Sarson-Greengram (ZT) (G+R) (FB)	15.37	42.12	35820	98.14	1.53	176.72
Sorghum+C.Bean(f)- Maize(C)+B. Gram- Methi - Cowpea (V+R)	23.49	64.36	55059	150.85	1.53	253.10
Pegionpea + blackgram-Wheat+ Mustard (ZT)-Cowpea(f)(ZT) (FB)	20.13	55.16	60465	165.66	1.84	279.63
Pegionpea -Wheat+Mathi (ZT)- Cowpea(f) (ZT) (FB)	17.14	46.95	50989	139.70	1.84	200.34
Maize+Cowpea(f)-Maize(C) +B. Gram- Wheat+Mathi—Greengram (G)	21.57	59.11	47473	130.06	1.53	211.51
Sorghum+Cowpea (f)-Oat(f)-Pearl millet+C. Bean(f) (ZT) (G+R)	19.38	53.10	47046	128.89	1.53	269.17

*WUE-water use efficiency, **REY-rice equivalent yield

38 t ha⁻¹ green foliage incorporated after 45 days of sowing and timely sown mustard crop in these furrows resulted in a good harvest (1.98 t ha⁻¹) and a bonus yield of lentil (0.13 t ha⁻¹) could be harvested on one hand and 33% of irrigation water could be saved as applied only in furrows. In the summer season, green gram could yield 1.88 t ha⁻¹ as grain while incorporation of green foliage of about 4.80 t ha⁻¹ in the soil further helped the system favorably. Bio-intensive System of raising sorghum+ clusterbean (fodder)- maize(cobs)+ blackgram- methi -cowpea (veg.+ residue) was also found better which resulted in 23.49 t ha⁻¹ as rice equivalent yield with productivity of 64.36 kg grain ha⁻¹day⁻¹ and profitability of Rs.184.6 ha⁻¹ day⁻¹. This system proved to be the second best in the order of merit. The lowest yield (10.39 t ha⁻¹) and profitability (Rs.83.73 ha⁻¹day⁻¹) was obtained under the conventional rice-wheat systems (Table 9.1/1).

Evaluation of resource efficient complementary bio-intensive cropping systems for enhancing productivity

Twelve different resource efficient complimentary bio-intensive cropping systems, namely Moong + Soybean + Arhar – Wheat + Sarson, Maize + Arhar – Gram + Raya, Maize + Cowpea (mulch) – Potato + Radish – Moong, Basmati rice (direct sowing) + *Dhaincha* (brown manure) – transplanted *Gobhi Sarson*, *Dhaincha* + Basmati Rice (transplanted) + Transplanted *Gobhi Sarson*, Summer Moong – Cow pea – Toria + *Gobhi Sarson*, Maize (in trench) + Moong (on bed) – Wheat + Raya (on bed), Maize (in trench) + Cowpea (on bed) – Wheat + Raya (on bed), Maize (in trench) + Moong (on bed) – Wheat + Gram + Raya (on bed), Pearl Millet + Cowpea (fodder) – Onion – Onion, Maize (Cob) – Toria + *Gobhi Sarson* – Summer Moong, and Rice – Wheat

Table 9.1/2. Effect of resource efficient complimentary bio-intensive cropping systems on yield and gross returns

Sl. No.	Cropping Systems (<i>Kharif</i> 2009-10)	Rice Equivalent Yield (q ha ⁻¹)	GrossReturn (Rs. ha ⁻¹)
1.	Moong+Soybean+Arhar	77	110400
2.	Maize+Arhar	72	100600
3.	Maize+Cowpea(M)	67	92600
4.	Basmati Rice (D)	36	33800
5.	Basmati Rice (T)	35	32250
6.	Cow pea	12	11600
7.	Maize(T)+Moong(B)	52	69600
8.	Maize(T)+Cowpea(B)	51	68400
9.	Maize(T)+Moong(B)	50	66100
10.	Pearl Millet+Cowpea(F)	26	32250
11.	Maize (Cob)	29	34200
12.	Rice	34	30700

T= Trench, B= Bed, D=Direct sowing, F= Fodder, M= Mulch

– GM, were evaluated for enhancing system productivity.

The rice equivalent yield (REY) and net returns of different cropping systems during *khariif* 2009-10 are presented in Table 9.1/2. The treatment moong + soybean + arhar gave maximum rice equivalent yield (REY) of 77 q ha⁻¹ followed by maize + arhar (72 q ha⁻¹) and maize + cowpea (67 q ha⁻¹), compared to traditional rice (34 q ha⁻¹) crop. The treatment moong + soybean + arhar also gave maximum net returns of Rs.1,10,400 ha⁻¹ followed by maize + arhar (Rs.1,00,600 ha⁻¹) and maize + cowpea (Rs.92,600 ha⁻¹), compared to traditional rice (Rs.30,700 ha⁻¹) crop.

Studies on intercropping in autumn planted sugarcane

A field experiment was conducted for three crop cycles (Nov.2006 to March, 2009) at research farm of Project Directorate for Farming Systems Research Modipuram, Meerut. Twenty-two treatments comprising two methods of sugarcane planting (37.5 cm bed and one sugarcane row in furrow of 30 cm and 50 cm bed and two rows of sugarcane in trench having 60 cm width) and eleven crops were sown on beds in a randomised block design with 4 replications. In narrow beds (37.5 cm + 30 cm) and in broad bed (50 cm + 60 cm), the plant population was kept same by placing 50,000 three-budded sets/ha. To improve germination, the sets were dipped in 0.25% solution of Emisan 6 before sowing. The sets were drenched in the furrow/trench by sprinkling 5 lit. Lindane ha⁻¹ in 1250 l of water to control the attack of termite and shoot borer. The different intercrops were pea (green pod) followed by summer moongbean, radish (Veg.) followed by onion, spinach (veg.) followed by spinach seed, lentil followed by summer moongbean, chickpea, garlic, linseed followed by summer moongbean, mustard followed by summer

moongbean, wheat followed by summer moongbean and barley followed by summer moongbean, both on narrow (37.5 cm) and broad beds (50 cm). Sugarcane (var. CoS 767) was planted on 6th November 2006 and all the intercrops were sown in the first week of November except onion which was sown on 20th January. The summer moongbean crop was sown after harvesting of previous *rabi* crop. All *rabi* crops were matured by the month of June and the sugarcane crop was continued up to January, 2008. The phosphorus and potash were applied @ 60 and 30 kg/ha at the time of sowing by broadcasting. The irrigation water was applied in furrow, keeping in view the need of cereals/pulses/oilseeds/vegetables and after June, the irrigation water was applied at 8-10 days intervals and depending on rainfall. In winter the interval was enhanced to 20-30 days depending upon the climate. The crops were kept weed free by manual weeding and pest free by using suitable pesticides. The soil samples were collected and analyzed before the start of the experiment. For statistical analysis, the yield of intercrops was converted in to wheat equivalent and system productivity in sugarcane equivalent.

The field observations were taken on yield and yield contributing characters of the intercrops and sugarcane, quality parameters of cane and cane juice, and soil fertility aspects. In addition, the economics of different treatments was worked out and profitability in term of net returns (Rs. ha⁻¹). The observations were taken on different aspects of soil and plant parameters and net returns (Table 9.1/3-7 & Fig. 9.1/3).

Intercrops

Thirteen intercrops belonging to cereals, pulses, oilseeds, green leafy vegetables and spice crops were grown between the rows of autumn planted sugarcane under eleven intercropping systems. The

three years (2006-07 to 2008-09) average yield ($t\ ha^{-1}$) of the intercrops converted in to wheat equivalent yield (WEY) were 2.98, 9.77, 13.53, 4.34, 3.41, 3.07, 14.3, 5.2, 5.8, 5.64, 6.29 for pea-moong, radish-onion, spinach, lentil-moong, chick pea, menthi, garlic, linseed-moong, mustard-moong, wheat-moong and barley-moong, respectively. The average yield figures as above clearly show that

spinach and garlic producing average WEY of 13.55 and 14.3 t/ha , respectively, gave highest gross production. The data thus clearly elucidate that more than double the productivity of barley and wheat have been accrued in these systems (Table 9.1/3). Spinach and many other intercrops including menthi, mustard, wheat and barley, however, had some smothering effect on sugarcane at early stage of

Table 9.1/3. Wheat equivalent yield (WEY) of different rabi season crops grown as an intercrop simultaneously in autumn sugarcane under changed planting techniques.

S.N.	Intercropping systems	WEY ($t\ ha^{-1}$)			
		First year	Second year	Third year	Average
1	Sugarcane (R&F) + Pea- moong	3.69	2.80	2.46	2.98
2	Sugarcane (Trench) + Pea- moong	3.33	3.19	2.45	2.99
3	Sugarcane (R&F) +Radish-onion	8.70	10.39	10.20	9.78
4	Sugarcane (Trench) +Radish-onion	8.94	10.49	9.60	9.67
5	Sugarcane (R&F)+Spinach	14.19	13.62	15.20	14.33
6	Sugarcane (Trench) +Spinach	13.86	12.15	12.20	12.73
7	Sugarcane (R&F) +Lentil-moong	5.31	3.18	4.80	4.43
8	Sugarcane (Trench)+ Lentil-moong	5.15	3.61	4.00	4.25
9	Sugarcane (R&F)+gram	3.32	1.77	3.40	2.83
10	Sugarcane (Trench) (two row) +gram	2.35	3.99	4.40	3.58
11	Sugarcane (R&F) +methi	2.53	4.41	1.80	2.91
12	Sugarcane (Trench) +methi	2.32	4.98	2.41	3.23
13	Sugarcane (R&F)+garlic	12.12	13.32	15.3	13.6
14	Sugarcane (Trench) +garlic	12.64	16.84	15.9	15.1
15	Sugarcane (R&F) + linseed-moong	6.58	2.46	6.7	5.24
16	Sugarcane (Trench) + linseed-moong	5.86	2.93	6.5	5.1
17	Sugarcane (R&F) +mustard-moong	3.50	3.26	9.2	5.3
18	Sugarcane (Trench) + mustard-moong	5.98	4.16	9.2	6.4
19	Sugarcane (R&F) + wheat-moong	5.99	5.58	4.9	5.49
20	Sugarcane (Trench) + wheat-moong	6.49	5.90	5.0	5.79
21	Sugarcane (R&F) + barley-moong	6.33	6.05	6.50	6.29
22	Sugarcane (Trench) + barley-moong	6.35	6.23	6.30	6.29
	CD at 5% level of significance	1.83	2.18	1.41	-

growth but it (sugarcane) recovered fast in later stages. Astonishingly, linseed did not compete much with growth of sugarcane but cane yield was adversely affected mainly in first year of the study. This may be because of some allelopathic effect of linseed on sugarcane.

Cane yield

The cane yield data recorded in respective years and averaged upon the crop seasons 2006-07 to

2008-09 (Table 9.1/4), revealed that intercropping systems sugarcane + spinach and sugarcane + garlic being at par gave significantly higher cane yield of 92.66 and 90.38 t ha⁻¹ year⁻¹, respectively. Among others, lentil-moong, chickpea and radish- onion intercropping systems were found better in autumn sugarcane. Intercropping of wheat, mustard and linseed adversely affected cane yield than other intercropping systems. The lower yield of cane in these systems were because of smothering effect of

Table 9.1/4. Yield of sugarcane as affected by different intercropping systems and planting techniques.

S.N.	Intercropping systems	Cane yield (t ha ⁻¹)			
		First year	Second year	Third year	Average
1	Sugarcane (R&F) + Pea- moong	79.10	79.77	79.2	79.36
2	Sugarcane (Trench) + Pea- moong	77.29	76.03	70.8	74.71
3	Sugarcane (R&F) +Radish-onion	81.97	77.12	80.6	79.90
4	Sugarcane (Trench) +Radish-onion	73.45	77.67	84.4	78.51
5	Sugarcane (R&F)+Spinach	69.29	76.10	99.2	81.53
6	Sugarcane (Trench) +Spinach	84.55	102.26	124.6	103.80
7	Sugarcane (R&F)+Lentil-moong	66.22	83.94	115.1	88.42
8	Sugarcane (Trench)+ Lentil-moong	64.88	80.64	110.8	85.44
9	Sugarcane (R&F)+gram	81.61	82.37	71.3	78.43
10	Sugarcane (Trench) (two row) +gram	75.12	82.05	103.3	86.82
11	Sugarcane (R&F) +methi	79.95	68.75	85.1	77.93
12	Sugarcane (Trench) +methi	80.44	60.80	64.9	68.71
13	Sugarcane (R&F)+garlic	82.59	80.64	101.9	88.38
14	Sugarcane (Trench) +garlic	92.33	78.64	106.2	92.39
15	Sugarcane (R&F) + linseed-moong	55.63	81.24	91.9	76.26
16	Sugarcane (Trench) + linseed-moong	59.81	81.94	80.7	74.15
17	Sugarcane (R&F) +mustard-moong	69.91	60.21	94.9	75.01
18	Sugarcane (Trench) + mustard-moong	76.42	61.07	103.1	80.20
19	Sugarcane (R&F) + wheat-moong	61.41	61.62	61.9	61.64
20	Sugarcane (Trench) + wheat-moong	67.97	64.97	69.6	67.51
21	Sugarcane (R&F) + barley-moong	75.26	70.80	103.1	83.05
22	Sugarcane (Trench) + barley-moong	72.37	65.51	84.9	74.26
	CD at 5% level of significance	14.61	12.88	14.01	-



Performance of various intercrops in autumn planted sugarcane

these crops on sugarcane resulted in poor plant stand. In case of linseed, there was less competition with the sugarcane but there seems some allelopathic effect on sugarcane which needs further investigation. Higher yield of sugarcane under intercropping systems involving spinach and garlic than other intercrops was because of synergistic effect due to number of irrigation, level of nutrition and biomass production. Besides intercropping systems the yield of cane was also affected by the method of planting. Trench planting with paired rows gave 1.5 t ha⁻¹ more cane yield than one row of sugarcane planted in



Performance of various intercrops in autumn planted sugarcane

furrows. Higher yield in trench planting than bed and furrow planting was mainly because of higher number of shoots and millable canes in trench planting. Higher population of shoots and millable canes in paired row trench planting could be attributed to the border effect that the rows received in the form of higher light interception and proper aeration due to wider spacing between the trenches.

Interaction effect between intercrops and method of planting was also observed and considerably higher cane yield of 103.80 t ha⁻¹ year⁻¹ was achieved under intercropping system sugarcane + spinach closely followed by sugarcane + garlic (92.39 t ha⁻¹ year⁻¹) in both the planting techniques.

System productivity

The system productivity in terms of sugarcane equivalent yield (SEY) with intercropping of sugarcane in trench and garlic on bed (197.35 t ha⁻¹ year⁻¹) and intercropping of sugarcane in trench and spinach on bed (195.04 t ha⁻¹ year⁻¹) was more or less same. The lowest SEY was under sugarcane + menthi (92.07 t ha⁻¹) followed by sugarcane + chickpea (98.03 t ha⁻¹), sugarcane+wheat-moong (101.35 t ha⁻¹) and pea-moong (101.41 t ha⁻¹), but all in narrow bed and furrow system of planting (Table 9.1/5). The planting technique containing broad beds for sowing intercrops and wide trench accommodating two lines of sugarcane gave 3% increase in the yield of intercrops and 5% more SEY.

Quality of cane and cane juice

The quality parameters of cane and cane juice including brix (%), pol (%) in cane, pol (%) in juice, juice (%), purity (%) and recovery (%) were also analysed. The data (Table 9.1/6-7) clearly indicate that both the intercropping systems and planting

Table 9.1/5. System productivity (SEY) as affected by different intercropping systems and planting techniques.

S.N.	Intercropping systems	SEY (t ha ⁻¹)			
		First year	Second year	Third year	Average
1	Sugarcane (R&F) + Pea- moong	112.68	101.36	90.20	101.41
2	Sugarcane (Trench) + Pea- moong	154.80	158.58	81.85	131.74
3	Sugarcane (R&F) +Radish-onion	161.14	157.27	155.48	157.96
4	Sugarcane (Trench) +Radish-onion	154.80	158.58	156.64	156.67
5	Sugarcane (R&F)+Spinach	198.42	181.16	166.08	181.89
6	Sugarcane (Trench) +Spinach	210.68	195.98	178.46	195.04
7	Sugarcane (R&F) +Lentil-moong	114.54	108.47	136.22	119.74
8	Sugarcane (Trench)+ Lentil-moong	111.74	108.48	128.40	116.21
9	Sugarcane (R&F)+gram	111.82	96.02	86.26	98.03
10	Sugarcane(Trench)+gram	96.50	112.82	122.66	110.66
11	Sugarcane (R&F) +methi	102.97	102.77	93.02	99.59
12	Sugarcane (Trench) +methi	101.55	99.21	75.46	92.07
13	Sugarcane (R&F)+garlic	192.88	183.39	169.22	181.83
14	Sugarcane (Trench) +garlic	207.35	208.54	176.16	197.35
15	Sugarcane (R&F) + linseed-moong	115.51	100.22	121.38	112.37
16	Sugarcane(Trench)+ linseed-moong	113.14	104.54	108.90	108.86
17	Sugarcane (R&F) +mustard-moong	101.76	85.35	135.38	107.50
18	Sugarcane(Trench)+mustard-moong	130.84	93.16	143.58	122.53
19	Sugarcane (R&F) + wheat-moong	115.92	104.66	83.46	101.35
20	Sugarcane (Trench) + wheat-moong	127.03	110.48	91.6	109.70
21	Sugarcane (R&F) + barley-moong	132.86	117.47	131.7	127.34
22	Sugarcane (Trench) + barley-moong	130.15	113.57	112.62	118.78

techniques influenced the quality of cane as well as cane juice. It is interesting to note that intercropping systems including leguminous crops improved in all the quality parameters (except a slight reduction in percent of juice in cane) over non leguminous crops *viz*: radish-onion, spinach, methi and garlic. In case of planting techniques, trench planting gave more values of brix, pole in cane and recovery however, a

slight reduction was noticed in case of pole in juice, juice in cane and purity. As the cane setts are planted deeper in pit than furrow planting, higher moisture availability at the base of the roots probably have increased stalk moisture during ripening, and the sucrose diverted towards growth which would otherwise be used for storage in the stem, which lowered pol reading.

Table 9.1/6. Effect of intercropping on the recovery and juice quality of cane

S.N.	Intercropping systems	Brix %	Pol juice %	Pol cane %	Purity %	Recovery %
1	Sugarcane (Ridge&Furrow) + Pea- moong	18.76	16.23	11.69	86.51	9.19
2	Sugarcane (Trench) + Pea- moong	19.26	17.30	12.46	89.82	9.96
3	Sugarcane(Ridge&Furrow)+Radish-onion	18.06	15.30	11.02	84.72	8.52
4	Sugarcane (Trench) +Radish-onion	18.86	16.50	11.88	87.49	9.38
5	Sugarcane (Ridge&Furrow) +Spinach	19.16	16.84	12.12	87.89	9.62
6	Sugarcane (Trench) +Spinach	17.36	14.48	10.45	83.41	7.84
7	Sugarcane(Ridge&Furrow)+Lentil-moong	19.16	16.67	12.00	87.00	9.50
8	Sugarcane (Trench) + Lentil-moong	17.16	14.27	10.27	83.16	7.62
9	Sugarcane (Ridge&Furrow)+gram	18.86	16.35	11.17	86.69	9.27
10	Sugarcane (Trench) + gram	18.86	16.23	11.69	86.06	9.19
11	Sugarcane (Ridge&Furrow) +methi	17.82	14.80	10.66	83.05	8.09
12	Sugarcane (Trench) +methi	17.36	14.75	10.62	84.97	8.04
13	Sugarcane (Ridge&Furrow) + garlic	18.86	16.45	11.84	87.22	9.34
14	Sugarcane (Trench) +garlic	18.06	15.45	11.12	85.55	8.62
15	Sugarcane(Ridge&Furrow)+linseed-mong	19.16	16.82	12.11	87.79	9.61
16	Sugarcane (Trench) + linseed-moong	18.36	16.07	11.57	87.53	9.07
17	Sugarcane(Ridge&Furrow)+mustard-mong	18.46	16.46	11.85	89.17	9.35
18	Sugarcane (Trench) +mustard-moong	19.36	17.04	12.27	88.02	9.77
19	Sugarcane(Ridge&Furrow)+ wheat-moong	17.26	14.55	10.48	84.30	7.80
20	Sugarcane (Trench) + wheat-moong	17.36	14.80	10.66	85.25	8.09
21	Sugarcane (Ridge&Furrow) + barley-moong	18.36	16.68	12.01	90.85	9.51
22	Sugarcane (Trench) + barley-moong	19.59	17.37	12.51	88.80	10.01

Profitability

Similar to yield of the intercropping systems and cane yield, the profitability was considerably higher under sugarcane + spinach intercropping system under trench planting (Rs.180539 ha⁻¹ annum⁻¹) and sugarcane + garlic intercropping system (Rs.176424 ha⁻¹ annum⁻¹) with same pattern of cropping as in case of spinach. The other profitable intercropping

systems were sugarcane + pea-moong (Rs.119256 ha⁻¹ annum⁻¹) and sugarcane + radish-onion (Rs.112313 ha⁻¹ annum⁻¹) under trench – bed and furrow-bed systems respectively (Fig. 9.1/1).

The results clearly entail that for realizing higher system productivity along with greater profitability of sugarcane with better quality of cane, paired row planting of sugarcane in 60 cm. wide trenches and

Table 9.1/7. Effect of type (Leguminous V/S non leguminous) of the intercrops and planting techniques on the quality parameters of cane and cane juice

Quality parameters/ treatments	Brix (%)	Pole in cane (%)	Pole in juice (%)	Purity (%)	Juice (%)	Recovery (%)
Type of intercrops						
Leguminous	18.56	11.62	16.20	87.21	45.73	9.13
Non- leguminous	18.19	10.67	15.57	85.53	46.49	8.68
Planting techniques						
Intercrops on narrow beds and one row of sugarcane in furrows	18.53	11.68	16.39	88.14	46.19	9.22
Intercrops on broad beds and two rows of sugarcane in trenches	19.51	11.81	16.29	87.79	46.03	9.31

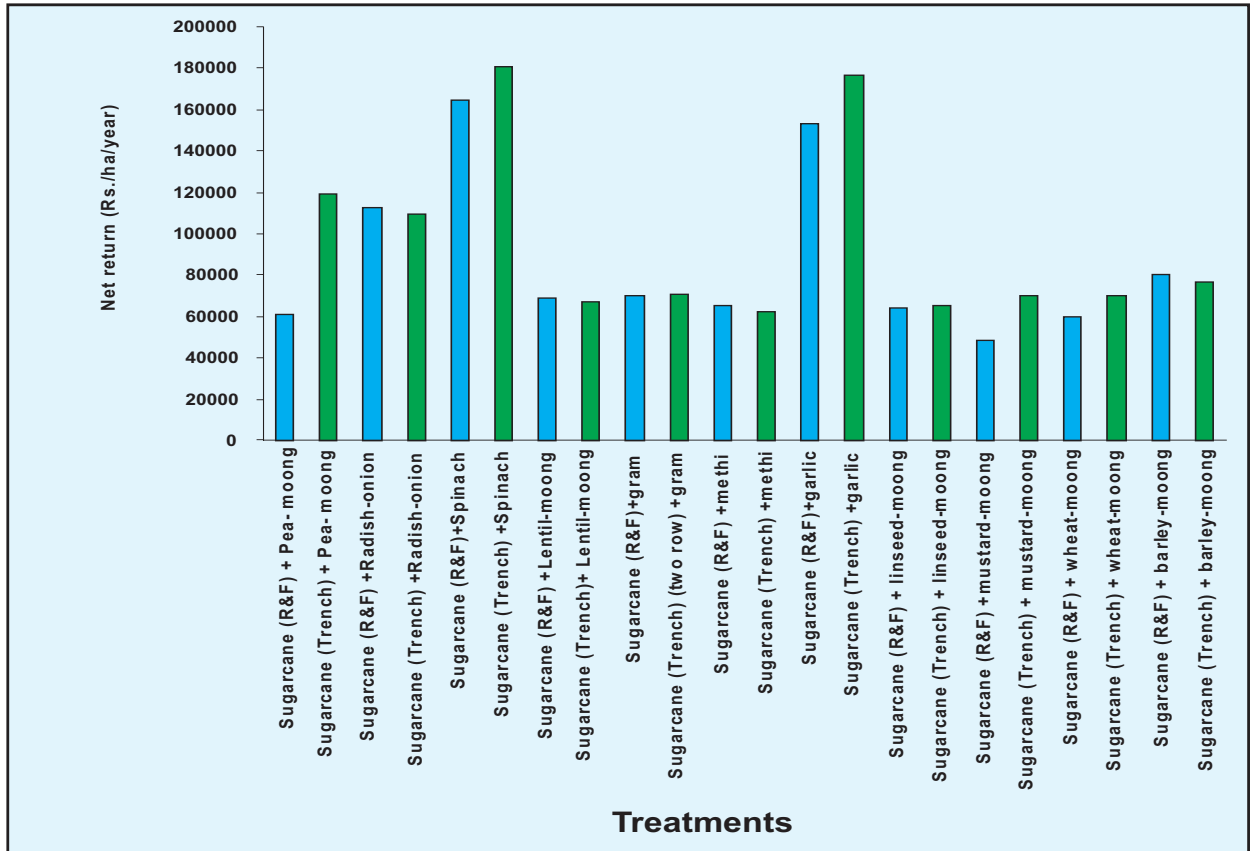


Fig. 9.1/1. Effect of intercropping systems and method of planting in autumn sugarcane on net returns

raising of *rabi* crops on 50 cm. broad beds was found better than prevailing practice of planting one line of sugarcane in narrow spaced rows and intercrops in between these rows. Further, spinach (2 cutting for green veg. and then taking seed) and garlic, an spice winter season crops, can profitably

be taken as an intercrops simultaneously, in autumn sugarcane without jeopardizing the growth and yield of main sugarcane crop. Leguminous crops as an intercrops also gave a slight improvement in soil fertility as well as cane juice quality.



Performance of various intercrops in autumn planted sugarcane

B. CROP ESTABLISHMENT, TILLAGE AND FARM MECHANIZATION, PRECISION FARMING

Intensification of rice- wheat cropping system for higher productivity and profitability under different tillage systems

The experiment on intensification through inclusion of legume and fodder crops and its effect on soil and cropping system productivity and profitability of rice based cropping systems under different tillage options was started in 2006. Ten treatment combinations of rice based cropping systems and tillage practices with 3 replications were evaluated. These combinations were T₁: Rice-Wheat (ZT)- Green gram (ZT), T₂: Rice- veg. Pea (ZT)- Pearl millet F. (ZT)- Green gram (ZT), T₃: Rice- Wheat (ZT)- Cowpea (ZT), T₄: Rice- Wheat (CT)- Green gram (CT), T₅: Rice- veg. Pea (CT)- Pearl millet F. (CT)- Green gram (CT), T₆: Rice- Wheat (CT)- Cowpea (CT), T₇: Rice- Wheat (BP)-

Green gram (BP), T₈: Rice- veg. Pea (BP)- Pearl millet F. (BP)- Green gram (BP), T₉: Rice- Wheat (BP)- Cowpea (BP), and T₁₀: Rice- Wheat (CT).

Conventional tillage (CT) adopted in previous *rabi* and summer season crops produced 5.25 t ha⁻¹ rice that was, respectively, 6 and 19% more than bed planting and zero tillage. Rice- vegetable Pea-Green gram (CT) cropping system produced maximum rice (5.38 t ha⁻¹) followed by 5.29 t ha⁻¹ in Rice-Wheat-Cowpea (CT) whereas Rice-Wheat (CT) produced only 5.08 t ha⁻¹ rice yield. Rice-vegetable Pea-Green gram system produced 4% more rice than Rice-Wheat-Green gram and Rice-Wheat-Cowpea systems.

The wheat yield obtained under bed planting, ZT (5.82 t ha⁻¹) was, respectively, 5.5 and 1.7 %

higher than conventional tillage (CT) and bed planting (BP). Rice-Wheat-Green gram (ZT) cropping system produced maximum wheat yield (5.88 t ha^{-1}) followed by 5.77 t ha^{-1} in rice-wheat-cowpea (ZT) whereas rice-wheat (CT) produced only 5.38 t ha^{-1} wheat. Rice-wheat-green gram system produced 7 and 1.5% more wheat than rice-wheat and rice-wheat-cowpea systems.

The maximum vegetable pea yield (5.12 t ha^{-1}) was obtained under rice-vegetable pea-green gram (BP) cropping system that was, respectively, 108 and 75 % higher than rice-vegetable pea-green gram (ZT) and rice-vegetable pea-green gram (CT) system.

The green gram yield obtained under bed planting (0.73 t ha^{-1}) was, respectively, 41 and 58 % higher

than conventional till sowing and zero till drilling. The green gram grown after vegetable pea yielded (0.64 t ha^{-1}) 48 % higher than that grown after wheat. The cowpea yield obtained under bed planting (2.35 t ha^{-1}) was, respectively, 78 and 27 % higher than zero till drilling and conventional till sowing. Rice-vegetable pea (BP)-green gram (BP) cropping system provided maximum rice equivalent yield of 16.4 t ha^{-1} followed by 16.3 t ha^{-1} in rice-wheat (BP)-cow pea (BP) and 15.9 t ha^{-1} in rice-wheat (CT)-cow pea (CT) compared to 11.9 t ha^{-1} in rice-wheat (CT) system (Fig. 9.1/2). Rice-vegetable pea (BP)-green gram (BP) cropping system provided maximum net returns (Rs 95354 ha^{-1}) and B:C ratio (3.15) followed by Rs 81948 ha^{-1} and 2.46 in rice-wheat (BP)-cow pea (BP) and Rs 76909 ha^{-1} and 2.32 in rice-wheat (CT)-cow pea (CT) compared

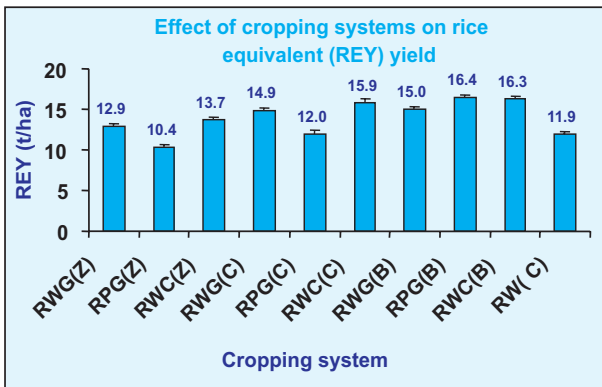


Fig. 9.1/2. Effect of tillage and cropping systems on rice equivalent system yield (REY)

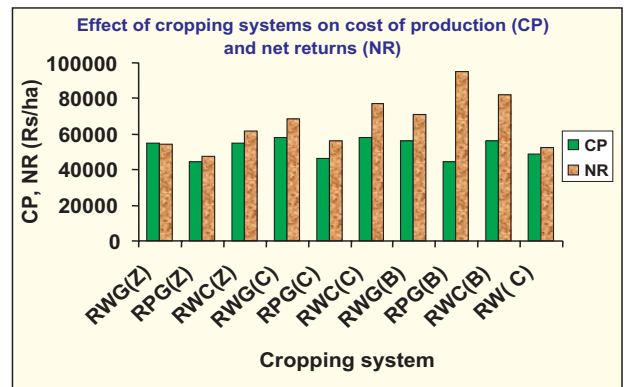


Fig. 9.1/3. Effect of tillage and cropping systems on cost of production (CP) and net returns (NR)

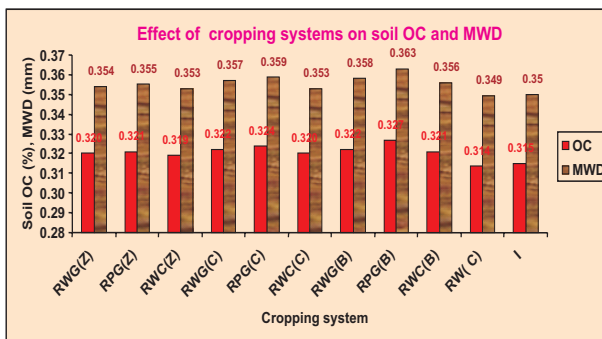


Fig. 9.1/4. Effect of tillage and cropping systems on soil organic carbon (OC) and mean weight diameter (MWD) of aggregates

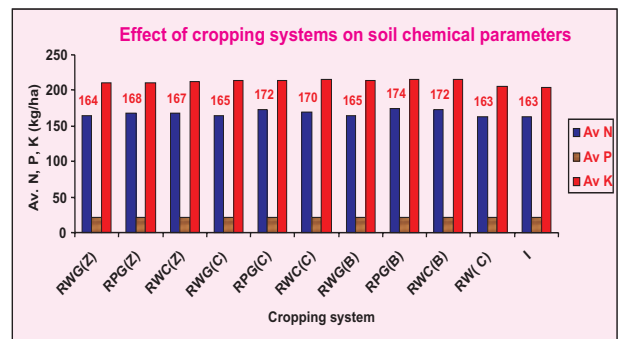


Fig. 9.1/5. Effect of tillage and cropping systems on available N, P and K of soil

to Rs 28900 ha⁻¹ and 1.61 in rice – wheat (CT) system (Fig. 9.1/3). Rice-vegetable pea (BP)-green gram (BP) cropping system provided maximum soil organic carbon (OC), mean weight diameter (MWD) of aggregates and available N, P, K after three years, compared to other treatments as well as respective initial values (Fig. 9.1/4-5).

Tillage and planting management in different cropping systems (AICRP-CS)

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

In rice – wheat cropping system at Kanpur, it was observed that during *kharif*, hand transplanting provided highest rice yield (4.35 t ha⁻¹) that was 9.0, 30.6 and 49.5 % higher than transplanting by transplanter, drum seeding and zero till drilling, respectively. During *rabi*, the conventional sowing provided maximum wheat yield (3.81 t ha⁻¹) which was at par with strip till drilling (3.75 t ha⁻¹) but 7.9 and 11.0 % higher than bed planting and zero till drilling, respectively. The highest system productivity (8.28 t ha⁻¹) of rice and wheat was recorded with treatment combination of hand transplanting of rice and conventional sowing of wheat.

In rice – wheat cropping system at Pantnagar, it was observed that during *kharif*, drum seeding provided highest rice (3.06 t ha⁻¹) that was respectively, 14.2, 14.6 and 96.2 % higher than zero till drilling, hand transplanting and mechanical transplanting. During *rabi*, bed planting (5.43 t ha⁻¹) provided highest wheat that was at par with conventional sowing (4.91 t ha⁻¹) and strip till drilling (4.55 t ha⁻¹) but 22.8 % higher than zero till drilling. Rice planting methods did not affect wheat yields

but wheat planting methods affected the rice yields significantly. The bed planting in wheat provided maximum rice yield (2.77 t ha⁻¹) that was at par with conventional sowing (2.60 t ha⁻¹) and strip till drilling (2.38 t ha⁻¹) but 24.7 % higher than zero till drilling. Zero till drilling of rice and bed planting of wheat was the best treatment combination for maximizing both rice (2.68 t ha⁻¹) and wheat (5.43 t ha⁻¹) yields.

In rice – wheat cropping system at Varanasi, it was observed that during *kharif*, hand transplanting provided highest rice (6.38 t ha⁻¹) that was at par with transplanting by transplanter (6.16 t ha⁻¹) but 22.0 and 41.8 % higher than and drum seeding and zero till drilling, respectively. During *rabi*, conventional sowing provided highest wheat (4.39 t ha⁻¹) that was at par with rotavator till drilling (4.19 t ha⁻¹) and strip till drilling (4.12 t ha⁻¹) but 9.2 % higher than zero till drilling. Also, the rotavator, strip and zero till drilling provided wheat yields at par. Both rice and wheat planting methods did not affect the yields of wheat and rice. Hand transplanting of rice and conventional sowing of wheat was the best treatment combination for maximizing both rice (6.64 t ha⁻¹) and wheat (4.25 t ha⁻¹) yields.

In rice – wheat cropping system at Sabour, it was observed that during *kharif*, transplanting by transplanter provided highest rice (6.48 t ha⁻¹) that was at par with hand transplanting (6.39 t ha⁻¹) but 10.8 and 14.1 % higher than drum seeding and zero till drilling, respectively. Among wheat planting methods, strip till drilling provided highest wheat (4.47 t ha⁻¹) that was at par with conventional sowing (4.30 t ha⁻¹) but 13.7 and 16.7 % higher than bed planting and zero till drilling, respectively. The residual effect of rice planting methods was not significant whereas strip till drilling and bed planting in wheat provided maximum rice (6.17 t ha⁻¹) which was 2.0 and 2.7 % higher than zero till drilling and conventional sowing, respectively. Transplanting by transplanter in rice and strip till drilling in wheat was

the best treatment combination for maximizing both rice (6.48 t ha⁻¹) and wheat (4.47 t ha⁻¹) yields.

In rice – wheat cropping system at Raipur, it was observed that during *kharif*, zero till drilling provided highest rice (6.13 t ha⁻¹) that was at par with hand transplanting (5.98 t ha⁻¹) but 6.4 and 6.8 % higher than transplanting by transplanter and drum seeding, respectively. During *rabi*, the residual effect of the rice planting methods was not significant. Among wheat planting methods, all the treatments were at par but conventional sowing provided numerically maximum wheat yield (3.25 t ha⁻¹). Wheat planting methods, however, affected the yield of rice and conventional sowing provided highest rice (6.24 t ha⁻¹) that was at par with strip till drilling but 9.8 and 12.4 % higher than zero till drilling and bed planting, respectively. Hand transplanting in rice and conventional sowing in wheat was the best treatment combination for maximizing both rice (6.64 t ha⁻¹) and wheat (3.38 t ha⁻¹) yields.

In rice – wheat cropping system at Jabalpur, it was observed that during *kharif*, all the planting methods provided statistically similar rice yield (4.98 to 5.07 t ha⁻¹). Among wheat planting methods, strip till drilling provided highest wheat (3.84 t ha⁻¹) that was 9.0, 9.7 and 13.3 % higher than conventional sowing, zero till drilling and bed planting, respectively. The residual effect of rice planting methods was significant and drum seeding in rice provided maximum wheat (3.84 t ha⁻¹) that was respectively, 3.8, 13.9 and 15.3 % higher than zero till drilling, hand transplanting and mechanical transplanting. Also, wheat planting method conventional sowing provided maximum rice yield (5.20 t ha⁻¹) that was, respectively, 3.8, 4.6 and 5.7 % higher than bed planting, strip and zero till drilling, respectively. Drum seeding in rice and strip till drilling in wheat was the best treatment combination for maximizing both rice (5.27 t ha⁻¹) and wheat (3.94 t ha⁻¹) yields.

In rice – wheat cropping system at R.S. Pura, it was observed that during *kharif*, hand transplanting provided highest rice (4.39 t ha⁻¹) that was 11.1, 13.7 and 21.3 % higher than drum seeding, transplanting by transplanter and zero till drilling, respectively. During *rabi*, the residual effect of the treatment zero till drilling provided maximum wheat (3.41 t ha⁻¹) that was at par with transplanting by transplanter (3.27 t ha⁻¹) but 9.6 and 11.8 % higher than hand transplanting and drum seeding, respectively. Among wheat planting methods, bed planting provided highest wheat (4.0 t ha⁻¹) that was 19.7, 39.8 and 52.0 % higher compared to conventional sowing, strip and zero till drilling, respectively. The residual effect of wheat planting methods also affected the rice yields and zero till drilling, strip till drilling and bed planting provided statistically similar rice yields but about 5.0% higher than conventional sowing. Hand transplanting of rice and bed planting in wheat was the best treatment combination for maximizing both rice (4.39 t ha⁻¹) and wheat (4.00 t ha⁻¹) yields.

In rice – groundnut cropping system at Rajendranagar, it was observed that during *kharif*, transplanting after normal puddling (after summer green manuring) produced maximum rice yield (5.37 t ha⁻¹). However, it was statistically at par with transplanting after normal puddling (4.99 t ha⁻¹) but five times higher than dry seeding. During *rabi*, main plot treatments did not affect the yield of groundnut statistically but groundnut succeeding direct seeded rice produced numerically higher yield (1.44 t ha⁻¹). The sub plot treatments also did not affect the groundnut yield. Therefore, summer green manuring in rice benefited only rice crop; and transplanting after normal puddling after summer green manuring in rice and ploughing twice and harrowing thrice was the best treatment combination for maximizing rice (5.37 t ha⁻¹) and ground nut (1.36 t ha⁻¹) yields.

In soybean based cropping systems at Parbhani, it was observed that the tillage and planting methods

did not affect yields of both *kharif* and *rabi* crops, however, zero tillage gave numerically maximum soybean yield (1.88 t ha^{-1}) in *kharif* and chick pea equivalent yield (1.03 t ha^{-1}) in *rabi*. The soybean yields of both soybean – chickpea and Soybean – safflower systems were also at par but during *rabi*, the soybean – chickpea system provided chickpea equivalent yield (1.17 t ha^{-1}) that was 116 % higher than that of soybean – safflower system. Zero tillage and soybean- chickpea system was the best treatment combination for maximizing both soybean (1.88 t ha^{-1}) and chickpea (1.17 t ha^{-1}) yields.

In soybean based cropping systems at Akola, it was observed that during *kharif*, soybean – safflower system gave maximum soybean yield (1.95 t ha^{-1}) that was at par with soybean – sorghum (1.92 t ha^{-1}) and soybean – mustard (1.82 t ha^{-1}) but 13.3 % higher than soybean – chick pea system. During *rabi* also soybean – safflower system gave maximum soybean equivalent yield (1.89 t ha^{-1}) that was 39.0, 42.1 and 101.0 % higher than soybean – sorghum, soybean – chick pea and soybean – mustard systems respectively. Among tillage methods, broad bed furrow (BBF) sowing gave maximum soybean yield (2.38 t ha^{-1}) that was 27.2, 34.4 and 71.2 % higher than conventional, minimum and zero tillage sowings respectively. During *rabi* also, the similar trend was obtained and broad bed furrow (BBF) sowing gave maximum soybean equivalent yield (1.72 t ha^{-1}) that was, respectively, 18.6, 37.6 and 54.9 % higher than conventional, minimum and zero tillage sowings. Soybean – safflower and broad bed furrow sowing system was the best treatment combination for maximizing both the yields of soybean and *rabi* crops.

In soybean based cropping systems at Rahuri, it was observed that during *kharif*, soybean – chick pea and soybean – onion systems gave maximum soybean yield (2.87 t ha^{-1}) that was at par with soybean – wheat (2.81 t ha^{-1}) but 13.4 % higher

than pearl millet – wheat and 14.3 % higher than pearl millet – chick pea and pearl millet - onion systems. During *rabi*, soybean – onion system gave onion yield of 29.16 t ha^{-1} which was 4.1 % higher than pearl millet – onion system; whereas, wheat and chick pea yields, of both the systems with soybean and pearl millet as *kharif* crops, were at par. Soybean – onion system provided highest soybean equivalent system yield (14.07 t ha^{-1}) followed by pearl millet – onion (11.76 t ha^{-1}). Among tillage methods, conventional tillage sowing gave maximum soybean yield (3.14 t ha^{-1}) that was, respectively, 14.6, 24.1 and 35.3 % higher than bed planting, minimum and zero tillage sowings. During *rabi* also, the similar trend was obtained. Also, the conventional tillage sowing gave maximum soybean equivalent system yield (8.68 t ha^{-1}) that was, respectively, 7.3, 18.1 and 27.6 % higher than bed planting, minimum and zero tillage sowings. Soybean – onion system and conventional tillage sowing was the best treatment combination for maximizing both the yields of soybean and *rabi* crops.

In soybean based cropping systems at Rudrur, it was observed that during *kharif*, minimum tillage sowing gave maximum soybean yield (1.04 t ha^{-1}) that was at par with conventional tillage (1.02 t ha^{-1}) but 31.6 % higher than zero tillage sowing. During *rabi* also, the similar trend was obtained and conventional tillage sowing gave maximum soybean equivalent yield (1.61 t ha^{-1}) that was at par with minimum tillage (1.53 t ha^{-1}) but 78.8 % higher than zero tillage sowing. The cropping systems did not affect the soybean yields (0.89 to 0.99 t ha^{-1}), however, soybean – mustard system gave maximum soybean equivalent yield (1.77 t ha^{-1}) of *rabi* crops followed by soybean – safflower (1.72 t ha^{-1}). Soybean – mustard system and conventional tillage sowing was the best treatment combination for maximizing both the yields of soybean and *rabi* crops.

In rice – rice cropping system at Kathalegere, it was observed that during summer, the system of rice intensification gave maximum rice yield (5.98 t ha^{-1}) that was at par with aerobic method (5.79 t ha^{-1}) but 34.3, 35.6, 42.0 and 45.5 % higher than hand transplanting, drum seeding, zero till drilling and mechanical transplanting, respectively.

In rice – rice cropping system at Bhubaneswar, it was observed that during *kharif*, bed planting gave maximum rice yield (5.87 t ha^{-1}) that was at par with drum seeding (5.54 t ha^{-1}) but 12.7, 12.9 and 13.1 % higher than mechanical transplanting, zero till drilling and hand transplanting, respectively. During *rabi* also, bed planting gave maximum rice yield (7.63 t ha^{-1}) that was, respectively, 4.1, 6.4, 23.3 and 28.6 % higher than mechanical transplanting, hand transplanting, drum seeding and zero till drilling.

In rice – rice cropping system at Kalyani, it was observed that during *kharif* hand transplanting gave maximum rice yield (3.33 t ha^{-1}) that was at par with sprouted seeding in line (3.00 t ha^{-1}) and sprouted broadcasting (2.79 t ha^{-1}) and drum seeding (2.79 t ha^{-1}) but 42.9 % higher than direct seeding under minimum tillage. During *rabi* also, hand transplanting gave maximum rice yield (5.16 t ha^{-1}) followed by sprouted line seeding (2.92 t ha^{-1}) and sprouted broadcasting (2.07 t ha^{-1}). The weed control practices did not affect rice yields both in *kharif* and *rabi*, however, numerically maximum yield was obtained in the treatment herbicide twice in *kharif* (2.99 t ha^{-1}) and herbicide once followed by hand weeding in *rabi* (2.17 t ha^{-1}).

In pearl millet based cropping systems at Hisar, it was observed that tillage as well as cropping systems did not affect yields of pearl millet and rabi crops. During *kharif*, the yield of pearl millet ranged between 3.32 and 3.43 t ha^{-1} . During *rabi*, the wheat equivalent yield in different tillage practices ranged between 5.56 and 5.84 t ha^{-1} . The pearl millet –

wheat cropping system gave wheat equivalent yield of 7.44 t ha^{-1} compared to 5.27 t ha^{-1} of pearl millet – mustard system.

In maize – Bengal gram cropping system at Siruguppa, it was observed that during *kharif* tillage practices did not affect the yield of maize crop, however, conventional tillage produced numerically maximum maize yield (3.75 t ha^{-1}). During *rabi*, the conventional tillage produced maximum yield of Bengal gram (0.72 t ha^{-1}) that was, respectively, 125, 126 and 160 % higher than reduced tillage, bed planting and zero tillage treatments. The crop residue management practices did not affect either maize (2.59 to 3.06 t ha^{-1}) or Bengal gram yields (0.35 to 0.45 t ha^{-1}).

In rice – sunflower cropping system at Siruguppa, it was observed that tillage as well as weed management practices did not affect yields of either rice or sunflower crops. Rice yield ranged between 4.97 and 5.21 t ha^{-1} whereas sunflower yield ranged between 0.39 and 1.71 t ha^{-1} . The tillage treatment wet cultivating and puddling in *kharif* - conventional tillage in *rabi* and integrated weed control was the best treatment combination to maximize the yield of rice (5.39 t ha^{-1}) and sunflower (2.57 t ha^{-1}) crops.

Long term effect of mechanization and resource conservation technologies in rice-wheat cropping systems on productivity, profitability and soil health

Mat type nursery raising technique for transplanter

It was observed under on-station as well as on-farm situations that the best combination for nursery raising was a size of $5.0 \text{ m} \times 1.2 \text{ m}$ nursery bed sown at 30 kg ha^{-1} seed (Saket - 4) rate and transplanting 16 to 20 days old seedlings at seedling

height (105–120 mm), root length (40-50 mm), trunk diameter (3.3-4.4 mm), thickness of seedling at the base of root (3.8-4.6 mm), leaf stage (3-5) and about 20 thousand seedlings m⁻² (Table 9.1/8).

Puddling requirement for transplanter

For determining optimum puddling requirement for rice transplanter, 4 levels of puddling; 0, 1, 2 and 3 passes of peg type puddler, were tried. In zero pass of puddling treatment, only dry tillage was done. The optimum puddling requirement for rice transplanter was one operation of puddler with corresponding puddling index of 39.7 per cent, depth of puddle profile of 57.4 mm, bulk density of 1.55 t m⁻³, water content of 47.4 per cent and penetration resistance of 1475 k Pa (Table 9.1/9).

Performance of rice transplanter

The performance of rice transplanter was good and was dependent on the condition of puddle bed, density of seedlings in the mat and operator's skills. Average number of hills m⁻² was found to be 42. The growth and subsequent establishment of the transplanted seedlings were faster having 0.42 million hills ha⁻¹ with 15-20 active tillers hill⁻¹. Under normal conditions the transplanter recorded 0.18 – 0.20 ha h⁻¹ field capacity, 2.35 – 2.5 l ha⁻¹ diesel consumption and planting of 3-5 seedlings per hill with average inter-hill spacing of 100 mm, standing angle of transplanted seedlings 70-75 degree and transplanting efficiency of 90 - 95 %. The uniform growth of crop was due to uniform depth of placement of seedlings at uniform spacing with equal number of seedlings per hill, resulting in higher yield in mechanically transplanted field.

Table 9.1/8. Rice yield (t ha⁻¹) obtained at different seed rates and ages of seedling transplanted by the transplanter

Seed rate (kg ha ⁻¹)	Age of seedling (days)				Mean
	16	20	25	30	
30	6.2	6.0	5.9	5.5	5.9
35	6.0	5.9	5.5	5.0	5.6
40	5.9	5.5	5.0	4.6	5.2
Mean	6.0	5.8	5.5	5.0	-

CD at 5% Seed rate= 0.14, Age of seedling= 0.16

Table 9.1/9. Characteristics of puddle bed as influenced by puddling level

Efficiency Parameter	Puddling level (No. of puddler passes)			
	0	1	2	3
Depth of puddle soil, mm	20.3	57.4	65.3	85.7
Amount of dispersion, %	15.4	39.7	45.3	55.3
Bulk density of puddle profile, t m ⁻³	1.64	1.55	1.58	1.67
Water content of puddle profile, %	33.2	47.4	48.6	49.7
Penetration resistance of puddle profile, k Pa	1900	1475	1600	1850

The grain yield of rice (Saket - 4) as affected by different levels of puddling and methods of transplanting is given in (Table 9.1/10). The results indicated that, the yield increased with puddling operations. The increase in grain yield was highest in one pass of puddler, both under manual (5.7%) and mechanical transplanting (9.1%), over zero pass. This increase in two passes of puddler was 3.4 and 5.0% under manual and mechanical transplanting respectively. The yield increase under three passes was 1.7% in manual and 3.2% in mechanical transplanting over two passes. The average increase in mechanical transplanting was 7.6 per cent compared to manual transplanting.

A comparison of cost under manual and mechanical transplanting revealed that the mechanical transplanting by rice transplanter provided considerable saving in labour (79%) and cost of operation (57%); higher yield (7.3%), net returns (27%), ben-

efit: cost ratio (21%), energy output: input ratio (13%); while requiring less specific cost (17%) and specific energy (11%) compared to manual transplanting (Table 9.1/11).

Evaluation of different crop residues management practices in rice-wheat cropping system on productivity, profitability and soil health

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

Table 9.1/10. Grain yield of rice as affected by different puddling levels and transplanting methods

Puddler passes	Transplanting method	Grain yield (t ha ⁻¹)
Zero	Manual	5.3
	Mech.	5.5
One	Manual	5.6
	Mech.	6.0
Two	Manual	5.8
	Mech.	6.3
Three	Manual	5.9
	Mech.	6.5

Table 9.1/11. Comparative economics and energy use of manual and mechanical transplanting of rice

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

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 straw (6 to 7 t ha⁻¹) as well as wheat straw (8 to 9 t ha⁻¹), the degree of recycling was 85-90%, and cost and energy of recycling of Rs 2650 ha⁻¹ and 2130 MJ ha⁻¹, respectively. There was appearance of yellowing in seedlings at the initial stage but subsequent establishment and growth of crops was found similar to non-straw recycled fields.

The recycled wheat straw got decomposed after about 50 to 55 days in rice fields.

The effect of different crop residue management practices on yield, benefit: cost ratio (B: C) and energy efficiency (EE) of rice and wheat are given in Fig. 9.1/6. The effect of crop residue management practices on the yield of rice and wheat over the years is depicted in Figs. 9.1/7-8. The *insitu* recycling of wheat straw produced 13 and 8 per cent higher rice yield than straw retrieval and burning treatments, respectively. The net returns under straw recycling were 17 and 11 per cent higher; B: C ratio

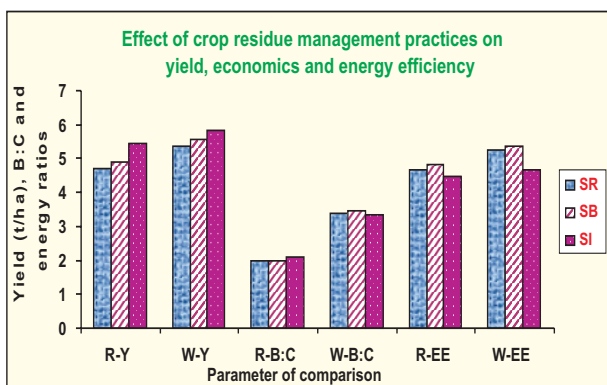


Fig. 9.1/6. Effect of crop residue management practices on yield (Y), economics (B:C) and energy efficiency (EE) of rice (R) and wheat (W) (SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)

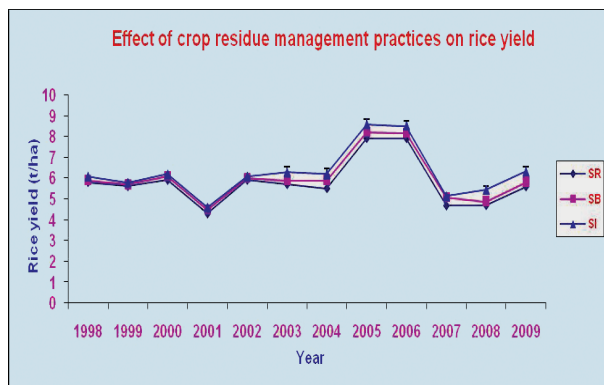


Fig. 9.1/7. Effect of crop residue management practices on rice yield over the years (SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)

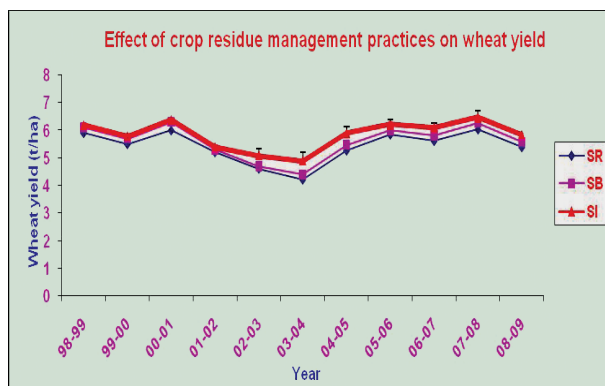


Fig. 9.1/8. Effect of crop residue management practices on wheat yield over the years (SR – Straw removed, SB – Straw burnt, SI – Straw incorporated)

and energy output: input ratio were 5 and 3% higher, and 3 and 6 per cent lower; and specific cost and specific energy 4 and 3 per cent lower, and 3 and 7 per cent higher, respectively. The recycling of rice straw increased the wheat yield (8%) and net returns (8%) but decreased B: C ratio (0.6%), energy output: input ratio (10%); and increased specific energy (12%) and specific cost (0.9%) compared to straw retrieval treatment. Crop residue recycling and burning improved soil organic carbon, SOC (39 and 8%) whereas retrieval decreased SOC (9%) compared to initial values after ten crop cycles. The recycling also improved SOC (54 and 30%) compared to retrieval and burning treatments. Crop residue recycling improved mean weight diameter of aggregates, MWD (15%), whereas retrieval decreased MWD (6%) compared to initial values after eleven crop cycles. The recycling also improved MWD (22 and 16%) compared to retrieval and burning treatments. The recycling of crop residues improved soil moisture content (13%), bulk density (1.2%) and cone index (17.5%) compared to residue retrieval.

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

Spent wash from sugar industries are being emanated in the combined drains, which contained very high organic carbon and other mineral nutrients. This effluent was studied for its use in crop production

and its subsequent impact on soil health. The field experiment conducted with two cropping systems as main plots (rice-wheat and rice-sugarcane), two planting techniques as sub plots (flat bed and raised bed) and five industrial effluents irrigation (normal water, 25, 50, 75 and 100% industrial effluents) as sub-sub plots. One irrigation as regards to the treatments was given to each crop and rest of the irrigation was compensated from the normal irrigation water. The effluent was characterized as pH 5.7-6.1, EC 30.5-38.2 dS m⁻¹ organic carbon 18.4 - 25.3 %, total solids 90845 – 11023 mg/l, nitrogen 650- 832 mg/l, P 164- 210 mg/l, Fe 121- 250 mg/l, Zn 17.6-21.3 mg/l, Cu 1.4-5.2 mg/l, Mn 12.3-14.5 mg/l and Na 980-1124 mg/l.

At the second year of the experiment, the grain yield of rice and wheat increased with the application of industrial effluent up to 50 percent, but it declined with subsequent increase in effluent concentration. On the other hand, straw yield in both the crops increased with the increased intensity of effluents for both the years, thus there was decline in the grain: straw ratio with the higher application of effluents.

Growing rice and wheat with the raised bed planting led to improve the grain: straw ratio (Table 9.1/12). Sugarcane yield, in contrast to rice and wheat, improved with the intensity of effluents. The yield was significantly better in raised bed (89.2 q ha⁻¹) over the flat bed 76.1 q ha⁻¹). The cane quality

Table 9.1/12. Impact of industrial effluent and planting technique on grain:straw ratio in rice and wheat

Irrigation	Rice		Wheat	
	Flat bed	Raised bed	Flat bed	Raised bed
Normal Irrigation Water	0.78	0.76	0.58	0.54
25%IE	0.32	0.41	0.47	0.48
50%IE	0.26	0.38	0.45	0.45
75%IE	0.24	0.34	0.44	0.45
100%IE	0.22	0.28	0.37	0.41

parameters analyzed during the harvest were improved with the use of industrial effluent as well as its intensity.

Soil microbial activities as determined by the DHA improved with the intensity of effluents. The equation $DHA = 19.936 \ln(\text{intensity of effluents}) - 89.23$ ($R^2 = 0.883^{**}$) clearly indicated the same. It could be correlated to the higher carbon content and availability of mineral nutrients in the effluents. After 2 years, the soil available nitrogen was marginally increased, but there was significant decline in the Olsen P content after 75% IE application. There was marginal increase in DTPA extractable Fe, Mn, Cu, Zn in the soil, and thus reflected by higher content of these nutrients in grain as well straw of both rice and wheat. There was higher retention of these minerals in the straw part of the plants.

Carbon mineralization study was conducted to correlate the higher carbon mineralization from soil surface after effluents application and its impact on biomass productivity. Lowering the grain: straw ratio was correlated with the higher carbon mineralization rates after effluents application (Fig. 9.1/9).

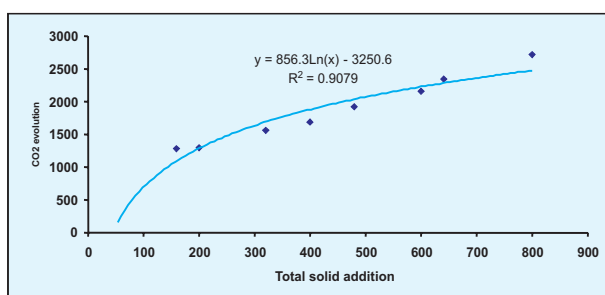


Fig. 9.1/9. Relation between total solid addition (g m^{-2}) soil and CO_2 evolution (mg m^{-2}) from the field

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

The experiment is being conducted under factorial RBD with 3 cropping systems (Rice- wheat,

Rice- barley and Rice- mustard) as main plots, 11 soil reclamation treatments (control), gypsum (@ 50% GR, FYM (@ 10 t ha⁻¹, FYM + gypsum, press mud (10 t ha⁻¹), press mud + gypsum, gypsum + *dhaincha* (green manure), gypsum + press mud (@ 5 t ha⁻¹) + FYM (@ 5 t ha⁻¹) and gypsum + press mud + FYM + *dhaincha* as sub- plots and two levels of fertilizers (25% excess N over recommended NPK) as sub-sub plots. Main plot treatments were significantly different from one another. Rice-barley gave highest rice equivalent yield, but in the IInd year the residual effect of mustard residue was highest on the productivity of rice for all the amendments. Among the amendments, gypsum + press mud (@ 5 t ha⁻¹) + FYM (@ 5 t ha⁻¹) gave highest REY (rice equivalent yield). Combination of gypsum with FYM and/or press mud together with green manure, in general, proved effective for increasing REY for all cropping systems, for soil microbial biomass, dehydrogenase activities in soil and root density (surface soil).

Application of 25% excess N over recommended NPK gave significantly higher REY in both experimental years than the recommended NPK. Interaction between cropping systems, amendments and fertilizer application were found significant for REY.

To test the field results of improving rice productivity after rice- mustard crop rotation, one micro plot experiment was conducted. During decomposition of mustard residues in the field there is marginal change in soil pH, which could be related with the better performance of rice under such system (Fig. 9.1/10).

REY was correlated with plant height ($r = 0.85$), number of tillers ($r = 0.97$), test weight ($r = 0.89$) and root density at 0-10 cm depth (0.78). After 2 year of experiment, marginal change in soil pH, soil organic carbon was recorded, but soil EC was

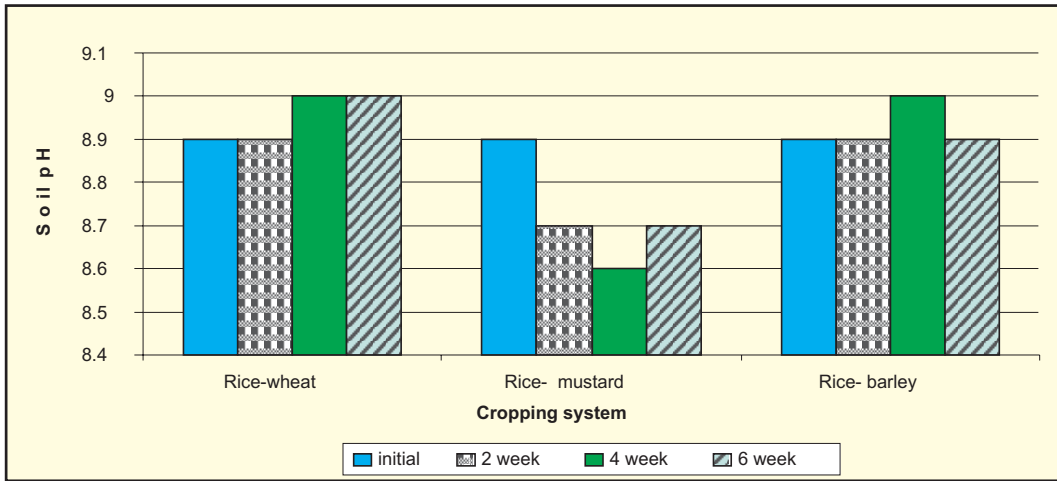


Fig. 9.1/10. Impact of different crop residue on soil pH

unchanged in all treatment. About 2.74 to 3.45 times increase in rhizospheric DHA activities were recorded when organic amendments were used either in isolation or in combination with gypsum. Among *rabi* crops, DHA activities were highest with rice-mustard combination. Application of 30% less irrigation to wheat, mustard and barley led to increase in REY by 25 to 37 percent in Ist year and 22-34 per cent in the IInd year.

Another micro plot experiment was conducted to find the means to minimize intensity of desiccation

of the saline-sodic soil, as after wetting, it becomes structureless and after drying it desiccated so fast to form very hard clods, almost impenetrable to soil air and hence adversely affecting plant growth. Five organic materials such as industrial effluent solids and residues of rice, wheat, mustard and barley were applied @ 1.0 kg /100 m² soil of 0- 5 cm depth was monitored for its weight loss gravimetrically at the alternate day. Application of effluent solid retained maximum moisture for the 10 days periods (Fig. 9.1/ 11).

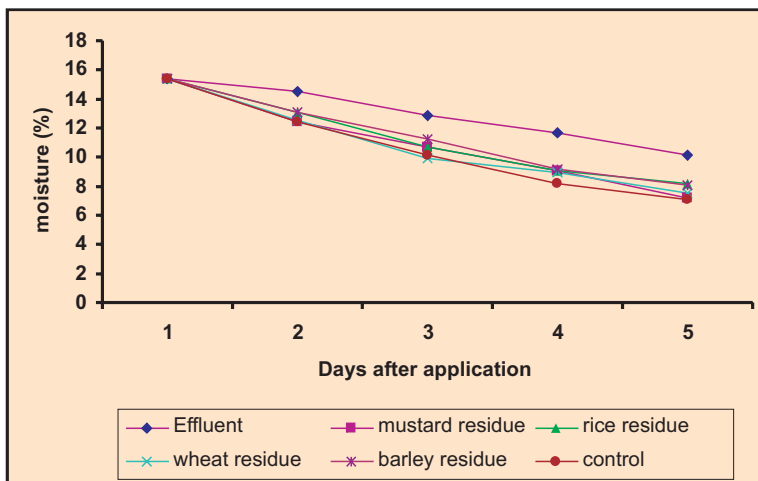


Fig. 9.1/11. Soil moisture receding in relation to residue type

Rice residue management for enhancing crop productivity, water and nutrient use efficiency and weed dynamics under rice-wheat system

Rice-wheat is a major crop rotation in the Indo-Gangetic Plains (IGP) of South Asia, spread over about 13.5 million ha. Effective management of crop residues is perhaps the foremost challenge for the intensive rice-wheat-producing regions. Burning of rice residues is cost-effective and the predominant method of disposal. Burning is often criticized for accelerating losses of soil organic matter and nutrients, increasing C emissions, causing intense air pollution, and reducing soil microbial activities used for *in situ* decomposition of rice straw.

Keeping above facts in view, a field experiment was conducted at the research farm of PDFSR, Modipuram during 2007-2009 with objectives to assess the effect of different methods of rice residue management on crop productivity, water and nutrient use efficiency, weed dynamics and soil organic carbon fractions in rice-wheat cropping system.

The results shows that the system involving direct seeded rice followed by residue incorporation along with application of 25% extra dose of nitrogen in conventional sown wheat crop gave significantly highest rice equivalent yield (REY) of about 12.48 t/ha/year, productivity of 34.20 kg ha⁻¹ day⁻¹ and irrigation water use productivity of 61.01 kg grain

Table 9.1/13. Effect of rice residue management on system and resource productivity of rice-wheat system

Kharif	Treatments Rabi	Rice Yield (t ha ⁻¹)	Wheat Yield (t ha ⁻¹)	REY (t ha ⁻¹ yr ⁻¹)	System Productivity (kg ha ⁻¹ day ⁻¹)	Resource use Productivity		Total weed biomass at 30 DAS (gm m ⁻²)
						Water (kg grain ha ⁻¹ cm)	Nutrient (kg grain kg ⁻¹ nut.)	
DSR	RR-RFD-CTW	4.58	4.48	10.18	27.89	49.75	63.38	42.8
DSR	RI-RFD-CTW	4.27	4.69	10.13	27.75	49.51	63.07	34.8
DSR	RI-25%extra N- CTW	4.63	5.52	11.53	31.59	56.36	67.22	39.4
DSR	RT-RFD-ZTW	4.52	5.21	11.03	30.22	53.91	68.68	33.2
DSR	RT-25%extra N- ZTW	4.80	6.15	12.48	34.20	61.01	72.76	43.2
DSR	RT-No ferti-ZTW	4.45	4.69	10.31	28.24	50.39	128.39	34.8
DSR	RR-No ferti-CTW	4.34	4.27	9.68	26.52	47.30	120.53	32.9
DSR	RR-RFD-CTW+ sunflower	4.56	5.42	11.33	31.04	55.38	70.55	28.6
DSR	RR-RFD-CTW+ maize	4.70	5.52	11.60	31.78	56.70	72.24	19.1
DSR	RR-RFD-CTW+ Celery	4.62	4.69	10.48	28.71	51.22	65.25	27.0
PuTPR	RR-RFD-CTW	4.75	3.96	9.70	26.57	41.34	60.39	11.2

DSR-Direct seeded rice, RI-Residue incorporated, PuTPR-Puddled transplanted rice, RFD-Recommended fertilizer doses, RR-Residue removed, CTW-Conventional tillage in wheat, RT-Residue retained, ZTW-Zero-tillage in wheat

ha⁻¹ cm of water (Table 9.1/13). In terms of nutrient use productivity retention of residue with no fertilizer application in wheat crop was found to be better which gave highest productivity of 128.39 kg grain/kg of nutrient used in the rice-wheat system. As for as weed bio-mass is concerned, the lowest weed biomass was recorded in wheat sown after conventional transplanted rice crop (11.20 g/m²) followed by the treatment where maize crop was grown in traffic lane (19.10 g/m²) for taking care related to micro-climate.

Impact on soil organic carbon fractions

The treatment comprised of three level of rice residue management (residue removed, residue retained and residue incorporated), two tillage application (zero tillage in case of plots where residue was retained, conservation tillage in plots wherein residue was removed and residue incorporated) and three level of fertilizer (no-fertilizer, recommended doses of NPK (RDF) and 25% extra N over RDF).

Water soluble carbon was found in order residue incorporated > residue retained > residue removed. Residue incorporation together with 25% extra N over RDF shown highest water soluble C (174 mg kg⁻¹ soil). Application of RDF increased the water soluble carbon over no-fertilizer in both plots where residue was retained at surface and residue incorporated in soil. On the other hand, removal of residue from the surface led to decrease in the content of water soluble carbon with fertilizer application. Humic acid carbon was slightly higher in treatments of residue removed as compared to the residue retained on surface or incorporated in soil. Application of fertilizer could not influence the humic acid carbon content in soil. Fulvic acid carbon was unaffected with the kind of residue management in case no-fertilizer was applied, but with RDF and 25% extra N over RDF it increased by 10.5 and 12.4 per cent, respectively. HA/FA ratio was decreased in case fertilizer application and residue retention/incorporation. Increased fulvic acid was correlated with the soil organic content in the soil and amount of residue leftover after rice harvest.

C. CONSERVATION AGRICULTURE

Evaluation of different resource conservation technologies for planting of rice

The comparative performance of different methods of rice planting, namely; hand transplanting (HT), transplanting by self-propelled transplanter (MT), transplanting by manual transplanter (MaT), bed planting (BP), zero till drilling (ZT), strip till drilling (ST), rotary till drilling (RT), drum seeding (DS) and sprouted broadcasting (BS), with respect to rice yield (Y), benefit: cost ratio (B: C), energy output: input ratio (EE), water use (WU), infiltration rate (IR) and weed infestation (We) was evaluated. The effect of planting methods on rice yield, benefit: cost ratio and energy efficiency is depicted in Fig. 9.1/12. The effect of planting methods on rice yield over the years is depicted in Fig. 9.1/13. We noted that the rice

(Saket – 4) yield was higher in MT (7.3%), ZT (6.3%), MaT (5.4%), BP (1.6%) and ST (1.0%); but lower in RT (0.5%); DS (3.0%), CS (8.6%) and BS (13.5%), respectively, compared to traditional HT (5.72 t ha⁻¹). The net return was 33% higher in ZT, 27 and 24% higher in MT and MaT; 15 to 19% higher in RT, ST and BP; 7% higher in DS; but 3 and 13% lower in CS and BS, respectively, compared to HT (Rs 26440 ha⁻¹). The B: C ratio was 33% higher in ZT, 22 to 18 per cent higher in ST, MT, MaT, BP and RT; 11 and 5% higher in DS and CS; but at par in BS, respectively, compared to HT (1.97). Energy output: input ratio was 26% higher in ZT, 15 to 5% higher in all the methods except DS, CS and BS, where it was 4 to 14% lower, compared to HT (5.57). The water use was 33% lower in BP; 1 to 5 per cent lower in all other

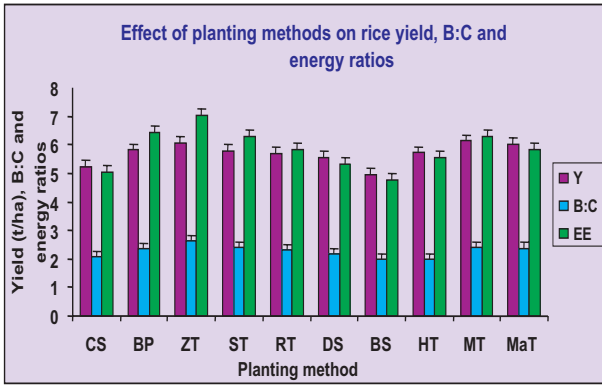


Fig. 9.1/12. Effect of planting methods on rice yield (Y), benefit: cost (B:C) and energy ratios (EE) (CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT – Transplanting by manual transplanter)

methods except CS, DS and BS, where it was 5 to 12% higher, compared to HT (202 ha-cm). The infiltration rate was maximum in BP (76 mm day⁻¹) and lowest (32 to 35 mm day⁻¹) in the three transplanting methods because of puddling. The weed dry matter was 88 to 265% higher in all the methods but 38 and 40 per cent lower in MaT and MT, compared to HT (52 kg ha⁻¹).

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

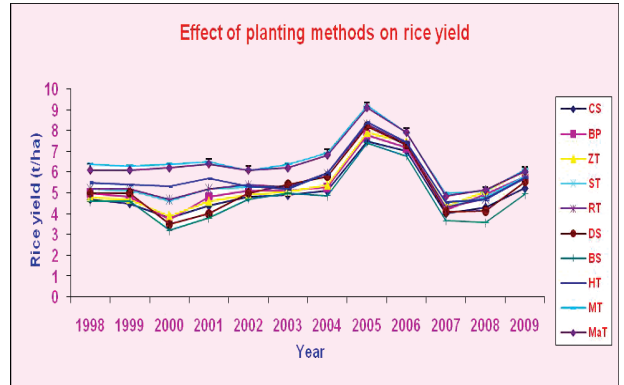


Fig. 9.1/13. Effect of planting methods on rice yield over the years (CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling, DS – Drum seeding, BS – Sprouted broadcasting, HT – Hand transplanting, MT – Mechanical transplanting, MaT – Transplanting by manual transplanter)

of rice saved time (88 to 85%), labour (87 to 83%), diesel (87 to 61%), cost (81 to 65%), energy (87 to 62%) and also irrigation water (6 to 37%) as compared to conventional sowing (Table 9.1/14). The rice yield, economics and energy use affected by different methods is given in Table 9.1/15. The zero till drilling produced higher rice yield (16 %), net returns (38 %), B: C ratio (26 %) and energy output: input ratio (39 %) while requiring lesser specific cost (20 %) and specific energy (28 %), compared to conventional sowing. The rotary till drilling produced output: input ratio (15 %) while requiring lesser specific cost (10 %) and specific energy (13 %), compared to conventional sowing. The strip till drilling produced higher rice yield (10 %), net returns (24 %), B: C ratio (15 %) and energy output: input ratio (25 %) while requiring lesser specific cost (13 %) and specific energy (19 %), compared to conventional sowing. The bed planting produced higher rice yield (11 %), net returns (22 %), B: C ratio (13 %) and energy output: input ratio (28 %) while requiring lesser specific cost (11 %) and specific energy (21 %), compared to conventional sowing.

Table 9.1/14. Performance parameters of different rice seeding machines

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

Table 9.1/15. Yield, economics and energy use in different methods of direct dry seeding of rice

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

Evaluation of drum seeder for direct seeding of sprouted rice

The performance of drum seeder was evaluated against broadcast method of direct sowing of sprouted rice under unpuddle condition. The pre-germinated rice (Saket - 4) seeds were sown at the rate of 30 kg ha⁻¹. The performance of 8-row drum seeder was satisfactory (field capacity = 0.06 ha

h⁻¹, field efficiency = 50 %, Cost of operation = Rs 500 ha⁻¹ and energy requirement = 70 MJ ha⁻¹). Drum seeding provided higher rice yield (12%), net returns (23%), B: C ratio (11%), energy output: input ratio (12%) while requiring lower specific energy (10%) and specific cost (10%) compared to broadcasting method of sprouted seeding of rice (Table 9.1/16).

Table 9.1/16. Economics and energy use of different methods of seeding of sprouted rice

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

Evaluation of different drill machines for planting wheat succeeding rice

The comparative performance of different machines namely; bed planter (BP), zero-till drill (ZT), strip-till drill (ST), rotary-till drill (RT), and conventional drill (CS), in terms of wheat yield (Y), benefit: cost ratio (B: C), energy output: input ratio (EE), water use (WU), infiltration rate (IR), *Phalaris minor* (PM) and other weeds (OWE) was assessed. The effective field capacities of RT, ST, ZT, BP and CS were 0.44, 0.41, 0.55, 0.35 and 0.48 ha h⁻¹, respectively (Table 9.1/17). The rotary, strip and zero till drilling and bed planting were time saving (80, 79, 85 and 75%), labour saving (70, 75, 76 and 72%), diesel saving (66, 85, 87 and 86%), cost

saving (59, 73, 83 and 79%), energy saving (66, 85, 87 and 86%) and also irrigation water saving (9.5, 9.1, 10.6 and 37%) compared to conventional sowing of wheat. Also, there was saving of about 20-25% in seed and fertilizer inputs in bed planting compared to conventional sowing. Zero, strip and rotary till drills and bed planter provided higher wheat yields (13-22%), net returns (25-34%), cost effectiveness (25-31%) and energy efficiency (33-41%); required lower specific energy (25-29%) and specific cost (20-24%); and reduced *Phalaris minor* (42-74%), other weeds (56-70%), compared to conventional sowing of wheat (Fig. 9.14). The effect of planting methods on wheat yield over the years is depicted in Fig. 9.1/15.

Table 9.1/17. Comparison of performance of bed planter (BP), zero (ZT), strip (ST) and rotary-till (RT) drills with conventional drill (CS)

Parameter	CS	BP	ST	ZT	RT
Row spacing, mm	180	120	180	180	180
No. of operations (including seed bed preparation)	6	1	1	1	1
Effective field capacity, ha h ⁻¹	0.48	0.35	0.41	0.55	0.44
Field efficiency, %	64	62	61	67	63
Fuel consumption, l ha ⁻¹	54.6	7.6	8.4	7.2	18.4
Cost of sowing, Rs. ha ⁻¹	3350	690	910	585	1375
Energy requirement, MJ ha ⁻¹	3096	436	480	412	1042
Grain yield, t ha ⁻¹	4.88	5.49	5.68	5.96	5.78
Benefit: cost ratio	2.90	3.64	3.60	3.80	3.63
Specific energy, k cal kg ⁻¹	627	472	463	445	469
Energy output: input ratio	4.79	6.36	6.48	6.75	6.40
Specific cost, Rs. kg ⁻¹	5.31	4.24	4.24	3.96	4.19

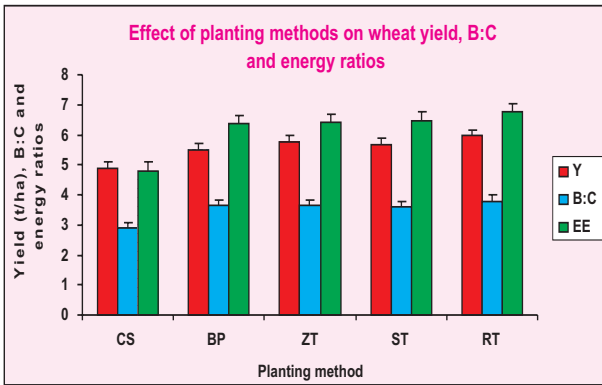


Fig. 9.1/14. Effect of planting methods on wheat yield (Y), benefit: cost (B:C) and energy ratios (EE) (CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)

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

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

An experiment was started during the *kharif* 2008 season in which the main plot treatments were direct seeded rice (DSR), SRI method of rice cultivation (SRI) and conventional rice cultivation.

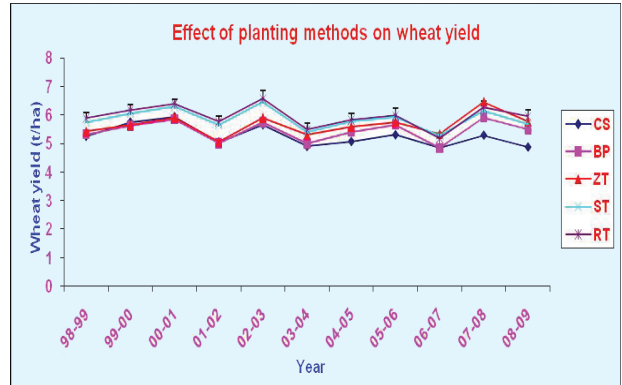


Fig. 9.1/15. Effect of planting methods on wheat yield over the years (CS – Conventional sowing, BP – Bed planting, ZT – Zero till drilling, ST – Strip till drilling, RT – Rotary till drilling)

In the main plot treatments, different sub-plot treatments like zero till wheat, bed planting of wheat, conventional tilled wheat, happy seeder planted wheat and zero till wheat was grown during *rabi* season. 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 water, which is required for transplanted rice. Twenty one day old seeding was transplanted at 20x15cm spacing.

Significantly higher grain yield of rice (5.21 t ha⁻¹) was recorded under SRI method of cultivation over direct seeded rice and conventional method of

rice cultivation. The yield increase of rice under SRI was 15 % compared to conventional method of rice cultivation. The yield attributing characters of rice were also highest under this treatment (Table 9.1/18). Various carbon inputs measured in above ground (shoot) and below ground (root) at different growth stages have been shown in (Table 9.1/19-20). Irrespective of growth stages, the root and shoot biomass accumulation was higher under SRI

method of rice cultivation. The dry root biomass accumulation was 1.12 t ha⁻¹ at a maximum tillering stage and shoot biomass 5.59 t ha⁻¹ at the same crop growth stage. Microbial population in soil in terms of various standard groups has been depicted in Table 9.1/23 which clearly shows the superiority of SRI over other treatment in terms of population structure. Likewise, microbial biomass carbon which was highest under SRI exhibited a gradual increase

Table 9.1/18. Yield and agronomic characters in rice under various cultural practices ((*khariif* 2009)

Treatment	Grain Yield (t ha ⁻¹)	Straw Yield (t ha ⁻¹)	Ear head Length (cm)	Plant Height (cm)	Effective Tillers 1m	1000 grain wt (g)
DSR	3.54	4.95	20.5	100.2	302	20.2
SRI	5.21	7.58	21.3	108.7	452	24.2
Conventional	4.53	7.25	20.9	105.4	425	23.8
Control	1.25	2.41	10.2	7.52	150	15.3
SEM(±)	0.52	0.82	0.3	2.7	21	1.2

Table 9.1/19. Above ground biomass accumulation in rice under various cultural practices

Treatments	Biomass (t ha ⁻¹)			
	20days after transplanting	30days after transplanting	40days after transplanting	Maximum tillering stage
DSR	0.79	1.89	3.01	4.21
SRI	1.50	2.51	3.52	5.59
Conventional	1.11	2.12	3.14	5.34
Control	0.54	0.67	0.75	2.56
SEM(±)	0.07	0.34	0.27	0.45

Table 9.1/20. Accumulation of root biomass carbon in rice as influenced by various cultural practices

Treatments	Root Biomass (t ha ⁻¹)			
	20days after transplanting	30days after transplanting	40days after transplanting	Maximum tillering stage
DSR	0.18	0.42	0.69	0.81
SRI	0.25	0.51	0.75	1.12
Conventional	0.21	0.49	0.61	0.93
Control	0.14	0.31	0.45	0.62
SEM(±)	0.07	0.11	0.15	0.23

Table 9.1/21. Micobial biomass carbon at different growth stages of rice under resource conservational packages

Treatment	MBC($\mu\text{g/g soil}$)			
	During transplanting	10 days after transplanting	20days after transplanting	Maximum tillering stage
DSR	82.0	125.7	155.3	207.4
SRI	89.0	148.3	190.2	250.4
Conventional	60.5	137.1	157.3	180.7
Control	55.4	80.3	120.1	125.8
SEM(\pm)	7.5	11.2	15.4	21.3

Table 9.1/22. Soil properties under various conservational practices in rice during maximum tillering stage

Treatment	O.C (%)	Average N (kg ha^{-1})	Average P (kg ha^{-1})	Average K (kg ha^{-1})
DSR	0.300	326.144	37.5	203.28
SRI	0.465	338.512	42.3	240.8
Conventional	0.315	301.056	32.8	201.61
Control	0.321	242.5	25.7	195.3
SEM(\pm)	0.03	23.3	5.7	11.4

Table 9.1/23. Microbial Population in soil under various conservational practices in rice during maximum tillering stage

Treatment	Heterotrophic Bacteria $\times 10^6$	Bacteria $\times 10^7$	Fungi $\times 10^4$	Actinomycetes $\times 10^5$	Nitrogen fixing bacteria		
					$\times 10^3$	$\times 10^4$	$\times 10^5$
DSR	27.951	100.36	16.262	25.3	125.33	76.66	36.66
SRI	66.746	231.19	21.666	32.6	148	95.33	40.66
Conventional	40.963	163.75	14.25	23.3	111	80.16	37.33
Control	25.43	87.5	10.2	18.5	91.2	25.8	30.2
SEM (\pm)	9.2	4.5	5.2	4.2	11.6	5.7	1.3

from transplanting to maximum tillering stage of rice (Table 9.1/21). Soil properties in terms of OC and NPK were also highest under SRI method of rice cultivation (Table 9.1/22).

Resource Conservation Modules for high yield realization of different cropping system

The field experiment was conducted during 2009-10 with the objective to study the resource

conservation modules for high yield of different cropping systems and to find out the high value cropping system based on productivity, resource conservation and climate change. The treatments consisted of two tillage levels i.e zero tillage (ZT) and conventional tillage (CT) in main plots and 4 cropping systems (i.e rice-wheat, rice-winter maize, rice-barley and rice-mustard) in sub plots whereas mulch @ 6 t ha^{-1} and no mulch x recommended fertilizers ($120:60:40 \text{ kg NPK}$) and 125% higher

Table 9.1/24. Yield and yield attributes of hybrid rice as influenced by tillage levels (mean of 2 *kharif* season)

Treatment	Plant height (cm)	Effective tillers m ⁻²	Panicle length (cm)	Panicle weight (g)	1000-grain weight (g)	Grain yield (t ha ⁻¹)
Direct seeded (ZT)	106.3	419.5	24.13	2.92	24.45	5.13
Mechanical transplanted (MT)	112.5	468.8	27.00	3.14	25.87	6.44
CD at 5%	2.92	15.67	1.57	0.13	0.93	0.94

than recommended fertilizers (RDF) in sub sub-plots in split split plot design with 3 replications. Results showed that mechanical transplanted hybrid rice produced the highest mean yield of 6.44 t ha⁻¹ which was 25% higher than zero till direct seeded rice (5.13 t/ha). This higher yield under mechanical transplanted rice was attributed to higher numbers of effective tillers m⁻², panicle length, panicle weight and 1000-grain weight (Table 9.1/24). The grain and rice equivalent yields were affected significantly due to different resource conservation practices (Table 9.1/25). Conventional tillage recorded significantly higher

grain (5.04 t ha⁻¹), straw (7.96 t ha⁻¹) and rice equivalent yield (6.05 t ha⁻¹) compared to zero tillage. The higher yield under conventional tillage could be attributed to better pulverization of soil resulting in proper seed and soil contact, which caused good germination, growth and development of plants. The grain yield was 6.32 per cent more in conventional tillage than that of zero tillage. The barley and winter maize produced significantly higher grain yield (6.21 t ha⁻¹) and straw yield (5.86 t ha⁻¹), respectively while wheat gave highest rice equivalent yield (7.24 t ha⁻¹) and lowest yields were recorded by mustard in rice

Table 9.1/25. Effect of resource conservation modules on yield, rice equivalent yield, harvest index, cost of production, net return and B:C ratio

Treatments	Grain yield (t/ha)	Rice equivalent yield (t/ha)	Harvest index (%)	Cost of production (Rs./ha)	Net return (Rs./ha)	Benefit: Cost ratio
<i>Tillage levels</i>						
Zero	4.74	5.67	37.25	16600	34590	2.08
Conventional	5.04	6.05	37.22	18.200	36232	1.99
CD (P=0.05)	0.27	0.19	NS	-	-	-
<i>Cropping Systems</i>						
Rice-wheat	5.73	7.25	37.28	18200	43684	2.40
Rice-winter maize	5.96	5.57	37.15	16700	30980	1.86
Rice-barley	6.21	6.17	37.26	17300	38590	2.23
Rice-mustard	1.65	4.45	37.25	10200	19500	1.91
CD (P=0.05)	0.21	0.12	0.13	-	-	-
<i>Mulch x fertilizer</i>						
Mulch (0) x RDF	4.63	5.53	37.28	18200	31804	1.75
Mulch (0) x 125% RDF	4.94	5.92	37.15	22474	39426	1.75
Mulch (6 t/ha) x RDF	4.77	5.70	37.26	19700	36837	1.86
Mulch (6 t/ha) x 125% RDF	5.21	6.29	37.25	24099	42442	1.76
CD (P=0.05)	0.21	0.12	NS	-	-	-

based cropping systems. Application of mulch @ 6 t ha⁻¹ and 125% higher than RDF resulted in significantly higher grain (5.21 t ha⁻¹), straw (8.26 t ha⁻¹) and rice equivalent yield (6.29 t ha⁻¹) over rest of the treatments. Application of mulch (@ 6 t ha⁻¹) along with recommended doses of fertilizer did not exhibit significant difference with respect to grain and straw yield. The higher yield under 125% higher than recommended fertilizer + mulch @ 6 t ha⁻¹ may be attributed to increased dose of fertilizer which enhanced the availability of nutrients to growing roots and resulted in vigorous growth of the plants and improved the yields. Application of mulch @ 6 t ha⁻¹ also suppressed the growth of weeds resulting in better growth and higher yield of crop. The harvest index was not affected significantly due to tillage and

mulch x fertilizer. However, highest harvest index (37.28%) was recorded in rice-wheat system while lowest being 37.15% in rice-winter maize cropping system. The economic returns were higher (Rs. 36,232 ha⁻¹) under conventional tillage due to higher grain yield and benefit: cost ratio was higher under zero tillage (2.08) on account of lower cost of production. Among cropping systems, rice-wheat system recorded the highest return (Rs. 43,684 ha⁻¹) and B: C ratio (2.40) while lowest net returns (Rs. 19,500) and B: C ratio (1.80) were obtained in rice-mustard and rice-winter maize system, respectively. The highest net returns (Rs. 42,442 ha⁻¹) and B: C ratio (1.86) was registered with mulch @ 6 t ha⁻¹ x 125% higher than RDF and mulch @ 6 t ha⁻¹ x RDF, respectively.

D. NUTRIENT MANAGEMENT

Integrated nutrient management in transplanted rice-wheat system

A long-term study initiated in *kharif* 1993 on sandy loam (Typic Ustochrept) soil at Project Directorate's research farms, Modipuram, was continued for the 17th consecutive year during 2009-10. The initial values for important soil characteristics at onset of the experiment were pH 7.98, EC 0.42 dS/m, organic carbon 0.41 percent, other P 16.4 kg/ha, available K 96 kg/ha and available S 14.5 kg/ha. Thus, the soil was low in OC, available K and S, and medium in available P content. The experiment was 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). The results pertaining to rice crop during 2009-10 are briefly described here:

Grain yield of rice and its productivity dynamics

Fertilizer NPK applied at recommended rate, resulted in significant increase in rice yield over unfertilized control that recorded lowest yields amongst the treatments (1.72 t ha⁻¹) (Table 9.1/26). Application of 45 kg S ha⁻¹ with recommended NPK+Zn application schedule had further additive effect on improving productivity of the crops. The yield advantage in rice, due inclusion of S in fertilizer application schedule over NPK+Zn treatment, was 29% during 2009-10. Among the organic sources used for integrated nutrient supply, SPM along with sub-optimal levels of fertilizer NPK i.e. 75% of recommended NPK was higher to FYM and GR incorporation after 16 crop cycles. Integrated use of SPM + 75% NPK Zn brought an yield advantages of 35% in rice over recommended NPK+Zn application. Such advantage was also noted with integrated FYM and GR over NPK+Zn

Table 9.1/26. Long term effect of integrated nutrient supply on the grain yield ($t\ ha^{-1}$) of rice and temporal change (%) in its productivity

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

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

treatment but it restricted only upto 21% t/ha in rice. Use of 75% NPK along with SPM or FYM in wheat did not proved beneficial where rice received recommended dose of NPK. Curtailing NPK fertilizer by 25% in both the crops for use of CR did not prove advantageous for rice yield as compared to NPK Zn treatments by 10% in rice.

A perusal of yield trends during last 17 years suggested that continuous rice-wheat cropping without fertilizer or manure application resulted in yield reduction by 28% in rice (Table 9.1/26). Fertilizer applied at recommended dose also could not prevent yield decline in rice, although the extent of reduction was smaller (-4.5%) than unfertilized plots. Balancing of fertilizer dose with $45\ kg\ S\ ha^{-1}$ accounted for higher yield improvement by 8.9% in rice. Among the organic sources used for substitution of 25% NPK, SPM proved superior over others, and gave 19% extra rice yield over its initial yield. Application of SPM or FYM to rice in monsoon

season crop had more pronounced effect than its application in winter crop. Growing of mungbean during fallow period of summer and its residue incorporation after picking of pod before rice transplanting +25% NPK substitution for rice crop gave 15% higher yield advantage over the years.

Effect on P Fractions

Soil P fractions were evaluated for water soluble P and Olsen P fractions during report period after rice crop harvest (Table 9.1/27). The Olsen P content in soil was modified with the integration of organic sources and highest being with SPM applied plots followed by GR applied treatment and FYM application use. The other treatments had 10 to 55% smaller Olsen P content compared to SPM, GR and FYM applied plots. Application of organic sources for 25% NPK substitution during *Rabi* season (wheat) did not prove its significance for Olsen P content. The water soluble P values ranged between

Table 9.1/27. Effect of integrated organic use on P fractions

<i>Rice</i>	<i>Wheat</i>	Water soluble-P (mg kg ⁻¹)	Olsen-P (mg kg ⁻¹)
Unfertilized	Unfertilized	NIL	22.7
NPK Zn	NPK	NIL	28.1
NPK Zn+S	NPK +S	NIL	31.4
75 NPK+25N (FYM)	NPK	3.7	39.2
75 NPK+25N (SPM)	NPK	2.4	41.7
75 NPK+GR	NPK	2.4	40.3
NPK	75 NPK+25N (FYM)	NIL	31.0
NPK	75 NPK+25N (SPM)	NIL	30.5
75 NPK +GR	75 NPK+25N (FYM)	2.7	37.9
75 NPK+25N (CR)	75 NPK+25N (CR)	1.2	38.2
NPK+25N (FYM)	NPK+25N (FYM)	3.1	40.1

1.2 to 3.7 mg/kg and was only noticed in treatments where integration of organic source was made during the *Kharif* (rice) season.

Development of sustainable production model for rice-wheat system

The field experiment initiated in *kharif* 1998 in order to develop a synthesized model of sustainable rice-wheat system was continued for twelfth consecutive year (2009-10) at the Directorate's Research Farm, Modipuram. In order to address the major non-sustainability issues of declining soil fertility and increasing weed infestation, the treatment included were as T₁- Control i.e., no chemical fertilizer or organic manure, T₂- Recommended fertilizer dose to rice and wheat (SR), T₃- 75% of recommended NPK as fertilizer+25% N as FYM to rice and recommended NPK fertilizer to wheat, T₄- Fertilizer similar to T₃, but substitution of every third wheat crop with berseem, T₅- Fertilizer similar to T₃, but substitution of every third rice crop with forage cowpea, T₆- Soil-test based fertilizer use in rice and wheat (STCR) and T₇- Organic farming.

Yield and yield attributes

Rice

The grain yield of rice ranged between 1.78 and 6.21 t ha⁻¹, being lowest in control and the highest with soil-test based fertilizer use (Table 9.1/28). With recommended fertilization i.e., 120 kg N+ 26 kg P+ 33 kg K ha⁻¹, the grain yield was higher by 3.7 t ha⁻¹ over control. Under organic farming which received 24 t FYM and entire straw component of preceding wheat, the grain yield was 4.26 t ha⁻¹ i.e., 1.22 t less than recommended fertilization. Different IPNS options (Treatment 3,4 and 5) did not differ among them self but had edge over STCR and state recommendations (SR). Straw yields ranging between 2.52 and 8.42 t ha⁻¹ followed a similar pattern. Compared with previous years, the yield differences between T₂, and IPNS/T₆ treatments broadened this year, indicating the superiority of balanced nutrition over local *ad hoc* recommendation. Amongst yield attributes, number of ear m⁻² and grain weight ear⁻¹ followed a trend similar to grain yield. Number of grains ear⁻¹, grain

and grain weight ear⁻¹ were similar in T₃, T₄, T₅ and T₆, although markedly higher than control (T₁), SR (T₂) and organic farming (T₇). The yield attributes given in Table 9.1/28 indicated that grain weight ear⁻¹ accounted most for higher yield under soil-test based fertilizer use. Interestingly, grain weight ear⁻¹ under organic farming was comparable with *ad-hoc* fertilization or IPNS treatments, although number of ears m⁻² and number of grains ear⁻¹ were distinctly low under organic farming.

Studies on weed infestation

The weed flora counted at 35 DAT in rice revealed the advantage of introduction of a break crop of forage legume (Table 9.1/29). The lowest count of 6-11 weed plants m⁻² in rice was recorded in treatments, where berseem or cowpea was grown to substitute wheat or rice at a definite time interval. Although the noxious weed population was substantially lower under organic farming plot but the other weed population was maximum in this treatment.

Table 9.1/28. Yield and yield-attributes of rice as influenced by nutrient and crop management strategies

Treatment	Yield (t ha ⁻¹)		No. of ears m ⁻²	No. of grains ear ⁻¹	Grain weight/ ear(g)
	Grain	Straw			
T ₁	1.78	2.52	181	46	0.84
T ₂	5.48	7.43	242	71	1.59
T ₃	6.06	8.12	263	82	1.67
T ₄	6.21	8.30	271	78	1.72
T ₅	6.13	8.42	255	80	1.65
T ₆	5.84	7.48	248	78	1.70
T ₇	4.26	4.11	216	67	1.58

T₃, T₄ & T₅ are integrated plant nutrient supply (IPNS)

Table 9.1/29. Effect of nutrient and crop management strategies on weed intensity in rice-wheat system

Treatt.	Rice (2001)			Total
	<i>Echinochloa</i> spp.	<i>Cynodon dactylon</i>	Others	
T ₁	8	4	6	18
T ₂	7	2	9	18
T ₃	5	2	12	17
T ₄	2	-	4	6
T ₅	3	-	8	11
T ₆	7	3	10	20
T ₇	4	2	16	22

E. CROP-CLIMATE RELATIONSHIP STUDIES

Physiological evaluation of rice and wheat genotypes under changing climatic scenario

A field experiment was started during *kharif* 2008 to evaluate 20 genotypes of rice and wheat for their phenological growth in relation to climatic conditions and to monitor different morpho-physiological parameters in relation to productivity. Twenty five days old seedlings of rice were transplanted in the field on June 18, 2009. Wheat was sown on November 17, 2009 during *rabi* 2009-10. Observations were recorded on various

phenophases and morpho-physiological parameters of growth and productivity (Fig. 9.1/16-18).

Phenological variations were observed in panicle emergence (PE), 50 % PE and maturity in different rice genotypes. Early panicle emergence (49-52 days after transplanting, DAT), 50 % PE (53-58 DAT) and maturity (82-96 DAT) were observed in Ananda, Poornima and Saket 4 among non-basmati types, PD-10, PD-12, PR 115, PR 111 & PR116, IR 74, Naveen

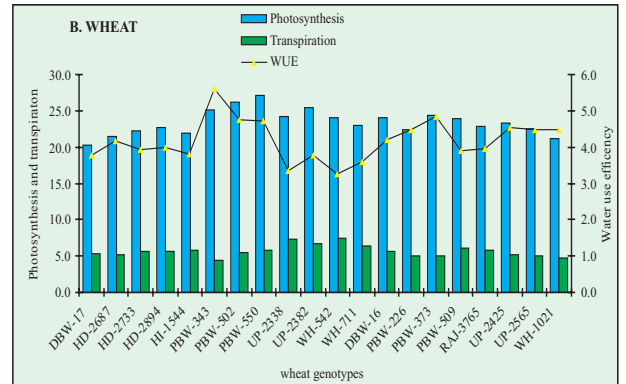
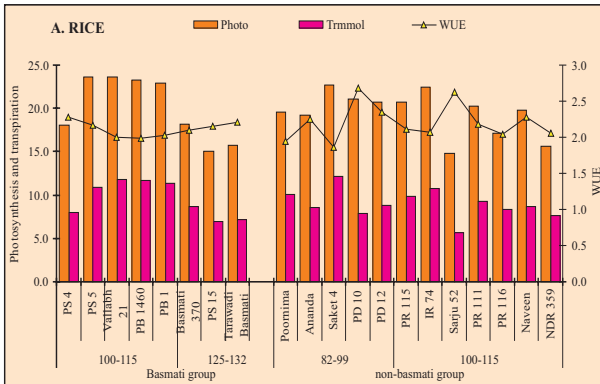


Fig. 9.1/16. Genotypic variations in photosynthesis, transpiration and water use efficiency (photosynthesis in μ mole $\text{CO}_2 \text{ m}^{-2} \text{ s}^{-1}$, transpiration in μ mole $\text{H}_2\text{O m}^{-2} \text{ s}^{-1}$ and WUE in μ mole $\text{CO}_2 \text{ mole}^{-1} \text{ H}_2\text{O}$)

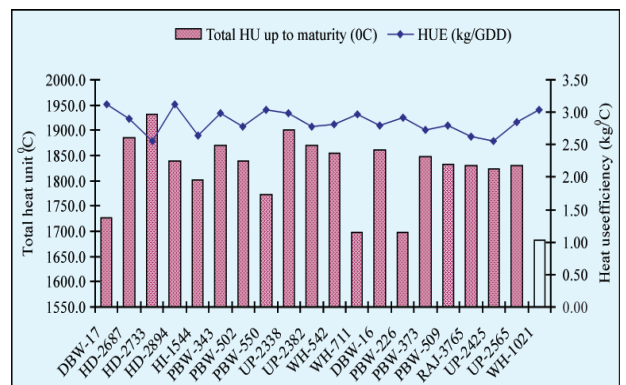
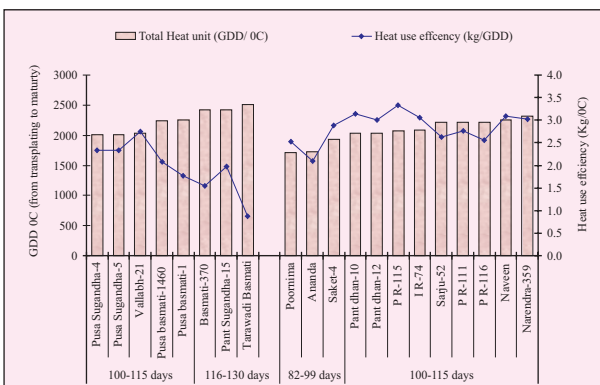


Fig. 9.1/17. Genotypic variations in total heat unit and heat use efficiency in rice

Fig. 9.1/18. Genotypic variations in total heat unit and heat use efficiency in wheat

and Narendra 359, behaved relatively early in terms of 50 % PE (60-75 DAT) and maturity (100-115 DAT) than the fine basmati genotypes (Basmati 370, Pant Sugandha 15 and Tarawadi basmati) which matured in about 115-130 DAT. Linear increase in LAI was observed in all the genotypes up to 9th week after transplanting (ATP) except in Ananda and PR 111 where maximum LAI reached at 6th week ATP, and Naveen, where it was linearly increased up to 12th week ATP. In all the genotypes, LAI started declining from 9th week ATP. Biomass accumulation was linearly increased up to maturity in all the genotypes, except in Poornima and Ananda, where linear increase in biomass was noticed only up to 12th weeks ATP, thereafter it was stabilised till maturity. Tillers number m⁻² was linearly increased up to 40 days after transplanting (DAT), thereafter it started declining in all the genotypes. Like biomass, plant height was also increased in all the genotypes up to maturity, except in Poornima, Ananda and Narendra- 359 (non-basmati types), and Pusa basmati 1 where it was more or less same at 84 DAT.

Photosynthesis (μ mole CO₂ m⁻² s⁻¹), in general, was higher in early basmati (22.9-23.6) and non basmati type (19.1-22.7) than the longer duration in both the groups, except in PS 4 and IR 74. LAI, on the other hand, was relatively lower in early types (4-5) in both basmati and non-basmati types than the longer duration in both the groups (5-8) except in IR 74 (Fig. 9.1/16A). Grain yield was, however, higher in early basmati types (4-6 t ha⁻¹) than the late maturing types (2-5 t ha⁻¹). On the other hand, among non-basmati types, higher grain yield was observed in late maturing genotypes (6-7 t ha⁻¹) than the early maturing genotypes (3.6-5.6 t ha⁻¹). High grain yield in early basmati genotypes was largely due to high HI (33-40 %) as compared to late maturing (17-32 %) group of genotypes. Among non-basmati types, HI was also higher in early maturing genotypes (45-47 %) but the 1000 grain weight was relatively low

(20-21 g) in these genotypes as compared to late maturing genotypes (18-27 g) resulting in low grain yield. Total heat unit requirement i.e. growing degree days (GDD) was relatively low in the early type genotypes (1700-2000 °C) than the late maturing genotypes (2030-2500 °C). Heat use efficiency (HUE, Kg/GDD) in basmati genotypes was more in early (2.33-2.75) than the late maturing (0.87-2.08) (Fig. 9.1/17). On the other hand in non-basmati genotypes, no such trend was noticed, however, relatively higher HUE was observed in late maturing genotypes (2.56-3.34) than the early types (2.10-2.89).

Genotypic variations in wheat were observed in stature (88-98 cm), crop phenology i.e. spike initiation (83-100 days after sowing, DAS), 50 % flowering (92-108 DAS) and physiological maturity (129-140 DAS), and different morpho-physiological parameters (biomass, leaf area, photosynthesis and water use efficiency) which resulted in accountable variation in grain yield and yield components (Fig. 9.1/16B). RAJ-3765, UP 2382, PBW 550, UP 2425, WH 1021, WH 711, HI 1544 and PBW 226 were early in flowering (92-98 DAS) than other genotypes which flowered in 98-108 days. All these genotypes attained physiological maturity in about 128-135 DAS. PBW 226, HD 2687, WH 1021, U.P. 2382, U.P. 2338, PBW 343, PBW 502, PBW 509, UP 2565, U.P. 2425, HD 2894 and WH 542 were relatively taller (94-98 cm) than HI 1544, RAJ 3765, WH 711, PBW 550, HD 2733, DBW 16, DBW 17, and PBW 373 (88-93 cm). There was a linear increase in leaf area (LAI) up to 87 DAS growth stage, where highest LAI was observed in all the genotypes except PBW 226 where it was highest at 66 DAS and declined thereafter. Biomass and plant height, on the other hand, were linearly increased up to 110 DAS. Sigmoid growth was observed in tiller numbers m⁻² and highest tiller numbers were recorded at 60 DAS in all the genotypes. Numbers of tillers were relatively higher

in PBW 550, PBW 343, PBW 373, HD 2687, DBW 16, PBW 50, and RAJ 3765 genotypes (480-507) as compared to UP 2382, WH 1021, UP 2425, HI 1544 and DBW 17 (400-450) genotypes. High photosynthesis ($24-27 \mu \text{mole CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) and water use efficiency ($4.73-5.60 \mu \text{mole CO}_2 \text{ mole}^{-1} \text{ H}_2\text{O}$) was observed in PBW 550, PBW 343, PBW 502 and PBW 373 (Fig. 9.1/16B). Significant genotypic variations in grain yield and different yield contributing parameters (spike length, number of spikelets, number of grains / spike and 1000 grain weight) were observed in wheat. Based on the yield performance, varieties were classified as low (4500-5000 Kg ha^{-1}), medium (5000-5500 Kg ha^{-1}) and high (5500-6000 Kg ha^{-1}) yielder. Yield performance was higher (5500-6000 Kg ha^{-1}) in HD 2894, UP 2338, PBW 343, and HD 2687, while it was lower

(4500-5000 Kg ha^{-1}) in PBW 373, WH 711, PBW 226, HD 2733, HI 1544, RAJ 3765 and UP 2425. Higher grain yield in HD 2894, UP 2338, PBW 343, and HD 2687 PBW 373, PBW 502, HI 1544, RAJ 3765 and HD 2733 was associated with high biomass productivity (125-137 q ha^{-1}), harvest index (42-45 %) and number of grains per spike (58-59). In general, the average productivity of early group of genotype was low (5000 Kg ha^{-1}) as compared to long duration genotypes (5400 Kg ha^{-1}) (Table 9.1/32). Total heat unit requirement i.e. growing degree days (GDD) was relatively low in the early genotypes (1765 $^{\circ}\text{C}$) than the late maturing genotypes (1856 $^{\circ}\text{C}$). However, there was not much difference in heat use efficiency (HUE, $\text{Kg}/^{\circ}\text{C}$) in different group of genotypes (Fig. 9.1/18).

F. ON-FARM RESEARCH

Accelerating the second-generation machineries for managing the crop residue through RCTs in western UP

i) Participatory trials on Zero-tillage wheat

Demonstrations on farmers participatory mode were conducted which covered about 148 acres area. The wheat yield under no-till drilling across farmers varied from 4.00 to 5.20 t ha^{-1} with average of 4.60 t ha^{-1} . Whereas, in bed planting it ranged from 4.20 to 4.60 with an average of 4.40 t ha^{-1} . The wheat yield under conventional till drilling across sites varied from 4.0 to 5.00 t ha^{-1} with an average of 4.50 t ha^{-1} . Results indicated that though across sites and farmers, the wheat yield under no-till is likely similar to conventional till (2.0% increase under zero till), but the profitability was higher under no-till and reduced till due to reduced cost of production about Rs.3000 per hectare. In the bed planting, the advantage is saving in irrigation water about more than 20 percent.

ii) Rice residue management using new generation planters

Farmer participatory field trials (32) on resource, economic and eco-friendly technology were conducted for growing the wheat crop at Bamrolly, Latifpur, Rethora kurd and Rithora kanla under Hastinapur block of Meerut districts to evaluate the happy seeder, turbo seeder and zero till drill for rice residue recycling under no-till conditions. The results of farmers participatory field trials revealed that rice residue retention @ 5.0 to 6.0 t ha^{-1} and sowing of wheat was done using the Happy and Turbo seeder. The wheat yield was increased by on an average 14 %. In addition, there was saving of fuel in tillage, time and less number of irrigation due to mulching that ultimately led to higher water use efficiency and yield. The number of weeds were found less and number of grains per ear head were more in comparison to conventional sowing and improving soil health in long-run over zero-till and conventional till planting.

Demonstration of Mat type nursery growing and transplanting by self propelled rice transplanter

Seven farmers' participatory mode crop trials were conducted in Meerut district during *kharif* 2009. The farmers were fully trained for growing of mat type nursery and operation of machine. Farmers are fully convinced about saving of resources as labour (80%), energy (60%) and monetary gain of about Rs 2500 ha⁻¹. It is preferred by the farmers due to its saving of labour, time and energy as compared to conventional methods. The yield of demonstration was significantly increased by 12% in comparison to manual transplanting, due to higher number of hills m⁻² (i.e. >30) as compared to hand transplanting (25 hills m⁻²) and better hill establishment during transplanting.



Demonstration of mat type nursery transplanting by self propelled rice transplanter

On-farm evaluation of rice transplanter

Ten demonstrations of mat type nursery raising technique for rice transplanter as well as transplanting by transplanter were carried out in nearby villages of Meerut district. Rice variety (PB-1) was used at all the locations. The performance of rice transplanter was very good and farmers were fully satisfied with the operation. The comparison was made between the machine transplanted and hand transplanted fields. The rice grain yield in machine transplanted fields ranged between 4.0 to 5.0 t ha⁻¹ (average 4.4 t ha⁻¹). The yield in hand transplanted fields ranged between 3.3 and 4.2 t ha⁻¹ (average 3.7 t ha⁻¹). On an average, there was a yield increase of 19 % in machine transplanted fields compared to hand transplanted fields.



Demonstration of happy seeder on farmer's field

9.2 ORGANIC AGRICULTURE SYSTEMS (OAS)

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

This experiment was started in 2003 and has completed 7 crop cycles. Seven treatments viz. 50% recommended NPK + Zn + S as per soil test + 50% N as FYM (T₁); 100% organic nutrient sources (FYM), vermi compost and neem oil cake each equivalent to 1/3 of recommended N (T₂); T₂ + intercropping (veg. cow pea in maize and radish in potato) (T₃); T₂ + agronomic practices for weed and pest control without addition of chemical sources of plant protection (T₄); 50% N as FYM + *Azotobacter* + rock phosphate + P solubilizing bacteria (T₅); T₂ + rock phosphate + bio fertilizers containing N and P carries, T₂ + bio fertilizers containing N and P carries (T₆) and 100% NPK + Zn + S through chemical fertilizers based on soil test (T₇) were compared at PDFSR research farm. The results for the year under report are summarized as follows:

Crop yield

Highest grain yield of maize (6.75 t ha⁻¹) was recorded during *khariif* 2009 under T₃ in which

organic sources of nutrients were added and maize was intercropped with cowpea with an additional yield of vegetable cowpea (0.25 t ha⁻¹). T₅ which consisted of organic nutrients + rock phosphate and phosphate solubilizing bacteria recorded second highest yield (5.88 t ha⁻¹) with 19.4% yield increase over inorganic sources of nutrients (4.92 t ha⁻¹). During *rabi* season, highest tuber yield of potato (21.2 t ha⁻¹) was recorded with treatment T₂ where 28.48% yield increase was observed over the chemical fertilizer (16.5 t ha⁻¹). Among other organic sources of nutrients, T₄ gave second highest yield of potato (19.7 t ha⁻¹) and 19.34% yield increase over chemical fertilizers. It was also noted that average yield level under intercrop treatment (T₃) was also highest at 37.57 t ha⁻¹ and 2.14 % yield increase over chemical fertilizers (Table 9.2/1).

The growth and yield attributing characters of maize and potato has been depicted in Table-9.2/2 and 9.2/3, which clearly demonstrated the superiority of various organic nutrient management packages over chemical fertilizers.

Table 9.2/1. Effect of various nutrient management packages on maize equivalent yield (MEY) in maize-potato-onion system

Treatments	Maize (<i>Kharif</i>)		Potato (<i>Rabi</i>)		MEY t ha ⁻¹
	Crop-yield (t ha ⁻¹)	% I/D over T7	Crop-yield (t ha ⁻¹)	% I/D over T7	Av. of last 3 years
T ₁	5.62	+14.2	17.6	+6.66	34.55
T ₂	5.38	+9.3	21.2	+28.48	36.7
T ₃	6.75+*0.25	+37.2	15.2+* 0.73	-7.87	37.57
T ₄	5.58	+13.4	19.7	+19.34	33.47
T ₅	5.88	+19.4	18.4	+11.5	37.13
T ₆	5.54	+12.6	17.9	8.48	37.15
T ₇	4.92	-	16.5	-	36.78

* Yield of intercrop cowpea and radish for respective crops, I-Increase, D-Decrease

Table 9.2/2. Effect of organic farming practices on various growth parameters in maize in M-P-O system (2009-10)

Treatment	Pl. ht. (cm)	No. leaves/ plant	Cob length (cm)	No. of lines/ cob	Root length (cm)	Bio mass (t ha ⁻¹)	Root biomass (t ha ⁻¹)
T ₁	154.3	9.4	19.5	15.0	19.66	8.46	5.64
T ₂	153.4	9.8	21.2	13.5	18.07	6.204	4.7
T ₃	173.0	10.6	18.3	13.5	21.53	4.888	5.64
T ₄	177.5	10.8	20.3	13.9	22.22	5.922	4.7
T ₅	156.0	11.4	20.9	13.5	21.83	6.58	4.7
T ₆	185.7	11.5	17.3	14.1	19.57	6.016	4.7
T ₇	143.0	9.7	16.9	12.8	19.38	6.08	5.64

Table 9.2/3. Effect of organic farming practices on some growth and yield in potato in M-P-O system

Treatment	Root length (cm)	Root vol./ plant (ml)	Fresh wt/ (g)	Dry wt/ (g)	Tuber wt. (kg)/ 10 plants	No. of tubers/ 10 plants	Av. wt. of tubers (g)
T ₁	27.98	7.28	7.02	0.75	5.09	61.36	86.3
T ₂	33.59	9.36	9.88	0.97	4.51	64.48	72.80
T ₃	36.4	11.44	12.90	1.26	3.81	64.48	50.96
T ₄	29.64	9.36	7.18	0.81	4.00	76.96	54.08
T ₅	31.82	8.32	7.90	0.95	4.63	59.28	81.12
T ₆	32.03	7.28	8.02	0.89	5.02	68.64	75.92
T ₇	20.75	10.4	8.95	1.14	4.80	69.68	71.76

Soil organic carbon, macro and micronutrients

The organic carbon content of soil under various treatments after harvest of maize and potato has been depicted in Fig.9.2/1, which shows that irrespective of treatments, OC % was highest after harvest of potato and T3 recorded highest O.C. content irrespective of crops. Likewise av. N and P were highest under T₃ after harvest of potato but, the available K content was highest under T₁, being integrated package of nutrient management (Fig.9.2/1-4).

The status of micro nutrients with respect to Cu, Zn, Fe and Mn has been shown in Fig.9.2/5 after harvest of potato, which showed that T5 maintains the soil at higher level of Cu, Zn, Fe and Mn over other nutrients management packages. The dynamics of microbial population with respect of bacteria, fungi and actinomycetes and P-solubilizing bacteria has been shown in Fig. 9.2/6-9. Irrespective of crops, microbial population was highest under T6 in onion followed by maize and potato.

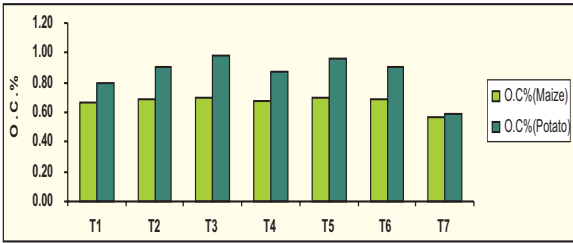


Fig 9.2/1. Effect of organic farming packages on soil organic carbon after maize and onion harvest

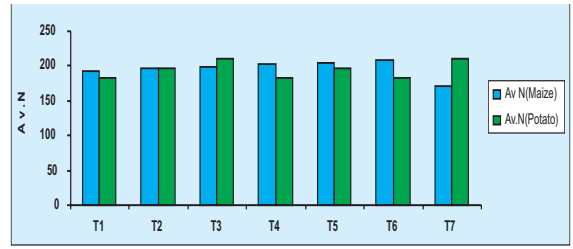


Fig. 9.2/2. Effect of organic farming packages on available N after maize and onion harvest

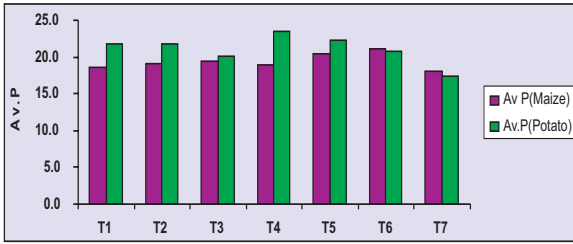


Fig. 9.2/3. Effect of organic farming packages on available P after maize and onion harvest

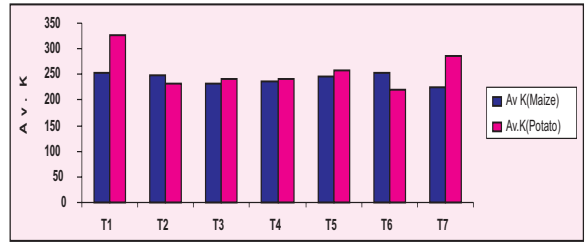


Fig. 9.2/4. Effect of organic farming packages on available K after maize and onion harvest

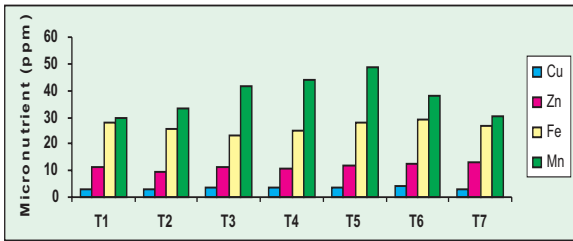


Fig. 9.2/ 5. Effect of organic farming packages on DTPA extractable micronutrients

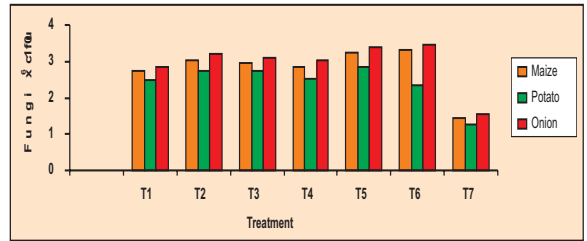


Fig. 9.2/6. Dynamics in fungal population in M-P-O system under organic nutrient management

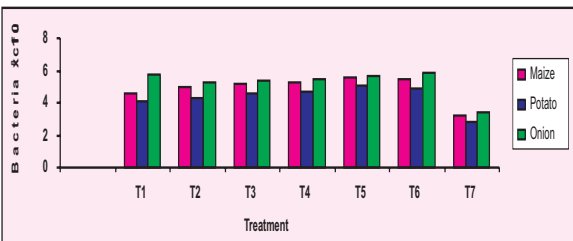


Fig. 9.2/7. Dynamics in bacterial population in M-P-O system under organic nutrient management

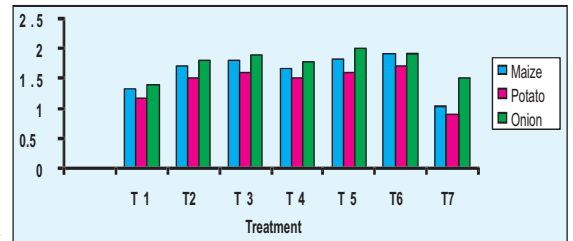


Fig. 9.2/8. Dynamics of actinomycetes population in M-P-O system under organic nutrient management

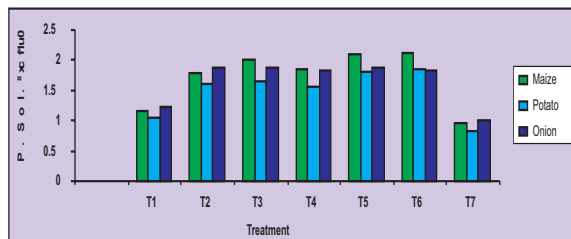


Fig. 9.2/9. Dynamics in phosphate solubilizing Bacteria in M-P-O system under organic nutrient management

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

Four cropping systems viz.: basmati rice-wheat, maize-potato-okra, rice-mustard-green gram and maize- *gobhi sarson* + toria were evaluated for their yield potential and returns under organic, inorganic, and integrated nutrient management practices. Maximum rice equivalent yield was obtained with maize- potato-okra (8659 kg ha⁻¹) cropping system followed by basmati rice-wheat (4987 kg ha⁻¹). However, maximum net return was obtained with basmati rice-wheat system (Rs. 51961 ha⁻¹). Maize-potato-okra and rice-mustard-green gram recorded 42.5 and 78.5 per cent respective higher returns under organic conditions as compared to inorganic conditions (Table 9.2/4).

Table 9.2/4. Rice equivalent yield (REY) and net returns as influenced by various nutrients management practices

Treatment	REY(kg ha ⁻¹)	Net return (Rs. ha ⁻¹)
<i>Basmati rice- wheat</i>		
Organic	4407	48214
Inorganic	4885	50023
Integrated	5662	57647
<i>Maize-potato-okra</i>		
Organic	8401	17311
Inorganic	8806	12147
Integrated	8771	9592
<i>Rice-mustard-g.gram</i>		
Organic	4825	47188
Inorganic	4530	26440
Integrated	5085	35632
<i>Maize-toria+gobhi sarson</i>		
Organic	2630	15351
Inorganic	2077	4456
Integrated	2578	6399

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

Two cropping systems *i.e.* basmati rice-chickpea and basmati rice-mustard were evaluated under two organic management practices, summer ploughing and green manuring. The rice-chick pea system proved more productive (34.4 per cent higher rice equivalent yield) as compared to rice-mustard system. Higher net returns were also recorded from rice-chick pea system. Summer ploughing proved better from yield as well as returns point of view as compared to green manuring in rice-chick pea system. Treated plots in both the systems recorded about 12.8 and 15.8 per cent higher rice equivalent yield and 19.1 and 26.4 per cent higher net returns as compared to untreated plots, respectively (Table 9.2/5).

Table 9.2/5. Rice equivalent yield (kg ha⁻¹) and net returns (Rs. ha⁻¹) as influenced by various treatments

Treatments	Green manuring		Summer ploughing	
	REY	Net returns	REY	Net returns
<i>Basmati rice-chick pea</i>				
Treated	4440	56541	4650	60178
Untreated	3870	46632	4190	51372
<i>Basmati rice-mustard</i>				
Treated	3464	38330	3382	32074
Untreated	2982	31235	2930	24459

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

An observational trial was conducted to find out the maximum production and profit from the cropping systems involving spices and high value crops.

Table 9.2/6. Rice equivalent yield and returns of various cropping systems involving spices and high value crops under organic conditions.

Cropping Systems	REY (kg ha ⁻¹)	Gross Returns (Rs. ha ⁻¹)	Net Returns (Rs. ha ⁻¹)
Maize(cob)-potato-onion	7284	154874	65074
Maize-garlic-gm	3281	72725	20525
Turmeric-gm	6900	138000	94000
Maize-potato-gm	4394	96500	33300
B.rice-coriender-gm	4450	89000	42800

(gm= Green manuring)

Maximum rice equivalent yield was obtained from maize (cob)-potato-onion (7284 kg ha⁻¹) system followed by turmeric- green manuring (6900 kg ha⁻¹). However, highest returns to the tune of Rs.94000 ha⁻¹ were obtained from turmeric- green manuring (Table 9.2/6) followed by maize (cob)-potato-onion (Rs.65074 ha⁻¹).

Evaluation of rice and wheat varieties in rice-wheat system for organic farming

Sixteen varieties of rice and thirty varieties of wheat were evaluated for their yield potential under organic conditions. Among the rice varieties, PD 10 recorded highest yield of 4752 kg ha⁻¹, followed by PR 115 (4488 kg ha⁻¹) and PR 116 (4445 kg ha⁻¹). Whereas, among the wheat varieties, HI 1544 (4650 kg ha⁻¹), Raj 4037 (4000 kg ha⁻¹) and Lok 1 (3650 kg ha⁻¹) attained the higher yields as compared to others.



Organically grown maize and *Haldi* at PDFSR, Modipuram

9.3 INTEGRATED FARMING SYSTEMS (IFS)

A. FIELD CROP BASED IFS-MODELS

Development of an Integrated Farming System Model for small farmers of Western Plain Zone of Uttar Pradesh

The study was conducted at Project Directorate for Farming Systems Research, Modipuram for ascertaining the livelihood security of marginal and small farmers under irrigated ecosystem. The results clearly advocate the beneficial effects of integrated farming system on productivity, profitability and

taken as 100 per cent. Thus, it is clear that the contributions of different enterprises strengthen the crop component and showed a margin of Rs.39498/ha/annum and their contribution rated about 35 per cent. The goat enterprise was the new intervention introduced in later phase (2007). However, goat rearing was not found suitable as well as profitable, because of high mortality of the animals under stall feeding conditions which were not permitting proper exercise and mixed vegetation of pastures, and grazing lands as liked by the animal.



Boundary plantation (*Aonla*) in integrated farming system

sustainability. The model was developed on 1.5 hectare area comprises of crops (0.72 ha), dairy (0.32 ha), horticulture (0.22 ha), fishery (0.10 ha) and miscellaneous (0.14 ha) which was used for goat, apiary, vermi-composting, threshing floor and household. Net returns from the crop, dairy, horticulture, fishery and apiary were Rs.53183, Rs.27515, Rs.7168, Rs.1445 and Rs.3372, respectively. The relative contribution from the dairy, horticulture, fishery and apiary towards net return was 52, 14, 3 and 6 per cent where crops were



Boundary plantation (*Karonda*) in integrated farming system



Crop component in integrated farming system



Intensive cropping in integrated farming system

employment generation also considered as a crucial input which is clear from the cultivation cost of Rs.109627/ha/annum. During fifth year (2008-09), net return per hectare increased up to Rs.131661/ha/annum and the cost of production was Rs.203445/ha/annum, which gave Rs.12101 net saving after fulfilling all the family requirements of 7

family members. So, the major share of cost of production goes to family labour in the farming system approach. As a result it ensures the livelihood security even for the medium to large family size. To substantiate the statement made above clearly illustrated in Table 9.3/1 and 9.3/2.

Table 9.3/1. Net returns and relative profit margin of FSR model at PDFSR, Modipuram

Enterprises	Net return (Rs./ha/annum)	Relative profit margin (%)
Crops	53183	100
Dairy	27515	52
Horticulture	7168	14
Fishery	1445	3
Apiary	3370	6
Total	92681	-

Table 9.3/2. Household security and economic viability of the IFS model

Developmental phases	Cost of production (Rs./ha/year)	Net return (Rs./ha/year)	Net saving after fulfilling 7 members family requirements
First 4 years (2004-2008)	109627	100573	Subsistence
5 th year (2008-09)	203442	131661	12101



Dairy component in integrated farming system

Gross and net returns

The gross and net returns (Table 9.3/3) in the current year (fifth year of the project) increased

tremendously (69.4% and 134.2%, respectively) as compared to the average income of last four years. This probably was due to inclusion of more enterprises i.e. vegetables and flower crops,

Table 9.3/3. Gross and net returns under IFS since start of the project (2004-05 to 2008-09)

S.No.	Enterprises	Gross Returns (Rs. year ⁻¹)				Over all Average (2004-09)
		Av. (2004-06)	2006-07	2007-08	2008-09	
1	Crops	88842	149338	134923	149702	122329
2	Dairy	51852	116333	111285	275823	121429
3	Horticulture	18984	15502	22678	20800	19389
4	Fishery	2220	11200	14160	15750	9110
5	Apiary	15610	7360	7750	15400	12346
6	Goat	NA	NA	NA	15180	15180
7	Miscellaneous (CR+Ur+GE+GM)	Recycled within the system				
		177508	299733	290796	492655	287640
Net Returns (Rs./year)						
1	Crops	45028	104056	80355	89662	63820.2
2	Dairy	22450	40705	32293	186273	56344.2
3	Horticulture	12148	3371	13456	14040	8603
4	Fishery	-4215	790	4297	7800	1734.4
5	Apiary	8103	-1548	3717	9950	4044.4
6	Goat	0	0	0	6400	6400
7	Miscellaneous (CR+Ur+GE+GM)	Recycled within the system				
		83514	147374	134118	314125	135825

CR= Crop residue of sugarcane, potato, red gram, berseem etc., Ur = Animal urine , GE= Goat excreta, GM=Green manuring



Farm household and fishery component in integrated farming system

strengthening of livestock and fishery units, optimum recycling of farm wastes and crop residues and better management of all the enterprises of the model maintaining higher level of production.

Nutrient Budgeting

The farming system approach makes the system so holistic that fulfil about 36% of the total nutritional (NPK) requirement from the system itself. The total

Table 9.3/4. Nutrient budgeting under Integrated Farming System at PDCSR, Modipuram

Source of nutrients and per cent nutrient content (N:P:K) on dry wt. basis	Available quantity at farm (kg)	Approx. released nutrient N (kg)	Approx. released nutrient P (kg)	Approx. Released nutrient K (kg)	Total NPK released/ required in the IFS
Green manure crops					
Sesbania spp. (1.29:0.36:1.64)	8800	189	53	240	482
Cowpea (1.29:0.36:1.64)	8500	183	5.1	232	466
Crop residues (dry wt.)					
Sugarcane leaves (0.4:0.18:1.28)	900	36	1.6	11.5	167
Arhar leaves (1.29:0.36:1.64)	232	30	0.8	3.8	76
Potato leaves (0.52:0.21:1.06)	1450	75	3.0	154	259
Cow dung (dry wt.) (0.4:1.2:1.9)	17600	704	211.0	334.0	6154
Total	-	121.7	226.8	411.9	7604
		30.4(10.7%)*	34.0(29.2%)*	123.6(100%)*	188.0(36.7%)*
Nutrient requirement/year (field + plantation crops)	-	285.3	116.3	1099	511.5

N, P and K requirements of the system tried in the IFS model at PDFSR, Modipuram were 285.5, 116.3 and 109.9 kg ha⁻¹, respectively (Table 9.3/4). In this way, recycling of all the farm wastes, crop residues, cow dung and green manuring etc. not only save the expenditure to be incurred on costly chemical inputs but also keep surroundings clean and environment safe.

Livelihood Security Through Integrated Farming System

Overall monitoring and livelihood analysis of the IFS model (Table 9.3/5) revealed that by removing the constraints responsible for yield gaps and optimum integration of farm and eco-friendly enterprises in existing on – farm farming system

Table 9.3/5. Impact of IFS approach on the productivity of a farm and household security.

Farm Enterprises/ Commodities	Production/year (Av. ** of first 4 years) (Tones)	Production/year (Fifth year; 2008-09) (Tones)	Annual demand of an 7 member Indian family (Tones)
A. Crops (0.72ha)			
Cereals	3.10	4.01	1.55
Oilseeds	0.16	0.29	0.13
Pulses	0.46	0.25	0.20
Fodders	53.00	90.20	86.60
Sugarcane	27.70	9.68	1.60
B. Horticulture (0.22ha)			
Fruits	1.80	0.56	0.20
Vegetables	3.10	3.27	0.90
C. Live stock (0.32ha)			
Dairy animals (Milk)	4.50	11.57	1.12
Meat animals (Goat meat)	NA	0.18	***
D. Pisciculture (0.10ha)			
Fishes	0.15	0.45	***
E. Apiary & others (0.14ha)			
Honey	0.19	0.16	0.02
Gross value (Rs.)	287640*	502655**	Av. Value of Family Consumption per year Rs. 119560/year
Cultivation cost (Rs.)	117858*	305163**	-
Net returns (Rs.)	169782*	197492**	-
Net saving (Rs.)	50222*	79732**	-

*Overall average ** Fifth year 2008-09, *** Not consumed in a veg. family



Horticulture component in integrated farming system

resulted in higher profits (Rs.113888 ha⁻¹ year⁻¹) than crops alone (Rs.61356 ha⁻¹ year⁻¹). As regard to livelihood security, the IFS approach adopted in the model met almost all the domestic family needs of food, fodder, fuel etc. and saved a sizable amount of money ranging from Rs.50222/- to Rs.77932/- in current year 2008-09 to meet the other liabilities of the family including education, health etc.

The gross and net returns in the current year, which was the fifth year of the project, increased tremendously (69.4% and 134.2%, respectively) as compared to the average income of last four years.

This probably was because of inclusion of more enterprising vegetables and flower crops, strengthening of livestock and fishery units, optimum recycling of farm wastes and crop residues and better management of all the enterprises of the model. The gross and net returns under crop production increased by about 11 percent as compared to last year 2007-08. This increase was attributed to inclusion of marigold, a high demand and more enterprising flower crop fetching income as high as Rs.110906 ha⁻¹ in a short period of 120 days. Similarly production of milk rose from an annual average production of 4.5 tons during last 4 years



Apiary component in integrated farming system

to 11.57 ton in current year 2008-09 (an increase of 157 percent). The production in other enterprises including pisciculture, horticulture and apiary was also maintained at higher levels. Fish production touched a yield level of 478 kg year⁻¹ and of vermi-compost to 15 t year⁻¹. Nutrient budgeting of the entire available farm wastes and crop residues etc. showed that by proper management and recycling of these farm resources, a farmer can save at least 10% of N, 30% of P and 100% of K (about 36% of NPK), which would otherwise be applied through chemical fertilizers. This will not only keep the farm periphery clean but save the environment from different type of pollutions.

Aquaculture

The fish pond having a water spread area of 0.08 ha was maintained on scientific lines. The repeated water exchange of the fish pond was carried out for creating conducive condition of water to avoid loss of dissolved oxygen syndrome (LODOS).

During March, 2009 the pond was having the stock of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*. The pond was fertilized by the excreta released from animal shed. The fish was fed with rice bran and mustard oil cake (1:1) @ 0.5 % body weight on alternate days. The random sampling of fish stock was carried out at the time of stocking

and harvest and is tabulated in Table 9.3/6 for growth. In all, fish production was 518.25 kg / 0.08 ha was realized in culture period of 11 months. When calculated on year basis, the growth rate was 7067 kg/ha/year. During this period revenue of Rs.25, 913 was realized.

During this period the physico-chemical parameters of the pond water were in the range of; water temperature 24.2 - 30.5 °C; pH 7.54 - 7.72; free carbon dioxide 1.8-2.0 ppm; total alkalinity 240- 370 ppm; dissolved organic matter 48-56 ppm; dissolved oxygen 6.24-7.64 ppm; gross primary production 729.16 - 922.91 mg C/m³/hr; net primary production 477.08 - 625.03 mg C/m³/hr and respiration 252.08 - 297.88 mg C/m³/hr. After final harvest, done during February, 2010 the left over 5,000 fry and fingerlings of Indian Major Carps were transferred to newly construct rearing pond.

The pond was dried up and de-silting of pond is in progress. The bunds of the ponds are being repaired and reshaped.

Construction of new fish ponds

One rearing fish pond having an area of 0.05 ha was constructed and was stocked with fry and fingerlings of Indian Major Carps removed from old

Table 9.3/6. Growth of carps, catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*)

Fish species	Initial Stocking, range (Average & S.D)		Harvest, range (Average & S.D)	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)
<i>Catla catla</i>	120-155 (137.5 ± 4.67)	12-20 (16.3 ± 4.13)	350-410 (375.0 ± 24.33)	245-350 (285.5 ± 37.44)
<i>Labeo rohita</i>	125-145 (123.2 ± 5.21)	11-18 (14.2 ± 3.07)	235-325 (275.7 ± 24.56)	250-345 (284.5 ± 39.25)
<i>Cirrhinus mrigala</i>	115-140 (124.2 ± 8.51)	10-14 (12.2 ± 2.34)	250-340 (302.1 ± 16.59)	215-350 (245.0 ± 19.18)



Fish catching at fish pond of IFS farm

fish pond. The rearing for production of fingerlings and advanced fingerlings is in progress. The advanced fingerlings will be restocked in the integrated farming system pond.

9.4 RESOURCE CHARACTERIZATION AND SYSTEM DIAGNOSIS (RCSD)

A. FARMING SYSTEM CHARACTERIZATION AND CONSTRAINTS ANALYSIS

Socio-economic impact assessment of resource conservation and AICRP-CS technologies in Indo-Gangetic Plain

The survey was conducted to assess the economic impact of the technologies viz. crop diversification, crop intensification, site specific nutrient management (SSNM), zero tillage, laser levelling, bed planting and leaf colour chart in Indo-Gangetic Plains where technology penetration is deep and amenable for impact quantification. Sampling were done at two levels (village and household) and two type of controls (villages and farmers with respect to adoption and non-adoption) and three forms of comparisons – with, without and across regions and cropping systems. Fifty three adopter and 14 non adopter farm households were covered in Rudrapur district of Uttaranchal. The farm level impact indicators identified were yield increase, income augmentation, cost reduction, cropping intensity and resource conservation, and aggregate level indicators were agriculture production and employment.

The majority of the sample households invariably adopted zero tillage in various degrees and shades,

in sole or in combination with other resource conservation technologies like residue management, green manuring, and laser leveling.

Table 9.4/1 indicates that percentage area under zero tillage decreased as farm size increased. It shows that adoption of zero tillage is negatively related to farm size. However, the average farm size in adopters was marked to 9.89 ha.

Table 9.4/2 shows the effect of age and education on adoption of zero tillage. The analysis of data did not depict wide variation in respect of age and education number of live stocks between adopters and non adopters of zero tillage. Average farmer found to be little educated i.e. below 5th class.

Figures 9.4/1 to 3 indicated that, there was 6-7 days early sowing in zero-tillage in comparison to non adopters and seed rate was also lower in case of zero tillage (128 kg ha⁻¹) than non adopters (144 kg ha⁻¹).

Fig 9.4/3 shows that the cost of sowing was lower for adopters of zero tillage as compared to non adopters. The analysis of data further showed

Table 9.4/1. Farm size wise percent area under zero tillage in Uttaranchal

Farm category	Farm size (ha)	Area under zero tillage (ha)	Percent area
Adopters			
Small	1.64	1.34	81.71
Medium	3.23	1.66	51.33
Large	13.48	6.39	47.40
Total	9.89	4.81	48.65
Non Adopters	18.59	0	0

Table 9.4/2. Effect of age and education on zero tillage

Particulars	Average	Standard deviation	Coefficient of variation
Adopter			
Small			
Age (yrs)	46.40	11.90	25.65
Education (class)	3.00	1.15	38.49
Medium			
Age (yrs)	48.43	7.91	16.34
Education (class)	3.00	1.83	60.86
Large			
Age (yrs)	54.39	13.06	24.02
Education (class)	3.53	1.68	47.67
Total			
Age (yrs)	52.09	12.58	24.15
Education (class)	3.36	1.61	47.83
Non Adopter			
Age (yrs)	59.38	22.51	37.90
Education (class)	2.64	1.95	73.62

that the expenditure on sowing was Rs.3000 ha⁻¹ by the non-adopter which was on higher compared to adopters (Rs. 500 ha⁻¹).

As per the observations of Table 9.4/3, the marginal variation in utilization of Urea and DAP between both the cases were seen. Non adopters

were using higher doses of fertilizer as compared to adopters of zero tillage.

Fig 9.4/4 indicated that irrigated area was slightly more in case of adopters as compared to non adopters. Non adopter incurred marginally higher expenditure on irrigation than adopters.

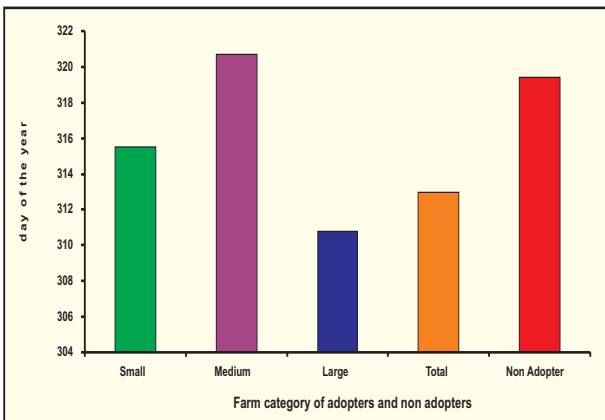


Fig 9.4/1. Difference in sowing time of adopters and non adopters of zero-tillage

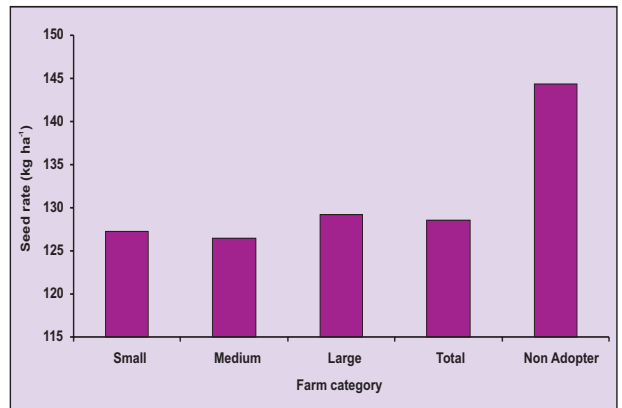


Fig 9.4/2. Difference in seed rate of adopters and non adopters of zero-tillage

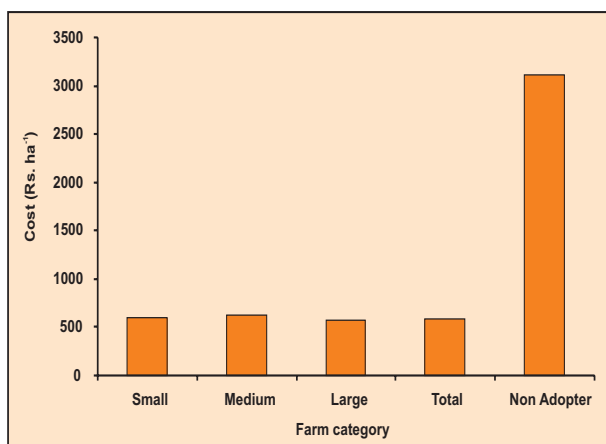


Fig 9.4/3. Cost of sowing ha⁻¹ in adopters and non adopters of zero-tillage

Table 9.4/4 indicated that the wheat yield was higher by 1.30 q ha⁻¹ in case of adopter than non adopters of zero tillage. Further, Table 9.4/5 indicated that the total variable cost spent on wheat cultivation was Rs.10542 ha⁻¹ as against Rs. 14097 ha⁻¹ by non adopters. Saving in cost of cultivation and additional income was Rs.3555 ha⁻¹ and Rs.2080 ha⁻¹ in case of adopters compared to non adopters. There was

a net gain of Rs.4500 ha⁻¹ for adopters over non adopters of zero tillage.

Reasons for adoption of zero tillage

- Reduces cost of cultivation
- Suits problem soils and shallow water table areas
- Saves fuel (diesel) bill and irrigation water
- Facilitates timely sowing
- Overcomes labour shortage
- Facilitates line sowing and ensures better germination
- Less weed intensity
- Minimizes machinery wear, tear and the maintenance and repairing costs

Reasons for discontinuing zero tillage

- Does not suit light soil
- Lack of timely availability of zero till machine and skilled labour

Table 9.4/3. Quantity of fertilizer applied by adopters and non adopters

Particular	Amount in Kg	Standard deviation	Coefficient of variation
Small			
Urea	72.50	34.26	47.25
DAP	55.00	10.54	19.17
Potash	38.00	30.20	79.48
Medium			
Urea	82.14	31.34	38.15
DAP	55.00	9.57	17.41
Potash	52.14	38.50	73.83
Large			
Urea	82.92	28.27	34.09
DAP	60.14	13.39	22.26
Potash	35.42	32.01	90.39
Total			
Urea	80.85	29.51	36.50
DAP	58.49	12.50	21.38
Potash	38.11	32.41	85.03
Non Adopter			
Urea	84.64	34.16	40.36
DAP	55.36	10.09	18.23
Potash	67.50	12.36	18.32

Table 9.4/4. Difference in yield of adopters and non adopter farms

Farm category	Yield (q ha ⁻¹)	Standard deviation	Coefficient of variation	Difference
Small	48.50	6.03	12.44	1.18
Medium	48.93	5.56	11.37	1.61
Large	48.78	5.46	11.19	1.46
Total	49.00	6.58	13.44	1.67
Non Adopter	47.32	3.46	7.32	0.00

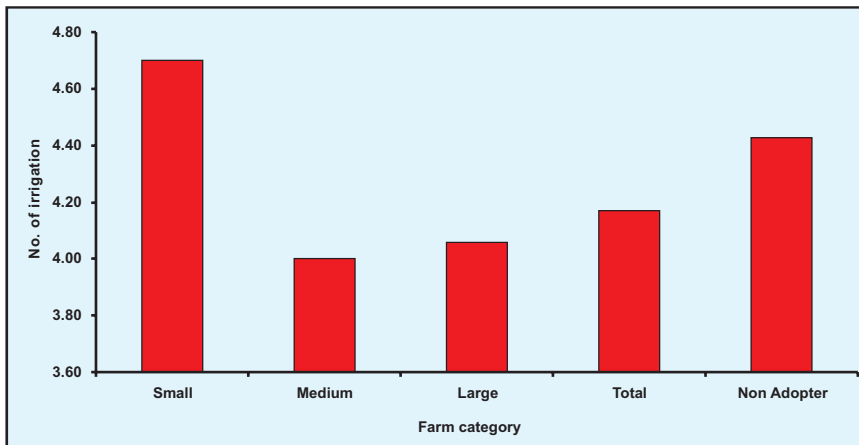


Fig 9.4/4. Difference in No. of irrigation by adopters and non adopters of zero-tillage

Table 9.4/5. Cost and return (Rs. ha⁻¹) of adopters and non adopters

Farm category	Cost of Production	Gross return	Net return	Added Return
Small	9329	53350	44021	4576
Medium	9443	53821	44378	44378
Large	9307	53663	44356	44356
Total	9425	53895	44470	44470
Non Adopter	12608	52054	39446	0

- Improper calibration leading to less seed rate and poor yield

Statistical analysis of cropping systems experiments in relation to soil parameters under different cropping systems

The crop yield is affected by weather, prevailing during crop season and inputs applied. As such

modeling cause and effect relationship between yield and these factors could provide an approach for reliable yield trend over years. To develop yield prediction model by including climatic parameters, digitized time series data of different years' climatic factors was analyzed with yield by using step wise regression models. Accordingly, backward step wise regression model was attempted with the assumption

that no repressor exists and attempted to insert variables until a suitable model is obtained. Backward elimination attempted to find a good model by working in the opposite direction. That is beginning with a model that includes all K regressors. Then the Partial F-statistic was computed for each regressor as if it were the last variable to enter the model.

With the help of C_p -statistic (C. L. Mallows, Technometrics, 1973) best fit was obtained by using following formula

- $C_p = \text{RSS}_p / s^2 - (n - 2p)$
- Where RSS_p is the residual sum of squares from regression model containing p parameters,
- p is the number of parameters in the model
- S^2 is the residual mean square from the largest equation postulated
- If $E(C_p) = p$, then the fit is adequate

The weather parameters under study were rainfall (Rf in mm), relative humidity (Rh in %), evaporation (Eva in mm), bright Sun shine hours (BSS in hours), wind speed (km/h), maximum temperature ($^{\circ}\text{C}$), minimum temperature ($^{\circ}\text{C}$) and also time metameter (Years). The backward step

wise regression equations were fitted on the yield data of rice-wheat crop sequence at Pusa, Pantnagar and Jabalpur, rice-rice crop sequence at Bhubaneswar, Chiplima, Hyderabad; and maize-wheat crop sequence at Ranchi, to study the effect of weather parameters under different treatments in the experiments, long range effect of continuous cropping and manuring on soil fertility and yield stability.

Under rice-rice cropping sequence, significant effect of year, relative humidity and wind speed was observed at Bhubaneswar in most of the treatments. In Chiplima, the significant effect of year, rainfall, temperature and evapotranspiration was found to be there. In Hyderabad, the significant effect of time and wind speed was observed. Under rice-wheat cropping sequence, at Pusa, rice crop had significant effect of rainfall, whereas, wheat crop had effect of year only. At Pantnagar, under rice crop there was significant effect of rainfall, whereas, wheat had effect of temperature and wind speed. At Jabalpur, under rice, temperature and rainfall had positive significant effect, whereas wheat crop was affected by temperature only. Under maize-wheat cropping sequence, maize crop had positive significant effect of temperature only. The models fitted were adequate as these could explain more than 75% variation in respect of all the treatments.

B. DIAGNOSTIC SURVEYS AND SYSTEM ANALYSIS

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

Survey was conducted in Bundelkhand region of Uttar Pradesh to study the ground water profile over time and space and to work out the comparative economics of crop production influenced by groundwater depth and motive for its lifting. Out of seven districts of Bundelkhand region, four districts

namely Jalaun, Jhansi, Hamirpur and Mohaba were surveyed during 2009-10. The analysis of survey data of Jalaun and Jhansi were carried out and their results are discussed as under:

District Jalaun : The average ground water table in Jalaun was 82.80' during the survey period (2009-10) while it was 89.10' and 53.70' before past five and ten years taking into account the base year 2009-10 (Fig. 9.4/5). Data further showed wide disparity

in water table depth within the district. For instance, in Rampur block of Jalaun, current ground water table was 122.50' while it was 87.2' and 38.8' in Dekore and Nadigaon blocks. The similar variation in water table depth was noticed before five and ten years in these blocks (Fig. 9.4/6). While studying the dynamics of energy consumption influenced by depth of water table, the average consumption of diesel during study period was 2.02 l h⁻¹ as against 2.39 and 1.54 l during past five and ten years. The corresponding per hectare consumption of diesel was recorded as 50.20, 71.70 and 30.1 l, respectively. The total cost incurred for irrigation for wheat cultivation was Rs.782, Rs.2366 and Rs.1857 ha⁻¹ during these years (Table 9.4/6).

The irrigation cost per hectare during past five years was of higher magnitude compared to survey period. Regular deficit in rainfall and prevalence of draught in the region during last five years caused speedy, depletion of ground water resulting in higher cost of irrigation. Later, due to some rainfall, the water table marginally increased in the wells which decreased the diesel consumption up to some extent during course of survey. The analysis further showed 31.20% growth in diesel consumption over past ten years while it declined to 18.30% over last five years. Similarly, the per hectare diesel consumption showed 66.8 and 42.8% growth over last ten and five years, respectively.

Regarding status of well and bore wells, out of 108 wells in the sample villages, 42 were found dry while 28 were marked failed. Only 38 wells (35.2% of the total observed) were working. Seasonal variation in water table recorded 76, 81.5 and 90.8 feet in rainy, winter and summer season respectively. The total annual household income which includes income from crops, live stocks, services and wages was computed Rs.53613 during survey period as against Rs.29375 and Rs.17697 during last five and ten years, respectively. This showed 202.9% growth in house hold income during a period of ten years.

The comparative economics of crops grown in various blocks and influence on water depth indicated that irrigation water consumed 11.5% of the total operational cost in Nandigaon block where depth of water table was comparatively less than other blocks. On the other hand, in Rampur block, where water depth was relatively deep, absorbed 14.8% of the total operational cost in production of wheat. The total operational cost and net gain in Rampur was calculated Rs.15577 and Rs.6423 ha⁻¹ while the corresponding figure in Nandigaon was Rs.14829 and Rs.9171 ha⁻¹ respectively (Table 9.4/7).

District Jhansi : In Jhansi, the ground water table was relatively low compared to Jalaun. During the study period, the water table was measured 43.8'

Table 9.4/6. Per unit diesel consumption influenced by water table in Jalaun.

Details	Before 10 years	Before 5 years	Current	Percentage growth	
				over 10 years	over 5 years
Per hour diesel of consumption (l)	1.54	2.39	2.02	31.20	18.30
Per hectare diesel consumption (l)	30.1	71.70	50.20	66.77	42.80
Total amount spent (Rs.)	782.00	2366.00	1857.00	137.46	(-) 27.40

Note: Per liter diesel rate was Rs. 26,33 and 37 during past 10 years, 5 years and current area

Table 9.4/7. Cost, returns and share of irrigation water (Rs. ha⁻¹) as influenced by water depth in different blocks of district Jalaun (Bundelhkand)

Name of Block	Variable cost	Interest on working capital	Total cost	Amount spent on irrigation	Total grain production (q ha ⁻¹)	Price of grain	Net Income	% Share Irrigation
Rampur	14695	882	15577	2110	22	22000	6423	14.8
Nandigaon	13990	839	14829	1605	24	24000	7605	11.5

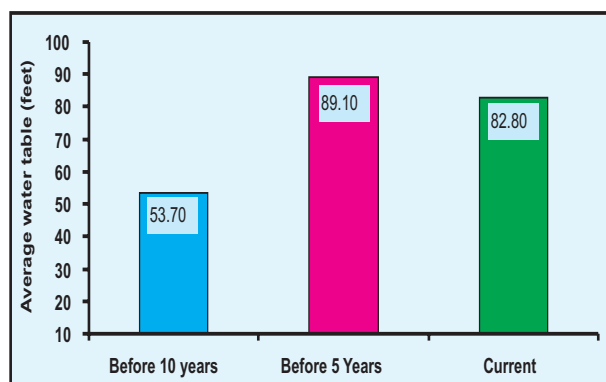


Fig. 9.4/5. Average ground water table in Jalaun at present and during past

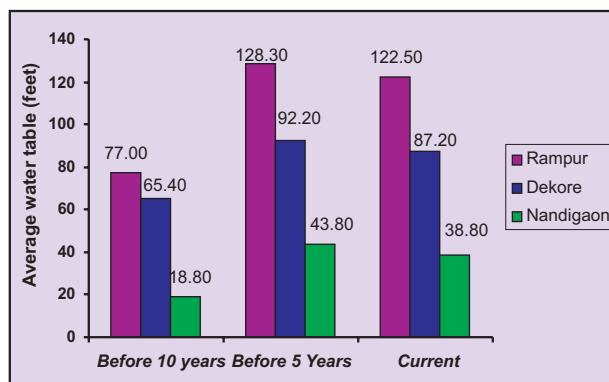


Fig. 9.4/6. Variation in average ground water table in different blocks of Jalaun

as against 49.2' and 25.9' during past five and ten years as appraised by the farmers. Wide variation in water table depth was recorded with in the district. For example, during course of survey, the water table in Bangra block was 34.9' while it was 49.4' in Babina block (Fig. 9.4/7).

The per hour diesel consumption during study period was 1.90 liter, while it was 2.20 and 1.45 liter in last five and ten years, respectively. Similarly, the per hectare diesel consumption was recorded 33.4 liter during course of survey compared to 39.7 and 23.4 liters in last five and ten years. The variation

Table 9.4/8. Average annual household income (rupees) of Jhansi block of Bundelkhand

Particulars	Before 10 years	Before 5 years	Current year (2009-10)
Crop	10123	18169	39156
Live stock	1263	3942	6842
Horticulture	0	0	0
Bee keeping	0	0	0
Service	6682	9860	17550
Wages	589	890	1823
Total	18657	32761	65371

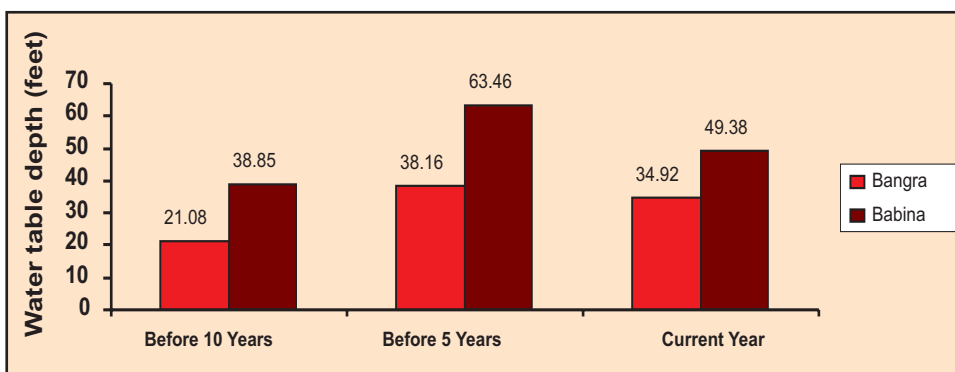


Fig. 9.4/7. Variation in water table depth in Jhansi district

in total amount spent on diesel was also on the similar line. About 60.7 percent additional cost was observed for construction of well during study period compared to past five years. The depth of irrigation was 1.85" compared to 1.45" in last five years. No change in pump capacity was observed during past five years and survey period. The study further revealed that 42.7% additional diesel was consumed during study period compared to last ten years. However, 18.8% diesel could be saved when depth of water table marginally increased during the survey period compared to last five years. The amount incurred on diesel consumption also showed the similar trend. The cost of construction of well and bore wells were relatively low in Jhansi compared to Jalaun district. However, 50 and 150% growth in per hour irrigation charge was noticed over last five

and ten years. The total annual household income was Rs.65371/household during the course of survey which showed 83.7 and 222.9% increase over last five and ten years (Table 9.4/8).

Regarding comparative economics influenced by water table, the Babina and Bangra blocks of Jhansi showed disparity in water table depth which affect the share of irrigation as well as net gain in wheat production. Of the total cost of cultivation, 10.8% was incurred for irrigation in Babina while the corresponding share of irrigation in Bangra was 9.0% only. The net return in Babina was Rs.3489 ha⁻¹ as against Rs.4036 ha⁻¹ in Bangra. This showed the influence of ground water depth on cost economics of wheat cultivation.

9.5 TECHNOLOGY TRANSFER AND REFINEMENT (TTR)

A. TECHNOLOGY PARK

Accelerating the proven technologies through Technology Park at PDFSR

Various proven cropping systems i.e. bottle guard -rice -cauliflower, ladyfinger-rice- vegetable pea, rice -radish - wheat, summer moong- rice - mustard, summer moong-rice -potato (varietal trial), summer moong-rice-potato (varietal trial), rice - wheat (site specific nutrient management-SSNM), rice-wheat (recommended NPK), rice (rec. NPK) - wheat (zero tillage-ZT), *dhaincha* (green manuring-GM) + rice -wheat (strip tillage-ST), summer moong (GM) + rice (rec. NPK) - wheat (bed planting-BP), summer moong + rice (MT) - mustard (ZT), rice (farmer's practice-FP) - wheat (FP), rice (rec. NPK) +brown manuring (direct seeded rice-DSR) - wheat, summer moong + rice (DSR)- chickpea (ZT), summer moong + rice (rec. NPK) - chickpea (BP) + wheat (furrow-F), summer moong + rice - chickpea + mustard, rice - garlic,

pigeonpea single row (raised bed-RB) -wheat (late sown-LS), pigeonpea one row +maize one row (RB)- onion, pigeonpea two rows +maize one row (RB) - wheat (LS), pigeonpea one row +maize one row (RB) - tomato, maize (RB) -potato-lady finger, maize one row (RB) -potato- black gram, vegetable pea (broad bed-BD) +mustard (F) - moong (BD) + *dhaincha* (F), lentil (BD) + mustard (F) - cowpea (BD) +*dhaincha* (F), maize cobs -toria -muskmelon, have been demonstrated and tested with superimposition of proven technologies and the area of each demonstration plot was kept 300 m². The maximum wheat equivalent yield was recorded in rice - wheat with SSNM (11.3 t ha⁻¹), *dhaincha* (GM) + rice -wheat (ST) (10.5 t ha⁻¹) and summer moong (GM) + rice (recommended NPK) - wheat (BP) (10.4 t ha⁻¹) followed by rice-wheat (rec. NPK) (9.7 t ha⁻¹) and rice (FP) - wheat (FP) (9.6 t ha⁻¹) and summer moong +rice (DSR)- chickpea (ZT) (6.3 t ha⁻¹).



Demonstration of proven technologies in Technology Park of PDFSR

B. ON-FARM RESEARCH AND DEMONSTRATIONS

Anusandhan Gaon ki Aur

Under this project during 2009-10, a total of 69 on-farm trials/ field demonstrations were laid out at farmers' field, of which 15 were on green manuring (*dhaincha*) + potash in different varieties of rice, 11 on band placement of FYM+ potash in different varieties of sugarcane, 13 on effect of potash in the yield of different varieties of sugarcane, 11 field demonstrations on cultivation of Napier grass and 19 were on wheat during *rabi*-2009-10. The result/ findings of on-farm trials/demonstrations are as follows:

OFT 1: Performance of green manuring (dhaincha) + potash in different varieties of rice:

A total of 15 OFT on Performance of green manure (*dhaincha*) + Potash in different varieties of rice were laid out. The improved practice (IP) (green manure + potash) resulted in increased yield by 16 % in 'Sugandha-5', 14.7 % in 'Saket-4', 13.8 % in 'PB-1' and 12 % in 'Basmati-370' varieties of rice over the farmers' practice. Cost of cultivation of both improved practice (IP) and farmers' practice (FP) of rice variety Sugandha-5 was worked out. The results revealed that making additional expenditure of Rs. 4030/- in form of green manure and potash, the net return in IP increase was Rs. 7975 ha⁻¹ over FP. As regards benefit cost ratio, it was 1.39:1 in IP as compared to 1.26:1 in FP. Cost of cultivation of both IP and FP of rice variety PB-1 was worked out. The results revealed that making additional expenditure of Rs. 4030/- in form of green manure and potash, the net return in IP increase was Rs. 6365 ha⁻¹ over FP. As regards benefit cost ratio, it was 1.37:1 in IP as compared to 1.27:1 in FP. Cost of cultivation of both IP and FP of rice variety Basmati-370 was worked out. The results revealed

that making additional expenditure of Rs. 4030/- in form of green manure and potash, the net return in IP increase was Rs. 9365 ha⁻¹ over FP. As regards benefit cost ratio, it was 1.62:1 in IP as compared to 1.45:1 in FP. Cost of cultivation of both IP and FP of rice variety Saket-4 was worked out. The results revealed that making additional expenditure of Rs. 4030/- in form of green manure and potash, the net return in IP increase was Rs.6365 ha⁻¹ over FP. As regards benefit cost ratio, it was 1.14:1 in IP as compared to 1.07:1 in FP. The highest percent yield (16%) increased over farmer practice was in the rice variety Sugandha-5 and highest net return (RS.9365/-) was found in Basmati-370.

OFT 2: Performance of band placement of FYM+ Potash in different varieties of sugarcane (plant crop)

A total of 11 OFT on performance of band placement of FYM + potash in different varieties of sugarcane (plant crop) were laid out. The improved practice (band placement of FYM + potash) resulted in the increased yield by 13.5 % in 'COS-767', 11.4 % in 'COS-8436', and 9.9 % in 'COS-8432' varieties of sugarcane as compared to farmers' practice. Cost of cultivation of both, improved practice (IP) and farmers practice (FP) of sugarcane varieties COS-767, COS-8436 and COS-8432 were worked out. The results revealed that making additional expenditure of Rs.5860/- in the form of FYM and potash application the net return in IP increase was Rs.13970, Rs.11610 and Rs.8220 ha⁻¹ over FP, respectively. Similarly the benefit cost ratio for IP was higher (1.97:1, 2.03:1 and 1.87:1 respectively) as compared to FP (1.88:1, 1.97:1 and 1.84:1, respectively). The highest percentage increase in yield (13.50%) and net return (Rs.13970) over farmers' practice was in the sugarcane variety COS-767.

OFT 3: Effect of Potash in different varieties of sugarcane (ratoon crop)

A total of 13 OFT on effect of potash in different varieties of sugarcane (ratoon crop) were laid out. The improved practice (potash application) resulted in increased yield of 9.3 % in 'COS-8436', 8.9 % in 'COS-767', and 7.9 % in 'COS-8432' varieties of sugarcane as compared to farmers' practice. Cost of cultivation of both, improved practice (IP) and farmers practice (FP) of sugarcane varieties COS-767, COS-8436 and COS-8432 were worked out. The results revealed that making additional expenditure of Rs.860/- in the form of potash application, the net return in IP increase was Rs.12393, Rs.15643 and Rs.11643 ha⁻¹ over FP,

respectively. Similarly the benefit cost ratio for IP was higher 2.04:1, 2.43:1 and 2.43:1 respectively) as compared to FP (1.90:1, 2.26:1 and 2.02:1, respectively). The highest percent increase in yield (9.29%) and net return (Rs.15643/-) over farmers' practice was in the sugarcane variety COS-8436.

OFT 4 : Performance of Napier grass as green fodder

A total of 11 demonstrations on Napier grass were laid out through cutting during 2008-09. It was further maintained as a ratoon crop and the yield of Napier grass as green fodder was recorded. The yield varied from 1375q ha⁻¹ to 1950 q ha⁻¹ with an average yield of 1635 q ha⁻¹.

C. TRAINING

Capacity building of stakeholders in integrated farming systems through training.

A training calendar including title of training, duration, tentative month of training, eligible participants, total intake of participants and approximate budget was prepared for each training programme. Major training areas viz., scientist-farmer interactive meet, crop production technologies for *kharif* crops, entrepreneurship development in profitable farming systems, resource conservation

and its utilization in farming systems, system-based integrated nutrient management, profitable cropping systems, crop production technologies for *rabi* crops, conduct of on-farm experiments and surveys in FSR perspective, organic-based farming systems, winter school on sustainable farming systems and crop production technologies for *summer* crops were identified for different categories of stakeholders. The learning objectives, expected outcome and course contents for each programme were prepared separately.

D. FRONTLINE DEMONSTRATIONS

OFD on oil seed-based cropping systems

There was increase in oilseed production with improved practice (IP) compared to farmer's practice (FP) to the extent of 15 % in castor +green gram and 8% in ground nut-mustard at Bachau and 17% at Junagarh in sesame-wheat cropping systems (Table 9.5/1).

OFD on pulse-based cropping systems

Improved practice showed superiority to the farmers' practice. The mean annual productivity of pulse based system increased by 10 % with improved practice compared to farmer's practice at Srinagar in rice-chickpea system (Table 9.5/2).

Table 9.5/1. Grain or pod yield (t ha⁻¹) of important oilseed-based cropping systems under frontline demonstration during 2008-2009 (mean over locations)

Agro-ecosystem	Cropping system	No. of Demons- tration	Farmer's Practice t ha ⁻¹		Improved practice t ha ⁻¹		Gain over Farmer's practice (%)	
			<i>Kharif</i>	<i>Rabi</i>	<i>Kharif</i>	<i>Rabi</i>	<i>Kharif</i>	<i>Rabi</i>
I Arid Bachau (GAU)	[Castor + green gram]	1	2.7+0.44	—	3.1+0.5	—	15	—
	[Ground nut-mustard-I P]	1	1.5	1.95	1.6	2.1	8	
II Semi-arid Junagarh (DAU)	Sesame-wheat	3	0.6	3.8	0.7	3.9	17	3

Table 9.5/2. Grain yield of important pulse-based cropping systems under frontline demonstration

Agro-ecosystem Centre	Cropping system	No. of Demons- tration	Farmer's method t ha ⁻¹		Improved method t ha ⁻¹		Overall gain of the system over farmers' method (%)	
			<i>Kharif</i>	<i>Rabi</i>	<i>Kharif</i>	<i>Rabi</i>	<i>Kharif</i>	<i>Rabi</i>
III Sub-humid Srinagar (GBPUA&T)	Rice-chickpea	1	5.7	1.7	5.8	2.0	10	

9.6 EXTERNALLY FUNDED PROJECTS

Evaluating production systems for attaining maximum productivity and profits under different cropping systems

In intensively cultivated areas of Indo-Gangetic Plain (IGP) region, inadequate and unbalanced fertilizer use on continued basis, has not only aggravated the deficiencies of K, S and micronutrients in the soils, but also caused decline in factor productivity. A field experiment was conducted during 2008-09 to evaluate the performance of five nutrient management options (1) Farmer's fertilizer practice (FFP), (2) State fertilizer recommendation (SR), (3) Improved state recommendation (ISR) (wherein 25% higher dose of N and 50% higher doses each of P and K as compared to SR were applied), (4) State soil testing laboratory recommendation (STLR) and (5) Site specific nutrient management (SSNM), with 5 important cropping systems i.e. sesamum-wheat, groundnut-wheat, pigeon pea-wheat, maize-wheat, sorghum (fodder)-wheat vis-à-vis rice-wheat cropping system in a split - plot design with 03 replications. The results of experiments are given as under:

Evaluating nutrient management options for wheat based cropping systems

The productivity of various monsoon crops varied in accordance with nutrient management options and the highest economic yield was registered with SSNM treatment. The productivity gain under SSNM treatment over FFP was 35.4%, 37.9%, 54.4%, 31.0%, 28.6% and 51.0%, respectively, for rice, maize, pigeon pea, sesamum, groundnut and dry sorghum fodder. The ISR had second position in terms of yield performance but had edge over SR and STLR. The increase in yield under ISR over SR and STLR was to the tune of

782 to 1173 kg ha⁻¹ in rice, 768 to 1068 kg ha⁻¹ in maize, 246 to 310 kg ha⁻¹ in pigeon pea, 39 to 80 kg ha⁻¹ in sesamum, 200 to 262 kg ha⁻¹ in groundnut, and 937 to 1350 kg ha⁻¹ in dry sorghum fodder. The yields obtained under SR and STLR were almost similar for different monsoon crops but had significant edge over FP.

The grain yield of wheat, grown on same layout without application of secondary and micronutrients, was highest in SSNM treatment followed by ISR, and the lowest in FFP. The highest wheat yield in SSNM treatment was registered after maize (6.4 t ha⁻¹) harvest, which was almost equal to groundnut-wheat system. The lowest wheat yield was recorded after sorghum (F) (5.61 t ha⁻¹) harvest. The enhancement in wheat yield in SSNM and ISR treatment options was attributed to longer ear size, more number of grains ear⁻¹ and higher number of effective tillers m⁻². The application of secondary and micronutrients in monsoon crops had visible residual effect on successive wheat crop in most of the cropping systems but the magnitude of response varied with cropping systems.

The system productivity in terms of wheat equivalent yield (WEY) varied with nutrient management options and the SSNM schedule resulted highest economic yield in all the cropping systems. Across the treatments, the highest system productivity, was recorded in rice-wheat (12.5 t ha⁻¹) followed by maize-wheat (10.8 t ha⁻¹), groundnut-wheat (8.86 t ha⁻¹), pigeon pea-wheat (8.83 t ha⁻¹), sesamum-wheat (7.69 t ha⁻¹) and lowest in sorghum (F)-wheat (5.99 t ha⁻¹). Across the cropping systems, system productivity (WEY) was 12%, 23%, 12% and 33% higher with state recommendation, improved state recommendation, soil test laboratory recommendation and site specific nutrient management options, compared with farmers

fertilizer practice (Table 9.6/1). On average, SSNM had 19% edge over improved state recommendation treatment due to secondary and micronutrient application in SSNM. Among the cropping systems, the highest increase in SSNM treatment over FFP was recorded in sorghum (F)–wheat (43%) followed by pigeon pea-wheat (35%), rice-wheat (35%), sesamum-wheat (34%), maize-wheat (29%) and groundnut-wheat (29%), respectively. These results clearly envisaged that generalized recommendations at state level and soil testing laboratory based on initial soil status (i.e. high, medium and low) do not work for achieving high yield target. On the other hand, recommendation made through SSNM based on indigenous nutrients supplying capacity of soil and targeted yield can be advocated for attaining yield potential of different crops and cropping systems.

Evaluating nutrient management options for rice based cropping system

In rice based cropping systems the highest rice equivalent yield (REY), on average, was reported in rice-garlic (40.36 t ha⁻¹) system followed by rice-potato (17.55 t ha⁻¹), rice-wheat (13.70 t ha⁻¹), rice-berseem (12.50 t ha⁻¹) and rice-chickpea (12.0 t ha⁻¹), and lowest in rice-mustard system (11.62 t ha⁻¹) across the nutrient management options (Table

9.6/2). Application of nutrient as per site- specific nutrient management out yielded the other nutrient management options and had 24 to 42% extra rice equivalent yield as compared to existing farmers' fertiliser management practice. The second most promising option was ISR, which gave 5 to 10% additional yield over SR, 4 to 10% over STLR and 17 to 47% over FFP. This improvement in SSNM over ISR was attributed to secondary and micronutrient application in SSNM treatment.

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

Field experiment was continued at PDFSR farm during 2008-09 for studying the effect of different tillage, crop establishment practices and residues management options on productivity of rice–maize cropping system. Eighteen treatments including nutrient options like NP, NPK+S and Zn, and NP+S/Zn under different crop establishment practices were evaluated under split plot design with 4 replications. The objective of the study was to access the effect of crop establishment and residue management options on potassium and micronutrient needs of rice and maize crop in the system.

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

Nutrient management option	System productivity WEY (kg ha ⁻¹)					
	Rice-wheat	Sesamum-wheat	Pigeon pea-wheat	Groundnut-wheat	Maize-wheat	Sorghum (F)-wheat
Farmers' Fertilizer Practice (FFP)	10598	6434	7686	7954	9697	4813
State recommendation (SR)	11999	7600	8559	8512	10296	5781
Improved state recommendation (ISR)	13463	8128	9282	9477	11051	6622
State soil test lab. recommendation (STLR)	12061	7652	8236	8483	10359	5859
Site specific nutrient management (SSNM)	14273	8639	10369	9877	12540	6862
Mean	12476	7691	8826	8861	10789	5987

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

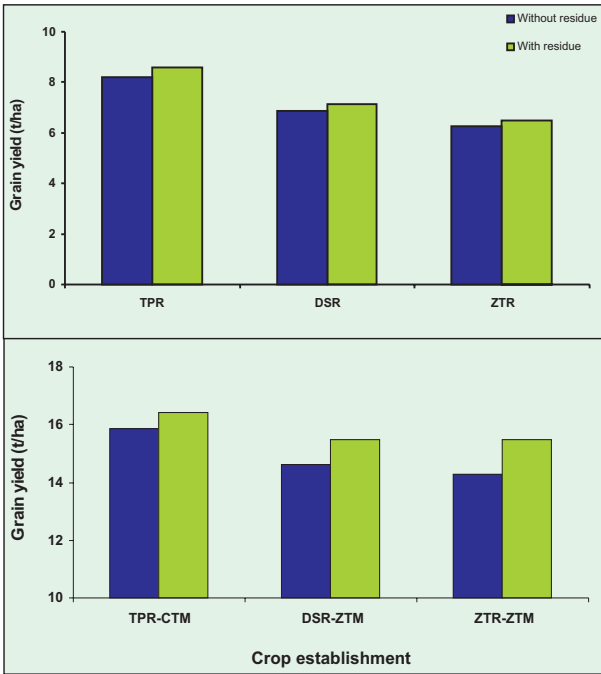
Nutrient management option	System productivity REY (kg ha ⁻¹)					
	Rice- mustard	Rice- chickpea	Rice- garlic	Rice- berseem	Rice- potato	Rice- wheat
Farmers' Fertilizer Practice (FFP)	9834	10247	29630	10914	14408	12221
State recommendation (SR)	11101	11688	40204	12326	17155	13296
Improved state recommendation (ISR)	12244	12336	43633	12913	18136	14302
State soil test lab. recommendation (STLR)	11623	11865	41669	12387	17030	13138
Site specific nutrient management (SSNM)	13272	13838	46695	13949	20542	15591
Mean	11615	11995	40366	12498	17554	13710

Effect on rice crop

Rice grain yield varied from 6.23 t ha⁻¹ to 8.88 t ha⁻¹ under different crop establishment practices and nutrient management. Residue recycling under transplanted rice crop had highest yield gain as compared to direct seeded or zero till rice crop (Fig. 9.6/1). Response to K+ S and Zn application was also modified in the presence of residue and the magnitude was 0.63, 0.86 and 0.54 t ha⁻¹, respectively for K + S and Zn under transplanted rice (TPR), direct seeded rice (DSR) and zero tillage rice (ZTR). Whereas such response under residue removed plots had 1.06, 1.09 and 0.88 t ha⁻¹, respectively. Individually response to K and S +Zn application was also more with residue removed plots (ranging from 0.44 to 0.58 t ha⁻¹ for K and from 0.35 to 0.31 t ha⁻¹ for S +Zn application). These findings clearly indicated that partial requirement of K, S and Zn was supplemented through residues recycling/ retention, which has curtailed the fertilizer nutrients requirement for rice crop. Among different crop establishment practices maximum K responses was noticed with DSR followed by ZTR and TPR.

Effect on maize crop

Winter maize productivity varied from 7.64 to 9.0 t ha⁻¹ under different crop establishment practices. The effect of residue recycling/retention was more pronounced under zero till-maize, followed by conventional till maize. The recycling of rice residue under different crop establishment options had significant effect on K + S and Zn response and, responses were more in the absence of in situ residue recycling (0.93 to 1.28 t ha⁻¹). Individually response to K was also more under conventional till Maize (CTM) i.e., 0.5 to 0.63 t ha⁻¹ as compared to zero till maize (ZTM) ranging from 0.3 to 0.52 t ha⁻¹. On other hand, responses to S and Zn were more spectacular under ZTM (0.23 to 0.97 t ha⁻¹) as against CTM (0.28 to 0.42 t ha⁻¹). It was pertinent to mention here that responses of residue retention/ recycling had attributed to the marked influence on soil micro-climate (buffering capacity ranged between 2 to 5 °C at grand growth period of crop, which ultimately influenced the soil chemical microbial process for nutrient transformations). Effect of residue management was also apparent for rice-maize system productivity (Fig.9.6/1) and individual nutrient response (Fig 9.6/2).

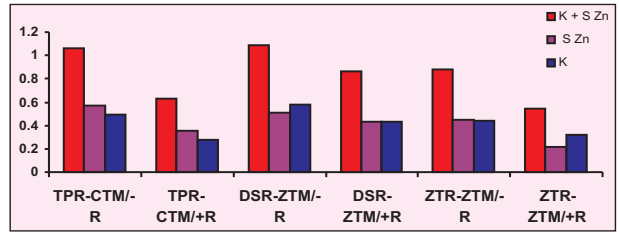


(TPR= Transplanted rice; DSR= Direct seeded rice, ZTR= Zero till rice, CTM= Conventional till maize; ZTM= Zero till maize)

Fig. 9.6/1: Grain yield of rice and rice- maize system productivity as influenced by different crop establishment practices and residue management options

Economics of farming system diversification towards high value enterprise in Uttar Pradesh

In India, agriculture and allied activities, despite their falling shares in the gross domestic product, are central to livelihood of millions of rural people. Nearly 72 % of India’s population lives in rural areas, and 75 % of it depends on agriculture and allied activities for their livelihood. Uttar Pradesh is far behind in farm business income than its counterpart Punjab in spite of having huge potential. The livestock was the main source of employment for small farmers and has a very good scope for increasing the farm income through livestock enterprises in Uttar Pradesh. Due to the gradual shrinking of land holding, it is necessary to integrate land based enterprises like livestock, dairy, fishery, poultry, duckery, apiary, field and horticultural crops



(TPR= Transplanted rice; DSR= Direct seeded rice, ZTR= Zero till rice, CTM= Conventional till maize; ZTM= Zero till maize; +/- = Residue retained/ recycled; - R= without residue)

Fig. 9.6/2: Response to K, S, and Zn application under different crop establishment practices and residue management options

etc. with in the bio-physical and socioeconomic environment of the farmers to make farming more profitable and dependable. Keeping this in view, the present study was conducted with the specific objective to study the cost and returns to factors of production from crop and live stock farming on different categories of farmers.

Five stage stratified random sampling was adopted for the study i.e. agro-climatic zone (first stage), district (second stage), development block (third stage), village (fourth stage) and operational holding (fifth stage). Three districts namely Agra, Aligarh and Badaun representing South West Semi Arid Plain, and Sitapur, Unnao and Jhansi representing Mid Plain, were selected. The sample size consisted of 108 farm households from each zone during 2006-07. Data were obtained through personal interview with the help of pre-tested structured schedules. Crop diversification index was calculated by using Simpson Index of diversity as below:

$$\text{Simpson Index of diversity, } I_i = 1 - (\sum_i S_i^2) / (\sum_i S_i)^2$$

Where S_i is the share of crop ‘i’ in gross crop area. A high Simpson Index indicates greater crop diversity, while a low index reflects more specialization. Tabular analysis was carried out to estimate various incomes, costs and returns to

different factors of production and economic surplus of the selected households. Different types of costs have been worked out in the study. Depreciation on fixed capital, interest on working capital and cost on different inputs had been included in cost A_1 . Cost A_2 was obtained by adding rent paid for leased in land to cost A_1 and cost B_1 was obtained by adding interest on fixed capital to cost A_1 . Cost B_2 was calculated by adding the rental value of owned land to cost B_1 . Cost C_1 was the total of cost B_1 and computed value of family labour. And cost C_2 was the sum total of cost B_2 and computed value of family labour. Return to factors of production from crop production and live-stock farming were computed. After deducting total cost from the gross income, per hectare net return or total return to management from crop production and live-stock production were obtained. Returns to land and management were calculated by taking out the imputed value of owned land from the total cost per hectare.

In Mid Plain the average size of operational holding varied from 0.66 ha for marginal farmers to 7.44 ha for large farmers. The range of land ownership was not varying much for marginal and large farmers in South West Semi Arid Plain (0.71 ha) as compared to Mid Plain (7.78 ha). However, proportion of area under cereals decreased as farm size increased across the groups. Pulses were the second most important crops and their share in gross cropped area increased as farm size increased. In all cereals, pulses and oilseeds comprised about 78 percent of gross cropped area. The cropping intensity was lowest (114%) for large farmers due to cultivation of oil seeds and pulses. It was found that farmers were more dependent on food crops and share of high value crops like, fruits and vegetables etc. in cropping pattern was found negligible due to their food security. In Mid Plain, rice-wheat was the major cropping system of the area and cereals, pulses and oilseeds constituted about 81% of the total gross cropped area. Fodder crops accounted only about

4 % area in the region. In South West Semi Arid Plain, *bajara* –wheat was the major cropping system. Cereal crops occupied about 63% area followed by fodder crops (10.51%). Farm size wise analysis indicated that area under fodder crop decreased as farm size increased except large farmers in Mid Plain while increased in South West Semi Arid Plain. The marginal farmers were less diversified in comparison to other farmers in all the zones except few cases. The average diversification index for marginal farmers was 0.6313 as compared to 0.7497 for large farmers in Mid Plain (Table 9.6/ 3). Similarly it was 0.6623 for marginal farmers as against 0.7168 for large farmers of South West Semi Arid Plain. In all, the sample household's followed medium to high degree crop diversification for fulfillment of family requirement and risk minimization. However, there is a large scope for diversification towards high value crops.

It was observed that buffalo was the important milch animal kept on the different farming systems. On the whole, a farmer possessed 0.19 cross bred cow in comparison to 1.34 buffaloes.

The livestock pattern in mid plain contains about 16 % draft animals in comparison to 7 % in South West Semi Arid Plain. This indicates that the farmers were less interested in keeping the cross bred cows because the price of the milk is not attractive in comparison to buffalo milk. It shows that the cross breeding programme and milk cooperatives need to be strengthened. Livestock pattern revealed that as farm size increased, the herd size also increased in both the zones except large farmers in South West Semi Arid Plain. A marginal and small farmer of South West Semi Arid Plain reared at least one goat or sheep for supplementing his income. Calves were the second largest flock of bovine population on all size groups. The live stock pattern indicates greater scope for expansion towards dairy and meat animals.

Table 9.6/3. Crop diversification of different size of farms in different zones of Uttar Pradesh

Level of Diversification	Marginal		Small		Medium		Large		Total	
	No. of HH	DI	No. of HH	DI	No. of HH	DI	No. of HH	DI	No. of HH	DI
Mid plain										
High	14	0.7603	21	0.7380	10	0.7394	9	0.7612	53	0.7473
Medium	33	0.5825	14	0.6386	5	0.6611	1	0.6466	54	0.6056
Low	0	0.0000	1	0.0000	0	0.0000	0	0.0000	1	0.0000
Average	47	0.6313	36	0.6788	15	0.7133	10	0.7497	108	0.6695
South west Semi arid Plain										
High	17	0.7584	15	0.7534	21	0.7797	10	0.7824	63	0.7681
Medium	15	0.5534	13	0.6006	11	0.6091	4	0.6395	43	0.5899
Low	0	0.0000	1	0.4444	0	0.0000	1	0.3704	2	0.4074
Average	32	0.6623	29	0.6742	32	0.7211	15	0.7168	108	0.6905
Overall										
High	30	0.7585	36	0.7444	31	0.7667	19	0.7724	116	0.7586
Medium	49	0.5737	27	0.6203	16	0.6253	5	0.6409	97	0.5986
Low	0	0.0000	2	0.2222	0	0.0000	1	0.3704	3	0.2716
Average	79	0.6439	65	0.6768	47	0.7186	25	0.7300	216	0.6800

HH-Household, DI-Diversification index

In Mid Plain, the per hectare cost A_1 found to be decreasing with increasing farm size except in case of small farmers. The cost A_1 varied from about Rs.11624 for marginal farmers to Rs.13303 for large farmers. As regards cost C_2 which included rental value of owned land and imputed value of family labour varied from Rs.36596 for marginal farmers to Rs.39591 for small farmers. Per hectare estimated gross return from crop production varied from about Rs.32801 for medium farmers to Rs.41577 large farmers of mid plain. In south west semi arid plain, cost A_1 was considerably higher on small farms (Rs. 15005) and lower on marginal farms (Rs.11110). With addition of rent paid for leased in land and interest on fixed capital, rental value of owned land and imputed value of family labour, the cost C_2 ranged from Rs.37134 on marginal farms to Rs. 43903 on medium farms indicating that cost B_1 increased as farm size increased except in case of medium farms. The inter-zonal comparison revealed

that the per hectare cost of production was lowest (Rs.38079) in Mid Plain and highest (Rs.40603) in South West Semi Arid Plain which was due to the low cost of production of sugarcane and maize crop in Mid Plain.

Economics of Livestock Farming

Dairy buffaloes (31%), calves (28%) and goats (13%) were found to constitute a major portion in the total live- stock in all the zones. The gross income from livestock was calculated by including income from milk, dung, meat and sale of livestock during the period of study. In Mid Plain, per hectare per annum burden of fixed as well as working resources (cost A_1) was found considerably higher on marginal farms (Rs. 48711) than average farmer (Rs. 24895). On including the interest on fixed capital and imputed value of family labour in the cost of live stock farming the total cost becomes still higher on marginal farms

(Rs. 62679) than average farm (Rs. 31608). Per hectare average income from livestock farming was also found to be higher (Rs 62819) than average farmer (Rs 27238). However, net income was higher in case of medium farms. In South West Semi Arid Plain, the cost on different purchased inputs including depreciation on fixed capital, came to be Rs.46026 per hectare on marginal farms followed by Rs.30096 on small farms. The trend remained the same after inclusion of interest on fixed capital and imputed value of family labour. In general, per hectare cost on livestock management varied from Rs.11636 for large farmers to Rs.61438 for marginal farmers indicating inverse relationship between farmers dependency on live-stock and farm size.

Return to Factors of Production from Crop Production and Livestock Farming

After deducting total cost from the gross income, per hectare net return or total return to management from crop production and live-stock production were negative in small farms in Mid Plain and positive on marginal and large farms. By taking out the imputed value of owned land from the total cost, the per hectare return to land and management were found to be highest on all farms ranging from Rs.16466 on large farms to Rs.108196 on medium farms in South West Semi Arid Plain and lowest in Mid Plain. When clubbed together, the return to land, labour and management, the maximum reward was witnessed in South West Semi Arid Plain. It was also observed that crop farming alone could fetch a positive return only on marginal and large farms in Mid Plain and small farms in South West Semi Arid Plain while, in all other farm categories of respective zone the net return or the return to management were negative because of higher rental value of owned land and inefficient management. But, the return to labour and management were found to be highest in South West Semi Arid Plain because of higher percentage of cross breed cows, dairy buffalo, goat

and sheep in comparison to Mid Plain. The returns to management from livestock enterprises were positive on all farms in both the zones except on small farms in Mid Plain, indicating livestock farming was a good source of income to all farmers especially in South West Semi Arid Plain.

Net farm income and net savings

Total net income was found to be about two and half time more for all farmers except large farmers in South West Semi Arid Plain in comparison to Mid Plain. The marginal, small and medium farmers of Mid Plain had a disposable income Rs.28262, Rs.56170 and Rs.90281, respectively, while the same was Rs.67803, Rs.164826 and Rs.395069 in South West Semi Arid Plain. The large farmers of Mid Plain had higher disposable income because of considerably higher income from crop production. The source wise income revealed that highest proportion of the income was provided by crop production in Mid Plain and from live stock in South West Semi Arid Plain. Net saving was calculated by deducting the domestic expenditure based on the NSS 59th Round Survey (2003) with 20 per cent increase in domestic expenditure due to price rise during period 2003 to 2007. It was observed that in general the marginal farmers could not meet their household requirement on the basis of their income from all sources like crop, livestock and off-farm income. They were in deficit of Rs.26061. Zone wise analysis indicated that the marginal and small farmers in Mid Plain and marginal farmers in South West Semi Arid Zone were in deficit of Rs.34254, Rs.28745 and Rs.20233, respectively.

It was concluded that farmers in general and marginal and small farmers in particular were able to get positive returns due to engagement of family labour. Otherwise if return to management or net return were considered, they realized negative return in both the zones particularly in crop production.

The live stock productivity was higher in South West Semi Arid Zone and, therefore, farmers were able to manage higher return in comparison to Mid Plain. The study indicated that farmers were surviving without proper maintenance of balanced food, health and education of their family. Their income can be

increased by expansion of farm activities i.e. dairying, goatery, poultry, bee keeping etc. besides providing low cost technology for farm production and reliable prices to their farm produce. This will enable them to bear the cost of health and education which became very dear in the era of commercialization.



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

Project Directorate for Farming System Research has well-established linkages with reputed International Institutes like IRRI, other ICAR

Institutes, State Agricultural Universities and *Tehri* Hydro Development Corporation etc.

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

Under the aegis of 'AICRP on Integrated Farming Systems' on-station research is going on at 31 main canter and 11 sub centers. These centers are engaged in basic and 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.

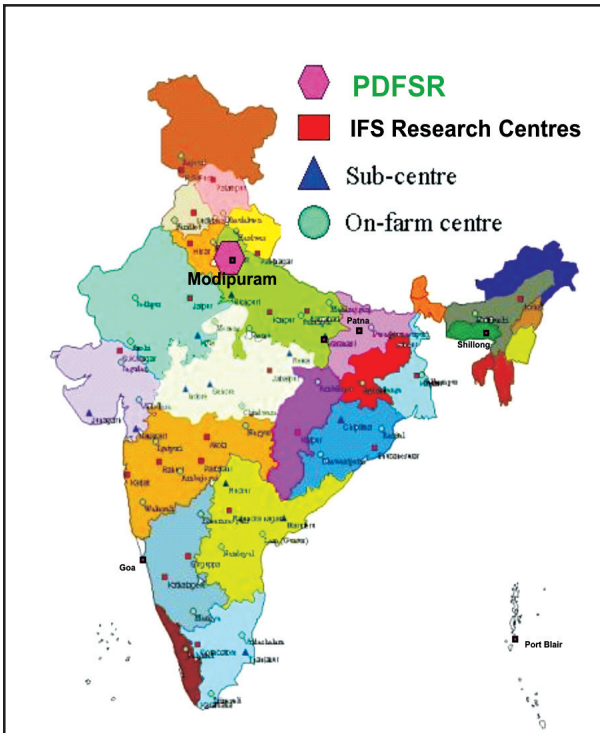
A. AICRP-IFS Centers

I. IFS Research Centres (*marked centers are operating as Sub-Centers)

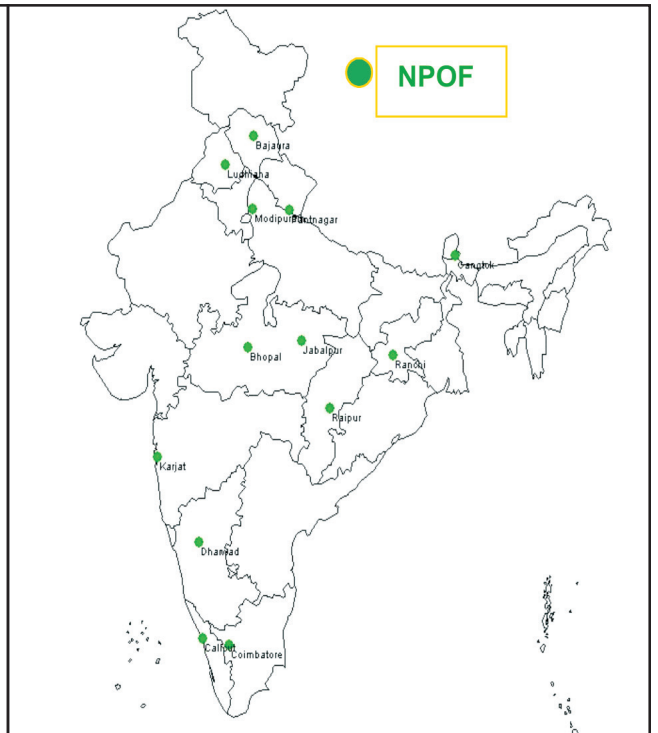
<i>Arid ecosystem:</i>	Hissar, S. K. Nagar and Siruguppa
<i>Semi-arid ecosystem:</i>	Modipuram, Ludhiana, Bichpuri*, Kanpur, Durgapura, Kota*, Indore*, Junagarh*, Akola, Rahuri, Rudrur*, Parbhani, Rajendranagar, Kathalagere, Coimbatore
<i>Sub-humid ecosystem:</i>	Faizabad, Varanasi, Pantnagar, Powarkheda*, Jabalpur, Rewa*, Raipur, Ranchi, Chiplima*, Bhubaneswar, Patna and Sabour
<i>Humid ecosystem:</i>	Jammu, Palampur, Kalyani, Shillong and Jorhat
<i>Costal ecosystem:</i>	Thanjavur*, Maruteru*, Navsari*, Karmana, Port Blair, Goa and Karjat

II. On-Farm Research Centers

- Arid ecosystem:* Bachau Dist. Kutch (Gujrat) and Sri Ganganagar (Rajasthan)
- Semi-arid ecosystem:* Arnej Dist. Ahemedabad (Gujrat), Kurukshetra (Haryana), Banglore and Nipani Dist. Belgaum (Karnataka), Seoni and Teekamgarh (M.P.), Sindhwahi Dist. Chandrapur, Ambajogai Dist. Beed and Chas Dist. Ahemadnagar (Maharastra), Fatehgarh Sahib (Punjab), Udaipur (Rajasthan), Thirupastsaram Dist. Tirunelveli and Tindivanam Dist. Villupuram (T.N.), and Banda (U.P.).
- Sub-humid ecosystem:* Nellore (A.P.), Patna (Bihar), Ambikapur Dist. Sarguja (Chhattisgarh), Dumka (Jharkhand), Mahisapat Dist. Dhenkanal (Orissa), Baharaich and Varanasi (U.P.) and Srinagar Dist. Pauri Garhwal (Uttrakhand).
- Humid ecosystem:* Tinsukia (Assam), Arkoapt Disat. Una (H.P.) and kathua Dist. Jammu (J&K) and Gayeshpur Dist. Nadia (W.P.).



Map 1.



Map 2.

12. GENERAL/MISCELLANEOUS

12.1 LIST OF PUBLICATIONS

A. Research/Review Papers

- Bhanu, C. 2009. *Puccinia jabalpurensis* sp. nov. on exotic weed *Lagascea mollis* from India. *Indian Phytopathology*, 62 (3): 365-368.
- Biswas, C., Singh, D., Singh, R. and Kumar, V. 2009. Incidence of bacterial blight and *Alternaria* leaf spot in Bt cotton. *Indian Phytopathology*, 62 (2): 256-57.
- Biswas, C., Singh, D. and Singh, R. 2010. Reaction of Bt and non Bt hybrids of upland cotton to major insect pests. *Environment and Ecology* (Accepted)
- Chaudhary, V. P., Gangwar, B., Pandey, D. K and Gangwar, K. S. 2009. Energy auditing of diversified rice-wheat cropping systems in Indo-Gangetic Plains. *Energy (Elsevier)* 34:1091-1096.
- Gangwar, K. S Chaudhary V.P., Gangwar, B. and Pandey, D. K. (2009) Effect of crop establishment and tillage practices in rice (*Oryza sativa*)-based cropping systems. *Indian Journal of Agricultural Sciences*. 79 (5): 334-9.
- Gangwar, K. S. and Singh, H. R. 2010. Effect of rice (*Oryza sativa*) crop establishment technique on succeeding crops. *Indian Journal of Agricultural Sciences*, 80 (1): 24-28.
- Gill, M. S., Shukla, A. K., Singh, M. P., Tomar, O. K., Majumdar, K. and Tiwari, K. N. 2009. Evaluation of Nutrient Management Options for Yield, Economics and Nutrient Use Efficiency. *Better crops (India)* (6) :12-15.
- Gill, M. S., Singh, J. P. and Gangwar, K. S. 2009. Integrated Farming System and Agriculture Sustainability. *Indian Journal of Agronomy* 54 (2):128-139.
- Kochewad, S. A., Chahande, J. M., Kanduri, A. B., Deshmukh, D. S., Ali, S. A. and. Patil, V. M. 2009. Effect of Probiotic supplementation on Growth parameters of Osmanabadi Kids. *Veterinary World*. 2009, 2(1): 29-30.
- Pandey, D. K., Gangwar, K. S. and Chaudhary, V. P. 2009. Weed management in direct sown rice. *Oryza* 46(2): 165-66.
- Shukla, A. K, Singh, V. K., Dwivedi, B. S., Gill, M. S. 2009. Macro role of Micronutrients. *Indian Journal of Fertilizer*, 5 (5) 11-30.
- Singh, A., Deka, B. C., Prakash, J., Patel, R. K. and Ojah, H. 2010. Problems and prospects of papaya cultivation in northeastern states of India. *Acta Horticulturae*. Vol. 851.
- Singh, D., Singh, P., Singh, J. P. and Kumar, V. 2009. Physiological studies on cotton and wheat genotypes for compatibility and productivity in cotton-wheat system. *J. Farming System Research & Development* 14(2):286-290. (In Press).
- Singh, Devendra, Pandey, Rakesh and Kumar, Vipin .2009. Effect of growth retardants on morpho-physiological parameters in cotton under irrigated conditions in cotton-wheat system. *Indian J. Plant Physiol.*, 14 (3):257-61.
- Singh, J. P., Gill, M. S., Singh, D., Singh, P. and Sharma, B. K. 2009. Suitability of crops and

planting methods under simultaneous cropping of winter season crops in autumn sugarcane. *J. Farming System Research & Development* 14(2):291-297. (In Press).

Singh, M., Singh, M. P., Brijmohan and Singh, K. P. 2009. Yield variation analysis in plant and ratoon crops of sugarcane at farmers fields in western Uttar Pradesh. *Indian Journal of Fertilizers*, Vol.V (7) :43-51.

Singh, S. P., Gangwar, B. Singh, M. P. and Singh, S. P. 2009. Constraints in integrated farming systems in western U.P. *Progressive Agriculture* (An International Journal), 9 (1) 12-18.

Singh, S. P., Gill, M. S., Gangwar, B. and Singh, M. P. 2009. Livestock in irrigated farming systems of Uttar Pradesh, *Indian Journal of Animal Sciences* 79 (9):94-100.

Singh, S. P., Ramasundraram, P., Gangwar, B. and Singh, M. P. 2009. Socio-economic aspects of Farming Systems in Mid-Western Plain of Uttar Pradesh. *Agricultural Situation in India*, Vol. LXVI, (3) :139-146.

Singh, V. K., Dwivedi, B. S. Shukla, A. K. and Mishra R. P. 2009. Permanent raised bed planting of the pigeonpea-wheat system on a Typic Ustochrept: Effects on soil fertility, yield, and water and nutrient use efficiencies. *Field Crops Res.* 116 (2010) 127-139

Tomar, R. K., Singh, D., Gangwar, K. S., Garg, R. N., Gupta, V. K., Chakraborty, D., Sahoo, R. N., Ranjan, R. and Chakravarty, K. 2009. Effect of tillage systems and irrigation schedules on soil cracking pattern, water requirement and performance of rice-wheat cropping system in Inceptisol in semiarid regions. *Journal of Soil and Water Conservation* 8(3):26-33.

Tripathi, K. P. 2008. Nitrogen fixation by *Lablab purpureus* grown in association with *Cenchrus ciliaris* in relation to natural abundance of VAM fungi in low fertility arid soils of India. *Journal of Farming Systems Research and Development* 14 (2), 207-218.

B. Popular /Technical Articles

Bhanu, C. 2009. Biological control of crop diseases and weeds under organic farming systems. In: Compendium of Lectures : Summer School on “Advances in Organic Farming” (M.S. Gill, Kamta Prasad, S. S. Pal and Prem Singh), 2-22 June, 2009, PDFSR, Modipuram, Meerut, India. pp: 190-196.

Bhanu, C. 2009. Containing global warming through improved farming practices. In: Compendium of lectures: Short course on SMS of KVKs Zone-II, on Integrated Farming Systems (Gill, M.S. and Singh, J. P.), 17-22 August, 2009, PDFSR, Modipuram, Meerut, India.

Bhanu, C. 2009. The risk of chemical pesticides to human health and environment. In: Compendium of Lectures : Summer School on “Advances in Organic Farming” (M.S. Gill, Kamta Prasad, S. S. Pal and Prem Singh), 2-22 June, 2009, PDFSR, Modipuram, Meerut, India. pp: 197-207.

Gangwar, B., Gangwar, K. S. and Mishra, P. P. 2009. रबी के दलहनी फसलों का फसल प्रणालियों में समावेश, महत्व एवं उन्नत खेती। pp 33-38.

Gangwar, B., Gangwar, K. S. and Mishra, P. P. 2010. जायद में दलहनी फसलों की वैज्ञानिक खेती। 51 (4):7-16.

- Gangwar, B., Pandey, D.K., Gangwar, K.S. and Chaudhary, V.P. 2010. धान-गेहूँ फसल प्रणाली विविधीकरण से उठाएँ लाभ। 64 (10): 23-29
- Pandey, Rakesh, Singh, Devendra and Paul, Vijay. 2009. Measurement of photosynthesis under changing environment. *In Summer School on “Photosynthetic Efficiency and Crop Productivity under Climate Change Scenario”, 25th August to 14th September, 2009, IARI, New Delhi, India, pp 111-114.*
- Pandey, Rakesh, Singh, Devendra and Paul, Vijay .2009. Photosynthetic light response measurement using infrared gas analyzer. *In training manual of ICAR winter school on training and capacity building on application of ionizing and non-ionizing energies in agriculture (Eds. Singh, B., Anand, A. and Koundal, K.R.) IARI, New Delhi, 37-42, pp228.*
- Singh, K. K. 2009. Cost Effective and Energy Efficient Farm Machinery for Integrated Farming Systems. *In: lecture notes of the short course / training on “Integrated Farming Systems” for Subject Matter Specialists of KVKs falling under zone-II, P. D. F. S. R., Modipuram.*
- Singh, V. K. and Tiwari, R. B. 2010. *Jayad Ki Fasalon Men Santulit Poshan Apnayen Adhik Utpadan Payen. Khad Patrika, March, 2010.*
- C. Books/Manuals/Book Chapters**
- Gill M. S., Sarkar, A., Ahlawat, I.P.S. and Gangaiah, B. 2009. Plant Water Nutrient Relationship in Crop Production. Published by Indian Society of Agronomy, IARI, New Delhi, Ist Edition, pp. 1-272.
- Sharma, A. R, Singh, V. K., Prasad, Rajender, Das, T. K., Swain, D., Blaise, D., Ghosh, P. K. and Gangaiah, B. 2009. Agronomic Terminology (Fifth Revised Edition, Sharma, A. R. and Gangaiah, B. Eds). The Indian Society of Agronomy, New Delhi-12, pp. 446.
- D. Technical/Research/Information Bulletins**
- Gill, M. S., Gangwar, B. and Sarkar, A. 2009. Farming system approach towards income enhancement. PDFSR Bulletin No.2009-1,pp. 1-92.
- Gill, M. S.; Prasad, Kamta, Pal, S. S. and Singh. P. 2009. Compendium of Lectures : Summer School on “Advances in Organic Farming”, 2-22 June, 2009, PDFSR, Modipuram, Meerut, India.
- Singh, S. P., Gangwar, B. and Singh, M. P. 2010. Characterization and Evaluation of Existing Farming Systems of Uttar Pradesh, PDFSR Bulletin No. 2010-11. PP 1-68. PDFSR, Modipuram, Meerut, India.
- E. Abstracts/Chapters in Proceedings of Seminar/ Symposia/ Conferences etc.**
- Bhanu, C. and Mishra, J. S. 2009. Biological control of exotic weed *Lagasea mollis* in soybean-mustard cropping system by using a potential rust bio-herbicide. Souvenir and Abstracts, 5th International Conference on Plant Pathology in the Globalized Era. November, 10-13, 2009, New Delhi, India. pp: 319
- Gangwar, B. and Singh, V. K. 2010. Soil sustainability through crop diversification

- during National Seminar on “Soil security for sustainable agriculture” held on 27-28, 2010 at College of Agriculture, Nagpur.
- Gill, M. S., Singh, V. K. and Mahapatra, I. C. 2009. Crop response to applied nutrient under different cropping systems during Brain storming Session on Crop response and nutrient ratio held on 28-29 May 2009 at National academy of Agricultural Sciences, New Delhi pp.79-91.
- Pal, S. S. and Rai, P. 2009. Effect of conservational practice on crop yield and soil organic carbon, carbondioxide evolution and microbial biomass carbon in rice wheat system. 74th annual convention and platinum jubilee of I.S.S.S., New Delhi from 22-25 December 2009.
- Prasad, K., Bhanu, C. and Gangwar, B. 2010. Weed management in organic farming research. *In: Extended summaries/Abstract, Biennial Conference on Advances in Weed Science Research-2010. 25-26 February 2010, IGKV, Raipur, L-4, p 6-7.*
- Sarkar, A. and Gill, M. S. 2009. On-farm response of rice-wheat cropping system under subhumid ecosystem of India. Proc. Indian Science Congress Association, 97 th Session Agricultural Sc. Section. pp.27.
- Sarkar, A., Singh, S. P. and Sharma, B. K. 2009. Studies on response of rice-wheat cropping system under on-farm situation in sub-humid ecosystem of India. Proc. Ist Indian Agricultural Scientists and Farmers Congress on Technological Innovations for Enhancing Agricultural Production organized by Society for Recent Development in Agriculture held at SBVP university of Agriculture and Technology, Modipuram, Meerut on 3-4 October, 2009. pp. 191-193.
- Sharma, B. K., Sharma, G. C., Singh, S. P. and Singh, Satya Pal. 2009. Attitude of farmers towards zero-tillage technology in Western Uttar Pradesh. 1st Indian Agricultural Scientist and Framers Congress on Technological Innovations for Enhancing Agriculture Production, October, 03-04, 2009. Organised by Society for Recent Development in Agriculture, SVPU&T, Meerut. Pp 416-417.
- Sharma, B. K., Singh, M. P., Singh, Naval and Singh, Satya Pal 2009. Participatory Research on Potash: Influence the Sugarcane yield, 1st Indian Agricultural Scientist and Framers Congress on Technological Innovations for Enhancing Agriculture Production, October, 03-04, 2009. Organised by Society for Recent Development in Agriculture, SVPU&T, Meerut. pp 318.
- Singh, Devendra, Gill, M. S. and Kumar Vipin .2009. Physiological evaluation of rice genotypes under changing climatic scenario. *Presented in National Conference on “Frontiers in Plant Physiology Towards Sustainable Agriculture”*, November 5-7, 2009, Jorhat, Assam. Abstract No.02-23, p 62-63.
- Singh, J. P. and Pandey, D. K. 2009. Integrated Farming System Approach- Future Hope of Farmers. In Souvenir & Abstract – First Indian Agricultural Scientists and Farmers Congress on Technological Innovations for Enhancing Agriculture Productivity. Held at CCS Univ., Meerut, 03-04 October, 2009, pp:311-312.
- Singh, K. K. and Mishra, R. P. 2010. Long term effect of resource conservation technologies on productivity, profitability and soil health in rice-wheat cropping system. Paper presented at the 44th annual Convention of Indian Society of Agricultural Engineers, IARI, January 28-30, 2010.



- Singh, M. P., Singh S. P., Gangwar, B. and Singh S. P. 2009. Technological package of cereal and sugarcane based farming systems in western Uttar Pradesh : An influence on livelihood of farmers. Ist Indian Agricultural Scientists and Farmers Congress, 03-04 :435-436
- Singh, M. P., Singh, S.P., Gangwar, B. and Singh, Satya Pal. 2009. Technological package of cereal and sugarcane based farming systems in western U.P. Ist Indian Agricultural Scientists and Farmers Congress on Technological Innovations for Enhancing Agricultural Production organized by Society for Recent Development in Agriculture held at SBVP university of Agriculture and Technology, Modipuram, Meerut on 3-4 October, 2009, pp. 435-36.
- Singh, S. P., Ramasundaram, P., Singh, M. P., Gangwar, B. and Sharma, B. K. 2009. Characterization of Farming Systems in Mid – Western Plain. Ist Indian Agricultural Scientists and Farmers Congress, 03-04 : 421-422.
- Singh, S. P., Ramasundram, P., Gangwar, B., Singh, M. P. and Sharma, B. K. 2009. Characterization of farming systems in mid-western plain of Uttar Pradesh. Ist Indian Agricultural Scientist and Framers Congress on Technological Innovations for Enhancing Agriculture Production, October, 03-04, 2009. Organised by Society for Recent Development in Agriculture, SVPU&T, Meerut. pp 421-422.
- Singh, V. K. and Gangwar, B. 2010. *Sthayee Uchh Kyari Bidhi Ka Arahara- Genhun Fasal Chakra Par Prabhaw* Paper presented during Twelfth Agriculture Science Symposium “*Satat Krishi Utpadan, Sambardhan Awam Sanrakshan Hetu Prakritik Sansadhano Ka Prabandhan* held from 22-24 April, 2010 at CSSRI Karnal (Haryana).
- Singh, V. K., Gill, M. S., Shukla, A. K., Singh, M. P., Gangwar, B., Sharma, R. K., Kumar, Vinod and Majumdar, K. 2009. Site-specific Nutrient Management for Sustained Higher Productivity and Profits during Platinum Jubilee Symposium organized by ISSS New Delhi held on 22-25 Dec., 2009 at IARI New Delhi.
- Tiwari, K. N., Dwivedi, B. S., Singh, V.K. and Meena, M. C. 2009. Effect of Potash on nutrient use efficiency- India Scenario during International Symposium on “Potassium role and benefits in improving nutrient management for food production, quality and reduced environmental damages organized by IPI-OUAT_IPNI held at OUAT Bhubaneswar during 5-7 November 2009.
- Tripathi, K. P., Gangwar, B. and Gill, M. S. 2009. Impact of different rice residue management methods on soil organic carbon fractions in rice-wheat cropping systems. In. Platinum Jubilee Symposium on Soil Science in Meeting the Challenges to Food Security and Environmental Quality held during 22-25 December 2009 at IARI, New Delhi, pp. 56.

F. Annual Reports/Newsletters/ other compilations

- Singh, Devendra., Bhanu, C., Prasad, Kamta and Sharma, Brijesh. 2009. Annual Report, 2008-09. Project Directorate for Farming Systems Research (ICAR), Modipuram, Meerut – 250 110, India.p.132.
- Tripathi, K. P. and Gangwar, B. 2009. PDFSR Newsletter. 16 (1), (Jan-June, 2009), 12 p.
- Tripathi, K. P. and Gangwar, B. 2009. PDFSR Newsletter. 16 (2), (July-Dec. 2009) 8 p.

12.2 MEETINGS OF RAC/IRC/IMC

Institute Research Committee (IRC) Meetings

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

21st Meeting of Institute Research Committee, held on 18 May 2009

The 21st meeting of Institute Research Committee of PDFSR was held on 18 May 2009. Twenty-two scientist members attended the meeting, which was chaired by Dr. M.S. Gill, Project Director, PDFSR. The main agenda items of the meeting were the presentations of new project proposals for approval.

In his introductory remarks the Chairman, IRC reminded the house that resource conservation is the niche area of this Directorate and reiterated to take up only the need based projects. Only three new project proposals were submitted for the approval of the house out of which only one project namely 'Agronomic evaluation of varieties of field crops under organic conditions' was approved as an observational trial.

22nd Meeting of Institute Research Committee, held on 26-27th October and 23rd November, 2009

Twenty second meeting of Institute Research Committee of PDFSR, Modipuram was held on Oct. 26-27 and Nov. 23rd, 2009. The meeting was chaired by Dr. B. Gangwar, Project Director (Acting), PDFSR, Modipuram. At the outset, Chairman desired that, in view of changed name of the Directorate with its mandate towards **Farming Systems**, the ongoing programmes and new proposals are to be re-oriented under following five programmes: 1. Cropping Systems and Resource Management (CSRM), 2. Organic Agriculture

Systems (OAS), 3. Integrated Farming Systems (IFS), 4. Resource Characterization and System Diagnosis (RCSA) and 5. Technology Transfer and Refinement (TTR) and these programmes are desired to be reflected in **farming system mode** instead of cropping system mode, irrespective of on-station/on-farm projects. Later on, the presentations were made as per agenda items.

Action taken report on the recommendation of 20th IRC meeting held on Sept. 9-10, 2008 and 21st meeting held on May 18, 2008 as received from the concerned scientists were presented by Dr. Devendra Singh, Member Secretary. In all, progress of 22 ongoing research projects were reviewed as presented by concerned project leaders/Principal Investigators. The progress on achievements, in general, was satisfactory but in some of the cases there was scope for further improvement. The meeting remained in-conclusive as new projects were required to be discussed in detail and hence it was decided to hold the meeting on 23.11.2009 so as to provide research projects to all the scientists in the Directorate and to focus research works towards **Farming System Mode**. The new research proposals were presented by the concerned scientists and discussed in detail during the IRC meeting held on 23rd November, 2009. In total 12 proposals were submitted for the approval of the house, however, only 9 could be presented and discussed and out of these 8 research projects were approved after desired necessary improvements.

Research Advisory Committee Meeting

The 16th meeting of Research Advisory Committee (RAC) of PDFSR was held on 25-27 March 2010 at PDFSR, Modipuram under the chairmanship of Dr. I. C. Mahapatra, the renowned world fame specialist in farming systems research.



Research Advisory Committee Meeting in progress

There were 26 participants, including eminent members like Dr R. C. Gautam, former Joint Director (Education) IARI, New Delhi, Dr. P. K. Aggarwal, National Professor (ICAR) IARI, New

Delhi and Dr R. Devendra, Professor & Head of Weed Sciences, University of Agricultural Sciences, Bangalore.



Dr. B. Gangwar, Project Director is showing the experiments to RAC members in the field during field visit of RAC

Dr. B. Gangwar, Project Director, while presenting the overview of the PDFSR, gave a brief account of progress of PDFSR beginning with genesis of SFT and Model Agronomic centres in 1953/1956 to the formation of PDFSR in 2009. He has emphasized that, PDFSR has been assigned the new mandates of Farming System Research with the change in its name as Project Directorate of Farming Systems Research. The action taken report of the proceedings of the last RAC meeting held on March 24-25, 2009 was presented by Dr Devendra Singh, Member secretary. The progress of on-going research programmes at the Directorate were presented before the committee by the Programme Facilitators and scientist of the Directorate like Dr

Kamta Prasad, Dr J.P. Singh, Dr G. C. Sharma, Dr S. S. Pal, Dr Anil Kumar and Dr S. P. Singh. Two lead papers were also presented from the eminent scientists like Dr P. K. Batra (IASRI) and Dr U. K. Behera (IARI) from New Delhi. Main stress was given on the strengthening of on-farm agricultural research for the poor and marginal farmers of the country. RAC emphasized that the integrated farming system research may be taken up in a holistic way to resolve the constraints in the production system of farming community. Diversification of the farming systems, organic agriculture system, management of farm resources and integrated farming systems were the main issues discussed in the meeting.

Institute management committee (IMC) meeting

The meeting of the IMC of PDFSR was held on 20-03-2010 to discuss various issues of the Project Directorate.

Name of Chairman and Member of IMC as on 31-03-2010 are as under:

1.	Dr. B.Gangwar, Project Director, PDFSR, Modipuram	Chairman
2.	Dr. P.C. Bhatia, EX- ADG- ICAR,	Member
3.	Dr. Chander Sen, Prof. & Head, Deptt of Economics, BHU, Varanasi.	Member
4.	Dr. N.D. Mazumdar, Project Coordinator- Pigeon pea, IIPR, Kanpur	Member
5.	Dr. S.S. Pal, Principal Scientist, PDFSR, Modipuram, Meerut	Member
6.	Mr. H.S. Chauhan, Asstt. Admn. Officer, PDFSR, Modipuram, Meerut	Member Secretary

Institute Joint Staff Council meetings

The IJSC meetings were held on 27-04-2009 and 06-02-2010 during 2009-2010.

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

PDFSR demonstrated its technologies, activities and publications in the Platinum Jubilee Symposium of Indian Society of Soil Science at IARI, New Delhi during 22-25 December, 2009.

Dr. B. Gangwar, Project Director, Dr. S. S. Pal (Principal Scientist, Soil Chemistry), Dr. Anil Kumar (Principal Scientist, Agrc. Extension), Dr. K. P. Tripathi (Senior Scientist, Soil Chemistry) and Dr. V. K. Singh (Senior Scientist, Agronomy) attended the Indian Society of Soil Science Platinum Jubilee Symposium at IARI, New Delhi during 22-25 December, 2009.

Dr. B. Gangwar, Project Director, Dr. M. P. Singh (Principal Scientist) and Dr. B. K. Sharma (Senior Scientist) participated in Ist Indian Agricultural Scientist and Framers Congress on Technological Innovations for Enhancing Agriculture Production, October, 03-04, 2009. Organized by Society for Recent Development in Agriculture, SVPU&T, Meerut, India.

Dr. B. Gangwar, Project Director participated in various divisionla meetings (NRM, Horticulture, Crop Sciences, Fisheries, Extension and Education) organised at ICAR, Headquarter under Chairmanship of DG, ICAR from January-February, 2010.

Dr. B. Gangwar, Project Director, Dr. Kamta Prasad, Dr. S. S. Pal, Dr. J. P. Singh, Dr. A. K. Nayak, (Principal Scientists), Dr. S. P. Singh, Dr. R.K. Langer (Senior Scientists) and Dr. Akath Singh (Scientist) : Attended the Brain storming Session-Cum-launching workshop of integrated farming Systems Programme and group meeting of AICRP-IFS during 6-7 March, 2010 at KAU, Thiruvanthapuram, Kerala.

Dr. Kamta Prasad, (Principal Scientists) partcpated in the Biennial conference of ISWS on Recent Advances in Weed Science Research-2010, 25-26 February, 2010, IGKV, Raipur.



Dr. Panjab Singh, Former Director General of the ICAR visiting PDFSR stall

PDFSR stall during the symposium

Dr. Devendra Singh, Principal Scientist, Crop Physiology, participated in National Conference on “Frontiers in Plant Physiology towards Sustainable Agriculture”, organized by Indian Society for Plant Physiology, IARI, New Delhi and Assam Agricultural University, Jorhat on November 5-7, 2009 at Jorhat (Assam).

Dr. G. C. Sharma, attended National workshop for sensitization of ARIS In-charges about uniform guidelines for websites under AGROWEB-Digital Dissemination System for Indian Agricultural Research (ADDSIAR)- Information, Communication & Dissemination System (ICDS) of Component” of NAIP Project at NBPGR, New Delhi on 19-03-2010.

Dr. J.P. Singh attended Farmer fair and training organized by State Agric. Deptt. Meerut on 18/03/2010.

Dr. J.P. Singh attended First Indian Agricultural Scientists and Farmers Congress on Technological Innovations for Enhancing Agriculture Productivity. Held at CCS Univ., Meerut, 03- 04 October, 2009, pp:311-312.

Dr. J.P. Singh attended *Harijali ganga – Krishak Prishchan Karyakram* organised by SBI, Palhera, Modipuram on 29/03/10.

Dr. J.P. Singh attended One day workshop as refresher course on Watershed Development and Management for Soil Conservation Officers of Meerut, Saharanpur and Moradabad Mandals held at PDFSR on 21/12/2010.

Sh. Chandra Bhanu, Scientist, Plant Pathology, attended the 5th International Conference on plant pathology held, at IARI, New Delhi. from 10-13 November 2009.

12.4 HUMAN RESOURCE DEVELOPMENT

Dr. Devendra Singh, Principal Scientist, Crop Physiology, participated in special training on Vigilance Administration for Vigilance officers of ICAR Institute from October, 29 to 31, 2009 at National Academy of Agricultural Research Management, Rajendra Nagar Hyderabad.

Dr. G. C. Sharma (Principal Scientist, Agricultural Statistics), Mr. J. P. Singh (Technical Officer-Computer Programmer) attended one day Sensitisation and Training Workshop on Project Information and Management System of ICAR held at IASRI, New Delhi on 26/11/2009.

Dr. G. C. Sharma attended Personnel Management Information System Network

(PERMIS net II) workshop at NASC Complex, New Delhi on 22-07-2009.

Dr. A. K. Nayak, Principal Scientist, Soil Chemistry/Fertility/Microbiology attended a short course on “Cropping System Models-Applications in Land Resource Management” at ICRISAT, Patancharu from 12-16 Oct., 2009. This course was jointly organized by ICRISAT and University of Florida, USA.

Dr. M. Shamim, Scientist and Sh. Vipin Kumar, Scientist, obtained training on IT based DSS for Geographical Information System for Rural Livelihood Assessment” at NIRD, Hyderabad (AP) during March 11th -20th 2010.



Scientists from PDFSR participated in the training programme on IT based DSS held at NIRD, Hyderabad

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

Sl. No.	Topic	Duration	Course Director
1.	Summer school on 'Advances in Organic Farming'	02.06.2009- 22.06.2009	Dr. M. S. Gill
2.	Short course for SMS of KVKs Zone-II, on 'Integrated Farming Systems'	17.08.2009-23.08.2009	Dr. M. S. Gill



Inaugural session of the Summer School

12.6 AWARDS/HONOURS/RECOGNITIONS

PDFSR was awarded the **first prize** in ICAR group in the All India Farmers Fare and Agro-Industrial Exhibition in October, 2009, organized by Sardar Vallabhai Patel University of Agriculture & Technology, Meerut.

PDFSR was again awarded the **first prize** in ICAR group in the All India Farmers Fare (North Zone) and Agro-Industrial Exhibition from March 10-12, 2010 organized by Sardar Vallabhai Patel University of Agriculture & Technology, Meerut.

Dr. B. Gangwar

1. **Hon. Fellowship Award 2009** by Hi-Tech Horticultural Society for Outstanding contributions in the field of cropping systems research on the occasion of First Indian

agricultural scientist and farmers' congress on "Technological Innovations for enhancing agriculture production" held on 3-4 October, 2009 at CCS University Meerut.

2. **Bharat Excellence Award 2009 with a Gold medal** for his outstanding contributions and praiseworthy achievements in his chosen field of agronomy, cropping systems management and farming systems research and management by Friendship forum of India, New Delhi on 20-10-2009.

3. **Meerut Ratan Award 2009** by All India Conference of Intellectuals for distinguished services rendered to the society at large in the 29th Annual Celebration held at Meerut on 21st February, 2010.



Dr. B. Gangwar, Project Director, receiving Hon. Fellowship Award from Vice Chancellor, S.V.B.P.U.A. & T., Modipuram, Meerut



Dr. B. Gangwar, Project Director, receiving Meerut Ratan Award 2009

4. Serving as Councilor, Indian Society for Coastal Agricultural Research, Canning, W.B.
5. Serving as Member, Executive Council, Indian Society of Dry-land Agriculture, Hyderabad
6. Serving as Member Executive “Agriculture Science Digest”
7. Serving as Chief Editor “Agricultural Reviews”
8. Serving as President, Modipuram Chapter of Indian Society of Agronomy.

Dr. S.P. Singh, Sr. Scientist, PDFSR Modipuram, Meerut was honored with **HTHS Gold Medal Award 2009** by High-Tech Horticultural Society for his understanding and recognition in the field of Cropping Systems Research on the occasion of “1st Indian Agricultural Scientists and Farmers Congress” on “Technological Innovations for Enhancing Agriculture Production” held on 03-04 October 2009 at CCS University Meerut - 250110 (U.P.).

Dr. N. D. Shukla, Sr. Scientist: Received **Third prize** in Agricultural Science Discipline of *Khad Patrika FAI*, 2009 for article entitled “*Barhti Janshankhya evam ghata khadyan – urvarak hee kar sakata hai eska nidan*”

Sh. Chandra Bhanu, Scientist : Selected for 1st commendation prize of **K.P.V. Menon Best Poster Paper awards** in 15th section of Poster Presentation in 5th International Conference on Plant Pathology in the Globalized Era., held during November, 10-13, 2009, IARI, New Delhi, India.

Sh. S. P. Singh, Technical Officer: Honored by High-Tech Horticultural Society for its **HTHS Young Scientist associated Award 2009** for his understanding and recognition in the field of Cropping Systems Research on the occasion of “1st Indian Agricultural Scientists and Farmers Congress” on “Technological Innovations for Enhancing Agriculture Production” held during 03-04 October, 2009 at C.C.S. University, Meerut - 250110 (U.P.)



Dr. S. P. Singh, Sr. Scientist receiving HTHS Gold Medal Award 2009



Sh. S. P. Singh, Technical Officer receiving HTHS Young Scientist Associated Award 2009

Dr. B. K. Sharma, Sr. Scientist received recognition from Project Director, PDFSR, Modipuram, Meerut for very good display of PDFSR stalls and getting 1st prize in ICAR group in

All India Farmers' Fair (North Zone) and Agro-industrial Exhibition from October 28-31, 2010, organized by Sardar Vallabhai Patel University of Agriculture & Technology, Meerut.

12.7 DISTINGUISHED VISITORS

Dr. A.K. Singh, Deputy Director General, NRM Division, ICAR visited the on-farm experiments under PDFSR at Hastinapur on 18.04.2009.



DDG (NRM), ICAR, New Delhi observing wheat crop in the farmers field

Dr. Silas C. Okoli from National Food Reserve Agency, Federal Ministry of Agriculture and Water Resources, Mabushi, Gwagwalada, Abuja, Nigeria visited PDFSR on 30-11-2009.



Dr. B. Gangwar, Project Director showing the field experiments to Dr. Silas C. Okoli from Nigeria

12.8 KISAN GOSTHIS/FARMER'S TRAININGS/FELD VISITS/ EXIBITIONS ORGANIZED BY PDFSR

Kisan Gosthi/ Field Visit

1. On 20 September, 2009 at Village Doodur, New Tehri District (Uttaranchal) and on 14 April and 05 December, 2009 at Village Kosi khurd,

District Mathura (U.P) Kisan Gosthi on “*Krishigat Pranali Prabandhan*” (Farming system management)” was organized under the aegis of PDFSR Modipuram and THDC, Rishikesh. More than 300 farmers/ farmwomen



PDFSR organised *Kisan Gosthi* at Village Kosi khurd, District Mathura (U.P)



Project Director, PDFSR, distributing seed packets and other inputs to farmers

were present at these occasions. The face-to-face interaction with Scientist and farmers was held regarding problem faced for adoption of new technologies related to crop and live stock production and on spot solution was suggested. The mini kits of green manure seed (*Dhaincha*), lemon, aonla plants and vegetable seeds for kitchen gardening were also distributed to the selected beneficiaries.

2. A group of 22 farmers from Byawara tahsil, Rajgarh district, Madhya Pradesh headed by

Agriculture Development Officer, Byawara visited the Directorate on 16th February, 2010. They were shown the Directorate's Museum, farm machinery and the experiments laid out by the scientists at the farm.

3. A group of 60 farmers from Bagpat district, Uttar Pradesh, headed by District Agriculture Officer, Bagpat visited the Directorate on 8th March, 2010. They were shown the Directorate's Museum, farm machinery and the experiments laid out by the scientists at the farm.



Participation in Exhibitions

1. An exhibition stall was put up by the Directorate in All India Farmers' Fair (North Zone) and Agro-industrial Exhibition from October 28-31, 2010 organised by Sardar Vallabhai Patel University of Agriculture & Technology, Meerut.
2. An exhibition stall was put up by the Directorate in All India Farmers' Fair (North Zone) and Agro-industrial Exhibition from March 10-12, 2010 organised by Sardar Vallabhai Patel University of Agriculture & Technology, Meerut.

Training organized and other activities performed

For the technological knowledge improvement of the farmers, following training on sustained livelihood security, promotion of vermin composting, fruit plantation, fish farming was made through farmers' participatory training, were organized during report period 2009-10:

1. Training for weed management in wheat crop- 207 Farmers
2. Fish production training- 4 Farmers



PDFSR stall during All India Farmers' Fair (North Zone) and Agro-industrial Exhibition

- | | |
|---|--|
| 3. Distribution of mineral mixture for milch animals- 130 nos Farmers | 6. Distribution of vegetable seeds for kitchen gardening-550 Farmers |
| 4. Distribution of lemon plants-90 Farmers | 7. Conduct of vermi-composting trials at village level- 15unit |
| 5. Residue management in sugarcane ratoon crop- 40 Farmers | |

12.9 हिन्दी पखवाड़े का आयोजन

निदेशालय में हिन्दी के उपयोग को बढ़ावा देने उद्देश्य से दिनांक १४-२६ सितम्बर २००६ के दौरान हिन्दी पखवाड़े का आयोजन किया गया। पखवाड़े के शुभारम्भ के अवसर पर परियोजना निदेशक डा. बाबू जी गंगवार ने अपने संबोधन में निदेशालय कर्मियों को अपने दैनिक कार्यों में हिन्दी के अधिकाधिक प्रयोग करने का आग्रह किया तथा राजभाषा के महत्व पर प्रकाश डाला।

विभिन्न प्रतियोगिताओं जैसे कविता पाठ, निबन्ध लेखन, हिन्दी ज्ञान प्रश्नोत्तरी, अन्त्याक्षरी एवं आशुभाषण का आयोजन किया गया। इन प्रतियोगिताओं में सभी संवर्ग के अधिकारियों एवं कर्मचारियों ने बड़-चढ़कर हिस्सा लिया। प्रतियोगिताओं में प्रथम, द्वितीय एवं तृतीय स्थान प्राप्त करने वाले प्रतिभागियों को प्रमाणपत्र एवं पुरस्कार स्वरूप हिन्दी साहित्य से संबंधित पुस्तकें एवं अंग्रेजी-हिन्दी



हिन्दी पखवाड़े का आयोजन व पुरस्कार वितरण समारोह

शब्दकोश प्रदान किये गये। अन्य समस्त प्रतिभागियों को भी सांत्वना पुरस्कार स्वरूप पुस्तकें प्रदान की गयीं। विभिन्न प्रतियोगिताओं में प्रथम पुरस्कार प्राप्त करने वाले

प्रतिभागियों में डा. प्रेम सिंह, श्री विपिनकुमार, श्री प्रेम सिंह, एवं डा. नरेन्द्रदेव शुक्ल रहे।

LIST OF CONTRIBUTORS

S. No.	Name of the Project	PI/Co-PI/Contributor (s)
A. Cropping Systems and Resource Management (CSRМ)		
1.	Bio-intensive complementary cropping systems for high productivity and profitability	B. Gangwar and K. S. Gangwar
2.	Evaluation of resource efficient complementary bio-intensive cropping systems for enhancing productivity	R. P. Mishra and K. K. Singh
3.	Studies on intercropping in autumn planted sugarcane	J. P. Singh
4.	Intensification of rice- wheat cropping system for higher productivity and profitability under different tillage systems	K. K. Singh and R. P. Mishra
5.	Tillage and planting management in different cropping systems (AICRP-CS)	K. K. Singh
6.	Long term effect of mechanization and resource conservation technologies in rice-wheat cropping systems on productivity, profitability and soil health	K. K. Singh
7.	Evaluation of different crop residues management practices in rice-wheat cropping system on productivity, profitability and soil health	K.K. Singh
8.	Utilization of industrial effluents from spent wash for crop production and soil health	K. P. Tripathi and V. K. Singh
9.	Reclamation of saline-sodic soils for crop production and soil health	K. P. Tripathi
10.	Rice residue management for enhancing crop productivity, water and nutrient use efficiency and weed dynamics under rice-wheat system	B. Gangwar and K. P. Tripathi
11.	Evaluation of different resource conservation technologies for planting of rice	K. K. Singh
12.	Studies on improvement of soil organic carbon in rice-wheat system under resource conservation technologies	S. S. Pal
13.	Resource Conservation Modules for high yield realization of different cropping system	V P Chaudhary and K S Gangwar
14.	Integrated nutrient management in transplanted rice-wheat system	V. K. Singh, R. P. Mishra and K. P. Tripathi
15.	Development of sustainable production model for rice-wheat system	V. K. Singh, R. P. Mishra and K. P. Tripathi
16.	Physiological evaluation of rice and wheat genotypes under changing climatic scenario	Devendra Singh
17.	Accelerating the second-generation machineries for managing the crop residue through RCTs in western U.P.	V. P. Chaudhary and M. P. Singh
18.	Demonstration of Mat type nursery growing and transplanting by self propelled rice transplanter	V. P. Chaudhary and M. P. Singh

S.No.	Name of the Project	PI/Co-PI/Contributor (s)
19.	On-farm evaluation of rice transplanter	K. K. Singh
B. Organic Agriculture Systems (OAS)		
20.	Development of organic farming package for maize-potato-onion system	S. S. Pal
21.	Studies on comparative efficiency of organic, inorganic and integrated nutrient management practices on soil health and crop productivity under various cropping systems	Prem Singh
22.	Disease and pest management in rice-chick pea and rice- mustard cropping systems under organic farming	Prem Singh
23.	Evaluation of some new cropping systems involving spices and other high value crops under organic farming	Prem Singh
24.	Evaluation of rice and wheat varieties in rice-wheat system for organic farming	Prem Singh
C. Integrated Farming Systems (IFS)		
25.	Development of an Integrated Farming System Model for small farmers of western plain zone of Uttar Pradesh	J. P. Singh
26.	Livelihood security through Integrated Farming System	J. P. Singh
27.	Aquaculture	R. K. Langer
D. Resource Characterization and System Diagnosis (RCSD)		
28.	Socio-economic impact assessment of resource conservation and AICRP-CS technologies in Indo-Genetic Plain	S.P. Singh
29.	Statistical analysis of cropping systems experiments in relation to soil parameters under different cropping systems	G. C. Sharma
30.	Impact of Ground Water Table on Cropping Systems Economics and Energetic in Bundelkhand region of Uttar Pradesh	N. D. Shukla and B. K. Sharma
E. Technology Transfer and Refinement (TTR)		
31.	Accelerating the proven technologies through Technology Park at PDFSR	M. P. Singh
32.	<i>Anusandhan Gaon ki Aur</i>	B. K. Sharma and Anil Kumar
33.	Capacity building of stakeholders in integrated farming systems through training	B. K. Sharma, Anil Kumar and A. Sarkar
34.	OFD on Oil seed-based cropping system	A. Sarkar
35.	OFD on Pulse-based cropping systems	A. Sarkar
F. Externally Funded Projects		
36.	Evaluating production systems for attaining maximum productivity and profits under different cropping systems	V.K. Singh and M.P. Singh
37.	Site-specific nutrient management (SSNM) for a rice-maize system as affected by crop establishment and residue management	V.K. Singh
38.	Economics of farming system diversification towards high value enterprise in Uttar Pradesh	S.P. Singh

LIST OF PERSONNEL*

(As on 31.03.2010)

Project Director: Dr. B. Gangwar

A. SCIENTIFIC

1. Dr. B. Gangwar, Project Director
2. Dr. Kamta Prasad, Principal Scientist (Agronomy)
3. Dr. Devendra Singh, Principal Scientist (Plant Physiology)
4. Dr. S.S. Pal, Principal Scientist (Soil Chemistry/Fertility/Microbiology)
5. Dr. A. Sarkar, Principal Scientist (Agronomy)
6. Dr. G.C. Sharma, Principal Scientist (Agril. Statistics)
7. Dr. J.P. Singh, Principal Scientist (Agronomy)
8. Dr. P. Ramasundaram, Principal Scientist (Agril. Economics)
9. Dr. M.P. Singh, Principal Scientist (Agril. Extension)
10. Dr. K.K. Singh, Principal Scientist (Farm Machinery and Power)
11. Dr. A.K. Nayak, Principal Scientist (Soil Chemistry/Fertility/Microbiology)
12. Dr. Anil Kumar, Principal Scientist (Agril. Extension)
13. Dr. S.P. Singh, Senior Scientist (Agril. Economics)
14. Dr. K.S. Gangwar, Senior Scientist (Agronomy)
15. Dr. N.D. Shukla, Senior Scientist (Agril. Economics)
16. Dr. B.K. Sharma, Senior Scientist (Agril. Extension)
17. Dr. Prem Singh, Senior Scientist (Agronomy)
18. Dr. V. K. Singh, Senior Scientist (Agronomy)
19. Dr. K.P. Tripathi, Senior Scientist (Soil Chemistry/Fertility/Microbiology)
20. Dr. P. Vijay Kumar, Senior Scientist (Agri-Meteorology)
21. Dr. R.P. Mishara, Scientist (Sr. Scale) (Agronomy)
22. Dr. V.P. Chaudhary, Scientist (Sr. Scale) (Farm Machinery and Power)
23. Sh. Chandra Bhanu, Scientist (Plant Pathology)
24. Dr. Akath Singh, Scientist (S.S.) (Horticulture)
25. Dr. Sanjeev Kumar Kochewad, Scientist (Livestock Production and Management)
26. Dr. Md. Shamim, Scientist (Agril. Meteorology)
27. Shri Sunil Kumar, Scientist (Agril. Statistics and Computer Application)

B. TECHNICAL

1. Sh. Chet Ram, T-9
2. Sh. Jagpal Singh, T-7/8
3. Sh Krishan Pal, T-7/8
4. Sh. Yogendra Singh, T-7/8
5. Sh. D. Tripathi, T-7/8
6. Sh. S.K. Duhoon, T-6
7. Sh R.B. Tewari, T-6
8. Sh K.V.Anand, T-6
9. Sh Vipin Kumar, T-6
10. Sh. D.P. Singh, T-6
11. Sh. Naval Singh, T-6
12. Sh Om Kumar Tomar, T-6
13. Sh Vinod Kumar, T-6
14. Sh. Brij Mohan, T-6
15. Sh S.P. Singh, T-6
16. Sh. P.P. Mishra, T-6
17. Sh. A.P. Dwivedi, T5
18. Sh. Brijesh Sharma, T-5
19. Sh. D.K.Pandey, T-5
20. Sh. Krishan Kumar, T-5
21. Sh. Jaipal Singh, T-2
22. Sh. Uma Shankar, T-3
23. Sh. Ashok Kumar, T-2
24. Smt Anju Verma, T-2
25. Sh. Mahendra Prasad, T-1

C. ADMINISTRATIVE

1. Sh. H.S. Chauhan, AAO
2. Sh. Tara Chand Sharma, AF&AO
3. Sh. Surya Kant, P.S. to P.D.
4. Smt. Alka Jain, Assistant
5. Sh. S.K. Gupta, Assistant
6. Smt. Sheela Devi, Assistant
7. Sh. Jata Kant, UDC
8. Sh. Ravi Kant Sharma, UDC
9. Sh. Attar Singh, P.A.
10. Sh. Rai Bahadur, P.A.
11. Smt. 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, LDC
16. Sh. Rajendra Kumar, LDC
17. Sh. Parmanand, LDC
18. Sh. D.C. Mishra, LDC

D. SUPPORTING

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

