Indian Institute of Soil Science

Nabi Bagh, Berasia Road, Bhopal - 462 038 (M.P.) India

IISS Annual Report 2008-09

भाकृअनुप
ICAR

वार्षिक प्रतिवेदन
Annual Report
2008-09

IISS

भारतीय मृदा विज्ञान संस्थान
INDIAN INSTITUTE OF SOIL SCIENCE

With Best Compliments

A. Subba Rao

(A. Subba Rao)
Director
Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal - 462 038

वार्षिक प्रतिवेदन
Annual Report
2008-09

भाकृअनुप
ICAR

भारतीय मृदा विज्ञान संस्थान
INDIAN INSTITUTE OF SOIL SCIENCE
(Indian Council of Agricultural Research)
NABI BAGH, BERASIA ROAD, BHOPAL - 462 038 (M.P.)

Editors
Dr. A. Subba Rao
Dr. K.B. Hebbar
Dr. K. Sammi Reddy
Dr. A.K. Tripathi
Dr. J. Somasundaram
Dr. N.R. Panwar

Typing & Computer Assistance
Ms. Kirti Singh Bais

Published by
Dr. A. Subba Rao
Director
Indian Institute of Soil Science, Bhopal (M.P.)
Phone : +91-755-2730946, 2747375, 2730970
Fax : +91-755-2733310
E-mail : asrao@iiss.ernet.in, director@iiss.ernet.in
Website : www.iiss.nic.in

CONTENTS

PREFACE

Soil is the most important environment factor that influences the crop nutrition, growth and production. Despite significant contribution of soil science research in enhancing crop productivity and quality, our soil resources continue to undergo increasing stresses due to population pressure, loss of vegetative cover, soil degradation, pollution, climate change and loss of biodiversity. So, the greatest challenges in future is to develop and implement real-time soil and crop specific nutrient management technologies to adopt to the changing production systems and also to monitor the environmental impact of the new agricultural production technologies on the soil.

In the present report the significant research output of the institute has been presented under twelve thematic areas involving basic, strategic and applied research of National and International importance. The physical, chemical and biological processes of soils were covered under fundamental research which is basic to agriculture. An attempt was made to fine-tune and integrate modern technologies with traditional knowledge by striking a judicious balance between organics and inorganics for higher and quality production. Major thrust was given to the frontier areas of research i.e. Climate Change and Carbon Sequestration, Nano-technology for enhancing nutrient use efficiency, Organic Farming, Soil Biodiversity, Bio-fortification of grains with micronutrients and Soil Quality and Human Health. Keeping in view the importance of farmers' participatory research, on-farm trials on Broad Bed Furrow (BBF), Balanced Fertilization and Integrated Nutrient Management and Front-line Demonstrations under AICRPs and ACIAR project are being taken up on farmers' fields. Further, this report presents a glimse of all the important activities undertaken by the institute during the reporting period. It is, thus, a great pleasure for me to bring out the 'Annual Report 2008-09' of the Indian Institute of Soil Science.

I wish to express my sincere appreciation to the Heads of Divisions and Project Coordinators who have constructively compiled the information for the respective research programmes. I also extend my gratitude to the scientists and other staff members of the Institute for their sincere and painstaking efforts in carrying out the research and other activities of the Institute and for providing requisite material for compilation of this report.

I also take this opportunity to put on record my appreciation to Drs. K.B. Hebbar, K. Sammi Reddy, A.K. Tripathi, J. Somasundaram and N.R. Panwar for their sincere effort in compiling and editing the report. I also thank Ms. Kirti Singh Bais for the assistance provided in typesetting the manuscript.

I am highly grateful to Dr. Mangala Rai, Secretary, DARE & Director General, ICAR and Dr. A.K. Singh, Deputy Director General (NRM), ICAR, New Delhi for their encouragement and guidance provided.

Bhopal
August 30, 2009

A. Subba Rao

(A. Subba Rao)
DIRECTOR

1. कार्यकारी सारांश

मृदा उर्वरता मूल्यांकन और डेटाबेज

- म. प्र. के होशंगाबाद एवं गुना जिलों से एकत्रित किए गए मिट्टी के नमूनों से नत्रजन, फास्फोरस, पोटाश, कार्बनिक कार्बन, पी.एच. और वैद्युत चालकता का विश्लेषण किया गया। गुना जिले के तहसील और जिले के सीमा वाले नक्शे बनाए गए । विभिन्न पोषक तत्वों के लिए पोइन्ट वैल्यू एवं स्पेशियल परीक्षण (क्रिगिंग) का प्रयोग करते हुए गुना (म.प्र.) जिले के जियो – रेफरेन्स्ड उर्वरता नक्शे तैयार किए गए। पेयर्ड – टी टेस्ट का प्रयोग करते हुए लगातार दो वर्षों तक सर्वेक्षण के बाद एकत्रित किए गये नमूनों के परीक्षण द्वारा नक्शों की वैद्यता को देखा गया। मृदा परीक्षण द्वारा प्राप्त पोषक तत्वों के वास्तविक परीक्षण मान और आकलित मृदा परीक्षण मान में अच्छी साम्यता पाई गई। दोनों जिलों में उचित मात्रा में उर्वरक प्रयोग के लिए मृदा परीक्षण मान के साथ अनुशंषाओं को जोड़ा गया।

- एन.आर.एस.ए., हैदराबाद से प्राप्त सेटेलाइट डेटा को होशंगाबाद एवं गुना जिलों की टोपोसीट्स को जियोरिफरेन्स करने में प्रयुक्त किया गया। चित्र के हिस्से से ग्रिड के आधार पर एन.डी.वी.आई. मान की गणना की गई। यूनियन आफ न्यूट्रिएण्ट पोलीगन में सांख्यकीय विश्लेषण किया गया। पोषक तत्व एवं एन.डी. वी.आई. मान के बीच सम्बन्धता का विश्लेषण किया गया। इन दोनों के बीच संतोषजनक सहसम्बन्धता पाई गई ।

- छः जिलों बड़ोदा (गुजरात), अहमदाबाद (गुजरात), बीकानेर (राजस्थान), अम्बाला (हरियाणा), लुधियाना (पंजाब) और धारवाड़ (कर्नाटक) से एकत्रित किए गए खाद, भूसा और पशुओं के खाने के नमूनों में काफी अधिक विविधता पाई गई। पशुओं का खाने में केवल भूसा से लेकर अनाज का काफी अच्छा मिश्रण पाया गया। सर्वे किए गए लगभग सभी जिलों में गोबर की खाद, ढेर विधि से ही बनाई जा रही है। गोबर की खाद से नाइट्रोजन की औसत प्राप्यता 21% तथा माध्यिका के साथ 39 % पाई गई जबकि फास्फोरस की औसत प्राप्यता 17% तथा माध्यिका के साथ 20% और पोटाश की औसत प्राप्यता 32% तथा माध्यिका के साथ 41% पाई गई। फसल अवशेष से बनाई गई कम्पोस्ट से नाइट्रोजन, फास्फोरस एवं पोटाश की औसत प्राप्यता क्रमशः 20, 14, और 34% पाई गई और गोबर की खाद की तुलना में कम मात्रा पाई गई।

आदाय प्रयोग दक्षता में सुधार

- ग्राइन्डिंग और सेडीमेन्टेशन विधियों द्वारा अल्ट्रा फाइन पार्टीकिल–साइज तैयार करने के लिए रॉक फास्फेट (फास्फोरस की मात्रा 1.6 – 15.3%) के नमूने प्रयोग में लाये गये। अस्थाई जीटा पोटेन्शियल (स्थाई सस्पेंशन के लिए जीटा पोटेन्शियल का क्षेत्र –30 मिली वोल्ट से लेकर + 30 मिली वोल्ट) की वजह से प्राप्त किए गए नैनो पार्टीकिल (हाइड्रोक्सी एपाटाइट $<$ 200 नैनो मीटर को छोड़कर) पानी में अत्यधिक अस्थाई पाये गये। परिणाम दर्शाते हैं कि जिंक आक्साइड के नैनों पार्टीकिल ने चने के अंकुरण को 2000 पीपीएम और सरसों के अंकुरण को 500 पीपीएम तक प्रभावित नहीं

किया। सोलूसन (घोल) कल्चर अध्ययन दर्शाता है कि परम्परागत 0.5 पीपीएम जस्ता (जिंक सल्फेट के रूप में) की तुलना से 0.27 पीपीएम जस्ता (जिंक आक्साइड के नैनों पार्टीकिल के रूप में) के प्रयोग से मक्का के पौधों की वृद्धि में बढ़ोत्तरी हुई।

दीर्घकालीन उत्पादकता का सतत निरीक्षण

- सोयाबीन – गेंहूँ फसल चक्र प्रणाली में लगातार पाँच वर्षो तक उर्वरक एवं कार्बनिक खादों के समन्वित प्रयोग द्वारा जल विलेय कार्बन की मात्रा में सुधार हुआ। वह उपचार जिसमें पोषक तत्वों की आपूर्ति केवल खादों द्वारा की गई उसमें जल विलेय कार्बन की मात्रा सर्वाधिक पाई गई। मृदा की 7.5 सेमी. उपरी सतह में जल विलेय कार्बन की मात्रा 43.6 – 67.9 पी.पी.एम. पाई गई। उप सतह (15–30 सेमी.) में जल विलेय कार्बन की मात्रा सर्वाधिक कम 20.9 से 27.1 पी.पी.एम. पाई गई तथा विभिन्न उपचारों में इसकी मात्रा में अर्थपूर्ण रूप से वृद्धि हुई। नियंत्रण की तुलना में विभिन्न समन्वित पोषक तत्व प्रबन्धन उपचारों में कार्बन से सम्बन्धित संकेतक जैसे – सी.पी.आई., सी.एल.आई. और सी.एम.आई. में सुधार हुआ। 0–30 सेमी. मृदा गहराई पर औसत सी.पी.आई. 1.00 से 1.32, औसत सीएलआई 1.00 से 1.10 और सीएमआई 1.00 से 1.46 पाई गई। सोयाबीन – गेंहूँ फसल चक्र प्रणाली में खादों एवं उर्वरकों के प्रयोग से मेक्रो – एग्रीगेट्स और माइक्रो – एग्रीगेट्स में परिवर्तन पाया गया। मृदा की सभी गहराइयों (0–7.5 सेमी., 7.5–15 सेमी. और 15–30 सेमी.) पर माइक्रो–एग्रीगेट्स (0.053 से 0.25 मिमी.) की तुलना में छोटे मेक्रो–एग्रीगेट् की मात्रा सर्वाधिक पाई गई। सर्वाधिक एग्रीगेशन में परिवर्तन उन उपचारों में पाया गया जिनमें केवल कार्बनिक खाद का प्रयोग चाहे फसल अवशेष के रूप में, गोबर की खाद के रूप में अथवा दोनों रूप में किया गया।

- किसानों के खेतों पर किए गए दीर्घकालीन उर्वरक परीक्षण के परिणाम स्पष्ट रूप से दर्शाते हैं कि एल्फीसोल मृदा में बाजरा और मक्का की फसल में फास्फोरस के प्रयोग की मात्रा को इन दोनों फसलों की उपज पर बगैर किसी प्रभाव के आधा तक किया जा सकता है लेकिन उत्पादकता बढ़ाने के लिए पोटेशियम के प्रयोग की आवश्यकता है। इसकी गोबर की खाद के प्रयोग द्वारा पूर्ति की जा सकती है। पंजाब की इनसेप्टीसोल्स मृदा पर मक्का–गेंहूँ फसल चक्र प्रणाली की पूर्ण उत्पादकता प्राप्त करने के लिए फास्फोरस एवं जिंक का प्रयोग आवश्यक है। बंगलौर की एल्फीसोल मृदा में बाजरा–मक्का की उत्पादकता बनाये रखने के लिए पोटेशियम एवं जस्ता का प्रयोग एवं अकोला की वर्टीसोल मृदा में सोयाबीन–गेंहूँ की उत्पादकता बनाये रखने के लिए गन्धक का प्रयोग आवश्यक है।

- कृषि विश्वविद्यालय बंगलौर में पोटेशियम प्रबन्धन व्यूह रचना पर किए गए प्रक्षेत्र परीक्षण के दो वर्ष के आंकड़ों के साझा विश्लेषण के परिणाम दर्शाते हैं कि 100% पोटेशियम के प्रयोग की तुलना से पोटेशियम की मात्रा के दो भागों में प्रयोग से फसल की उपज में वृद्धि हुई। रागी और लोबिया में पोटेशियम की विभक्ति मात्रा के प्रयोग से उपज में बढ़ोत्तरी पोटेशियम के विनिमेय रूप में लाभदायक परिवर्तन की वजह से हुई । लेकिन उपचार में पोटेशियम की कमी के कारण यह उर्वरक प्रयोग में बदलाव दो साल भी उपज को बरकरार नहीं रख सका। सम्पूर्ण पद्यति उत्पादकता पोटेशियम के विनिमेय रूप से अत्यधिक प्रभावित हुई।

मृदा के भौतिक वातावरण का प्रबन्ध

- भूपरिष्करण पर दीर्घकालीन परीक्षण परिणाम दर्शाते हैं कि सोयाबीन के बीज और बायोमास की उपज पर भूपरिष्करण उपचार का अर्थपूर्ण रूप से कोई प्रभाव नहीं पाया गया। इसके विपरीत 50% नाइट्रोजन की अनुशंषित मात्रा के प्रयोग की तुलना में 150% एवं 100% नाइट्रोजन की अनुशंषित मात्रा के प्रयोग से सोयाबीन एवं बायोमास की उपज अर्थपूर्ण रूप से प्रभावित हुई। भूपरिष्करण उपचार और नाइट्रोजन की मात्रा के प्रयोग के अन्तर से भूपरिष्करण उपचार में मृदा का स्थूल घनत्व प्रभावित हुआ तथा नाइट्रोजन की मात्रा के प्रयोग में अन्तर वाले उपचार में मृदा की ऊपरी 5 सेमी. सतह की स्थूल घनत्व अर्थपूर्ण रूप से प्रभावित हुई। इसी प्रकार परम्परागत भूपरिष्करण की तुलना से विभिन्न भूपरिष्करण उपचारों में स्टीडी स्टेट इनफिल्टरेशन दर अर्थपूर्ण रूप से अधिक पाई गई। नो–टिलेज और परम्परागत टिलेज के अन्तर्गत मृदा नमी की बदलती मात्रा एवं मृदा स्थूल घनत्व के आंकड़े दर्शाते हैं कि नमी की मात्रा में कमी नियर सेटुरेशन से परमानेन्ट बिल्टिंग प्वाइंट से नीचे तक रही। वर्टीसोल मृदा का स्थूल घनत्व 0–7.5 सेमी. एवं 7.5–15.0 सेमी. दोनों ही गहराइयों पर कम हुआ। 7.5–15.0 सेमी. गहराई की तुलना से 0–7.5 सेमी. गहराई पर स्थूल घनत्व और नमी की मात्रा के साथ सम्बन्धता अधिक पाई गई।

- सभी भूपरिष्करण उपचारों में 0 एफ.वाई.एम. –कार्बन की तुलना से 10 टन प्रति है. एफ.वाई. एम.–कार्बन के प्रयोग द्वारा मृदा जल की अधिक मात्रा पाई गई। वर्ष 2008–09 के गेंहूँ में गोबर की खाद के विभिन्न दरों में प्रयोग के द्वारा गेंहूँ की उपज एवं बायोमास की मात्रा पर अर्थपूर्ण रूप से प्रभाव हुआ। दोनों ही मृदा गहराइयों (0–7.5 सेमी और 7.5–15 सेमी.) पर मृदा परीक्षण के आंकड़े दर्शाते हैं कि नो–टिलेज और परम्परागत टिलेज उपचार में नाइट्रोजन की अधिक उपलब्धता पाई गई। भूपरिष्करण उपचार के अनुसार फास्फोरस एवं पोटाश की उपलब्धता में उल्टी दर देखी गई। गोबर की खाद की मात्रा की दर में वृद्धि के साथ–साथ सुलभ नाइट्रोजन, फास्फोरस एवं पोटाश की उपलब्धता में वृद्धि देखी गई। गमलों में किए गए अनुसंधान के अनुसार सोयाबीन की फसल में बगैर फसल वाले गमलों में मृदा कार्बनिक कार्बन, मृदा सूक्ष्मजैविक बायोमास कार्बन और मृदा श्वसन अधिक पाया गया। इसके विपरीत बगैर फसल वाले गमले की तुलना से फसल वाले गमलों में एल्केलाइन फास्फेटेज एवं डिहाइड्रोजिनेज एन्जाइम की सक्रियता अधिक पाई गई।

मृदा रासायनिक संरचनाओं का सतत परीक्षण

- तीन अलग गुणों वाली मृदाओं में कार्बनिक एवं अकार्बनिक रूप में फास्फोरस के प्रयोग का उनके द्वारा फास्फोरस शोषण का तुलनात्मक

अध्ययन किया गया। मृदा के प्रकार को संज्ञान में न लेते हुए अकार्बनिक फास्फोरस शोषण की तुलना में कार्बनिक फास्फोरस शोषण कम पाया गया। विभिन्न मृदाओं में कार्बनिक अथवा अकार्बनिक फास्फोरस का शोषण इस क्रम में रहा: ऑक्सीसोल > वर्टीसोल > मोलीसोल। सामान्य रूप से अकार्बनिक फास्फोरस के प्रयोग की तुलना से लैंगम्यूर आइसोथर्म से प्राप्त फास्फोरस शोषण मैक्सिमा (b), बोंडिंग इनर्जी स्थिरांक (k) और आदर्श फास्फोरस मांग (एसपीआर) कार्बनिक फास्फोरस प्रयोग में थोड़ी कम पाई गई। फास्फोरस के सभी अवयवों के औसत के आधार पर फास्फोरस की सम्पूर्ण मात्रा में केंचुआ खाद में 11.4%, शहरी ठोस अपशिष्ट पदार्थ 12.5%, कुक्कुट खाद 31. 5% , हरी खाद 30.9%, गोबर की खाद 38.4%, सीडीएम 47.1%, सूबबूल 42.7 और गेंहूँ के भूसा 64.1 प्रतिशत कार्बनिक एवं अकार्बनिक फास्फोरस पाया गया।

- मध्यप्रदेश के विदिशा और सीहोर जिले की चिन्हित जगहों से जियो–रिफरेन्सड् मृदा के नमूने एकत्र किए गए। मृदा के प्रारम्भिक परीक्षण से ज्ञात हुआ है पूर्वकालीन मृदा की तुलना से सीहोर जिले में फसलोत्पादन की वजह से मृदा की ऊपरी सतह (0–15 सेमी.) में कार्बनिक कार्बन की मात्रा 31.0% ,सुलभ लोहा की मात्रा में 44.6%, एवं सुलभ मैगनीज की मात्रा में 35.8%, की कमी आई है जबकि विदिशा जिले में मृदा के कार्बनिक कार्बन की मात्रा में 46.3%, सुलभ पोटाश की मात्रा में 47.6%, एवं सुलभ लोहा की मात्रा में 19.9% की कमी आई।

मृदा की जैविक दशा में सुधार

- जमीन की ऊपरी सतह (0–15 सेमी.) में जिन उपचारों में गोबर की खाद का प्रयोग किया गया उनमें कार्बन पूल जैसे मृदा सूक्ष्मजैविक बायोमास कार्बन (एस.एम.बी.सी.), जल विलेय कार्बन (डब्लू.एस.सी.), एसिड डाइड्रोलाइजेबिल कार्बोडाइड्रेट (ए.एच.सी.) की सर्वाधिक मात्रा पाई गई उसके बाद 50% ना.फा.पो. + फसल अवशेष, 50% ना.फा.पो. + गोबर की खाद और 100% ना.फा.पो. में पाई गई।

- इन उपचारों में स्लो पूल कार्बनिक कार्बन जैसे पर्टीकुलेट कार्बनिक कार्बन (पी.ओ.एम–सी) की मात्रा सम्पूर्ण कार्बनिक कार्बन की 14.7 से 28.4%, पाई गई और यह बगैर उर्वरक प्रयोग वाले प्लाट में सबसे कम पाई गई। अतः इन मृदाओं में सम्पूर्ण कार्बनिक कार्बन का 71.6 से 85.3%, भाग मिनरल एसोसिएटिड कार्बनिक कार्बन (< 0.053 मिमी.) के रूप में पाया गया।

- सभी उपचारों में 0–15 सेमी. गहराई के नमूनों के रिवेटिड सैन्ड फ्री मास एग्रीगेट साइज डिस्ट्रीब्यूशन्स में छोटे मैक्रो – एग्रीगेट्स (25–2000 माइक्रो मी.) की संख्या मृदा के शुष्क भार के 55.5– 70.6%, के बराबर थी उसके बाद माइक्रो–एग्रीगेट्स (53–250 माइक्रो मी.) जो 18 –37%, पाये गये। बालू रहित मेक्रो–एग्रीगेट कार्बन 250–2000 माइक्रो मी. साइज क्लास में अधिक तथा उसके बाद माइक्रो–एग्रीगेट्स में था।

- अधिक सूक्ष्मजैविक सक्रियता के कारण गोबर की खाद के प्रयोग वाले उपचारों में एफ.डी.ए. (7.9 माइक्रो ग्रा. फ्लोरोसीन / ग्रा. / घंटा) सर्वाधिक पाया गया। 60 दिन के निवेशन के बाद यह देखा गया कि इन उपचारों में कार्बन डाई आक्साइड का उत्सर्जन 40 दिन की अवधि तक सर्वाधिक हुआ। तीन हाइड्रोलोजीकल रिजीम में, वर्टीसोल मृदा में कार्बनडाई आक्साइड गैस का उत्सर्जन 100% डब्लू.एच. सी. वाले उपचार में सर्वाधिक हुआ इसके बाद पूर्णतया जलमग्न अवस्था में और सबसे कम 35°C तापमान पर 50%, डब्लू.एच.सी. वाले उपचार में हुआ। 100%, डब्लू.एच.सी. एवं 100%, गोबर की खाद वाले उपचार में कार्बन डाई आक्साइड का उत्सर्जन (192 मिग्रा. कार्बन डाई आक्साइड/100ग्रा.) सर्वाधिक हुआ उसके बाद ना.फा.पो. + फसल अवशेष, 100%, ना.फा. पो. और 50%, ना.फा.पो. + गोबर की खाद में हुआ। यह सब जल विलेय कार्बन और एसिड हाइड्रोलाइजेबिल कार्बन की अधिक मात्रा में निष्कासन की वजह से हुआ जो कि अधिक मात्रा में इक्सोजीनस सूक्ष्म जीवों के लिए जैव ऊर्जा के एक स्त्रोत के रूप में कार्य किया।

सूक्ष्म जैविक विविधता और जैव उर्वरक

- चम्बा (हि.प्र.) से एक अत्यधिक दक्ष फास्फोरस विलेयक, आई.आई.ए. और साइडेरोफोर उत्पादित करने वाली बैसीलस सरकुलैंन्स, जो कि डियेटोफोरा नेकाट्रिक्स को रोकने में प्रभावी थी, किस्म का चयन किया गया।

- आसाम में धान में एक टन प्रति हे. की दर से जैव उर्वरक समृद्धि कम्पोस्ट का 50% ना.फा. के साथ प्रयोग से धान की अधिकतम उपज 3.9 टन/हे. प्राप्त हुई एवं 50% ना.फा. उर्वरकों की बचत हुई।

- बिहार में धान की फसल में सूक्ष्मजीव आधारित बायोन्यूट्रिएन्ट पैकेज जिसमें कि एजोस्पा–इरीलम, समृद्धि माकोस्ट्रा (स्पेन्ट अवशेष + स्यूडोमोनास प्रजाति) और तम्बाकू अपशिष्ट पदार्थ आधारित साइनोबैक्टीरिया के प्रयोग द्वारा धान में लगभग 50%, पोषक तत्व की भरपाई की जा सकती है।

- बैसीलस, स्यूडोमोनास और रायजोबियम के लिए आन्ध्र प्रदेश कृषि विश्वविद्यालय, हैदराबाद द्वारा प्रयोग की मात्रा एवं आवरणयुक्त बीज के भण्डारण का मानकीकरण किया गया।

- म. प्र. के जनजातीय क्षेत्रों में किसानों के खेतों पर बायो न्यूट्रिएन्ट पैकेज का प्रदर्शन किया गया। सोयाबीन, मक्का, कोदों, कुटकी और नाइगर की उपज में क्रमशः 17, 25, 40, 20 और 18% की वृद्धि देखी गई।

- दस बैक्टीरियल आइसोलेट्स की डिग्री आफ ओलिओट्राफी का अध्ययन किया गया। यह दोगुना आसुत जल में चार महीने तक जीवित अवस्था (10^5–10^6 कोशिका/मिली.) में रखा जा सकता है।

- मैनीटोल, ग्लसरोल और 0.5% ईस्ट एक्सट्रेक्ट से एक नये मीडिया को बनाया गया जो वाई.ई. एम.ऐ., किंग्स अथवा न्यूट्रिएन्ट अगर माध्यम की तुलना से एच.सी.एन. की अधिक सहिष्णु जाँच की जा सकती है।

- सोयाबीन रायजोबिया की विविधता का मूल्यांकन इनट्रिकसिक एन्टी बायोटिक (आई.ऐ.आर.) पैटर्न द्वारा किया गया। नैलीडिक्सिक एसिड, ट्राईमिथोप्रिम, वैंकोमाइसिन, नोवोबा–योसिन एवं पोलीमिक्सिन–बी के लिए सामान्यतया प्रतिरोधी पाई गई। डेन्डोग्राम दर्शाता है कि छः विशिष्ट समूहों में अत्यधिक विविधता एवं क्लस्टरिंग पाई गई।

प्रदूषित मृदाओं का सुधार

- हरित गृह अध्ययन के अनुसार भारतीय मृदाओं की लैड एवं कैडमियम की कुमुलेटिव लोडिंग सीमा क्रमशः 170 कि.ग्रा. लैड प्रति हे. एवं 0.8 कि.ग्रा. कैडमियम प्रति हे. की गणना की गई । इन गणना किए गए मान के अनुसार, कम्पोस्ट में लैड एवं कैडमियम की अधिकतम सीमा क्रमशः 170 किग्रा. लैड प्रति हे. एवं कैडमियम 0.8 किग्रा. प्रति हे. आकलित की गई। इसका आशय यह है कि 100 साल के पुनः चक्रण प्रोग्राम में 1000 टन प्रति हे. की दर से जमीन में नगरीय ठोस अवशिष्ट कम्पोस्ट की कुमुलेटिव प्रयोग योग्य दर है।

- शहरी ठोस अपशिष्ट कम्पोस्ट के द्वारा लैड प्रदूषण विशेषकर अधिक मात्रा में प्रयोग के द्वारा एन्जाइम जैसे – डिहाइड्रोजिनेज, एल्केलाइन फास्फेटेज, एसिड फास्फेटेज की सक्रियता में अर्थपूर्ण रूप से कमी आई। क्षारीय फैलने – सिकुड़ने वाली भारी कण विन्यास वाली मृदाओं की तुलना से हल्के कण विन्यास वाली अम्लीय मृदाओं में सूक्ष्म जैविक सक्रियता पर यह विपरीत प्रभाव अधिक पाया गया।

- पीथमपुर जिला धार (म.प्र.) के औद्योगिक क्षेत्र की मृदा एवं पानी/अपवाह नमूने लेने के लिए जिओ–रिफरेन्स्ड सर्वेक्षण किया गया। चीराखानी और सिलोटिया गाँव (जो कि औद्योगिक क्षेत्र के नजदीक है) के कुओं और ट्यूब बैल के पानी में उच्च लवणीयता पाई गई इसमें लगभग 82% पानी के नमूनों में तीव्र क्लोरीन द्वारा नुकसान की सम्भावना है। इसलिए इस पानी के प्रयोग की अनुशंसा केवल सहिष्णु फसलों में प्रयोग के लिए ही की जाती है। जिन मृदाओं में प्रदूषित जमीनी जल का प्रयोग किया गया उनमें क्रोमियम और मैंगनीज की उच्च मात्रा पाई गई।

- मरकरी हमारे वातावरण में प्राकृतिक एवं मानव निर्मित दोनों प्रक्रियाओं की वजह से पाया जाता है। क्लोरअल्कली उद्योगों में दूसरे कुछ अन्य धातु के इलेक्ट्रोड और इलेक्ट्रोलाइट सैल के प्रयोग द्वारा अथवा प्रभावशाली उपचार (सूक्ष्म जीव आधारित तकनीक, कम लागत वाली रेजिन का प्रयोग–ग्राफ्टिड कोकोनट हस्क, अधिक क्रियाशील धातुयें जैसे एल्युमिनियम, लोहा, ताँबा, जस्ता आदि के द्वारा मरकरी का तलछेदन) द्वारा इन प्रदूषण वाले उद्योगों के अपवाहन का शोधन करके प्रदूषण को काफी हद तक कम किया जा सकता है।

कृषि भूमि में विभिन्न अपशिष्ट पदार्थों का पुनः चक्रण एवं उपयुक्त प्रयोग

- भारतीय मृदा विज्ञान संस्थान के प्रक्षेत्र परीक्षण में पूर्ववर्ती गेंहूँ की फसल में वाहित मल जल सिंचाई करने पर बाद की सोयाबीन की फसल के वृद्धि कारकों एवं उसकी उपज में अर्थपूर्ण रूप से वृद्धि हुई। परन्तु सोयाबीन के तेल की मात्रा पर इसका कोई प्रभाव नहीं हुआ। वाहित मल जल द्वारा दीर्घकालीन सिंचाई करने से किसानों के खेतों पर सुलभ जस्ता, ताँबा और मैंग्नीज की मात्रा में वृद्धि हुई लेकिन उन जमीनों पर उगाए गये गेंहूँ में केवल लोहा और मैंग्नीज की मात्रा में वृद्धि हुई।

- मध्य प्रदेश के चार शहरों भोपाल, ग्वालियर, जबलपुर और इन्दौर से एकत्रित नमूनों में एम.बी.ए.एस. (मिथायल ब्लू सक्रिय पदार्थ) सक्रियता एवं एस.टी.पी.पी. की मात्रा आधार पर साबुन के प्रयोग द्वारा होने वाले प्रदूषण की गणना के लिए एक सर्वेक्षण किया गया। चारों शहरों में, इन्दौर में एल.ए.एस. और एस.टी.पी.पी. की सर्वाधिक मात्रा पाई गई।

- भारतीय मृदा विज्ञान संस्थान के प्रक्षेत्र परीक्षण (सीवेज जल द्वारा दीर्घकालीन सिंचाई) में मिथाइल ब्लू सक्रिय पदार्थ भूजल एवं वाहित मल जल दोनों ही द्वारा सिंचित जमीन में पाए गए। लेकिन, भूजल द्वारा सिंचित जमीन की तुलना से वाहित मल जल द्वारा सिंचित जमीन एम.बी.ए.एस. की मात्रा अधिक पाई गई। भूजल द्वारा सिंचित जमीन की अपेक्षा वाहित मल जल द्वारा सिंचित जमीन में एल.ए.एस. और एस.टी.पी.पी. की अधिक मात्रा पाई गई।

कार्बनिक खेती

- कार्बनिक खेती की उत्पादन क्षमता एवं अर्थशास्त्र की परम्परागत खेती से तुलना एवं मृदा गुणवत्ता का मूल्यांकन करने के लिए छः राज्यों महाराष्ट्र, कर्नाटक, तमिलनाडु, केरल, उत्तराखंड और पोंडिचेरी के कार्बनिक खेती के प्रक्षेत्रों का सर्वेक्षण किया गया। बहुत सी दशाओं में कार्बनिक खेती में उत्पादन कम पाया गया और उत्पादन में यह कमी 1.3 से 25.0 प्रतिशत पाई गई। कुछ दशाओं जैसे तमिलनाडु में काजू और आम एवं केरल में नारियल की उत्पादकता कार्बनिक खेती में अधिक पाई गई। उन दशाओं को छोड़कर जहाँ पर किसान अपनी उपज की लाभकारी दर प्राप्त कर रहा है, कार्बनिक खेती में आर्थिक लाभ भी कम है। सभी छः राज्य जहाँ पर सर्वेक्षण किया गया वहाँ पर परम्परागत खेती की तुलना में कार्बनिक खेती में मृदा गुणवत्ता कारकों में सामान्यतया वृद्धि देखी गई।

जलवायु परिवर्तन के प्रति फसल अंगीकारता

- गमलों एवं हाइड्रोपोनिक्स में जलवायु के कुछ परिवर्तन जैसे सोयाबीन में सडन विल्ट, गेंहूँ में सेनेस्सेंस एवं कपास के खेत में पत्तियों का लाल हो जाना के अध्ययन के लिए मध्य भारत की काली मृदाओं पर उगाये गये पौधों की पादप कार्यिकी, जैव रासायनिक एवं पादप पोषण अनुक्रियायें देखी गईं। सोयाबीन की प्रजाति जे.एस. 9305 में खराब स्टोमेटल रेगुलेशन की वजह से विल्टिंग हुई जिससे यह जलवायु परिवर्तन के प्रति संवेदनशील हुई जबकि सोयाबीन की प्रजाति जे.एस. –335 अच्छे स्टोमेटल रेगुलेशन की वजह से काफी समय तक सूखे को सहन कर गई। गेंहूँ की सहिष्णु प्रजाति जो कि पानी एवं पोषक तत्वों के बाधित शोषण से गेंहूँ में शीघ्र सीनेस्सेंस हुआ की तुलना से सीनेस्सेंस संवेदनशील प्रजातियां जिसमें कि

जड़मूल बहुत ही कम मात्रा में पाए गए। हरे पौधों की तुलना में कपास के लाल हुए पौधों में कम मात्रा में पोटाश, लोहा, मैंग्नीज और मैंग्नीशियम पाया गया।

किसानों के खेतों पर अनुसंधान एवं प्रभाव मूल्यांकन

- विदिशा जिले के रंगई गाँव में तीन प्रदर्शन परीक्षण के औसत आंकड़े दर्शाते हैं कि समतल भूमि का समन्वित पोषक तत्व प्रबन्ध में समावेश की तुलना में जलमग्न् खेत में समन्वित पोषक तत्व प्रबन्धन के साथ बी.बी.एफ. के समावेश से सोयाबीन की उपज में 92% की वृद्धि हुई। किसान विधि की तुलना से उन प्रक्षेत्रों में जिसमें खरीफ के समय में बी.बी.एफ. था, रबी के गेंहूँ में सवन्मित पोषक तत्व प्रबंधन एवं संतुलित उर्वरक प्रयोग से क्रमशः 18 और 24% अधिक उपज प्राप्त हुई।

- सोयाबीन में बी.बी.एफ. और आई.एन.एम. तथा गेंहूँ में आई.एन.एम. अपनाने से एक किसान को रू. 68121 की आय एवं लाभ : लागत अनुपात 3:1 आयेगा बशर्ते जलमग्न भूमि में सोयाबीन–गेंहूँ फसल चक्र प्रणाली को एक यूनिट समझा जाय। इस परीक्षण के परिणाम स्पष्ट रूप से दर्शाते हैं कि किसान खरीफ में जलमग्न मृदा में बी.बी.एफ. एवं आई.एन.एम. के साथ सोयाबीन तथा रबी में आई.एन.एम. के साथ गेंहूँ उगा सकते हैं।

- देश के तीन गरीब राज्यों बिहार, म. प्र. और उड़ीसा में किए जा रहे सामाजिक–आर्थिक अध्ययन के परिणाम दर्शाते हैं कि पिछले दशक में कृषि के सम्पूर्ण उपादानों से वृद्धि काफी कम रही। बिहार में कृषि में वृद्धि 4.79% रही। तीनों राज्यों में कृषि आय का प्रमुख हिस्सा फल एवं सब्जी वाली फसलों द्वारा हुआ। दो समय अन्तराल (1970–89 एवं 1990–2005) में प्रमुख फसलों की वृद्धि परीक्षण के आंकड़ों के अनुसार दूसरे समय अन्तराल में कुछ अपवादों को छोड़कर न केवल प्रमुख फसलों के अन्तर्गत क्षेत्रफल में कमी आई अपितु उपज वृद्धि भी कम हुई। उड़ीसा में 1990 के बाद सभी फसलों में उपज वृद्धि नकारात्मक रही। इसका मतलब यह हुआ कि कृषि वास्तव में एक घाटे का सौदा है जहाँ पर 75% आबादी कृषि पर निर्भर है। इन प्रदेशों में बिहार को छोड़कर (लगभग 60%) सिंचित सम्पूर्ण जुताई योग्य क्षेत्रफल 30% से कम है। भू जल द्वारा सिंचाई के लिए किसान डीजल पर निर्भर हैं अतः अधिकांश लघु और सीमांत कृषक अपनी फसलों की जीवन दायक सिंचाई करते हैं। इसके अलावा इन प्रदेशों में उर्वरक उपभोग (35–45 किग्रा./हे.) काफी कम है। इसी प्रकार खराब साख का वितरण (रू. 1800–2500 प्रति हे.) इन गरीब प्रदेशों की कृषि की वृद्धि को और दबाता है। सन् 1990 2004 के बीच राज्य सरकारों द्वारा कृषि क्षेत्र में खर्चे में वृद्धि की ओर इंगित करती है। परन्तु यह सभी खर्चे राजस्व खाते पर किए गए इसका मतलब यह हुआ कि सम्पूर्ण खर्च का केवल 10–15% ही सम्पत्ति/सम्पदा को बनाने में प्रयुक्त हुआ।

Soil Fertility Evaluation and Database

Soil samples collected from Hoshangabad and Guna districts were analyzed for N, P, K, OC, pH and EC. District and tehsil boundary maps of Guna were prepared. Using point values, geo-referenced fertility maps of Guna district were prepared for different nutrients through spatial analysis (kriging). Post-survey sample analysis of the two consecutive years has been used to validate the maps using paired t-test. There was a good agreement between estimated soil test values and those determined by actual sampling. Prepared fertility maps of Hoshangabad district have been validated through post-survey soil sample analysis. Interlinking of the recommendations with soil test values has been done for both the districts for using the information for precise fertilizer application.

Satellite data (soft copy) obtained from NRSA, Hyderabad was used to georeference the toposheets of Hoshangabad and Guna districts. The NDVI values were extracted grid wise from a part of the scene. Statistical analysis was carried out in the union of nutrient polygons. The relationships between nutrients and NDVI values, following different forms of NDVIs, have been analysed. The results indicated satisfactory relationships between nutrients and NDVI values.

The manure, straw, and feed samples (230 nos.) collected from six districts *viz.,* Baroda (Gujarat), Ahmedabad (Gujarat), Bikaner (Rajasthan), Ambala (Haryana), Ludhiana (Punjab), and Dharwad (Karnataka) showed wide variation in the composition of cattle feed ranging from only wheat straw to rich mixtures. The FYM was predominantly prepared by heap method in almost all the districts surveyed. The mean N recovery from FYM was 39% with a median of 21%. For P and K, the corresponding values were 20 & 17%, and 41 & 32%, respectively. The compost prepared primarily from plant trashes had the mean recovery values of N, P, and K of 20, 14, and 34%, respectively, relatively lower values than FYM.

Improving Input Use Efficiency

Rock phosphate samples (P content ranged from 1.6 % to 15.3%) were used to prepare ultra fine particle-size by grinding and sedimentation methods. The procured nano particles were highly unstable in water (except Hydroxy apatite <200nm) because of their zeta potential (range of zeta potential for stable suspension is -30 mv to +30 mv zeta potential). Results revealed that zinc oxide nano particle did not affect germination of gram seed upto 2000 ppm and that of mustard seed upto 500 ppm. Solution culture study showed that 0.27 ppm Zn (as nano zinc oxide particle) enhanced the growth of maize plant in comparison to conventional 0.5 ppm Zn (as $ZnSO_4$).

Monitoring Long-term Productivity

Conjunctive application of inorganic fertilizers and organic manures to soybean-wheat cropping system for five years improved the water-soluble carbon (WSC) content and the highest WSC was recorded in the treatment receiving only organic manure as source of nutrients for soybean and wheat. Water-soluble carbon content ranged between 43.6 and 67.9 mg kg^{-1} in 7.5 cm soil layer. Sub-surface (15-30 cm) layer contained the lowest amount of WSC where it ranged between 20.9 and 27.1 mg kg^{-1} with significant increase in WSC among various treatments. Various IPNS interventions improved carbon related indices such as CPI, CLI and CMI in comparison to control. The mean CPI, CLI and CMI for 0-30 cm soil depth varied from 1.00 to 1.32, 1.00 to 1.10 and 1.00 to 1.46 respectively. Changes due to manures and fertilizer addition to soybean wheat cropping systems were noticed both on macro-aggregates and micro-aggregates. At all the three soil depths (0-7.5 cm, 7.5-15 cm & 15-30 cm), small macro-aggregates (0.25-2 mm) constituted maximum proportion followed by micro-aggregates (0.053 to 0.25 mm). The highest change in aggregation was recorded under the treatments involving only manure addition in either the form of residues, FYM or both.

In fertilizer experiments conducted on farmers' fields, clearly indicated that in Alfisols P dose can be reduced to half safely without any reduction in finger millet and maize yields but to enhance the productivity, K application is needed in more quantity and part of that could be supplemented through FYM. Application of P and Zn is essential to harness the potential productivity of crops under maize-wheat system in Inceptisols of Punjab. To sustain the productivity of finger millet - maize system in Alfisols of Bangalore, soybean-wheat in Vertisols of Akola application of K, Zn and S are essential, respectively.

The pooled analysis of two years data of a field experiment conducted on potassium management strategy (GKVK Bangalore) indicated that application of K in two splits and soil inversion resulted in increased yield of crop compared to 100% K application. Split application of K has enhanced yield of finger millet and cowpea due to favourable changes in exchangeable form of K. However, soil inversion could not sustain the yield even for two years of cultivation due to dearth of potassium in this treatment. Total system productivity was highly influenced by only exchangeable form of K.

Managing Soil Physical Environment

Long-term tillage experiment, revealed that seed and biomass yields of soybean did not differ significantly among the tillage treatments. In contrast, seed and biomass yields were significantly higher in 150% and 100% recommended dose of nitrogen than the 50% of N. Imposition of tillage treatments and variations in nitrogen levels significantly influenced the bulk density of tillage treatments, and variations in nitrogen levels significantly influenced the bulk density of the top 5 cm soil. Similarly, the steady state infiltration rates of plots under various tillage treatments were significantly higher except under conventional tillage. Data on changing soil moisture content vs bulk density of soils under no tillage and conventional tillage system revealed that with decrease in moisture content from near saturation to below permanent wilting point, the bulk density of the Vertisol decreased at both 0-7.5 and 7.5-15 cm depths. The BD and moisture content relationship was greater at 0-7.5 cm depth than that at 7.5-15 cm depth.

Across tillage, 10 t ha^{-1} FYM-C recorded higher soil moisture content than 0 FYM-C. Different levels of FYM had significant effect on grain and biomass yields of wheat during 2008-09. Soils analysis revealed greater availability of N under no-tillage than conventional tillage at both soil depths (0-5 and 5-15 cm). The reverse trend was observed in available P and K at both soil depths with respect to tillage. Available N, P and K were found to increase significantly with increase in levels of FYM. In pot-culture with soybean crop, it was found that SOC, SMBC and basal respiration were higher without crop compared to with crop. In contrast, alkaline phosphatase and dehydrogenase activities were relatively greater in cropped than non-cropped pots.

Monitoring Soil Chemical Properties

A comparison was made between additions of P in organic and inorganic forms on P sorption in three contrasting soils. Irrespective of soil type, organic-P sorption was lower than inorganic-P sorption. The sorption of either inorganic or organic P in soils followed the order: Oxisol > Vertisol > Mollisol. In general, the P sorption maxima (b), bonding energy constant (k) and standard P requirement (SPR) derived from Langmuir isotherms were relatively lower for organic-P addition compared to inorganic-P. Averaged over all fractions, the organic and inorganic P accounted for 11.4, 12.5, 31.5, 30.9, 38.4, 47.1, 42.7 and 64.1 per cent of total P in vermicompost, municipal solid waste, poultry manure, green manure, farmyard manure (FYM), cow dung manure, subabool and wheat residue, respectively.

Geo-referenced soil samples were collected from the identified sites in Vidisha and Sehore districts of Madhya Pradesh. The preliminary soil analysis indicated that due to cultivation of crops, the soil organic C (SOC), available Fe and Mn from the surface (0-15 cm) soil layer were decreased by 31.03, 44.6 and 35.8%, respectively in Sehore district; while the SOC, available K and available Fe were decreased by 46.3, 47.6 and 19.9% respectively in Vidisha district as compared to pristine soil.

Improving Soil Biological Condition

The higher concentrations of C pools such as soil microbial biomass carbon (SMBC), water-soluble carbon (WSC) and acid hydrolysable carbohydrates (AHC) were observed in FYM treated plots followed by 50% NPK+CR, 50%NPK+FYM and 100%NPK in surface layer (0-15 cm).

The slow pool of carbon i.e., particulate organic carbon (POM-C) varied from 14.7 to 28.4 % of TOC in these treatments and it was the lowest in unfertilized control. Therefore, 71.6 - 85.3 % of TOC was present in the form of mineral associated organic matter (<0.053 mm) in these soils.

In all the treatments, rewetted sand free mass aggregate size distributions at 0-15 cm depths were dominated by small macro aggregates (25-2000 µm) accounting for 55.5-70.6% of dry soil weight followed by micro aggregates (53- 250 µm), accounting for 18- 37%). The sand free macro-aggregate carbon was greater in 250-2000 µm size classes followed by micro-aggregates.

The maximum FDA was (7.9 µg Fluorescein /g/h) observed in the FYM treated plots due to greater biological activities. After 60 days of incubation, it was observed that the CO_2 evolution increased maximum up to 40 days in these treatments. Among the three hydrological regimes, the higher amount of CO_2 evolution observed in 100 %WHC followed by submerged condition and the least in 50 % WHC at 35ºC in Vertisol. Further, the CO_2 evolution was maximum (192 mg CO_2/100) by the application of 100 % FYM at 100 % WHC followed by NPK +CR, 100% NPK and 50% NPK+ FYM possibly due to the greater release of water-soluble carbon and acid hydrolysable carbohydrates, which acted as source of bio-energy for higher amount of exogenous micro organisms.

Microbial Diversity and Biofertilizers

A highly efficient P-solubilizing, IAA and siderophore producing *Bacillus circulans* effective in inhibiting *Dematophora necatrix* identified from Chamba, H.P.

Biofertilizer enriched compost at 1 t ha^{-1} along with 50 % NP gave the highest rice yield of 3.9 tons/ha, saving 50% NP in Assam.

A microbial based bionutrient package consisting of Azospirillum, enriched mycostraw (spent residue + Pseudomonas sp.) and tobacco waste based Cyanobacteria could substitute nearly 50% of the nutrients for rice crop in Bihar.

Liquid inoculant production protocols developed for Bacillus, Pseudomonas and Rhizobium. Dosage for application and storage conditions of coated seeds standardized. (ANGRAU)

In tribal areas of M.P., bionutrient package demonstrated on farmer's fields. Yield increment of 17, 25, 40, 20 and 18% in soybean, maize, kodo, kutki and niger were recorded respectively.

The degree of oligotrophy of 10 bacterial isolates was studied- can be maintained in viable state upto 4 months (105-106 cells/ml) in double distilled water.

A new media formulated with mannitol, glycerol and 0.5% yeast extract gave more sensitive detection of HCN as compared to YEMA, King's or Nutrient agar medium.

Diversity of soybean rhizobia was assessed by intrinsic antibiotic resistance (IAR) pattern. Largely resistant to Nalidixic acid, Trimethoprim, Vancomycin, Novobiocin and Polymyxin-B. Dendrogram showed lot of diversity and clustering into 6 distinct groups.

Amelioration of Contaminated Soils

Based on green house studies, Cumulative Loading Limits of lead and cadmium for Indian soil were calculated as 170 kg P ha^{-1} and 0.8 kg Cd ha^{-1} respectively. On the basis of these computed values, maximum permissible Pb and Cd concentrations in the compost were computed as 170 mg Pb kg^{-1} and 0.8 mg Cd kg^{-1}, respectively, assuming cumulative allowable MSW compost application rate in crop land as 1000 Mg/ha during the 100 years of recycling programme.

Lead contamination through municipal solid waste composts, particularly at higher level caused significant reduction in the activity of soil enzymes, *viz.*, dehydrogenase, alkaline phosphatase, acid phosphatase. Such adverse effect on microbiological activity was more pronounced in light textured acid soil compared to heavy textured alkaline swell-shrink soil.

A geo-referenced survey was undertaken from Pithampur, Dhar (Madhya Pradesh) industrial area for soil and water/effluents sampling. The water of wells and tube wells in Cheerkhani and Silotia villages near to the industrial area is categorized as high salinity and sodium hazard and about 82 % of the samples have potential for severe Cl^- hazard permitting their use as irrigation in tolerant crops. The soil receiving polluted ground water is also high in chromium and manganese.

Mercury occurs as a result of both natural and anthropogenic sources in our environment. The pollution can be substantially reduced either by the use of some other metal electrodes and electrolytic cell in the chlor-alkali plants or by the effective treatment (Micro-organism based technology; Use of low cost Resins - grafted coconut husk; Precipitation of mercury by a more reactive metal, such as Al, Fe, Cu, Zn etc.) of the effluents from these polluting industries.

Recycling and Rational Usage of Different Waste in Agricultural Soils

In a field experiment at IISS Farm, sewage irrigation to previous crop of wheat had significant effect on growth parameters as well as seed yield of subsequent crop of soybean. However, it did not have any effect on seed-oil content. Long-term sewage irrigation increased the available Zn, Cu and Mn contents in soils of farmers' fields, but only Fe and Mn contents increased in grain of the wheat growing thereon.

A survey was conducted to have an estimate of detergent pollution from four cities of Madhya Pradhesh *viz*. Bhopal, Gwaliar, Jabalpur and Indore, based on MBAS (methylene blue active substances) activity and STPP content in the samples collected. Among the four cities, Indore recorded the highest content of LAS and STPP.

In a field experiment at IISS Farm (long term sewage irrigation), methylene blue active substances were present both in the ground water and sewage water irrigated soils. However, content of MBAS in sewage-irrigated soils were higher than groundwater irrigated soils. Sewage water irrigated soils have more LAS and STPP than ground water irrigated soils.

Organic Farming

A survey of organic farms was conducted in five states *viz*. Maharashtra, Karnataka, Tamil Nadu, Kerala, Uttarakhand and Pondicherry to compare the production potential and economics of organic farming and to evaluate the soil quality in comparison to the conventional farming. The productivity of crops under organic farming is less in most cases and the reduction in yield varies from 1.3 to 25.0 %. In few cases (Cashew, Mango in Tamil Nadu and Coconut in Kerala), the productivity is higher under organic farming. The economic benefit of organic farming is also less in organic farming except in cases where the farmers are getting premium price for their produce. In general, there is an improvement in the soil quality parameters in organic farms compared to conventional farms in all the 5 states surveyed.

Crop Adoptability to Climate Change

The physiological, biochemical and nutritive responses of plants grown in black soils of central India were studied to some of the changes in climate such as sudden wilt in soybean, senescence of wheat and leaf reddening of cotton in field, pot culture and hydroponics. Poor stomatal regulation in soybean variety JS 9305 led to wilting and made it vulnerable to climate change while JS 335 withstood the prolonged dry spell due to better stomatal regulation. The senescence sensitive varieties of wheat had fewer root hairs compared to tolerant varieties which restricted the water and nutrient uptake and led to early senescence in wheat. In cotton reddened plants found to contain less amount of K, Fe, Mn and Mg compared to green plants.

On-farm Research and Impact Assessment

The mean data of 3 demonstration trials conducted at Rangai village, Vidisha district showed increase of 92% in soybean seed yield with integration of BBF with INM on waterlogged fields over that of integration of flat land with INM. On plots those had BBF in *kharif* season, INM and Balanced fertilization produced 18% and 24% higher *rabi* wheat yield, respectively over the farmers' practice. If soybean-wheat system grown on water-logged fields considered as a unit, a farmer can get a net income of Rs.68121/- and B:C ratio of 3:1 with the adoption of BBF and INM in soybean and INM in wheat. These results clearly brought out the fact that farmers can cultivate soybean in waterlogged fields with BBF and INM in *kharif* and wheat with INM in *rabi*.

Socio-economic study being carried out in Bihar, Madhya Pradesh and Orissa- the 3 poorest states in India indicated that growth in total value of output from agriculture during last decade has been abysmally low. In Bihar, agriculture has shown significant resilience with 4.79 per cent growth. In all 3 states, major contributor in this growth had been fruits and vegetable crops. Two periods (1970-89 and 1990-2005) growth analysis of major crops showed that not only area under all the major crops has declined during Period II, but the yield growth too has decelerated, barring few exceptions. In Orissa, growth in yield for all crops after 1990s was found to be negative. This means, agriculture in the state is in real crisis, where about 75% of rural population depends on it. In these states, percentage of GCA irrigated is still as low as less than 30%, except in Bihar (about 60%). But, the farmers mainly depend on diesel engine for groundwater irrigation and therefore, most of the small and marginal farmers apply only life saving irrigation to the crop. Furthermore, consumption of chemical fertilizers in these states is very low (35-45kg ha^{-1}). Similarly, poor credit disbursement for agriculture (Rs. 1800-2500 ha^{-1}) in these poor states further depressed agricultural growth. Public expenditure by the state governments in agriculture during 1990-2004 shows an increasing trend, although, most of these expenditures were incurred on revenue account, which means only 10-15 per cent of total expenditures were meant for creation of assets.

3. INTRODUCTION

India is endowed with a rich diversity of soil and water resources having different prospects for supporting wide range of flora and fauna. The overall sustaining growth of our country's economy is heavily dependent on good health of its soil, the productivity of which is the resultant effect of its intrinsic characteristics, coupled with interactions of external inputs like water, plant nutrients, climate, energy, tillage and other factors. Over-exploitation of soil resources as a result of burgeoning population, industrialization / urbanization with the quest for short-term gains to meet the growing demands without long term perspectives have, however, resulted in soil degradation at an alarming rates. Therefore, to tackle the basic problems pertaining to scientific management of nutrient, water and energy in crop production, the ICAR established Indian Institute of Soil Science (IISS) in 1988 at Bhopal as a nodal center to provide scientific basis for enhancing and sustaining productivity of our soil resources through basic and strategic research.

Since its inception, the Institute completed over two decades of its existence after crossing a number of hurdles and has grown up in its stature in terms of scientific manpower and R & D infrastructure. The Institute activity has been strengthened further by the scientific and managerial activities of All India Coordinated Research Projects. These four institute based AICRPs act as a part of the "Network-support-programmes" of the IISS with these centres located in State Agricultural Universities, providing access to the diverse soils, agro-ecosystems across the agro-ecological zones of the country for effective implementation of the programmes of the Institute on regional basis. During the year under report, the Institute has made notable scientific contribution in the areas of integrated plant nutrient supply system (IPNS), organic farming, efficient utilization of applied nutrients, nutrient transformation processes and dynamics in soil-plant systems, environmental impact due to utilization of solid wastes, waste water, bioremediation etc. The salient research findings are briefly highlighted in the report.

3.1 Mandate

The mandate of the Institute is "to Provide Scientific Basis for Enhancing and Sustaining Productivity of Soil Resources with Minimal Environmental Degradation", with the following objectives:

a) To carry out basic and strategic research on soils especially physical, chemical and biological processes related to management of nutrients, water and energy.

b) To develop advanced technologies for sustainable systems of input management in soils that is most efficient and least environmental polluting.

c) To develop expertise and back-stop other organizations engaged in research on agriculture, forestry, fishery and various environmental concerns.

d) To exchange information with scientists engaged in similar pursuits through group discussions, symposia, conferences and publications.

e) To collaborate with State Agricultural Universities, National, International and other Research Organizations in the fulfillment of the above objectives, and

f) To develop database repository of information on soils in relation to quality and productivity.

3.2 Priorities and Thrust Areas

The priorities of the institute are to broaden the soil science research by encouraging multidisciplinary research for efficient utilization of already created infrastructure and, therefore, carry out research work rigorously in the following areas:

Improve crop response to nutrient and their use efficiency in dominant soil groups of India.

Develop efficient integrated plant nutrient supply and management systems for sustainable agriculture in different agro-ecological regions.

Identifying and quantifying basic soil and crop factors and processes responsible for gains and losses, storage, release and movement of nutrients in dominant soil groups of India.

Determining the quality of organic carbon pools, capacity for sequestering carbon and its quantification in soils.

Defining, identifying, and quantifying soil health parameters.

Quantifying nutrient-water-tillage interaction and root growth dynamics in the soil environment for the sustainability of important agricultural systems.

Developing and validating models describing the fate of applied nutrients and water for efficient nutrient and water management for sustainable agriculture.

Quantifying the role of soil microbial biomass, VAM, root exudates, legumes in N, P, S, Zn and Fe solubilization and/or mineralization to enhance their use-efficiency in soils with diverse properties.

Developing technology for efficient recycling of urban solid wastes and agro-industrial effluents.

Developing methods for the quality assessment of manures and establishing quality standards.

Studying ecological impacts of nutrient input and waste management practices on soil health.

Quantifying processes responsible for retention, release and bioavailability of heavy metals and their upper threshold values in soils.

Fine-tuning, the technologies on farmers' fields.

Carrying out diagnostic surveys and

Strengthening weak research database on soil and nutrient management provide a sound base for further carrying out basic and strategic research.

3.3 Organization Set-Up

Divisions

(i) Soil Physics
(ii) Soil Chemistry & Fertility
(iii) Soil Biology
(iv) Environmental Soil Science

Section

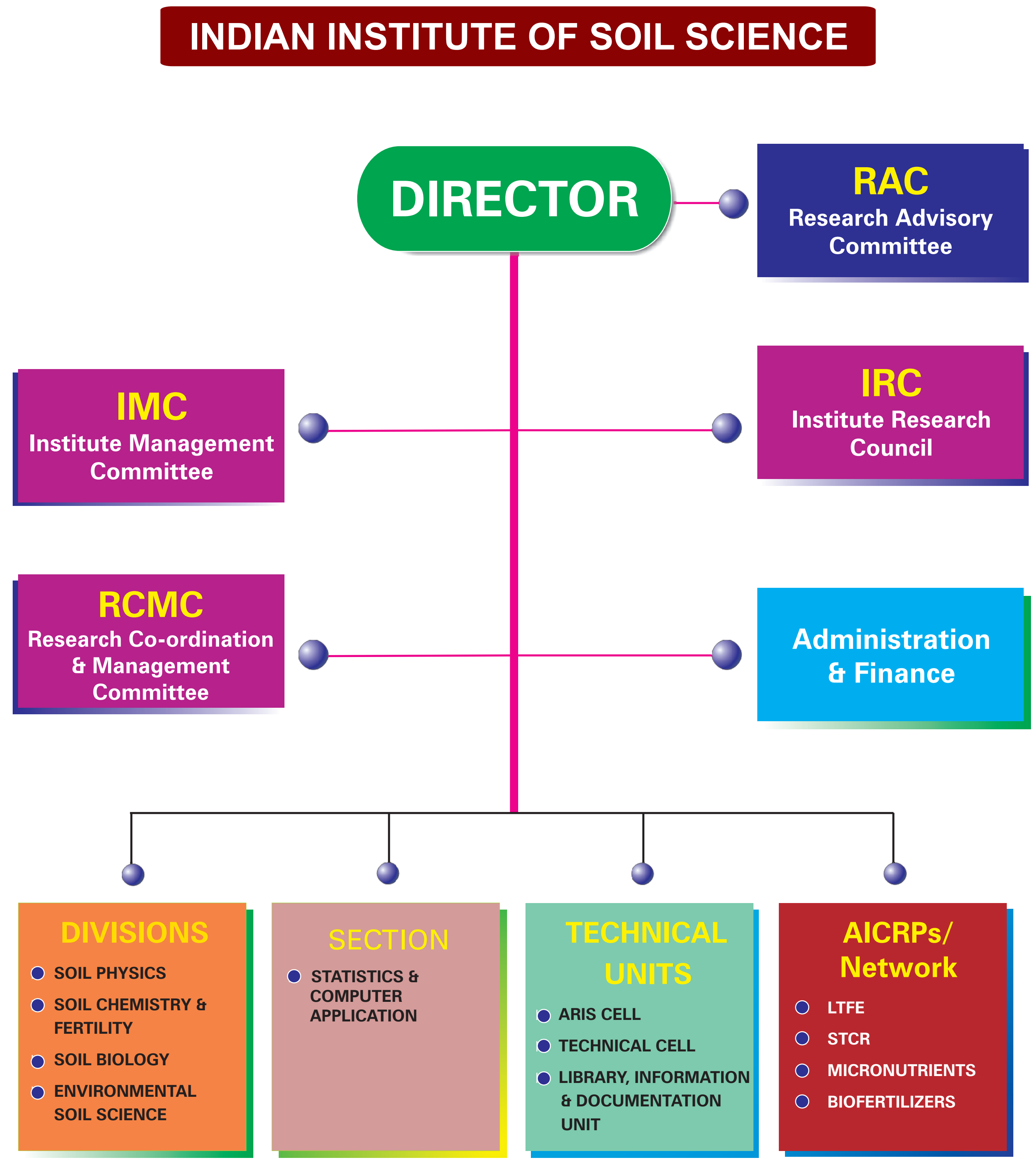
Statistics and Computer Application

Technical Units

(i) ARIS Cell
(ii) Technical Cell
(iii) Library, Information and Documentation Unit

All India Co-ordinated Research Projects (AICRPs)

(i) Long-Term Fertilizer Experiments (LTFE)
(ii) Soil Test Crop Response Correlation (STCR)
(iii) Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (Micronutrients)
(iv) All India Network Project on Biofertilizers (BF)



Organizational Structure of Indian Institute of Soil Science, Bhopal.

3.4 Summary of Staff Position

(a) Scientific Positions

S.No.	Discipline	MAIN INSTITUTE							
		Sanctioned				In Position			
		PS	SS	S	TOTAL	PS	SS	S	TOTAL
1	Soil Physics / Soil & W.C.	2	2	5	9	2	3	2	7
2	Soil Chemistry/Fert./Micro.	9	7	13	29	9	8	5	22
3	Agronomy	1	2	4	7	2	1	1	4
4	Plant Physiology	1	1	1	3	1	2	0	3
5	Agricultural Statistics	0	2	2	4	0	1	2	3
6	Biochemistry	0	1	1	2	0	1	0	1
7	Computer Application	0	0	1	1	0	0	1	1
8	Agricultural Economics	0	1	1	2	0	1	0	1
	Total	**13**	**16**	**28**	**57**	**14**	**17**	**11**	**42**

(b) Technical posts

Designation	Sanctioned	In Position
T-1	11	1
T-2	0	3
T-3	9	3
T-4	0	4
T-5	0	4
T-6	0	2
T-7-8	2	1
T-9	0	1
Total	**22**	**19**

(c) Administrative posts

Designation	Sanctioned	In Position
Administrative Officer	1	1
Asstt. Finance & Accounts Officer	1	1
Private Secretary	1	1
Personal Assistant	5	3
Stenographer Gr-III	5	3
Security Supervisor	1	1
Assistant	5	4
Upper Division Clerk	1	2
Lower Division Clerk	7	3
SS Gr.- IV	2	0
SS Gr.- III	4	2
SS Gr.- II	8	7
SS Gr.- I	11	14
Total	**51**	**42**

3.5 Financial Statement (2008-09)

3.5.1 Closing Balance In Various Projects, Externally Funded Schemes, Contractual And Consultancy Research Programmes

PROJECT CODE	PROJECT DETAILS	OPENING BALANCE AS ON 1.4.2008	FUNDS RECEIVED DURING 2008-09	EXPENDIUTRE INCURRED DURING 2008-09	REFUNDS DURING 2008-09	CLOSING BALANCE AS ON 31.3.2009
CONTRACTUAL AND CONSULTANCY RESEARCH PROJECTS						
705	COROMONDEL GROMOR SULPHUR	75961	0	27130	0	48831
706	INSTITUTE RESOURCE GENERATION	120322	0	11980	0	108342
707	ICAR RESOURCE GENERATION FUND	3038	0	0	0	3038
708	IISS WELFARE FUND	1178	269	0	0	1447
709	ICAR WELFARE FUND	843	115	0	0	958
710	CHEMIE ALLIANCE FORTIFIED BORAX	266313	0	89013	0	17730
711	DR DD REDDY GRAMIN VIKAS TRG.	10000	0	9830	0	170
712	DR HEBBAR DEVI CROP SCIENCE	133433	205962	198372	0	141023
713	DR DD REDDY TRAINING TO STUDENTS OF ALLAHABAD	0	9600	9600	0	0
714	DR KB HEBAR M/S WIKNROCK INTERNATIONAL INDIA NE	0	141102	47980	0	93122
	TOTAL	**611088**	**357048**	**393905**	**0**	**574231**
EXTERNAL FUNDED SCHEMES						
403	OFS-DR DLN RAO NETWORK ON BF	20000	0	0	0	20000
405	DR KS REDDY ACIAR-ICAR AUSTRALIA	1189147	1035094	1015714	0	1208527
406	DR A SUBBA RAO NATIONAL SEMINAR	496	0	0	0	496
408	DR DD REDDY TMC-MMI	0	0	0	0	0
410	GOLDEN JUBILEE	80000	0	0	0	80000
411	DR MV SINGH CHOUDHARY DEVILAL	100000	0	0	0	100000
414	REGIONAL WORK SHOP AICRP STCR	0	0	0	0	0
415	DR KN SINGH MAPCOST	73047	0	0	0	-78213
416	FLD STCR ISOPOM DRM NEW DELHI	2000	0	0	0	2000
417	FLD STCR IIPR KANPUR	0	0	0	0	0
418	REGIONAL WORKSHOP AICRP-STCR	0	0	0	0	0
419	REGIONAL WORKSHOP AICRP-MSN	0	0	0	0	0
420	DR Y MURLIDHARUDU FLD ON OILSEEDS UNDER ISOPOM	0	280000	280000	0	
0						
421	DR KB HEBBAR TMC MMI FROM CICR NAGPUR	0	263925	93166	0	170759
422	DR P RAMESH MODEL TRAINING COURSE IN EFFICIENT	0	73500	91718	1907	-20125
423	DR Y MURLIDHARUDU SUMMER/WINTER SCHOOL 21 DA	0	175000	178487	0	-3487
424	DR Y MURLIDHARUDU FLD UNDER ISOPOM	0	100000	0	0	100000
	TOTAL	**1464690**	**1927519**	**1810345**	**190**	**1579957**

PROJECT CODE	PROJECT DETAILS	OPENING BALANCE AS ON 1.4.2008	FUNDS RECEIVED DURING 2008-09	EXPENDIUTRE INCURRED DURING 2008-09	REFUNDS DURING 2008-09	CLOSING BALANCE AS ON 31.3.2009
APCESS FUNDED PROJECTS						
103	DR AK BISWAS-NITRATE CONTAMINA	139420	0	141620	0	-2200
104	DR KN SINGH- SOIL FERTILITY MAPING	177855	0	432835	0	-254980
105	DR RANJIT SINGH	204160	186300	223173	0	167287
	TOTAL	**521435**	**186300**	**797628**	**0**	**-89893**
PLAN NETWORK PROJECTS						
3001	DR P RAMESH ORGANIC FARMING	84618	623000	686282	0	21336
3002	DR AK MISRA CLIMATE CHANGE	0	0	0	0	0
3003	DR DLN RAO AMAAS	681420	837000	1181924	0	336496
	TOTAL	**766038**	**1460000**	**1868206**	**0**	**357832**
AICRP						
2501	PLAN AICRP MSN	191009	32000000	31901280	610760	-321031
2502	PLAN AICRP STCR	56339	27000000	27023329	0	33010
2503	PLAN AICRP LTFE	79720	23000000	22932761	0	146959
2504	PLAN NETWORK ON BF	283692	12000000	11979129	0	304563
	TOTAL	**610760**	**94000000**	**93836499**	**610760**	**163501**
NON PLAN SCHEME						
2001	NP AICRP MSN	-655562	2633000	2612134	278751	-913447
2002	NP AICRP STCR	89296	1900000	1406547	175000	407749
2004	DR MUNESHWAR SINGH SUMMER SCHOOL	-4380	0	0	0	-4380
2006	DR DLN RAO WINTER SCHOOL	-252	0	0	0	-252
2006	DR AK MISHRA SUMMER SCHOOL SOIL ORGANIC CARBON	8502	0	0	0	8502
	IISS PLAN	-	15000000	14941113	-	-
	IISS NON-PLAN	-	37700000	39015589	-	-
	TOTAL	**-562396**	**4533000**	**4018681**	**453751**	**-501828**
	GRAND TOTAL	**3411615**	**102463867**	**102725264**	**1066418**	**2083800**

3.5.2 Resource Generation

Sl.No.	Particulars	Amount
1	Sale of Farms Produce	577652
2	Sale of Publication and Advertisement	559
3	Licence Fee	114952
4	Interest earned on Loans and Advances	188738
5	Leave Salary and Pension Contribution	223907
6	Analytical and Testing fee	500
7	Unspent Balance of grants	3413715
8	Interest earned on short term deposits	1235389.10
9	Income generated from Internal Resource generation	59600
10	Recoveries of Loans and Advances	1575073
11	Miscellaneous Receipts	373679
	Grand Total	**7763764.10**

4. RESEARCH ACHIEVEMENTS

4.1 Soil Fertility Evaluation and Database

4.1.1 Development of suitable methodology for soil fertility mapping using GIS and GPS tools for precise fertilizer recommendations based on spatial variability

Validation of the prepared maps through post soil sample analysis

Soil samples were collected from all the blocks of Hoshangabad district. The collected soil samples were analysed and compared with previous year data. Similarly, two sets of estimated data were generated through prepared maps. These samples were analyzed in the laboratory and the results are given in the Table 4.1.1. Soil data were tested using paired t-test (x_i, y_i) which showed that in the subsequent year there was no change in the nutrients except soil pH. For other values, there was no significant difference. Therefore, it was inferred that the soil parameters for Hoshangabad district did not change significantly for at least two consecutive years except for pH.

Table 4.1.1. Comparison of actual nutrients analyzed and their values through prepared maps (response surface)

	N (kg ha^{-1})	P (kgh a^{-1})	K (kg ha^{-1})	OC (%)	EC (dS m^{-1})	pH
Mean (Analysed)	222.02	16.88	388.13	0.62	0.176	7.53
Mean (estimated)	218.38	16.64	390.95	0.61	0.174	7.62
df	85	85	85	85	85	85
t Stat	-1.484	-1.458	0.80	-1.23	-0.98	4.12
t (Critical two-tail) for P<0.05	1.988	1.988	1.988	1.988	1.988	1.988

Interlinking of the recommendations with soil test values

The prepared maps were georeferenced. One of the utilities of map is that in case a farmer is able to obtain the location (Latitude, Longitude) of his field, he can easily get the available nutrients status of the soil from the prepared maps.

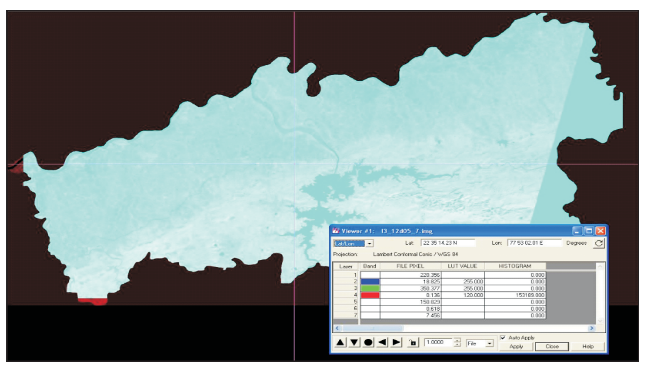


Fig. 4.1.1. Estimation of different parameters using longitudes and latitudes

If we type Latitude and Longitude values in the Fig.4.1.1 (at the place specified for it) and press enter key then the curser on the screen will automatically move at the specified location and the estimated values of all the nutrients will be displayed on the screen as (FILE PIXEL). These values will be used further for the recommendation of fertilizer doses for the targeted yield.

To open the maps in the internet, type http://localhost/NPKSpatial/default.htm) the main page shown below (Fig. 4.1.2) will be displayed:

To view the photos as in Fig.4.1.3 click photo gallery or else can go to project details as shown in Fig. 4.1.4. All the maps will be displayed on the screen as shown in Fig. 4.1.5.

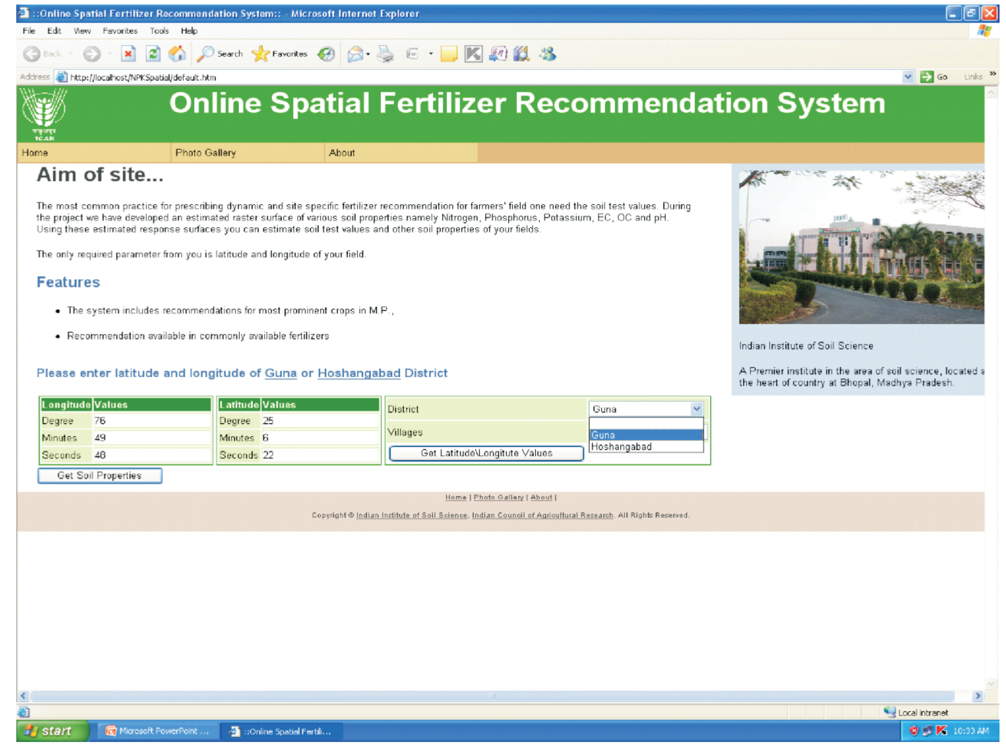


Fig. 4.1.2. First screen on running the application with an Internet browser

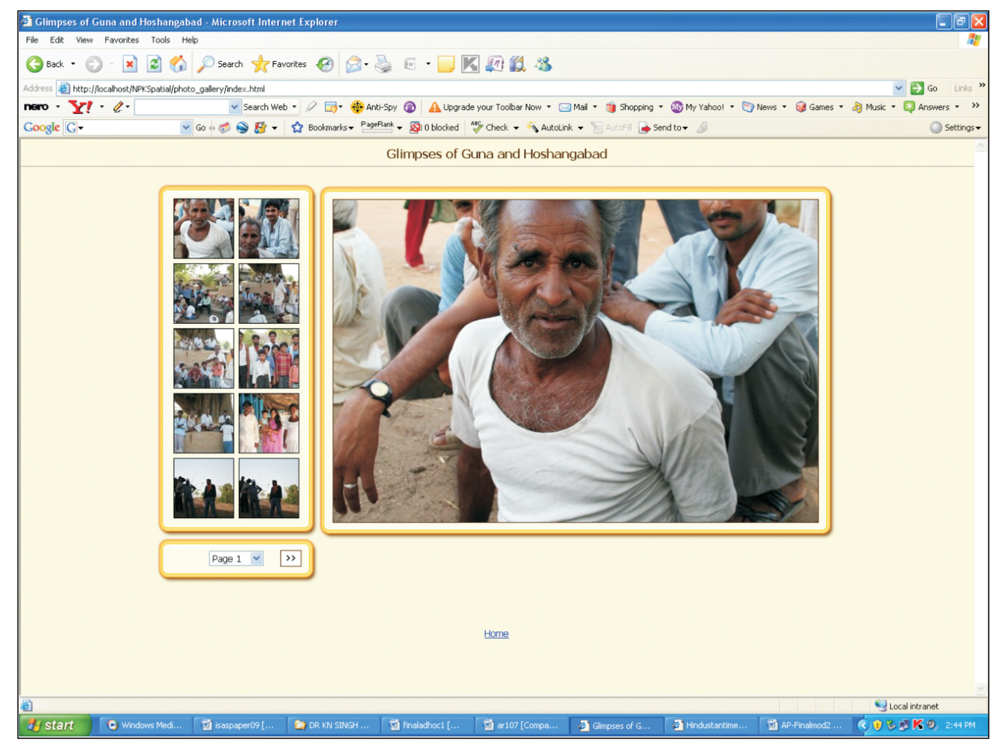


Fig. 4.1.3. Screen displaying photos taken during survey

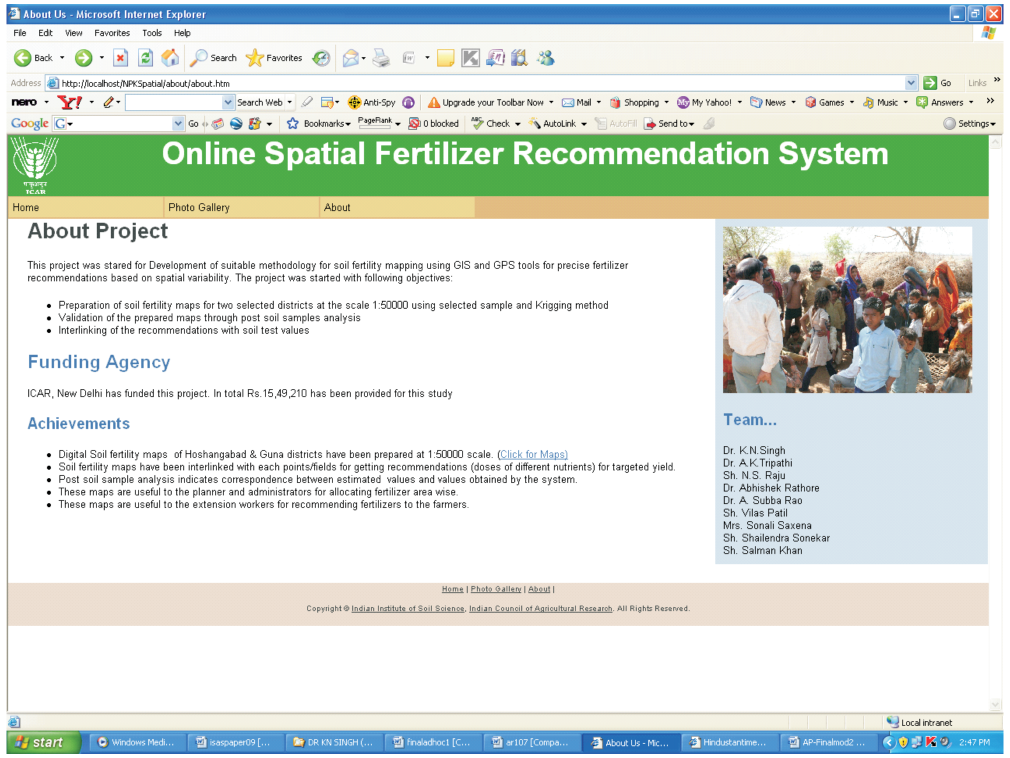


Fig. 4.1.4. Screen displaying project summary

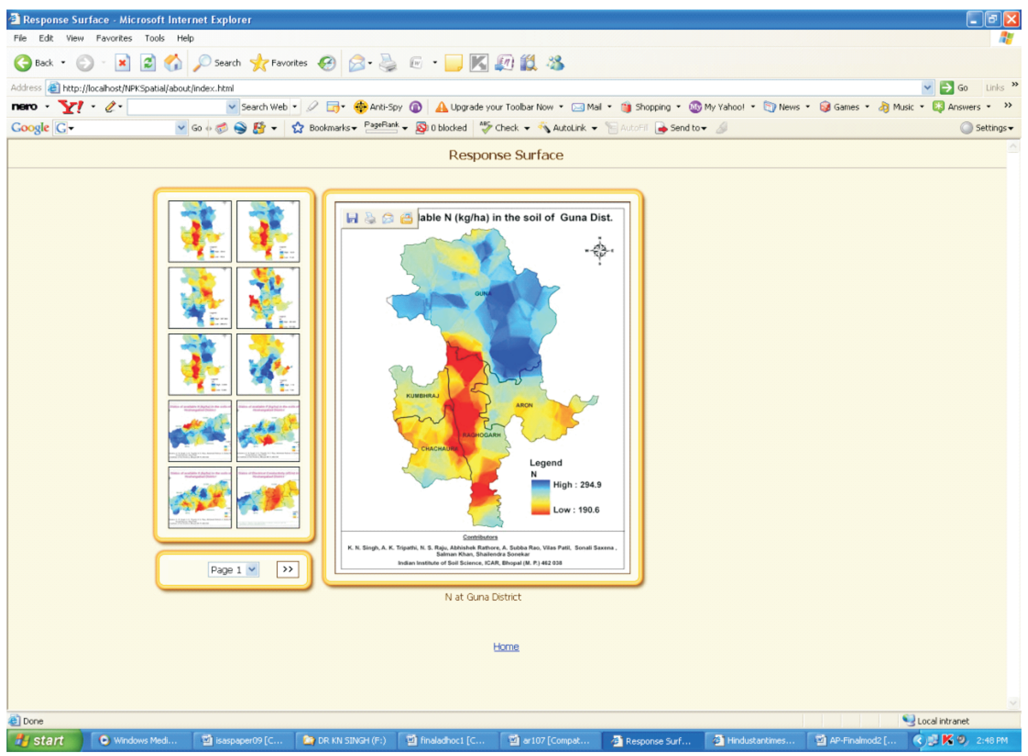


Fig. 4.1.5. Screen displaying prepared soil fertility maps

The main page contains the names of the district and Longitude (Lon) and Latitude (Lat). Here, users have option to input the Lat & Lon of his field to get the recommendation. In case if Lat and Long values are not available, village names can be typed and still can get the recommendation.

After selecting the village the following page will be displayed in Fig. 4.1.6.

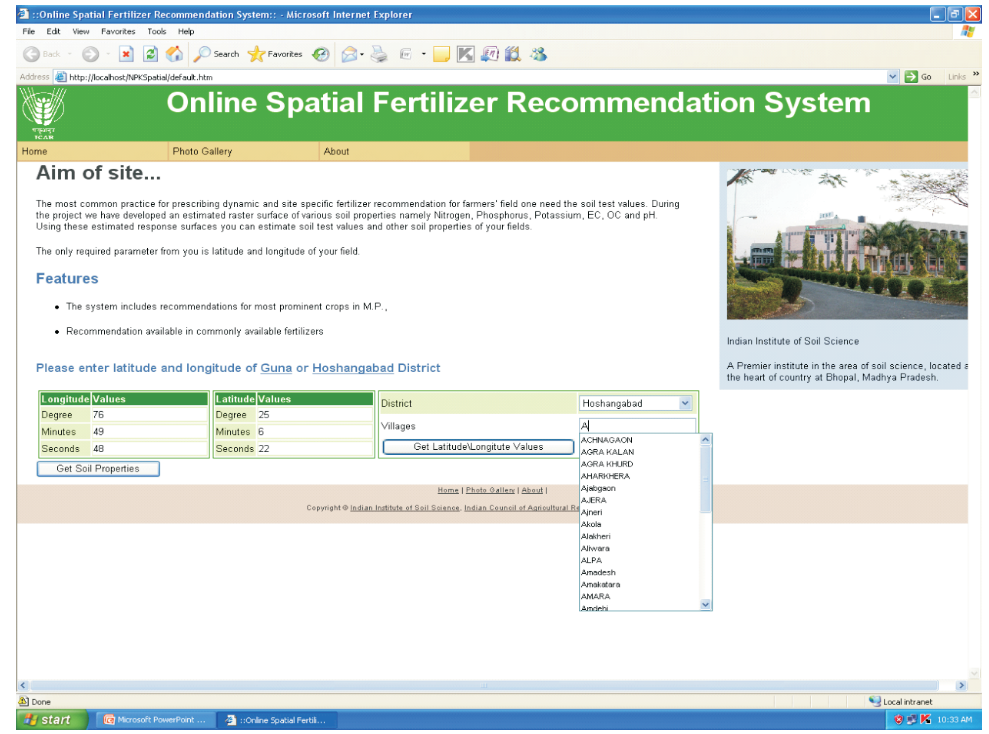


Fig. 4.1.6. Screen displaying list of villages starting with the letter "A"

The system will automatically take the Latitude & Longitude of the village as shown in Fig. 4.1.6. Now the farmer has to select the crop to be sown and fix the target (yield q ha^{-1}) from the given range. This range has been obtained such that these targets can be achieved. The target range is fixed based on the experimentation conducted at IISS, Research Farm. The target outside this range will not be realistic since they are outside the range of targets achieved during the experimentations. A case study involving a farmer who is interested in wheat and is fixing target as 50 q ha^{-1} is shown in Fig. 4.1.7.

The display shows that for the target of 50 q ha^{-1} yield of wheat the farmer has to apply 100 kg N, 91 kg P_2O_5 and 54 kg of K_2O. Dose will be 219 kg Urea, 569 kg SSP and 93 kg MOP. The computation is done for these fertilizers (Urea, SSP and MOP) because they are generally the common fertilizers in India and also they were used in the experimentation. However, if the user wants to apply other fertilizer such as DAP, or some other fertilizer, he can use that by calculating its dose taking into consideration the nutrient required by the soil (obtained from the software) and the nutrients available in the fertilizer. The complete system has been provided in an executable CD.

Soil fertility maps with complete information for both the districts including village name have been prepared and submitted along with the complete system to the Council as well to the State Agriculture Department for its dissemination/use. For example, two maps are presented here in Fig.4.1.9 and 4.1.10.

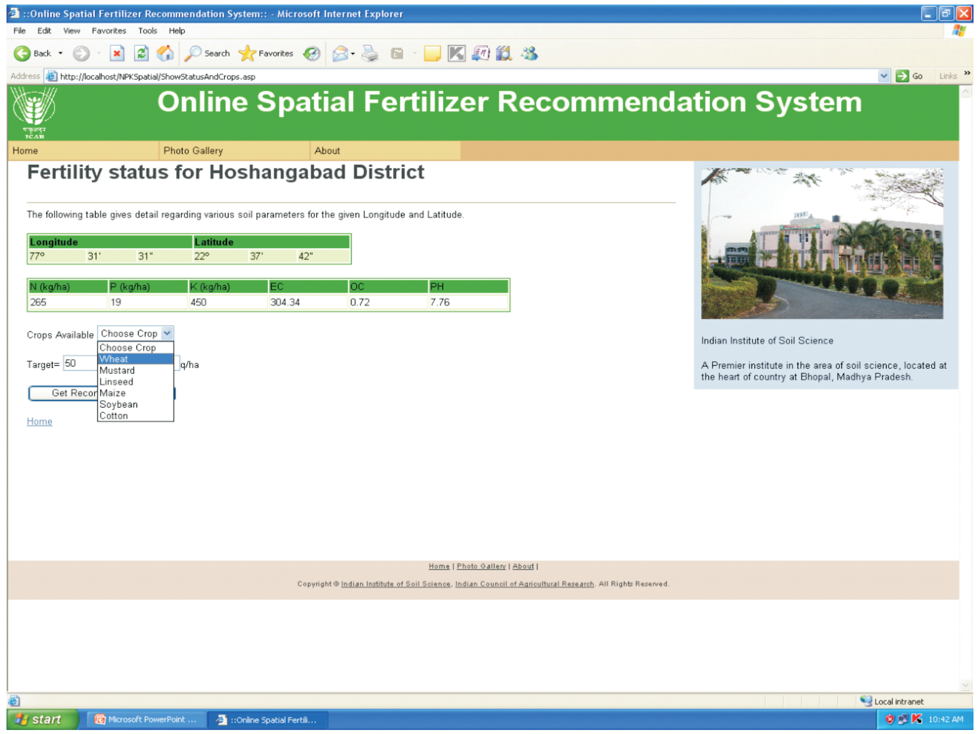


Fig. 4.1.7. Screen displaying selected crop and the targeted yield

The user can obtain the recommendation as shown in Fig. 4.1.8.

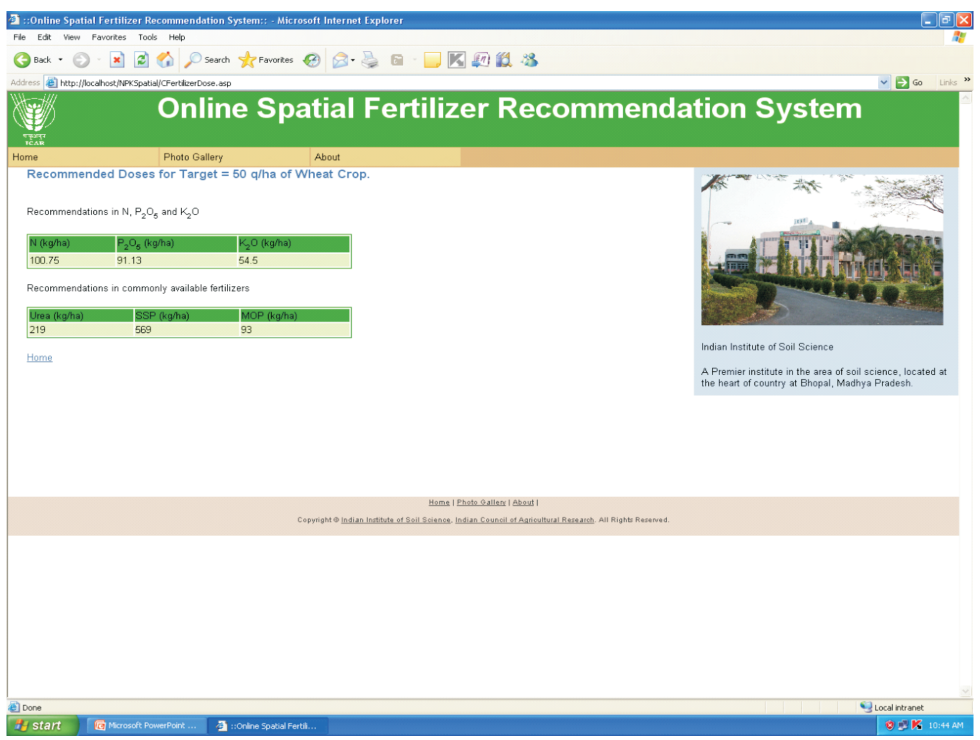


Fig. 4.1.8. Screen displaying the recommendation

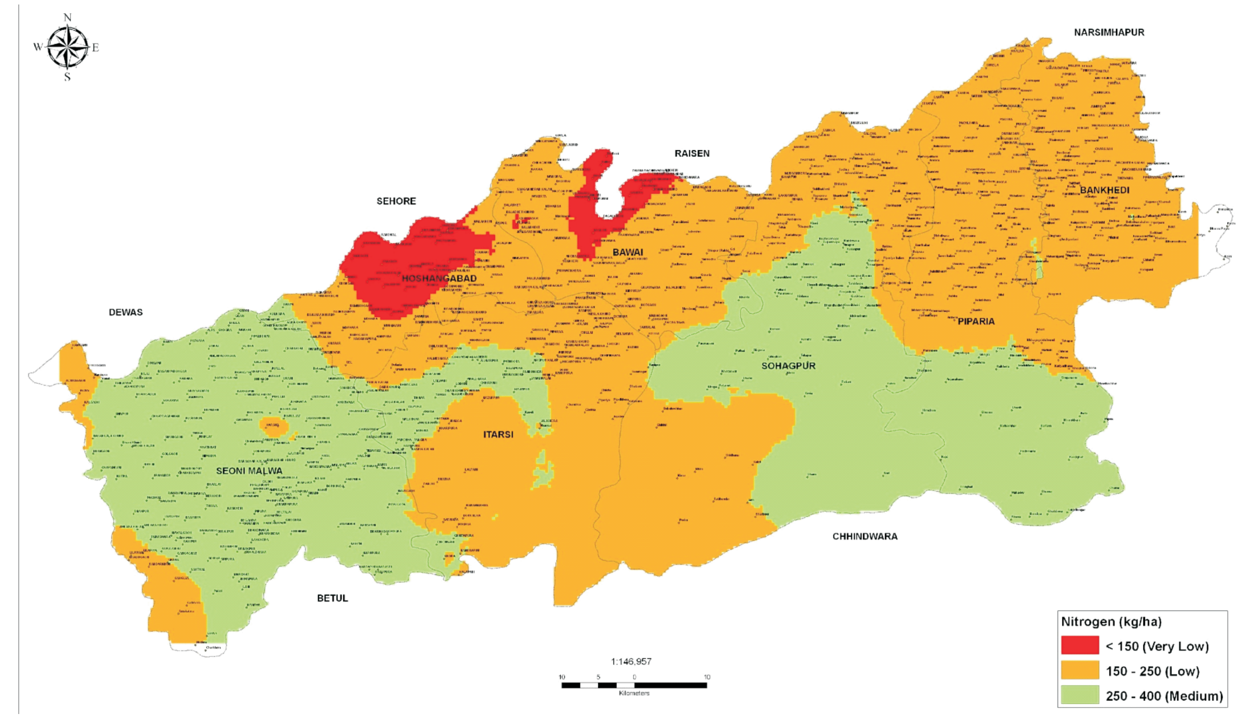


Fig. 4.1.9. Available N (kg ha^{-1}) status in the soils of Hoshangabad district

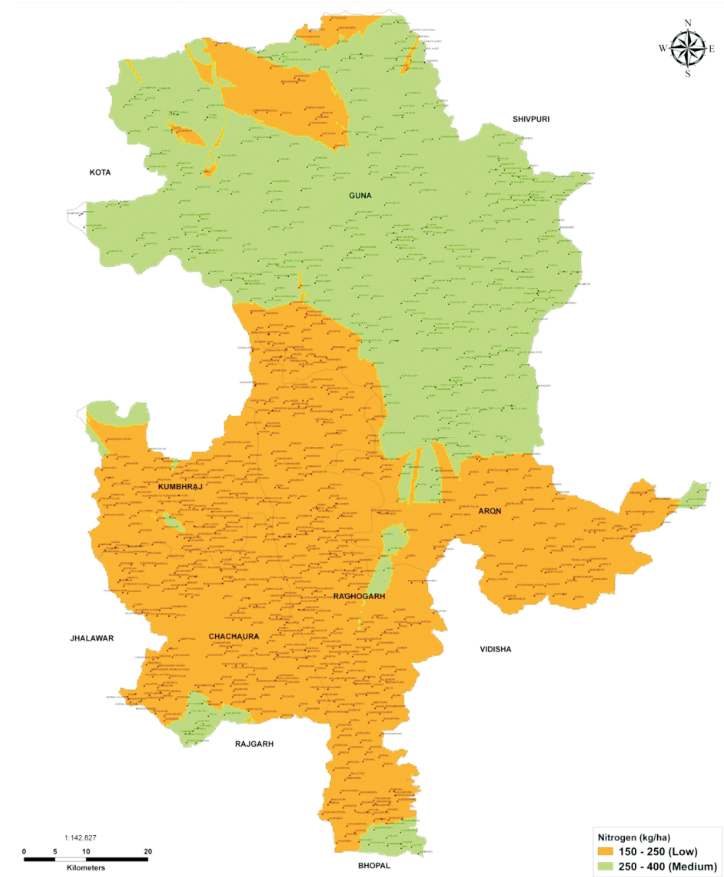


Fig. 4.1.10. Available N (kg ha^{-1}) status in the soils of Guna district

4.1.2 Development of methodology using RS, GPS & GIS for delineating area of a district in different fertility zones for precise fertilizer recommendations based on available soil nutrients

Preparation of NDVI Images and Unions

Satellite data (soft copy) for selected areas of Guna district was purchased from NRSA, Hyderabad. The cloud free data was processed for the months of December 2005 and January and March 2006. Fig. 4.1.11 and 4.1.12 showed the uncorrected and corrected area of Guna district under the scene of December 05. The NDVI image of December is given in Fig. 4.1.18. The NDVI values vary from -0.55 to 0.67. Figs. 4.1.13 & 4.1.15 showed the uncorrected area under the scenes of part of Guna district for the months January and March 2006 and corresponding corrected images are given in Fig. 4.1.14 and 4.1.16 respectively. Similarly Figs. 4.1.19 and 4.1.21 showed the area of Guna district obtained from the corrected scene for the months January and March 2006 and corresponding NDVI images are given in Figs. 4.1.20 and 4.1.22.

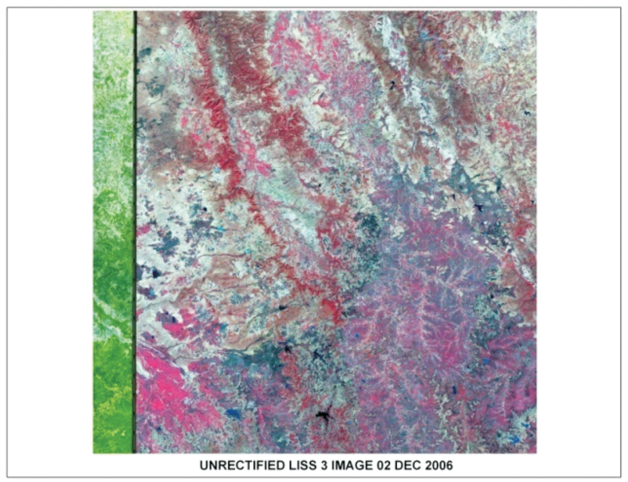


Fig. 4.1.11. Uncorrected LISS III image on 02-12-2006

Fig. 4.1.12. Corrected LISS III image on 02-12-2006

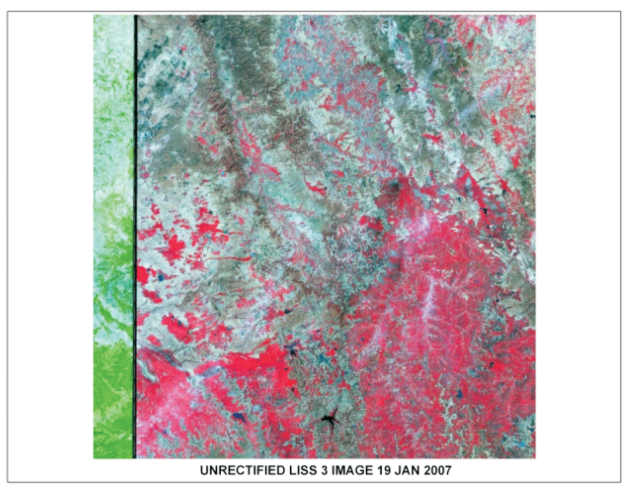


Fig. 4.1.13. Uncorrected LISS III image on 19-01-2007

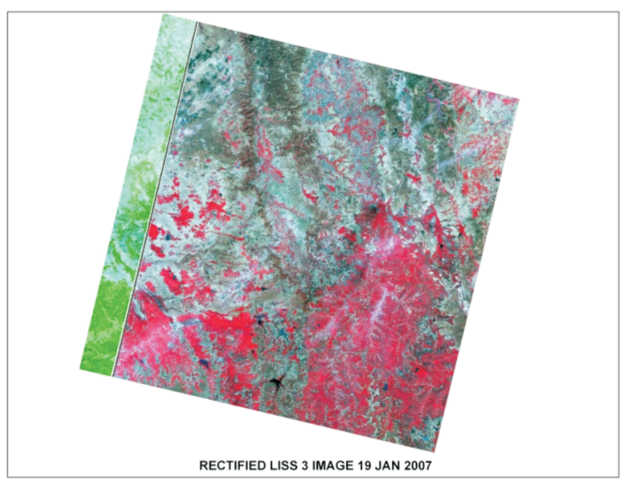


Fig. 4.1.14. Corrected LISS III image on 19-01-2007

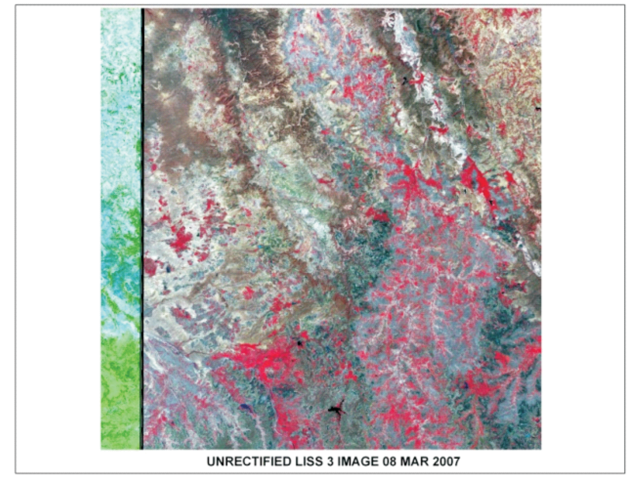


Fig. 4.1.15. Uncorrected LISS III image on 08-03-2007

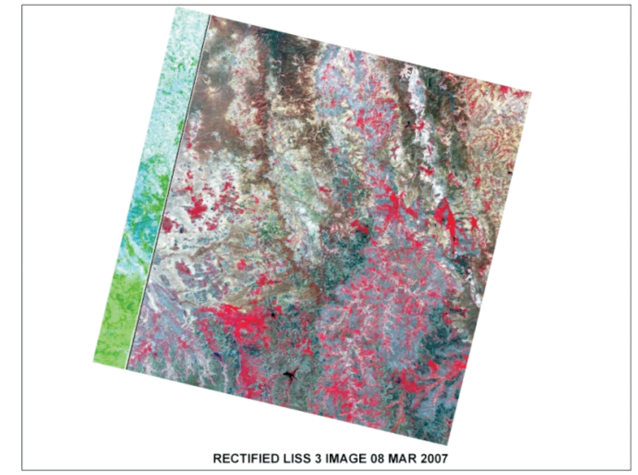


Fig. 4.1.16. Corrected LISS III image on 08-03-2007

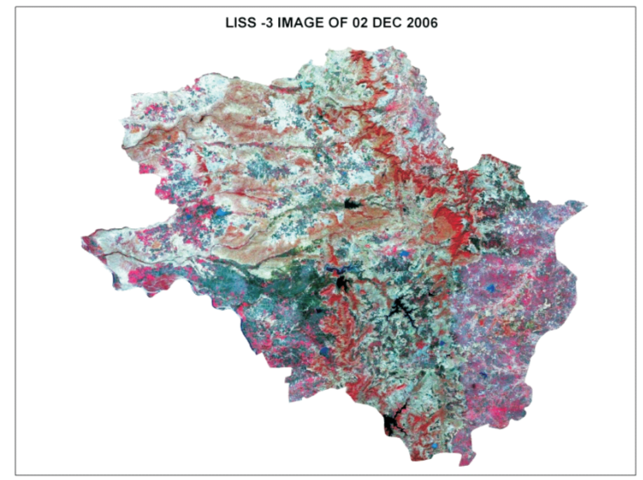


Fig. 4.1.17. Part of Guna district obtained from the corrected scene on 02-12-2006.

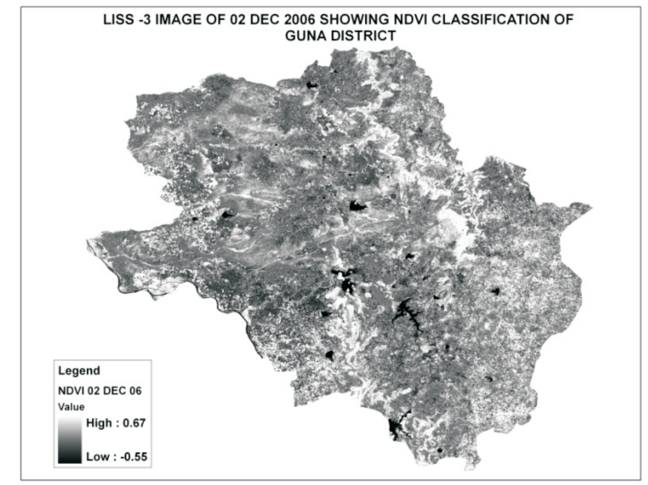


Fig. 4.1.18. NDVI image of part of Guna district on 02-12-2006.

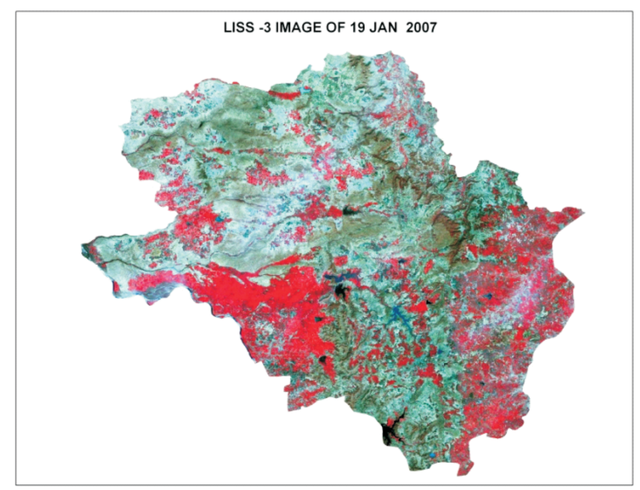


Fig. 4.1.19. Part of Guna district obtained from the corrected scene on 19-1-2007.

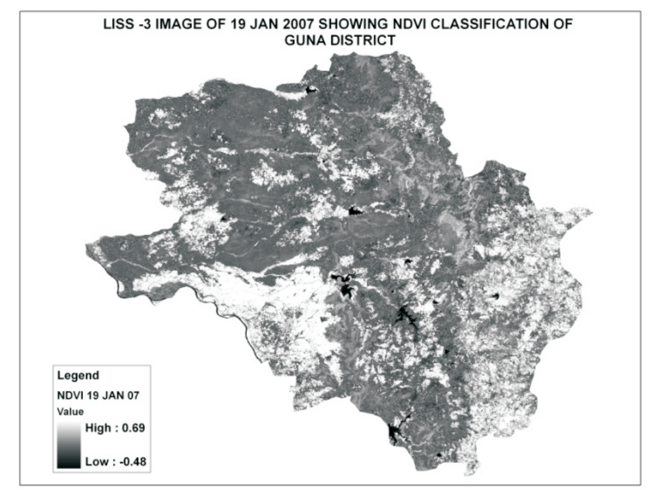


Fig. 4.1.20. NDVI image of part of Guna district on 19-1-2007

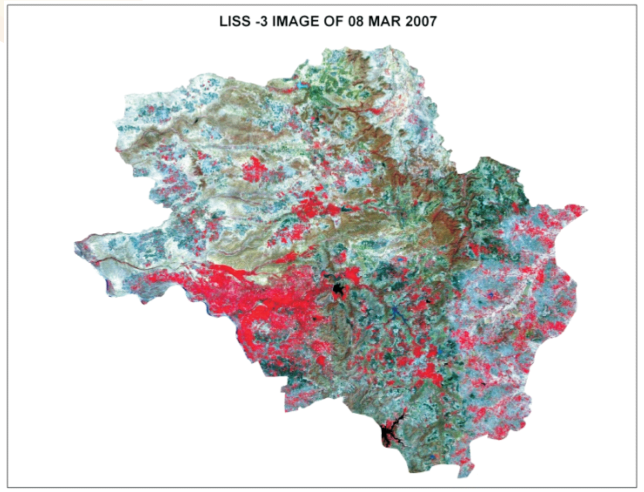


Fig. 4.1.21. Part of Guna district obtained from the corrected scene on 08-3-2006.

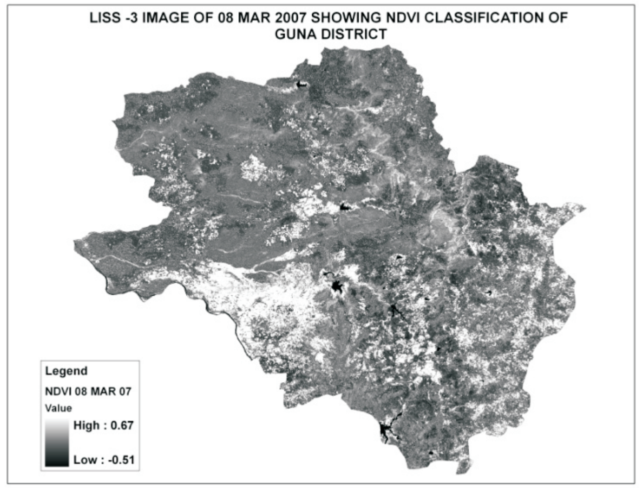


Fig. 4.1.22. NDVI image of part of Guna district on 08-3-2006.

It is clear from Fig. 4.1.19 that the agricultural vegetation was at its full swing in the month of January.

To carry out statistical analysis the union was performed as below (Fig. 4.1.23):

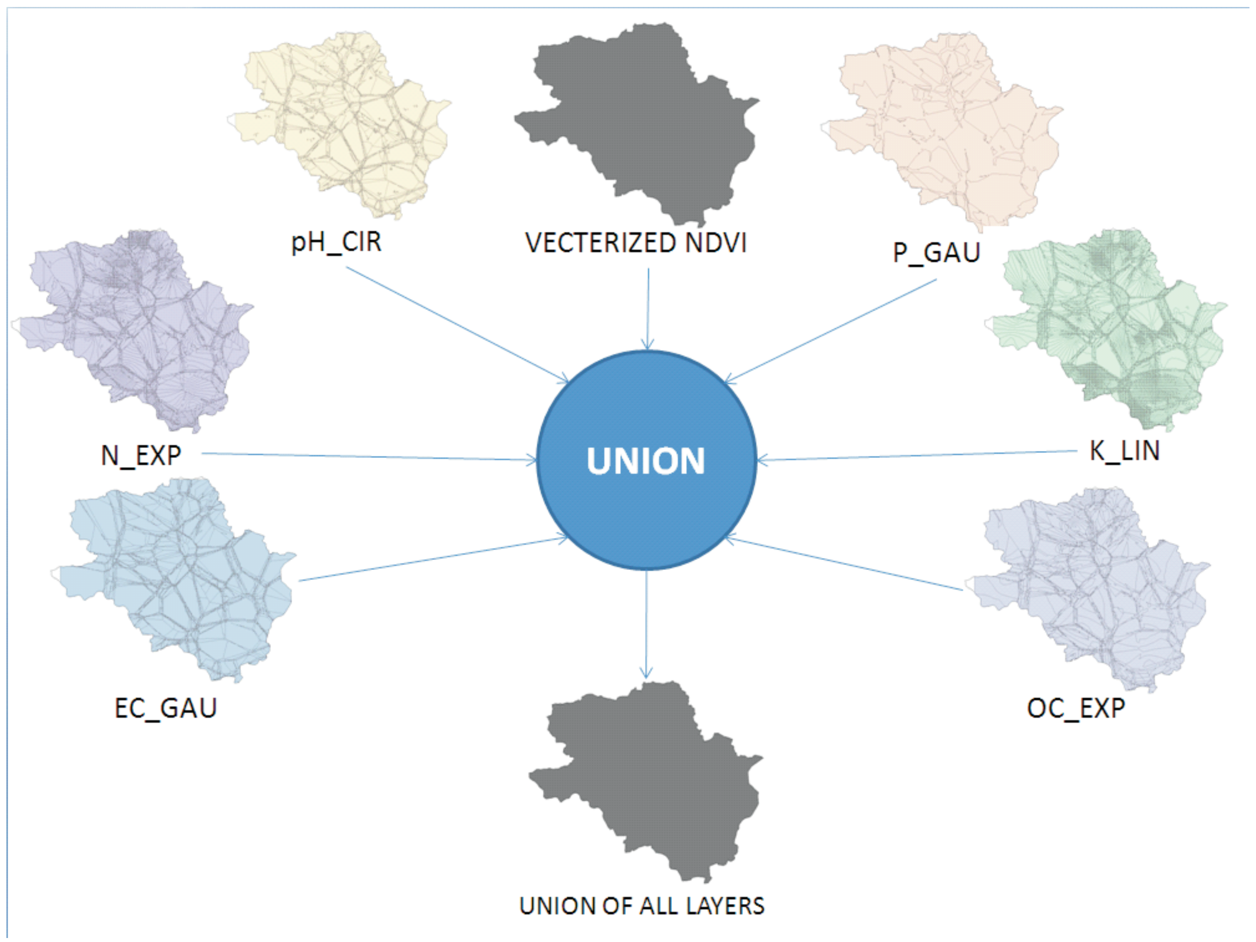


Fig. 4.1.23. Guna district along with union of vector layers of NDVI and different nutrients (N, P& K)

While performing unions we obtained frequency data for each nutrient polygon. This frequency will be used to fit weighted polynomials (least square estimation) to improve the relationship. The k^{th} degree polynomial with their usual meaning can be expressed as:

$$Y = \quad + {}_1X + \quad {}_2X^2 + \text{--------} + \quad {}_kX^k$$

Weighted least square estimates can be obtained by minimizing error sum of squares as follows:

$$e_i^2 = \quad w_i \,(\quad + {}_1X + \quad {}_2X^2 + \text{--------} + \quad {}_kX^k)^2$$

Where w_i 's are weight (frequency) for ith polygon (nutrient value).

In this report only simple correlation is being presented. The results indicate satisfactory relationship between nutrients and NDVI values.

Table 4.1.2. Correlation Coefficient (r) between available Nitrogen and NDVI values for different periods

	12 Dec 05	29 Jan 06	22 Feb 06	18 Mar 06
Min of Min of NDVI	-0.283	-0.152	-0.070	-0.190
Max of Max of NDVI	0.410	0.533	0.606**	0.430
Average of Average of NDVI	0.495	0.088	-0.047	-0.256

Table 4.1.3. Correlation Coefficient (r) between available Phosphorus and NDVI values for different periods

	12 Dec 05	29 Jan 06	22 Feb 06	18 Mar 06
Min of Min of NDVI	0.674	0.643	0.656	0.640
Max of Max of NDVI	-0.535	-0.166	-0.009	-0.625
Average of Average of NDVI	-0.845	0.869	0.967**	0.711

Table 4.1.4. Correlation Coefficient (r) between available Potassium and NDVI values for different periods

	12 Dec 05	29 Jan 06	22 Feb 06	18 Mar 06
Min of Min of NDVI	0.017	0.023	-0.008	-0.083
Max of Max of NDVI	-0.288	0.062	0.235	0.119
Average of Average of NDVI	-0.610**	0.194	0.402**	0.347

** $P < 0.01$

Table 4.1.2 clearly showed that there was a greater agreement between available nitrogen and Max of Max of NDVI values and it can be best estimated in the month of December and February. Similarly Table 4.1.3 showed that available phosphorus can be estimated using Average of Average of NDVI values in the month of February. Table 4.1.4 shows that Potassium can be estimated using Average of Average of NDVI for the month of December. These relations will further improve with higher order polynomials which will be presented in the final report.

4.1.3 Soil fertility mapping and reassessment of micronutrients in Indian soils

Soil fertility mapping using GIS is being carried out involving geo-referenced soil sampling for various states. The data revealed that zinc deficiency has declined in the states of Punjab, Haryana and Uttar Pradesh while it is increasing in Bihar, Maharashtra, Karnataka and Tamil Nadu. Zinc deficiency status showed little change in Andhra Pradesh, Orissa and other states.

Geo-referenced mapping for Punjab indicated that 76% of the soil samples are high in available zinc and 24 % are deficient in it. Most of the soils are well supplied with available copper. Deficiency of manganese is increasing in wheat and other winter crops. Durum wheat is more affected than aestivum wheat varieties. GIS aided mapping (1:2,50,000) indicated that 10 % of the total geographical area of Punjab is suffering from zinc deficiency. There are 78 polygons in this deficient class (Fig. 4.1.24 and Table 4.1.5). High zinc status covers 14 % (7050.68 km^2) of total area of Punjab. There are 44 polygons in this class. The areas under this highest range are parts of Hoshiarpur of Siwalik hills and undulating plain eco-sub region.

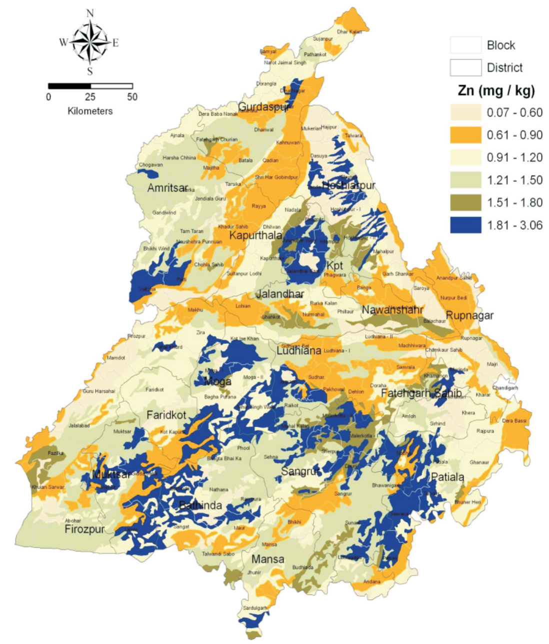


Fig. 4.1.24. DTPA extractable zinc in Punjab Soils

Table 4.1.5 Mapping parameters of GIS aided DTPA Zn map of Punjab

Class	DTPA-Zn ($mg\ kg^{-1}$)	No. of polygons	Sum of area of polygon	Mean	SD	Area of Punjab state in km^2	Per cent area of Punjab
1	0.07-0.60	78	0.47	0.40	0.14	5036.20	10.0
2	0.61-0.90	93	1.08	0.76	0.07	10576.02	21.0
3	0.91-1.20	143	1.02	1.02	0.08	11583.26	23.0
4	1.21-1.50	124	1.21	1.34	0.09	13597.74	27.0
5	1.51-1.80	37	0.23	1.62	0.01	2518.10	5.0
6	1.81-3.06	44	0.51	2.27	0.40	7050.68	14.0
	Total	**519**	**4.53**			**50362.00**	**100**

A study was also undertaken in Coimbatore district which comprises of nine talukas *viz.*, Avinashi, Coimbatore North, Coimbatore South, Mettupalayam, Palladam, Pollachi, Tiruppur, Udumalpet and Valparai with 18 blocks, in order to asses the micronutrient status of soil at block level. Coimbatore district lies between 10º58' to 11º01'N latitude and 76º58' to 77 º 06' E longitudes at an altitude of 426.7 m above mean sea level. This district falls under western agro climatic zone of Tamil Nadu. The average rainfall of this district is 653.7 mm out of which 57 % is received during north east monsoon. The soils of the study area classified as ustic moisture regime and iso-hypothermic temperature regime. A total of 1885 georeferenced surface soil samples (0-15 cm) from eighteen blocks representing different soil units as per the available soil map (1 : 50,000 scale) were collected randomly village-wise by adopting standard procedure. The collected soil samples were shade-dried, processed and analyzed for DTPA extractable micronutrients such as Zn, Fe, Cu and Mn. The analyzed soil samples were grouped as deficient or sufficient based on the critical limits fixed for soils.

Analysis of soil samples revealed 94.7 per cent Zn deficiency in Sulthanpet and the lowest deficiency of 4.60 per cent was noted in Valparai block. The highest Fe, Mn and Cu deficiency was recorded in Udumalpet block (70.5 %), Sulthanpet (80.3 %) and Madukarai block (83.6 %), respectively. The lowest deficiency of Fe, Cu and Zn in Valparai (1.50, 1.50 and 4.0 %) and Mn in Madukarai (1.70 %) was observed. Comparing the various micronutrients, Zn was predominantly deficient in most of the blocks followed by Cu, Fe and Mn. As a whole, 68.5 % Zn, 56.6% Cu, 40.4% Fe and 15.3% Mn deficiency was observed in the district. Fertility rating of the soils of Coimbatore district was worked out using the nutrient index values. The Zn status was low to very low in most of the blocks, while Fe was found low to very high. Generally Mn status was high to very high in most of the blocks and the Cu status was very low to marginal. Thematic maps prepared for available micronutrient status in the soils of Coimbatore district are depicted in Figs. 4.1.25 to 4.1.28.

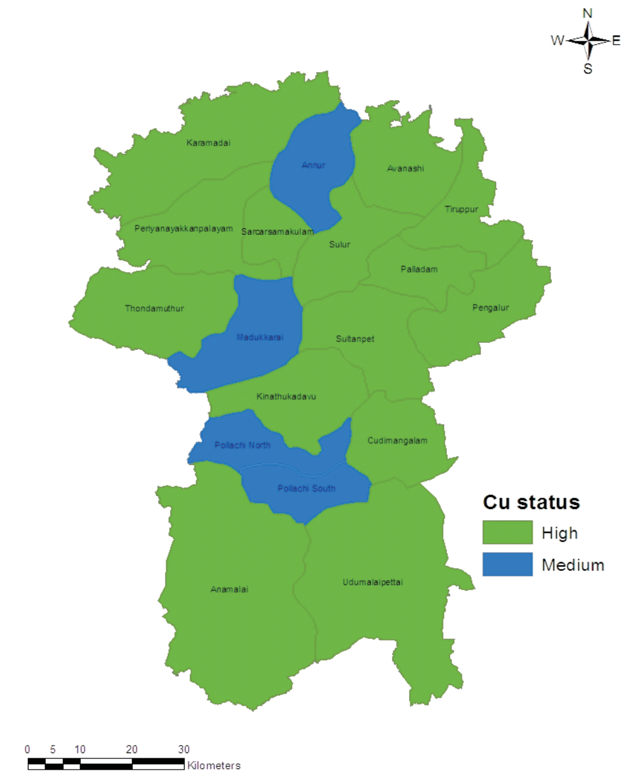


Fig. 4.1.26. Available Copper status in Coimbatore district

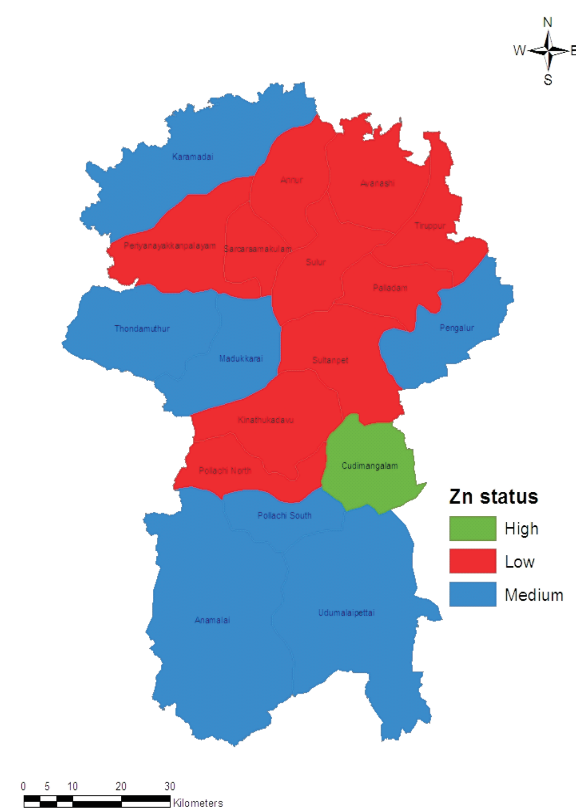


Fig. 4.1.25. Available Zinc status in Coimbatore district

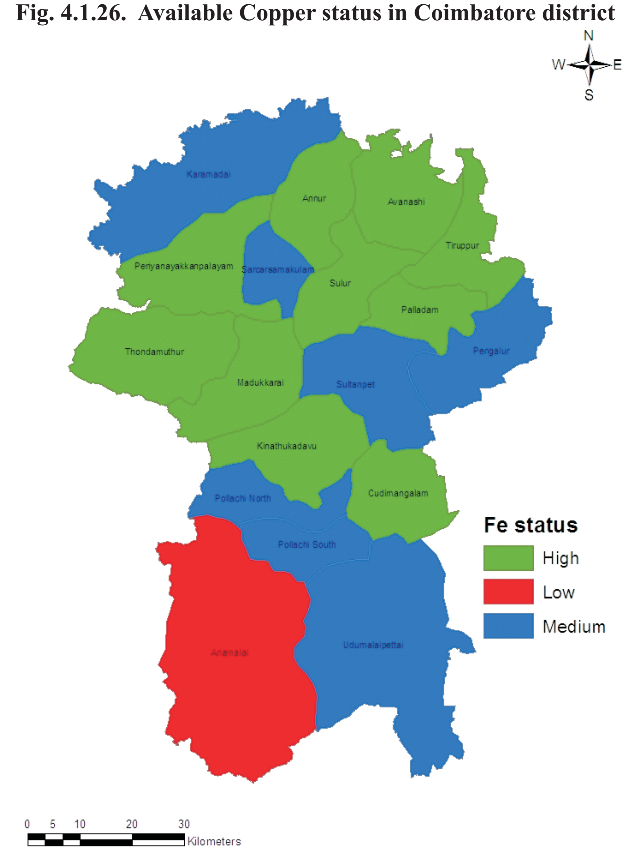


Fig. 4.1.27. Available Iron status in Coimbatore district

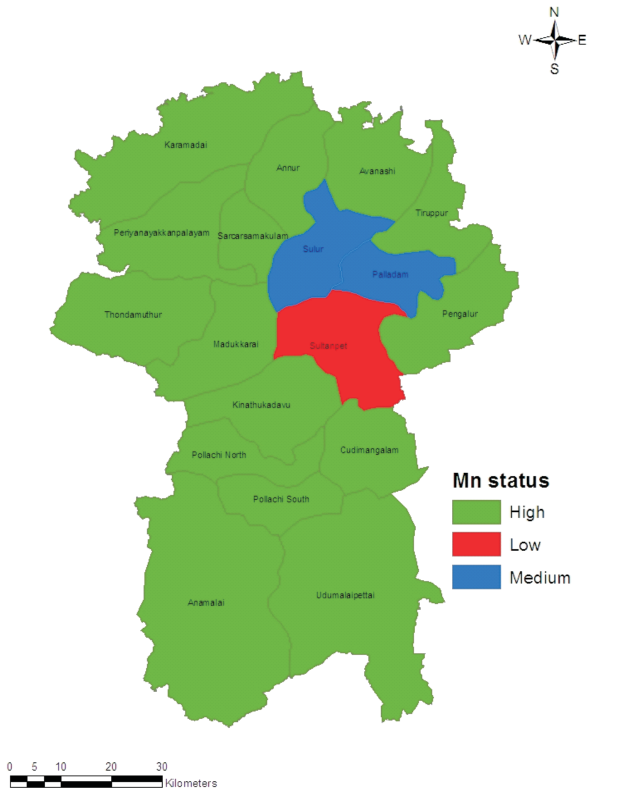


Fig. 4.1.28. Available Manganese status in Coimbatore district

4.1.4 Developing region-specific databases on nutrient resources in agriculture and user friendly intelligent data retrieving system for rational and efficient nutrient management

The nutrient requirements of important crops were computed and the data was up-scaled at district level to compute the nutrient uptake. The nutrient uptake was computed for rice, wheat and maize. Fertilizer nutrient production, imports, consumption data has been entered in excel sheet form.

Six districts *viz.,* Baroda (Gujarat), Ahmedabad (Gujarat), Bikaner (Rajasthan), Ambala (Haryana), Ludhiana (Punjab), and Dharwad (Karnataka) were surveyed. Two hundred and thirty farmers' were surveyed and the data on manure, cattle feed and straw samples were collected. The manure samples were analyzed for N, P and K content. There was wide variation in the composition of cattle feed ranging from only wheat straw to rich mixtures. Farm yard manure (FYM) was mostly prepared by heap method in almost all the districts surveyed. Crossbred animals were more in Haryana and Punjab than in other states surveyed. Huge piles of dung cakes were seen in Ambala and Ludhiana districts. Mostly the dung is going in the making of dung cakes. Mammoth animal sheds were observed in Rajasthan having as many as 2000 animals. Wide variation in the N, P and K content was observed across the locations and among the different manure and feed materials.

Table 4.1.6. Nutrient recovery coefficient (%) for different manure types (Data pooled across the crops and soils)

Manure	Recovery (%)		
	N	P	K
Compost			
Median	16	11	30
Mean	20	14	34
FYM			
Median	21	17	32
Mean	39	20	41
Mustard oil cake			
Median	35	32	154
Mean	35	27	156

Manure nutrient recovery coefficients

Manure nutrient recovery coefficients were computed for different manure types for different crops (Table 4.1.6). In case of rice the recovery of nitrogen from different types of manures ranged from 6-86% with a mean and median 31% and 23%, respectively. For P, the range was 6-65% with mean and median 24 and 17%, respectively. For potassium the range was 9-154%, with mean and median 49 and 32%, respectively. The values above 100 indicated the enhanced availability of soil and fertilizer nutrients in the presence of manures. The mean and median values indicated the recovery of N, P and K in case of wheat were 28 & 21, 11 & 10, and 17 & 36%, respectively. The nutrient recovery coefficients for maize, bajra, barley, ragi, groundnut, onion, soybean, tapioca, sweet potato, cauliflower, tomato, guar, and cabbage have also been compiled and fed to database.

The nutrient recovery coefficients were also arranged according to type of manure. The mean N recovery from FYM was 39% with a median of 21%. For P and K, the corresponding values were 20 & 17%, and 41 & 32%, respectively (Table 4.1.6). This shows the recovery of K from FYM is the highest followed by N and P. The compost prepared primarily from plant trashes had the mean recovery values of N, P and K at 20, 14, and 34%, respectively, relatively lower values than FYM. The recovery coefficients from other manures like bio gas slurry, poultry manure, *Azospirillum*, oilcakes, press-mud have also been compiled and fed into the database.

4.1.5 Transformation and phyto-availability of zinc and boron in selected bench mark acid soils amended with lime and farmyard manure

Status of extractable zinc in selected bench mark acid soils of India

Table 4.1.7. Extractable zinc (mg kg^{-1}) in selected bench mark acid soils

Parameters	Minimum	Maximum	Mean	SD
Hariharapur soil series				
DTPA-Zn	0.04	1.26	0.52	0.24
0.1 N HCl-Zn	0.40	3.76	1.75	0.59
Mehlich 1-Zn	0.28	3.36	1.39	0.54
Mehlich 3-Zn	0.56	3.04	1.41	0.52
Debatoli soil series				
DTPA-Zn	0.08	5.20	0.60	0.86
0.1 N HCl-Zn	0.28	14.88	1.45	2.28
Mehlich 1-Zn	0.48	14.68	1.91	2.35
Mehlich 3-Zn	0.8	12.4	2.17	1.88
Rajpora soil series				
DTPA-Zn	0.28	9.12	1.72	1.29
0.1 N HCl-Zn	0.68	8.36	2.75	1.53
Mehlich 1-Zn	0.48	8.08	2.62	1.58
Mehlich 3-Zn	0.88	8.08	3.15	1.38
Neeleswaram soil series				
DTPA-Zn	0.14	10.82	1.49	1.46
0.1 N HCl-Zn	0.80	14.24	3.54	2.70
Mehlich 1-Zn	0.48	11.64	2.58	1.85
Mehlich 3-Zn	0.16	6.24	1.84	1.19

In order to assess the suitability of different soil extractants for estimating the status of available zinc in acid soils of India, four hundred surface (0-15 cm) soil samples representing four soil series namely Hariharapur (Bhubaneswar, Orissa), Debatoli (Ranchi, Jharkhand), Rajpora (Palampur, Himachal Pradesh) and Neeleswaram (Kasaragod, Kerala) were collected and analyzed for pH, EC, organic carbon content and DTPA, Mehlich 1, Mehlich 3 and 0.1 N HCl extractable zinc. The pH values of soil samples varied from 3.90 to 6.45, 4.11 to 5.89, 4.48 to 5.94 and 4.16 to 6.28 for Hariharapur, Debatoli, Rajpora and Neeleswaram soil series, respectively, whereas EC values ranged from 0.03 to 0.16., 0.03 to 0.19, 0.02 to 0.19 and 0.01 to 0.40 dS m^{-1}, respectively. The organic carbon content of four soils varied from 0.12 to 1.07% (for Hariharapur series), 0.11 to 0.85% (for Debatoli series), 0.52 to 2.79% (for Rajpora series) and from 0.39 to 3.46 % (for Neeleswaram series).

The values of extractable zinc in soils of all the four series are given in Table 4.1.7. Among the different extractants, DTPA extracted the lowest quantity of zinc in all the four soil series whereas 0.1 N HCl extractant extracted the highest amount of zinc in Hariharapur and Neeleswaram soil series and Mehlich 3 extractant extracted the highest amount of zinc in Debatoli and Rajpora soil series. In general, the contribution of soil pH towards DTPA extractable zinc is insignificant (R^2 = 0.05) whereas soil organic carbon contributed significantly (R^2 = 0.21*). The extracted zinc by different extractants in all the four soils is well correlated with one another.

4.2 Improving Input Use Efficiency

4.2.1 Development of Potassium Management Strategies for Alfisol in View of Lessons Learnt from Long-Term Fertilizer Experiments

Grain yield, total system productivity (TSP) and potassium harvest index

The pooled grain yield data of 2 years on finger millet indicated that the treatment 100% NP + 200% K recorded maximum yield (44.93 q ha^{-1}) over 100% NP + 100% K (Split application) and 100% NP + soil inversion (Table 4.2.1). However, in cowpea 100% NP + 100% K (Split application of K) registered maximum yield (11.78 q ha^{-1}) but was at par with 100% NP + 200% K, 100% NP + 100% K and 100% NP + 100% K + lime @ 1 t ha^{-1}. However, 100% NP + soil inversion could not perform well in cowpea and recorded significantly lower yield (10.67 q ha^{-1}) compared to 100% NP + 100% K (split application of K) with 11.78 q ha^{-1}.

Table 4.2.1. Pooled mean grain yield (2 years) of finger millet and cowpea and total system productivity (TSP)

Treatments	Finger millet (q ha^{-1})	Cowpea (q ha^{-1})	TSP (q ha^{-1})
Control	19.09	7.85	28.8
100% NP	31.80	9.71	43.9
100% NP + Lime @ 1 t ha^{-1}	33.40	10.51	46.5
100% NP (adjusted) + FYM @ 10 t ha^{-1}	24.03	9.68	36.8
100% NP + 100% K + Lime @ 1 t ha^{-1}	40.28	11.08	54.1
100% NP + 100% K	38.91	11.23	52.9
100% NP + 200% K	44.93	11.55	59.4
100% NP + 2 Splits of 100% K*	43.54	11.78	58.3
100% NP + Soil inversion (0-30 cm depth)	42.79	10.67	56.1
Farmers' practice	30.37	9.88	42.7
LSD (0.05)	2.69	0.78	3.4

* 50% K at basal & 50% K at 30 DAS

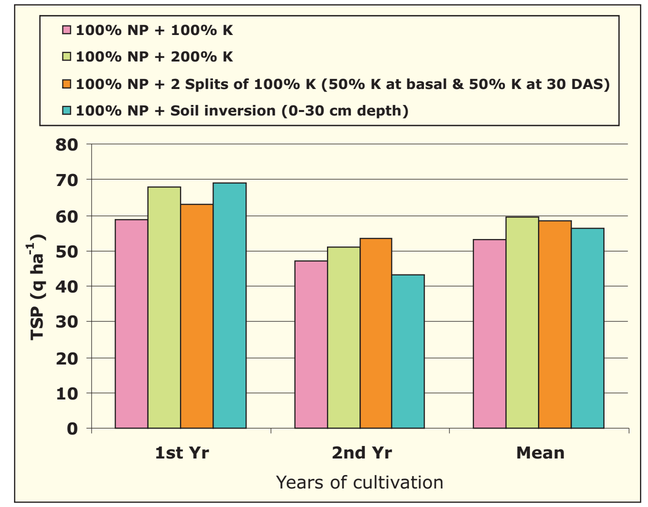


Fig. 4.2.1. Influence of soil inversion treatment vis-à-vis K-management strategies on total system productivity

Potassium harvest index denotes the amount of K taken by grains with respect to total biomass. The K-management strategies did not show any significant impact on this parameter (Table 4.2.2). This was probably due to proportionate change in the K-uptake by grain and straw in both finger millet and cowpea in respective treatments.

Relationship of SYI, Yield, TSP with soil parameters

The regression equation was fitted between sustainable yield index (SYI) (finger millet and cowpea) and different soil parameters namely soil pH, EC, OC, available N, P and K. The significant regression equations are depicted in Fig. 4.2.2. The results from experiment on potassium management strategies indicated that amongst these parameters only pH and available K contributed significantly to the SYI of both the crops. The contribution of pH to SYI was 28% in cowpea and 10% in finger millet. Similarly the extent of contribution of available K was 33% in cowpea and 35% in finger millet. Thus results indicated that potassium is the most important as far as yield and sustainable yield index is concerned.

Table 4.2.2. Impact of potassium management strategies on potassium harvest index under finger millet - cowpea system at Bangalore

Treatments	Finger millet	Cowpea
Control	0.39	0.44
100% NP	0.40	0.47
100% NP + Lime @ 1 t ha^{-1}	0.40	0.48
100% NP (adjusted) + FYM @ 10 t ha^{-1}	0.40	0.45
100% NP + 100% K + Lime @ 1 t ha^{-1}	0.40	0.43
100% NP + 100% K	0.41	0.50
100% NP + 200% K	0.41	0.45
100% NP + 2 Splits of 100% K*	0.40	0.43
100% NP + Soil inversion (0-30 cm depth)	0.40	0.46
Farmers' practice	0.40	0.46
LSD (0.05)	NS	NS

*50% K at basal and 50% K at 30 DAS

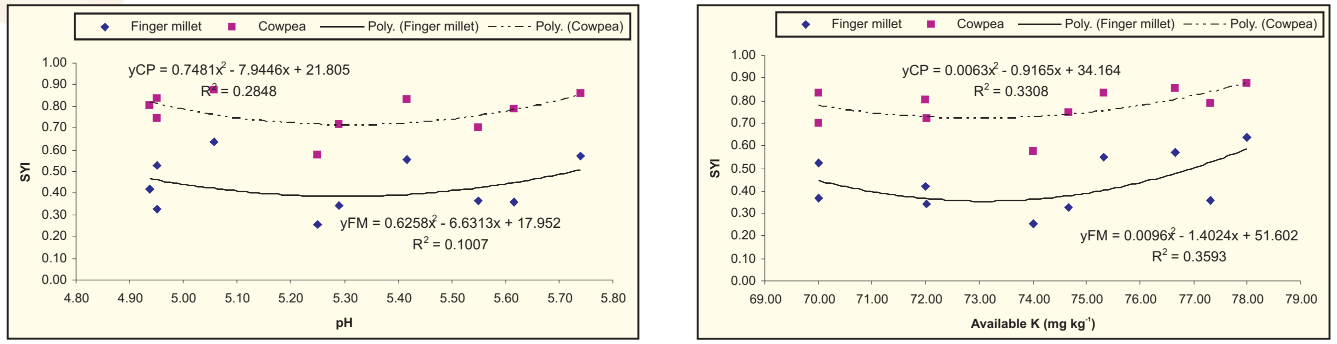


Fig. 4.2.2. Regression of SYI with pH and available K under finger millet cowpea cropping system

Regression analysis data revealed that relationship of yield/ total system productivity is significant with only exchangeable form of K. The relationship indicated nearly 60% contribution of exchangeable K (Table 4.2.3).

Table 4.2.3. Regression equation and r^2 value with finger millet and cowpea

Crop/Particulars	Equation	R^2 value
Finger millet	Y = 1.62 exch K - 20.14	0.57*
Cowpea	Y = 0.23 exch K + 2.78	0.60*
TSP (Total system productivity)	TSP = 1.91 exch K - 16.77	0.61*

*significant at 5% level

4.2.2. Nano-Technology for Enhanced Utilization of Native Phosphorus by Plants and Higher Moisture Retention in Arid Soils

A NAIP sub-project on nano-technology has been initiated at the institute as a cooperating centre and the institute has made a modest beginning in the pursuit of developing a nano-rock phosphate and evaluating its effect on soil and crop. Rock phosphate (RP) samples have been collected from Sagar (6 samples), Meghnagar (6 samples) and Udaipur (19 samples) for their characterization with regard to total P, water soluble P, citrate soluble P and heavy metal content apart from some basic physico-chemical parameters. The Sagar rock phosphate total P content varied from 5.58 to 14.52 %, pH from 6.46 to 6.81 and EC from 0.053 to 0.071 dS m^{-1}. The Meghnagar rock phosphate total P content varied from 4.46 to 13.12 %, pH from 8.26 to 8.31 and EC from 0.153 to 0.325 dS m^{-1} and in the Udaipur rock phosphate total P content varied from 10.38 to 20.12 %, pH from 6.80 to 7.86 and EC from 0.187 to 0.631 dS m^{-1}. The heavy metals namely, selenium (0-114 ppm), arsenic (Tr–52 ppm) and chromium (0-13 ppm) were also present in rock phosphate samples. Characterization of rock phosphate samples would help in grading the samples so as to find their suitability in fertilizer use. Enrichment of rock phosphate and consequent downsizing will be further attempted by physico-chemical and mechanical methods through outsourcing.

Meanwhile, commercially available nano particles of ZnO, CuO, Iron oxide, Zn, Cu, and Fe hydroxyl apatite and calcium phosphate were used to understand their physico-chemical behaviour in aqueous system and to test their integrity and stability in various matrices including soil, water and plant systems. Size distribution and zeta potential of the nano particles (Table 4.2.4 and 4.2.5) were estimated by dynamic light scattering techniques. The size distribution carried out under aquous medium clearly indicated that all the particles had dimensions more than claimed by the concerned supplying firm. This was attributed to the fact that the negative charged surface of the particles had strong affinity towards water and the hydrated radii of the particles were much higher than their unhydrated counterparts. The procured nano particles are highly unstable in water (except hydroxyl apatite <200 nm) because of their low zeta potential in aqueous medium (range of zeta potential for stable suspension is –30 mv to +30 mv) and has a strong tendency to agglomerate and settle down. Results revealed that zinc oxide nano-particle had no toxic effect (2000 ppm) on gram seed germination, whereas, it prevented the germination of mustard seed at the level greater than 500 ppm. Solution culture study showed that nano zinc oxide particles could enhance and maintain the growth of maize plant vis-a-vis conventional Zn fertilizer (as $ZnSO_4$), indicating that plant root might have got the unique mechanism of assimilating nano-Zn and using for its growth and development.

Table 4.2.4. Size of nanoparticles in aqueous system

Sl. No.	Name of the nano particles	Distribution in different fraction (nm)		
		10%	40%	40%
1	Zinc oxide (<100nm)	<109.10	109.10 - 188.00	188.00 - 325.40
2	Cu- oxide (<50nm)	<126.70	126.70- 185.90	185.90- 275.80
3	Iron oxide <100nm)	<97.80	97.80- 176.20	176.20- 310.10
4	H- apatite (<200nm)	75.40	75.40- 145.60	145.60- 283.50
5	Cu, Fe, Zn oxide (<100nm)	116.90	116.90 - 195.20	195.20- 360.80
6	TCP (<200nm)	92.30	92.30- 232.20	232.20- 616.10

Table 4.2.5. Zeta potential of different nanoparticles

SL. No.	Name of the Nano Particle	Zeta Potential (mv)
1	Zinc oxide (<100nm)	-26.99
2	Copper oxide (<50nm)	-1.91
3	Iron oxide (<50 nm)	-3.36
4	Hydroxy apatite (<200nm)	-46.74
5	Copper iron zinc (<100 nm)	-2.52
6	Calcium phosphate (<100nm)	-20.49

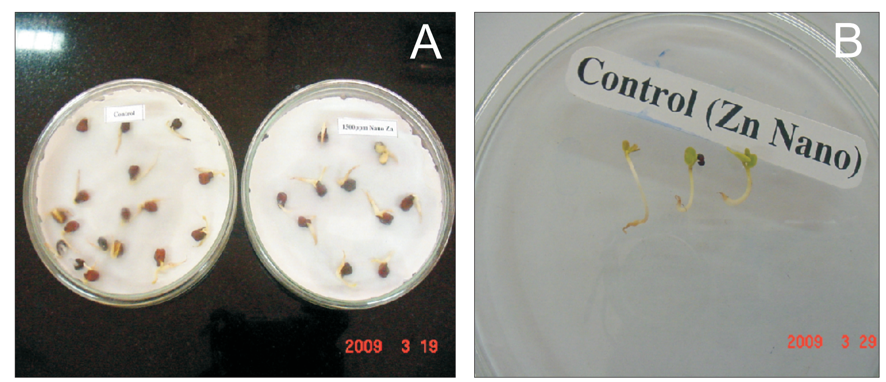


Fig. 4.2.3. Effect of nano fertilizers on germination of (A) Gram and (B) Mustard

Fig. 4.2.4. Effect of nano fertilizers on plant growth

4.2.3 Boom Flower (Nitrobenzene 20% EW)- its influence on growth, physiology and mutrient uptake of tomato plant

The effect of boom flower on nutrient uptake pattern was studied in hydroponically grown tomato plants (Fig. 4.2.5). Plants were sprayed with nitro benzene (NB) at regular time intervals and the plant growth, physiological and biochemical changes, rate of water and nutrient uptake with and without chemicals were recorded. The nitrogen use efficiency with boom flower was estimated in field grown maize. As with the growth, Boom Flower (Nitrobenzene 20% EW) 2ml L^{-1} had significantly increased the uptake of major nutrients *viz.* N, P and K in tomato. However, the nutrient content did not change in different plant parts. In hydroponically grown tomato plants it was seen that the rate of NO_3^- and water uptake was greater in NB treated plants. The nitrate reductase activity of leaves increased immediately with NB application. The carbohydrate content did not change; however, leaf protein and amino acid contents were higher in NB treated plants. NB treatment did not have a significant effect on the nitrogen use efficiency of the field grown maize.

Fig. 4.2.5. Tomato plant response to NB at flowering in hydroponics

4.3 Monitoring Long Term Productivity

4.3.1 Long Term Fertilizer Experiments to study changes in soil quality, crop productivity and sustainability (AICRP on LTFE)

Demonstration of LTFE technology through satellite experiments

To evaluate technologies generated from LTFE and to develop strategies for enhancing the productivity of the region by intervening the management practices, few centers (Bangalore, Ludhiana and Akola) conducted satellite experiments on farmer's field. The purpose of conducting the demonstration experiments was to educate the farmers about judicious and balance use of nutrients. Survey conducted by the centers revealed that majority of the farmers are using N alone and some of the farmers are using N and P through external source of nutrients. Due to continuous use of phosphatic fertilizer there has been built up in soil P as observed in LTFE plots. To exploit the higher built up P in soil, experiments were conducted.

Bangalore

The results of the experiment conducted with maize at Verammanahally village revealed that reduction of P doses to half did not have adverse effect on yield, whereas increase in K dose to double resulted in increased yield of maize from 37.9 q ha^{-1} (100% NPK) to 48.6 q ha^{-1} (Table 4.3.1). Incorporation of lime increased the productivity of maize but could not show any improvement in productivity of finger millet. Increase in maize yield with lime application was due to increase in availability of K as a result of increased soil pH. However, incorporation of 5 t ha^{-1} FYM resulted in increased maize yield as well as finger millet significantly. This suggested that phosphorus dose can be reduced safely and the diversion of the money saved equivalent to half dose of P to the K and lime would fetch more benefit to farmers.

Table 4.3.1. Evaluation of alternate nutrient management strategies of fertilizer use to sustain productivity of maize and finger millet

Treatments	Maize		Finger millet	
	Grain yield (q ha^{-1})	FRR (yield kg^{-1} fertilizer)	Grain yield (q ha^{-1})	FRR (yield kg^{-1} fertilizer)
Control (NPK)	37.92	6.84	34.00	6.13
N ½ P K	37.44	9.86	34.60	9.74
N ½ P 2K	48.61	7.54	35.00	8.22
N ½ P K + lime	48.61	6.23	36.00	11.18
N ½ P K + 5 t FYM	51.33	10.67	39.80	10.14

FRR= Fertilizer response ratio

To evaluate the nutrient response ratio (NRR) in most sustainable nutrient management options of LTFE and to compare with the farmer's practice field experiments were conducted on farmer's field in Kolar, Tumkur and Madenahalli districts of Karnataka. The results obtained (Table 4.3.2) revealed that though the maximum yields of maize (45.2 q ha^{-1}) was recorded with the application of 150% NPK but the response ratio was least. The highest nutrient response ratio (kg grain kg^{-1} nutrient) was obtained on application of 100% NPK+ 15 t FYM in both the crops. The yield of maize and response ratio of nutrients under farmers' practice is comparable with intervention but both yield and nutrient ratio were low in case of finger millet. The maximum yield in 150% NPK further supports the findings that to sustain the productivity at higher level K should be added in larger quantity.

Table 4.3.2. Evaluation of efficiency of most sustainable fertilizer use practices

Treatments	Maize		Finger millet	
	Grain yield (q ha^{-1})	FRR (yield kg^{-1} fertilizer)	Grain yield (q ha^{-1})	FRR (yield kg^{-1} fertilizer)
150% NPK	45.20	14.08	37.00	15.04
100% NPK+FYM@5t ha^{-1}	42.10	19.67	27.50	16.77
Package of practice	37.72	17.46	25.50	15.55
Farmers' practice	40.83	18.77	22.00	8.76
Control (100% NPK)	37.92	17.72	26.00	15.85

Package of practice = 100% NPK+ 10t FYM, Farmers' practice = 64 kg N + 46 kg P FYM (15-20 t ha^{-1}); FRR= Fertilizer response ratio

Thus results at farmers' field clearly indicated that the P dose can be reduced to half safely without any reduction in yield. But to enhance the productivity, K is needed in more quantity and part of that could be supplemented through FYM. To harness greater nutrient utilization efficiency integrated use of chemical fertilizer with FYM is a better option (Fig. 4.3.1).

Ludhiana

To assess the soil fertility status of farmers fields of nearby districts and also to compare and simulate with the management options of LTFE, soil samples from Ludhiana, Bathinda and Gurdaspur districts of Punjab were collected and analysed for their fertility status. Field experiments were conducted with 6 treatments as per the details given in Table 4.3.3 with maize-wheat

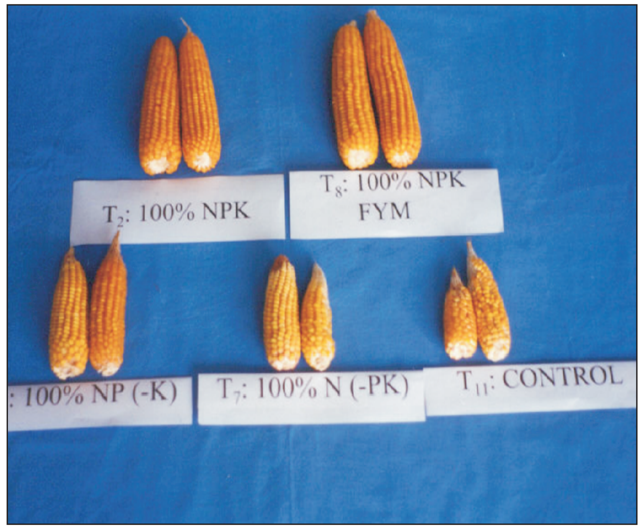


Fig. 4.3.1. Impact of potassium deficiency on growth and cob quality of hybrid maize at Bangalore

system in three villages. The results obtained indicated that reduction in P dose to half resulted decline in yield significantly at some of the sites compared to 100% P. However, application of Zn resulted in increased yield of both maize and wheat at all the sites. Critical evaluation of data further indicated that conjunctive use of chemical fertilizer and FYM resulted in highest productivity at all the sites. The yield obtained was at par with the yields obtained with application of nutrient on soil test basis; nutrient application was in similar quantity. Decline in yield (may not be statistically significant) of maize and wheat on reduction in dose of P indicated that still the P built up was not sufficient enough to curtail the P dose at farmers field.

Thus, results clearly indicated that application of P and Zn is essential to harness the potential productivity of crops. But to sustain the productivity at higher level conjunctive use of chemical fertilizer and FYM is the only option. This supports the strategies developed out of LTFE results.

Table 4.3.3. Effect of organic and inorganic fertilizer on grain yield (q ha^{-1}) in maize-wheat cropping system in different zones

Treatment	Jhaloa		Ramgarh		Rajewal	
	Maize	Wheat	Maize	Wheat	Maize	Wheat
100%N 50%PK	36.5	47.0	38.3	40.7	36.7	44.2
100%NPK 50%Zn	40.6	52.8	44.7	45.3	46.3	47.3
100%NPK	40.0	55.0	44.0	45.5	43.6	49.5
100%NPK+FYM	45.3	59.7	50.0	51.9	53.3	54.1
Farmers' practice	37.2	50.5	41.3	41.1	41.0	44.1
Soil Test basis	41.2	53.0	44.3	46.9	45.7	48.0
CD 5%	3.9	4.2	4.7	4.5	4.2	4.4

Farmers' practice = 150 kg N + 45 kg P_2O_5 + 0 kg K_2O to Maize and 150 kg N + 60 kg P_2O_5 + 0 kg K_2O to Wheat

Akola

To evaluate the strategies developed out of the results of LTFE, field experiments were conducted at 6 farmers' fields in 5 villages using soybean-wheat as test cropping system. The results recorded revealed that Zn and S are essential to harness the potential yield in addition to N, P and K. Application of Zn + S over and above NPK resulted in increased soybean yield from 11.17 q ha^{-1} to 14.12 q ha^{-1} and wheat yield from 27.6 q ha^{-1} to 33.1 q ha^{-1} (Table 4.3.4). The result further revealed that the conjunctive use of NPK+FYM resulted in highest productivity of both soybean and wheat. The decline in yield under farmer's practices was due to imbalanced use of nutrients and P application in less quantity in both soybean and wheat.

From the field experiments it was concluded that to sustain the productivity of soybean-wheat system Zn and S are essential in Akola region of Maharashtra. But to sustain the productivity at higher level and sustain over a long period of time integrated use of fertilizer and FYM is essential.

Table 4.3.4. Yield of soybean and wheat at Akola as influenced by various treatment (Av. 6 experiments)

Treatment	Grain (q ha^{-1})	
	Soybean	Wheat
RD NP	11.17	27.69
RD NPK + Zn	12.19	29.66
RD NPK + S + Zn	14.12	33.15
RD NPK + 10 t FYM ha^{-1} + Zn	16.79	37.61
Farmers' practice	9.35	24.49
CD at 5%	0.67	2.06

RD for soybean N-30, P-75, K-0, Wheat N-120, P-60, K-60, Zn 2.5 kg ha^{-1}, S-40
Farmers' practice: Soybean N = 25 kg, P= 50 kg, Wheat- 100 kg N

4.3.2 Long-term effects of fertilizer and manure application on carbon pools dynamics in a Vertisol under soybean-wheat system

Total soil organic carbon and water soluble carbon

Application of manures and fertilizers for five year in soybean-wheat system in a Vertisol improved various carbon related parameters. The total organic carbon content increased in the surface soil (0-7.5 cm) layer between 0.78 to 1.16%. Application of 8 t FYM ha^{-1} to soybean and 16 t FYM ha^{-1} to wheat without any inorganic fertilizers has resulted in highest total organic carbon content in all the three layers *viz*. 0-7.5, 7.5-15 and 15-30 cm, followed by 50% NPK annually along with 20 t FYM ha^{-1} once in four years to soybean and 100% NPK to wheat. The treatments T_5, T_7, T_8, T_{10}, T_{11} and T_{12} significantly increased the total organic carbon content over the GRD and STCR doses of fertilizer application to soybean and wheat. In 7.5-15.0 cm soil layer the organic carbon content ranged between 0.72 and 0.93% with almost a similar trend to that of surface soil, however, significantly higher total organic carbon content was recorded under application of 24 t of FYM ha^{-1} (T_{11}) every year to soybean-wheat system. Minimum content of total organic carbon was in 15-30 cm soil layer, which ranged between 0.48 and 0.59% among all the treatments. Water soluble carbon content ranged between 43.6 to 67.9 mg kg^{-1} with the highest being under T_{11} (fully organic) treatment in top 7.5 cm soil layer (Table 4.3.5). Various integrated nutrient management treatments improved the water soluble (WSC) carbon content and the highest WSC was again recorded in T_{11}. The magnitude of WSC decreased in 7.5 15.0 cm soil depth, which ranged from 24.3 to 46.5 mg kg^{-1}. However, the sub-surface (15-30 cm) layer contained the lowest amount of WSC where it ranged between 20.9 and 27.1 mg kg^{-1} with significant increase in WSC among various treatments.

Table 4.3.5. Effect of different IPNS modules on water-soluble carbon (mg kg^{-1})

No.	Treatments to cropping sequence		Soil depth (cm)		
	Soybean	Wheat	0–7.5	7.5–15	15–30
T_1	No Fertilizer/ Manure	No Fertilizer/ Manure	43.6	24.3	20.9
T_2	GRD (20–60–20)	100- 50- 30	49.0	25.6	21.5
T_3	STCR (25–30–20) for 1.6 t Soybean	70–30–30 for 3 t Wheat	46.5	28.5	22.0
T_4	50% of T_3	100% of T_3	46.9	30.7	21.0
T_5	50% of T_3+5 t FYM	100% of T_3	53.9	38.2	23.3
T_6	50% of T_3+1 t PM	100% of T_3	44.0	33.8	21.9
T_7	50% of T_3 + 5 t UC	100% of T_3	49.9	33.4	25.4
T_8	50% of T_3 + WR	100% of T_3 + Gly#	55.2	36.6	20.5
T_9	WR + 1 t PM	100% of T_3	49.0	35.3	22.3
T_{10}	WR + 5 t FYM	100% of T_3	56.9	45.5	25.9
T_{11}	8 t FYM (Every season)	16 t FYM (Every season)	67.9	46.5	27.1
T_{12}	50% of T_3+ 20 t FYM*	100% of T_3	59.9	44.8	24.9
	CD (5%)		9.97	8.30	3.21

* FYM applied once in four years, # Gly-Glyricidia

Carbon pool index (CPI), carbon lability index (CLI) and carbon management index (CMI)

Loss of carbon from a small pool size is of great concern than loss of same quantity of carbon from large pool of carbon. CPI takes into account this aspect. Similarly, loss of labile carbon is of great concern than loss of non-labile carbon, thus CLI plays an important role in assessment of various interventions. CMI is a product of carbon pool index and carbon lability index. Higher values of CMI indicate an improvement in quality of soil organic carbon stocks and eventually resulting in higher soil quality and sustainability of the system. Also, CMI help in evaluating the management practices with respect to their impacts on soil organic carbon and soil quality. Various IPNS interventions improved carbon related indices in comparison to control and the values with respect to CPI, CLI and CMI ranged between 1.00 to 1.59, 1.00 to 1.30 and 1.00 to 1.49 in 0-7.5, 7.5 to 15 and 15-30 cm layer, respectively. The mean CPI, CLI and CMI for 0-30 cm soil depth varied from 1.00 to 1.325, 1.00 to 1.10 and 1.00 to 1.46 respectively (Fig. 4.3.1).

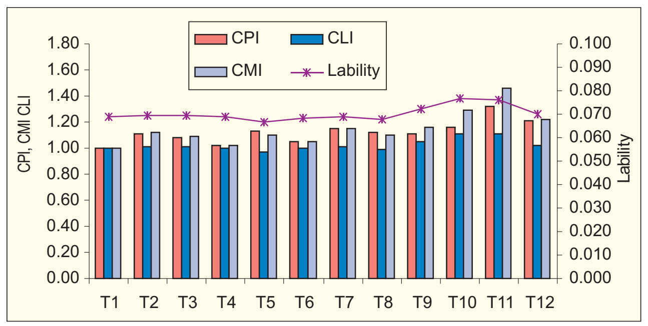


Fig. 4.3.1. CLI, CPI and CMI for 0-30 cm soil depth under different IPNS interventions

Distribution of soil aggregates

Aggregate analysis study revealed that there were almost similar proportions of aggregates of the large macro-aggregates (>2 mm) and silt size fraction in the top 15 cm soil depth. In 15-30 cm soil depth the large macro-aggregates further declined. Also, in all the three depths maximum proportion was of small macro-aggregates (0.25-2 mm) followed by micro-aggregates (0.053 – 0.25 mm). With increase in depth there was an increase in the small size macro-aggregates and a decrease in micro-aggregate proportion under IPNS interventions. Changes due to manures and fertilizer addition to soybean-wheat cropping system were noticed both on macro-aggregates and micro-aggregates as compared to control plot. In all the three depths, small macro-aggregates (0.25-2 mm) constituted maximum proportion followed by micro-aggregates (0.053 – 0.25 mm). Highest change in aggregation was recorded under treatments involving only manure addition in the form of residues, FYM or both (Fig. 4.3.2).

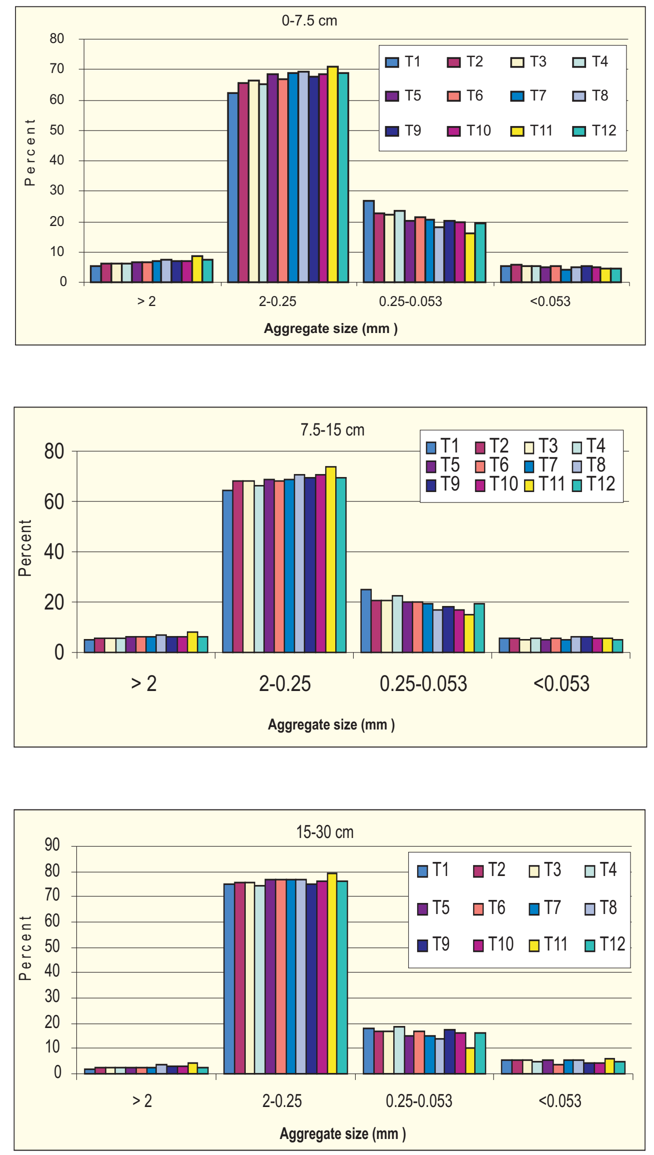


Fig. 4.3.2 Effect of INM interventions on soil aggregation

4.3.3 Effect of continuous use of organic manures and inorganic fertilizers on transformation of different fractions of Zinc in a Vertisol

The status of different fractions of Zn as influenced by continuous application of inorganic fertilizers alone, manures and fertilizers, manures alone in a Vertisol after five years of soybean-wheat cropping has been investigated. Surface (0-15 cm) soil samples collected after 5 years have been analyzed for Zn fractions *viz.* soil solution and exchangeable Zn (CA-Zn), Zn bound by inorganic sites (AAC-Zn), Zn bound by organic sites (PYRO-Zn), Zn occluded by free oxides (AMOX-Zn), Residual Zn (RES-Zn) using sequential extraction method of McLaren and Crawford (1973). The total zinc content in the soil varied from 97 mg kg^{-1} in soils received STCR based dose of NPK to 145 mg kg^{-1} in plots which received farmyard manure alone @ 24 t ha^{-1} year^{-1} (Table 4.3.6). Among the zinc fractions, residual Zn constituted the major fraction of total zinc in Vertisol followed by AMOX-Zn, PYRO-Zn, AAC-Zn and CA-Zn. The 5-year continuous integrated use of NPK with FYM or poultry manure (PM) or urban compost (UC) and FYM alone significantly influenced only the PYRO-Zn, and AMOX-Zn fractions. The highest status of AMOX-Zn was observed in treatment that received FYM alone @ 8 t ha^{-1} to soybean and 16 t ha^{-1} to wheat every year. This treatment also maintained the highest total Zn. Among other treatments, integrated use of NPK with FYM and NPK with urban compost maintained higher status of AMOX-Zn and PYRO-Zn in the soil. The influence of different INM modules on the status of other Zn fractions (CA-Zn and AAC-Zn) was very little. The residual Zn in soil was not affected by different treatments even after 5 years.

Table 4.3.6. Effect of different INM modules on the status of different fractions of zinc in soil five years after cropping

No.	Treatments to cropping sequence		Content of Zn fraction (mg kg^{-1})					Total Zn (mg kg^{-1})
	Soybean	Wheat	CA-Zn	AAC-Zn	PVRO-Zn	AMOX-Zn	RES Zn	Total Zn
T_1	No Fertilizer/ Manure	No Fertilizer/ Manure	0.22	2.11	2.3	9.45	90.92	105
T_2	GRD (20–60–20)	100- 50- 30	0.39	1.85	1.88	7.23	87.65	99
T_3	STCR (25–30–20) for 1.6 t Soybean	70–30–30 for 3 t Wheat	0.34	1.90	1.46	4.80	88.50	97
T_4	50% of T_3	100% of T_3	0.30	2.65	1.84	7.97	89.23	102
T_5	50% of T_3+5 t FYM	100% of T_3	0.36	2.16	4.64	19.61	93.23	120
T_6	50% of T_3+1 t PM	100% of T_3	0.30	1.12	4.24	17.24	89.09	112
T_7	50% of T_3 + 5 t UC	100% of T_3	0.33	1.56	7.89	27.42	92.80	130
T_8	50% of T_3 + WR	100% of T_3+Gly	0.21	1.16	2.34	10.39	91.90	106
T_9	WR + 1 t PM	100% of T_3	0.29	1.51	5.14	15.65	93.41	116
T_{10}	WR + 5 t FYM	100% of T_3	0.27	2.34	5.47	24.62	90.30	123
T_{11}	8 t FYM (Every season)	(Every season) 16 t FYM	0.29	2.18	7.34	43.11	92.07	145
T_{12}	50% of T_3 + 20 t FYM*	100% of T_3	0.41	1.90	5.10	16.51	91.08	115
	LSD (P=0.05)		0.055	0.53	0.61	1.29	5.8	6.1

* FYM applied once in four years

4.4. Managing Soil Physical Environment

4.4.1 Tillage and Residue Management for Sustainable Crop Yield and Improved Soil Health

The performance of different tillage systems and nitrogen rates on soil quality and crop productivity in Vertisols has been assessed through a long-term tillage experiment being conducted at Bhopal since 1999. In the rainy season soybean as a rainfed crop was grown with four tillage treatments namely, mould board plough (MB), conventional tillage (CT), reduced tillage (RT) and no tillage (NT) as main plot and three nitrogen levels (50%, 100% and 150%) as subplots. Results showed that the seed and biomass yield of soybean did not differ significantly among the tillage treatments. However, the seed and biomass yield of soybean recorded at 150% and 100% recommended dose of nitrogen was significantly higher than that recorded at 50% recommended dose of N treatment. The average seed yield among the various treatments varied between 880 to 1420 kg ha^{-1}. Addition of biomass to the plots in the form of leaf litter and crop residues addition was recorded after soybean harvest. On an average 680 kg ha^{-1} residue were added to the soil surface. However, treatment effect on residue addition was not significant (Table 4.4.1).

Soil moisture storage: The total rainfall received during the rainy season was 754 mm which is 25% lower than the long-term average rainfall (Fig. 4.4.1). The moisture storage in the soil profile (0-90 cm) was monitored during the cropping season. During the initial stages moisture storage mainly fluctuated due to rainfall and treatment affect was not conspicuous.

Table 4.4.1. Grain and biomass yield of soybean as influenced by tillage treatment and nitrogen levels in 2008

Treatment	Seed (kg ha^{-1})	Biomass (kg ha^{-1})	Residue (kg ha^{-1})
NT-Soybean	1232	4242	713
RT-Soybean	1068	4112	644
MB-Soybean	1181	4283	568
CT-Soybean	1203	4252	686
LSD (P=0.05)	NS	NS	NS
NT- wheat	1177	4277	654
RoT- wheat	1165	4167	653
LSD (P=0.05)	NS	NS	NS
N50%	1041	4011	627
N100%	1196	4266	688
N150%	1275	4390	645
LSD (P=0.05)	117	297	NS

But at 65 DAS during a relatively dry period moisture retention in NT-NT and RT-RoT treatment was higher than CT-CT and MB-RoT treatment. Moisture retention in all the depths was lower in MB-RoT treatment (Fig.4.4.2).

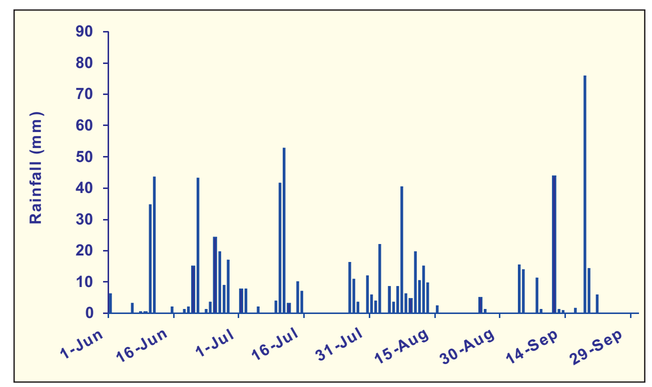


Fig. 4.4.1. Rainfall distribution during the rainy season of 2008

Effect of tillage and nitrogen levels on soil properties: Imposition of tillage treatments and variations in nitrogen levels significantly influenced the bulk density of the top 5 cm soil recorded during the pod filling stage of soybean. The BD was minimal in RT-RoT (1.20 Mg m^{-3}) and MB-RoT (1.21 Mg m^{-3}) treatments while it was the highest in CT-CT treatment (1.29 Mg m^{-3}). Among the nitrogen levels BD was maximal at 50% N level and it was significantly higher than the BD recorded at 100% and 150% N level (Table 4.4.2).

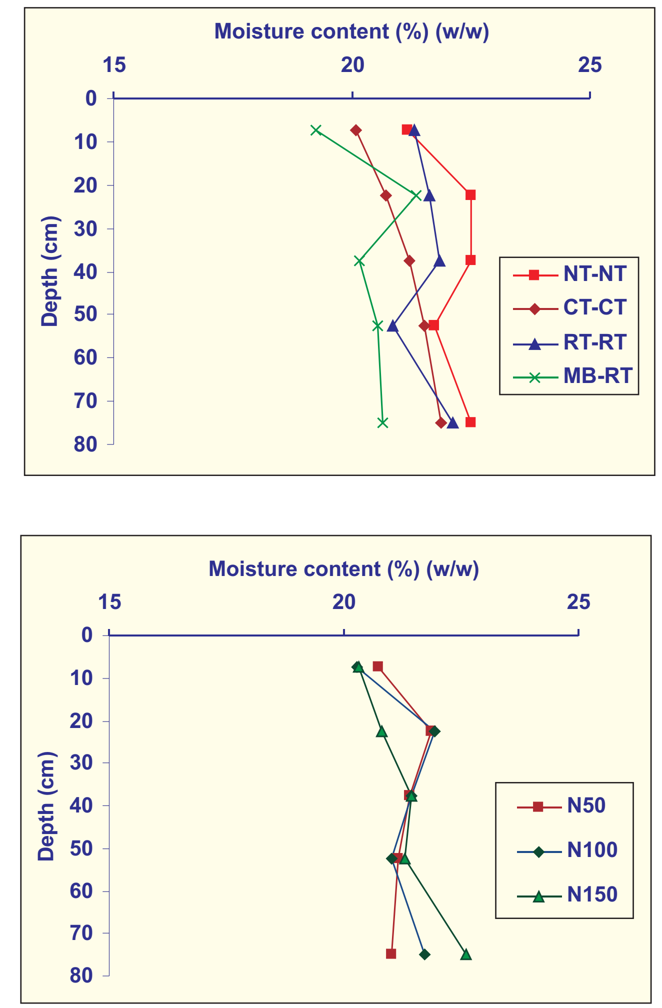


Fig. 4.4.2. Moisture content of the soil profile after 65 DAS

Table 4.4.2. Tillage and nitrogen level effect on BD (Mg m^{-3}) of 0-5 cm soil

	Nitrogen levels			
Tillage	$N_{50\%}$	$N_{100\%}$	$N_{150\%}$	Average
CT-CT	1.32	1.28	1.27	1.29
MB-RoT	1.31	1.17	1.15	1.21
RT-RoT	1.22	1.21	1.16	1.20
NT-NT	1.26	1.21	1.25	1.24
Average	1.28	1.21	1.21	

LSD (P=0.05): Till: 0.06; N: 0.06 & TXN: NS

Effect of tillage treatments and nitrogen levels on infiltration rate of the soil was studied after harvest of soybean during the fallow period. The steady state infiltration rates of plots under no tillage (NT-NT), mouldboard tillage (MB-RoT) and reduced tillage (RT-RoT) treatments were significantly higher than that of conventional tillage (CT-RoT) treatment (Table 4.4.3). Among the nitrogen levels, $N_{100\%}$ and $N_{150\%}$ level recorded significantly higher infiltration than $N_{50\%}$ level.

Table 4.4.3. Tillage and Nitrogen level effect on infiltrability (cm hr^{-1})

	Nitrogen levels			
Tillage	$N_{50\%}$	$N_{100\%}$	$N_{150\%}$	Average
CT-CT	3.02	2.84	1.08	2.31
MB-RoT	2.96	7.53	8.61	6.37
RT-RoT	2.85	8.88	6.24	5.99
NT-NT	3.04	10.91	11.05	8.33
Average	2.97	7.54	6.74	

LSD (5%): Tillage: 3.75; Nitrogen: 2.09 and T X N: 4.18

Tillage and moisture content effect on soil bulk density: A study was conducted to evaluate the effect of changing soil moisture content on bulk density of soil under no tillage and conventional tillage system. The data clearly showed that with decrease in moisture content from near saturation to below permanent wilting point the bulk density of the Vertisol decreased at both 0-7.5 and 7.5-15 cm depths**.** The BD and moisture content relationship (as expressed through coefficient of determination) was stronger at 0-7.5 cm depth than that at 7.5-15 cm depth. The trend in the increase of BD with depletion of moisture content was similar in CT-CT and NT-NT treatments.

4.4.2. Tillage and Manure Interactive Effect on Soil Aggregate Dynamics, Soil Organic Carbon Accumulation and Bypass flow in Vertisol

With respect to soil moisture content, no tillage showed significantly higher moisture content at 30 and 90 DAS however at other sampling dates it was found to be at par with conventional tillage. Across tillage, T7 (10 t ha^{-1} FYM-C) was found to have higher moisture content than T1 (0 FYM-C) at 0-5, 5-15 and 15-30 cm soil depth. At the same time 90, 120 DAS and after harvest T1 was found to have more soil moisture than T7 at 15-30 cm soil depth. Tillage, manure and their interaction were found to be significant on root weight and root volume at 0-15 cm soil depth. However, tillage did not have significant effect on root weight and volume at 15-30 cm soil depth. Root weight and volume were found to be significantly greater in treatment receiving the highest level of FYM and the minimum in control. Different levels of FYM had significant effect on grain and biomass yield of wheat 2008-09. Grain yield ranged from 3.4 to 4.0 Mg ha^{-1}. The effect of FYM-C levels 2 (T4) and 2.5 (T5) t ha^{-1} on grain yield was the highest and also found to be at par. Biomass yield ranged from 6.0 (T1) to 7.3 (T7) Mg ha^{-1}. After harvest of wheat, No tillage resulted in higher available N than conventional tillage at both soil depths (0-5 and 5-15 cm). Reverse trend was observed in available P and K at both soil depths with respect to tillage. Available N, P and K were found to increase significantly with increase in levels of FYM. TOC per cent was found to vary from 0.89 (T1) to 1.48 (T7)% after wheat harvest. However levels of FYM, tillage and manure interaction had significant effect on TOC at 0-5 and 5-15 cm soil depth.

In 90 day old pot grown soybean it was found that SOC, SMBC and basal respiration were higher without crop as compared to with crop pots at 0-5 and 5-15 cm soil depth. However, alkaline phosphatase and dehydrogenase activity were relatively greater in cropped than non-cropped pots. In contrast to that in field experiment, tillage didn't have any significant effect on biological activities. Whereas, biological activities increased significantly with increased levels of FYM. Fluorescein diacetate was found to have highest correlation of 0.45 and 0.52 with water soluble carbon and acid hydrolysable carbohydrate, respectively.

4.5. Monitoring Soil Chemical Parameters

4.5.1 Investigations on Phosphorus Fractions in Diverse Organic Manures and Their Effects on Phosphorus Speciation and Availability in Contrasting Soils

This study was initiated with the objective: a) to survey, collect and characterize different manures, b) to assess the effect of manure P composition on soil P speciation, and c) to understand the relative sorption behavior of organic and inorganic phosphate in contrasting soils.

Sorption behavior of inorganic and organic phosphorus

Sorption behavior of inorganic and organic phosphorus in three contrasting soils *viz.*, Vertisol (Bhopal), Oxisol (Dapoli) and Mollisol (Pantnagar) was studied. The soils were subjected separately to inorganic P (KH_2PO_4) and organic P ($C_6H_{18}O_{24}P_6$) at a series of concentrations (2.5 to 60 mg P L^{-1}) and equilibrated at a temperature of 27 °C for 6 days with intermittent shaking. The P sorbed by each soil was calculated as the difference between the amount of P present in the solution initially and that remaining after equilibration.

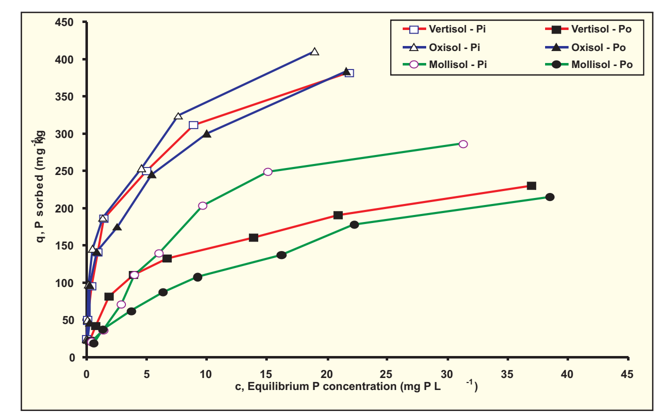


Fig. 4.5.1. Inorganic and organic P sorption isotherms for Oxisol, Vertisol and Mollisol

Organic-P sorption was lower than inorganic-P sorption in all the three soils. The sorption of either inorganic or organic P in different soils followed the order: Oxisol > Vertisol > Mollisol (Fig. 4.5.1). The inorganic and organic P sorption data for all three soils conformed to the linear form of the classical Langmuir equation (Fig. 4.5.2). The goodness of fit was highly significant with the coefficient of determination (R^2 values) being in the range of 0.954** to 0.986**. In general, the P sorption maxima (b), bonding energy constant (k) and standard P requirement (SPR) derived from Langmuir isotherms were relatively lower for organic-P compared to inorganic-P. The lower sorption

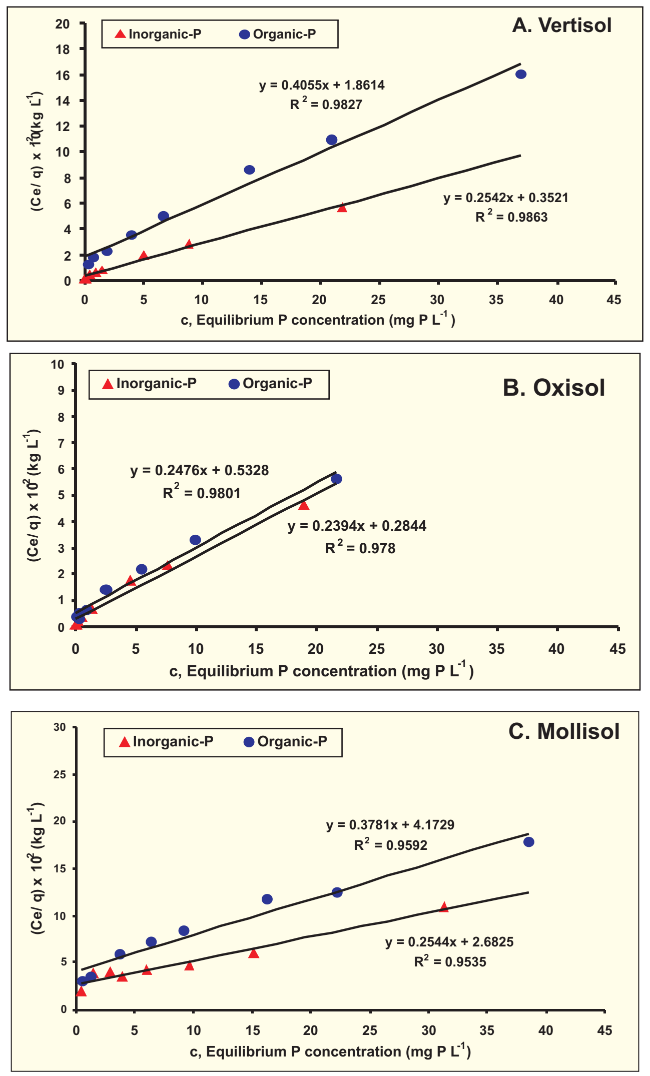


Fig. 4.5.2. Langmuir isotherms for inorganic and organic P sorption in contrasting soils

of organic-P vis-à-vis inorganic-P in different soils was primarily through a decrease in either sorption maxima (b) as in Mollisol, bonding energy constant (k) as in Oxisol or both b and k as in Vertisol.

Sequential extraction of P from manures and manured soils

The total-P as well as relative proportions of H_2O-P, $NaHCO_3$-P, NaOH-P, HCl-P and Residual P varied widely across the organic manures. Averaged over all fractions, the organic P accounted for 11.4, 12.5, 31.5, 30.9, 38.4, 47.1, 42.7 and 64.1 per cent of total P in VC, MSW, PM, GM, FYM, CDM, Subabool and WR, respectively (Fig. 4.5.3). A laboratory incubation study was carried out using all the three contrasting soils to assess the effect of P forms in organic manures on P availability and soil P speciation. All the organic manures/materials, with the exception of subabool and WR with wide C:P ratio, showed an improvement of available (soil test-P) P in all soil types (Fig. 4.5.4). However, the magnitude of increment in the soil test-P varied between organic materials and soil types. The recovery of P added through organics was generally high in high P fixing soil (Oxisol) and least in Mollisol with less P fixing ability at 30 days after incubation. The recovery of added P was strikingly high (40.49%) in all soils. Generally, decomposed manures (VC, MSW, PM, GM, FYM and CDM) were found more effective than un-decomposed subabool and WR. FYM proved more effective than all other organics and

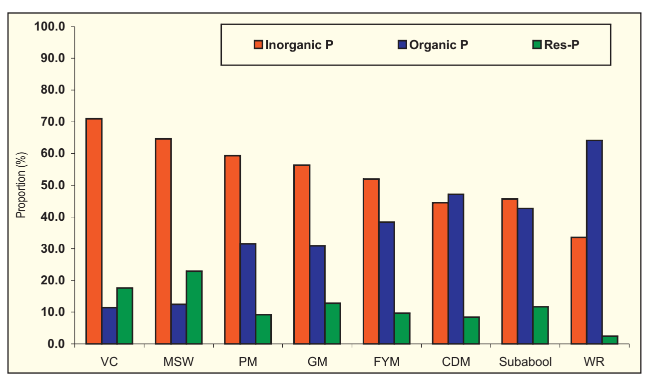


Fig. 4.5.3. Inorganic and organic P proportions in different manures

was 1.2, 2.2 and 1.1 times as effective as inorganic P in Vertisol, Oxisol and Mollisol, respectively with respect to P availability. Potential of organics in improving P availability in different soils followed the order Oxisol > Vertisol > Mollisol.

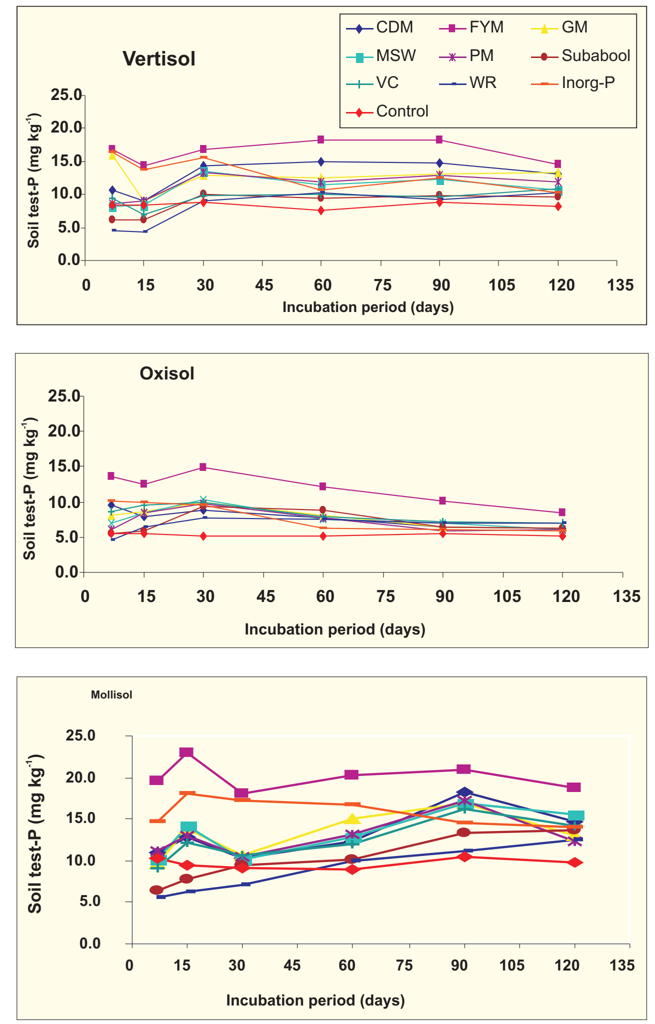


Fig. 4.5.4. Effect of organics on available P during incubation

4.5.2 Assessment of Quality and Resilience of Soils under Diverse Agro-ecosystems

The NAIP sub-project entitled "Assessment of quality and resilience of soils under diverse agro-ecosystem" started in a network mode with IISS, Bhopal as the lead centre and BCKV, Kalyani, PAU Ludhiana, CRIDA, Hyderabad and NBSS & LUP, Nagpur as the cooperating centers. As per the work schedule, all the centres procured maps of the two districts and identified the soil sampling norms. All the identified sites were geo-referenced using GPS. Soil sampling was completed before start of winter season crops in all the centres. The target districts for soil sampling were Vidisha & Sehore (under AESR 10.1), Rupnagar & Ludhiana (under AESR 4.1), Warangal & Nalgonda (under AESR 7.2) and Hoogly & Bankura (under AESR 15.1).

The preliminary soil analysis results indicated that due to continuous cultivation of crops, the soil organic C (SOC), available Fe and Mn from the surface (0-15 cm) soil layer were decreased by 31.0, 44.6 and 35.8%, respectively in Sehore district; while the SOC, available K and available Fe were decreased by 46.3, 47.6 and 19.9% respectively in Vidisha district (Table 4.5.1) as compared to pristine soil.

The pH was slightly higher in Rupnagar district compared to Ludhiana district. Soils in both the districts of Rupnagar and Ludhiana tested low to high in organic carbon with mean SOC content falling in the medium category. Mean SOC content was slightly higher in Ludhiana district (4.9 g kg^{-1}) as compared to Rupnagar district (4.4 g kg^{-1}). Olsen extractable P in soil samples from both the districts ranged from low to high or very high. However, the average P status in both the districts was in high category and varied between 42 and 45 kg P ha^{-1} (Table 4.5.2).

The district maps of Nalgonda and Warangal were digitized in ARC-GIS environment and were projected as WGS-84, as GPS works in WGS-84 coordinate system. Around 53 out of 139 samples from Nalgonda district had BD more than 1.6 Mg m^{-3} and in case of Warangal, 38 out of 149 samples had BD more than 1.6. Bulk density of Nalgonda soils (Table 4.5.3) was relatively higher than those of Warangal. Available nitrogen was low (<280 kg ha^{-1}) in entire area of Warangal district whereas in Nalgonda district 16 out of 160 samples were in medium range of available N (281-560 kg ha^{-1}); and remaining samples were low in

Table 4.5.1. Soil analytical data of Sehore and Vidisha districts of Madhya Pradesh

District	Land use		pH	EC (dS m^{-1})	OC (%)	Available content (ppm) N	P	K	Fe	Mn
Sehore	Pristine	Min.	7.03	0.59	0.08	71.5	0.10	3.88	1.08	4.34
		Max.	8.32	1.99	1.46	620.0	2.34	37.42	5.36	34.74
		Mean	7.69	1.32	0.87	272.5	0.49	15.83	2.88	16.15
		Std. Dev.	0.35	0.39	0.33	135.7	0.47	8.73	1.05	10.53
	Cultivated	Min.	6.65	0.50	0.05	87.5	0.10	0.72	1.04	2.02
		Max.	8.38	2.89	1.26	845.0	1.66	25.80	6.30	37.28
		Mean	7.75	1.35	0.60	275.4	0.43	8.76	2.18	10.36
		Std. Dev.	0.37	0.39	0.19	173.9	0.26	5.42	0.92	7.23
Vidisha	Pristine	Min.	6.79	0.74	0.27	110.5	0.06	5.46	0.92	3.38
		Max.	8.35	2.95	2.63	987.0	0.82	20.24	3.84	16.04
		Mean	7.88	1.22	0.82	332.3	0.27	9.05	1.54	5.99
		Std. Dev.	0.41	0.58	0.72	960.0	0.18	3.76	0.71	3.14
	Cultivated	Min.	6.08	0.36	0.03	97.5	0.10	2.28	0.60	1.66
		Max.	8.30	5.70	1.71	453.2	0.68	25.52	3.62	30.58
		Mean	7.90	1.28	0.44	295.6	0.25	7.25	1.24	6.94
		Std. Dev.	0.40	0.57	0.19	196.6	0.11	3.19	0.45	3.87

Table 4.5.2. Range, mean and standard deviation of some chemical properties in Ludhiana and Rupnagar districts of Punjab

Soil properties	Minimum	Maximum	Mean	S.D
Ludhiana				
pH	6.87	8.39	7.78	0.285
EC (dS m^{-1})	0.07	0.60	0.21	0.083
Organic carbon (g kg^{-1})	2.1	11.1	4.9	2.2
Olsen P (kg ha^{-1})	10.3	96.5	45.0	19.54
Rupnagar				
pH	7.17	8.59	8.14	0.22
EC (dS m^{-1})	0.12	0.44	0.23	0.07
Organic carbon (g kg^{-1})	1.0	8.7	4.4	1.8
Olsen P (kg ha^{-1})	7.0	99.6	42.4	16.33

available N. Out of 160 samples analyzed, 12% samples were low (<10 kg ha^{-1}), 56% samples were medium (11-25 kg ha^{-1}) and 32% samples were high in available P in the soil collected from Nalgonda district, whereas in Warangal 19% low, 53% medium and 28% were high in available P.

In *Kataban* soil series of Bankura district, values of soil organic carbon (SOC*)* of C_{24N} (Walklay and Black,

1934) of rice-sesame-potato (R-P-S) cropping system varied from 3.28 to 5.39 g kg^{-1} soil with average value of 4.33 g kg^{-1} soil, whereas, in *Bulanpur* soil series of Bankura district, values of soil organic carbon (SOC*)* of C_{24N} of rice-sesame-potato(R-P-S) cropping system varied from 5.03 to 9.65 g kg^{-1} soil with average value of 7.34 g kg^{-1} soil. In *Baligori* soil series of Hooghly district, values of microbial biomass carbon (MBC) of rice-sesame-potato (R-P-S) cropping system varied from 335.53 to 1083.61 g g^{-1} soil with average value of 709.57 g g^{-1} soil. In *Kataban soil* series of Hooghly district, values of microbial biomass carbon (MBC) of rice-sesame-potato (R-S-P) cropping system varied from 306.47 to 643.58 g g^{-1} soil with average value of 474.97 g g^{-1} soil.

4.5.3 Biofortification of wheat grains with zinc and iron

To prove the fact that the foliar applied Zn and Fe is better option for enrichment of wheat grains, a field experiment was conducted in Ludhiana for two consecutive years (2006-07 to 2007-08) with foliar sprays of Zn (0.5%) and Fe (0.5%). The soil of the field was loamy sand (*Typic Ustochrept*) having pH 7.8, EC 0.12 dS m^{-1}, organic carbon 0.34 %, available nitrogen 252 kg ha^{-1}, available phosphorus 15.8 kg ha^{-1} and available potassium 184 kg ha^{-1}. The DTPA-extractable Zn and Fe levels at the time of sowing of wheat were 0.72 and 4.80 µg g^{-1}, respectively. Five wheat varieties *viz.* PDW 274, PDW 291, PBW 343, PBW 502 and PBW 550 were selected for experimental study. These

Table 4.5.3. Mean, minimum, maximum and coefficient of variance (CV %) of some soil parameters collected in Nalgonda and Warangal districts of Andhra Pradesh

Parameters	Mean	Minimum	Maximum	Coefficient of Variance (CV %)
Nalgonda				
Bulk Density (Mg m^{-3})	1.55	1.17	1.87	9.41
Moisture @ 0.3 Bar (w/w%)	14.4	2.30	37.03	52.04
Moisture @ 15 Bar (w/w%)	7.2	0.81	22.6	68.1
AWC (mm m^{-1})	110.45	20.87	282.62	49.86
pH	7.93	5.39	9.32	9.17
EC (dS m^{-1})	0.21	0.03	0.87	80.7
Available N (kg ha^{-1})	177.85	86.55	469.15	37.39
Available P (kg ha^{-1})	19.37	3.36	77.73	67.62
Available K (kg ha^{-1})	267.14	75.94	630	43.61
Warangal				
Bulk density (Mg m^{-3})	1.5	1.15	1.79	8.77
Moisture @ 0.3 Bar (w/w%)	15.18	3.51	38.36	49.17
Moisture @ 15 Bar (w/w%)	7.94	1.77	19.93	54.2
AWC (mm m^{-1})	107.28	24	378.22	56.22
pH	7.52	5.48	8.92	10.12
EC (dS m^{-1})	0.19	0.03	0.84	62.3
Available N (kg ha^{-1})	149.24	82.79	270.95	21.94
Available P (kg ha^{-1})	21.8	0.45	105.95	78.57
Available K (kg ha^{-1})	237.14	62.05	655.76	47.08

include both durum and aestivum varieties. Four foliar sprays were applied as Zn (0.5%) and Fe (0.5%) during growth period of different wheat varieties. The 1st and 2nd spray of Zn and Fe was made at maximum tillering and flower initiation stages. Whereas, 3rd and 4th spray was made at milk and dough stages. The concentration of Zn and Fe in wheat grain ranged from 30.4 - 43.3 µg g^{-1} and 36.6– 50.3 µg g^{-1} with foliar applications of Zn and Fe, respectively. The data further revealed that application of Zn raised the maximum concentration of Zn to 43.3 µg g^{-1} (PDW 291) and 42.8 µg g^{-1} (PBW 502), which were 38.8 and 37.7 % higher over control, respectively. Also the application of Fe raised the maximum concentration of Fe to 50.9 µg g^{-1} (PBW 343) and 47.9 µg g^{-1} (PBW 502), which was 24.8 % and 23.1 % more, respectively over control.

4.6 Improving Soil Biological Condition

4.6.1 Studies on the effect of organic sources on yield and quality of pomegranate

The effect of various nutrient sources on yield and quality of pomegranate under organic farming was assessed. The maximum fruit yield was recorded in INM (7.79 kg $plant^{-1}$) treatment followed by organics (7.11 to 7.30 kg $plant^{-1}$) and inorganic alone (6.89 kg $plant^{-1}$), while the least was in control (4.72 kg $plant^{-1}$). Number of fruits per plant and average fruit weight (g) was higher in all the nutrient treatments compared to control. Although, the highest fruit number was recorded in RDF treatment, but the highest average fruit weight was recorded (185.57 g) in cattle dung manure (CDM) treatment followed by INM (185.56 g). The fruit quality parameters such as sugars, total soluble salts (TSS) and ascorbic acid content increased significantly with the application of INM, organic and inorganic alone, whereas, juice acidity, carotenoids and tannin content did not vary significantly due to application of various nutrient sources (Table 4.6 1 & 4.6.2). Juice recovery percentage was the highest in CDM (59.8%) followed by INM (58.3%), vermicompost (55.8%) and phosphocompost (55.4%) and was the lowest in control (41.0%). Maximum TSS was recorded in cattle dung manure (CDM) treatment. The fruit juice acidity recorded in the range of 0.28-0.35% in winter season pomegranate fruit and the minimum juice acidity was recorded in all the nutrient treatments. The decrease in acidity percentage of fruit juice might be due to the application of organic, inorganic and integrated nutrient sources. Higher accumulation of ascorbic acid was recorded in INM (19.3 mg $100g^{-1}$) treatment followed by organics and inorganic treatments and was the lowest in control (16.2 mg $100g^{-1}$). Supply of all the essential nutrients through organic and INM treatments probably contributed to a better pomegranate fruit quality.

Table 4.6.1. Effect of different nutrient sources on yield and quality of pomegranate

Treatments	Total No of fruits ($plant^{-1}$)	Average fruit wt (g)	Fruit yield (g $plant^{-1}$)	TSS (%)	Sugar (%)	Vitamin C (mg $100g^{-1}$)
Control	31	150.57	4.72	11.2	0.35	16.2
Vermicompost	40	177.87	7.11	12.7	0.29	18.3
Phosphocompost	40	184.10	7.30	12.6	0.29	18.5
Cattle dung manure (CDM)	39	185.57	7.17	13.0	0.28	18.9
RDF (400:250:200 g NPK $plant^{-1}$)	44	155.43	6.89	11.7	0.32	18.0
50% RDF+ 50% CDM	42	185.56	7.79	12.9	0.29	19.3
CD (P=0.05)	2.3	6.7	1.6	0.1	NS	0.5

Among the mineral elements such as Ca and Fe contents increased significantly due to application of INM followed by organic and inorganic alone and was the lowest in control; Mg, Cu and Zn content on the other hand in fruits were not influenced due to application of different nutrient sources.

It can be concluded from the study that application of 18 kg vermicompost or 21kg compost or 29 kg cattle dung manure (CDM) per plant or a combination of 50% CDM+50% RDF improved the fruit yield as well as quality of pomegranate fruits.

Table 4.6.2 Effect of different nutrient sources on juice recovery, acidity and mineral content of pomegranate

Treatments	Juice recovery	Acidity	Ca content	Mg content	Cu content	Fe content	Zn content
	(%)		(mg $100g^{-1}$)				
Control	41.0	0.35	12	11	0.17	0.36	2.0
Vermicompost	55.8	0.29	13	12	0.20	0.44	2.3
Phosphocompost	55.4	0.29	16	12	0.20	0.44	2.4
Cattle dung manure (CDM)	59.8	0.28	16	13	0.22	0.50	2.6
RDF (400:250:200 g NPK $plant^{-1}$)	45.9	0.32	15	11	0.18	0.44	2.4
50% RDF+ 50% CDM	58.3	0.29	17	14	0.23	0.49	2.7
CD (P=0.05)	3.3	NS	1.1	NS	NS	0.07	NS

4.6.2. Quality assessment of crops under different nutrient management system in long term experiment

Improving nutritional quality of wheat grain under LTFE experiments

Adoption of different nutrient management practices improved the nutritional quality parameters such as protein and tryptophan content of wheat. However, methionine, cysteine amino-acids and NPN content did not vary significantly due to different nutrient management practices, but these constituents were recorded higher in all the nutrient management practices compared to control. Protein (12.2%), methionine (1.43 g 16 g^{-1}N) and cysteine (1.48 g 16 g^{-1}N) were the highest with the application of 100% NPK + FYM and was the lowest in control (Table 4.6.3). Nutritionally important mineral elements such as P, K, Zn, Cu, Mn and Fe contents were higher in different nutrient management practices compared to control.

Improving nutritional quality of soybean seed under LTFE experiments

Quality of soybean seed was assessed grown under LTFE experiments. Nutrient management practices significantly influenced the 100-seed weight, crude protein and true protein content. The highest 100 seed weight was recorded with the application of balanced nutrition (100% NPK+ FYM) compared to other treatments and was the lowest in control. Protein, carbohydrates and oil contents did not vary significantly due to different nutrient management practices, whereas, nutrients had effect on true protein, methionine and cysteine content in seed (Table 4.6.4). Results of the Ranchi Centre is also showed the similar trend with respect to the above mentioned quality parameters in soybean seeds (Table 4.6.5).

Table 4.6.3. Effect of different nutrient management practices on wheat grain quality (LTFE, Jabalpur)

Treatments	Methionine	Cysteine	Tryptophan	Non Protein Nitrogen (NPN)	Protein	True Protein	Total minerals	N	P	K
	(g 16 g^{-1}N)			(%)						
Control	1.28	1.30	1.22	0.16	10.6	10.41	1.68	1.78	0.24	0.40
100% N	1.30	1.36	1.29	0.19	11.0	10.81	1.70	1.85	0.25	0.47
100% NP	1.34	1.39	1.31	0.19	11.8	11.61	1.69	1.99	0.30	0.49
100% NPK	1.37	1.40	1.39	0.20	11.9	11.70	1.74	2.00	0.30	0.66
100% NPK + FYM	1.40	1.45	1.40	0.18	12.2	12.02	1.77	2.05	0.32	0.69
100% NPK - S	1.43	1.48	1.36	0.20	11.8	11.60	1.76	1.99	0.21	0.66
CD (P=0.05)	NS	NS	0.06	NS	0.16	0.14	NS	NS	NS	0.06

Table 4.6.4. Effect of different nutrient management practices on soybean seed quality (LTFE, Jabalpur)

Treatments	100-seed wt.	Moisture	Protein	Carbohydrates	Oil	True protein	NPN	Methionine	Cysteine	Tryptophan
		(%)						(g 16 g^{-1}N)		
Control	8.70	9.1	34.83	22.0	18.2	34.17	0.46	1.67	1.55	1.78
100% N	9.74	8.9	37.34	20.7	20.8	37.25	0.49	1.79	1.67	1.84
100% NP	10.64	8.9	36.97	21.8	21.1	36.49	0.48	1.80	1.64	1.81
100% NPK	9.97	9.4	38.37	21.5	18.6	37.87	0.50	1.87	1.78	1.80
100% NPK + FYM	12.00	9.3	39.16	20.6	19.2	38.66	0.50	1.92	1.84	1.81
100% NPK - S	10.85	9.3	38.74	21.5	19.0	38.16	0.48	1.84	1.70	1.80
CD (P=0.05)	0.21	NS	1.47	NS	NS	1.20	NS	0.12	0.11	NS

Table 4.6.5. Effect of different nutrient management practices on soybean seed quality (LTFE, Ranchi)

Treatments	100-seed wt.	Moisture	Protein	Carbohydrates	Oil	True protein	NPN	Methionine	Cysteine	Tryptophan
		(%)						(g 16 g^{-1}N)		
Control	8.66	9.2	35.34	22.40	18.7	34.88	0.46	1.64	1.57	1.71
100% N	9.67	9.5	38.24	20.13	20.0	37.74	0.50	1.74	1.64	1.89
100% NP	10.51	9.2	37.74	21.50	20.5	37.26	0.48	1.78	1.62	1.80
100% NPK	10.71	9.5	38.16	21.72	19.8	37.68	0.48	1.82	1.66	1.81
100% NPK + FYM	12.10	9.6	39.41	19.74	19.2	38.92	0.49	1.85	1.68	1.83
100% NPK - S	10.70	9.4	38.17	20.16	20.2	37.69	0.48	1.82	1.63	1.79
CD (P=0.05)	0.31	NS	1.42	NS	NS	1.34	NS	0.09	0.05	NS

It can be concluded from the study that the 100-seed weight, protein, true protein, methionine and cysteine content increased significantly due to different nutrient management practices over control in soybean seed.

4.6.3 Soil Organic Carbon Dynamics vis-à-vis Anticipatory Climatic Changes for Crop Adaptation Strategies

To establish the relationship among C mineralization, biological activities and C pools under different hydrological regimes, selected treatments such as NPK, NPK + FYM, NPK+ WR and FYM were used after 5 cycles of soybean-wheat in rotation. The higher concentrations of C pools such as SMBC, hot water soluble carbon and acid hydrolysable carbohydrates were observed in FYM treated plots followed by 50% NPK+WR, 50% NPK+FYM and 100% NPK in surface layer (0-15 cm) (Table 4.6.6). The POM-C varied from 14.7 to 28.4 % in these treatments and it was lowest in unfertilized control. Therefore, 71.6 - 85.3 % of TOC was present in terms of mineral associated organic matter (<0.053 mm) in these soils. The sand free soil mass aggregates in the size classes of >2000μm were very low in Vertisol. In all the treatments rewetted sand free mass aggregate size distributions at 0-15 cm depths were dominated by small macro aggregates (25-2000 μm) accounting for 55.5-70.6% of dry soil weight followed by micro aggregates (53- 250 μm, accounting for 18- 37%) (Fig. 4.6.1). The sand free water stable aggregate carbon was greater in 2000-250 μm size classes followed by 250-53 um and least was observed in mineral associated (silt + clay fraction). It was also observed that the substantial improvement of water stable carbon due to continuous application of manure through FYM followed by FYM + NPK and NPK+ WR under soybean-wheat system in Vertisol (Fig. 4.6.2). The disruption of aggregates organic matter subsequently reduces the labile pool of carbon where cultivation is practiced in a long run. Dynamic interrelationship between soil structure and SOC indicated that the decomposition of SOC affects soil aggregation and aggregate stability upon microbial action.

The hydrolysis of the fluorescein diacetate (FDA) has also been used to estimate microbial activity in soil. As FDA is hydrolyzed by esterases, proteases and lipases, all enzymes are involved in the microbial decomposition of organic matter in soil. It is used as an alternative estimate of the content and size of soil microflora. It has been observed that the maximum FDA was (7.9 µg Fluorescein g^{-1} h^{-1}) in the FYM treated plots due to greater biological activities. After 60 days of incubation, it was observed that the CO_2 evolution increased with increase in incubation period and it was maximum at 40 days for all these treatments (Fig. 4.6.3). Amongst the hydrological regimes, the higher amount of CO_2 evolution was observed in 100 %WHC followed submerged condition and least was observed in 50 % WHC. Application of NPK with 100 % WHC the CO_2 evolution was maximum (192 mg CO_2 $100g^{-1}$) followed by NPK+WR, 100% NPK and 50% NPK+ FYM possibly due to greater release of waster soluble carbon and acid hydrolysable carbohydrates, which acted as source of bio energy for higher amount of exogenous micro organisms.

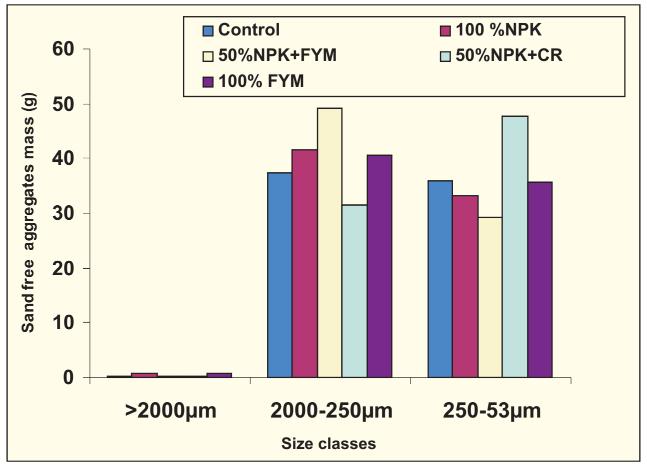


Fig. 4.6.1 Long-term effect of fertilizer, manure and crop residues on sand free aggregate mass (g) in different size classes

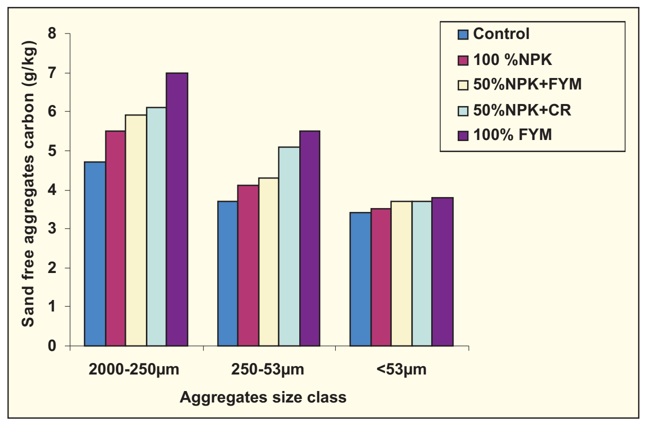


Fig. 4.6.2. Long-term effect of fertilizer, manure and crop residues on sand free aggregate carbon (g kg^{-1}) in different size classes

Table 4.6.6. Soil biochemical parameters (0-15 cm depth) after 5 cycles of soybean-wheat rotation

Parameters	Control	100% NPK	50% NPK+ FYM	50% NPK+CR	100% FYM
SR (mg CO_2-C $100g^{-1}$ d^{-1})	3.70	3.63	3.94	3.38	3.50
DHA (µg TPF g^{-1} d^{-1})	40.00	56.50	59.80	60.80	67.50
Alkaline phosphatase (µg PNP g^{-1} $2h^{-1}$)	360.00	420.00	460.00	510.00	710.00
Urease (µg NH_4-N g^{-1} h^{-1})	124.00	138.00	168.00	216.00	224.00
FDA (µg Fluorescein g^{-1} h^{-1})	4.17	4.59	5.80	6.93	7.98
Active pools of Carbon					
SMBC(mg kg^{-1})	188.00	245.00	450.00	595.00	625.00
WSC (mg kg^{-1})	26.00	27.00	30.40	32.80	52.50
WS Carbohydrates (mg kg^{-1})	290.7	396.2	476.0	480.9	528.5
POM-C (mg kg^{-1})	709	729	889	917	1906

SR: Soil Respiration; DHA: Dehydrogenase Activity: FDA:Fluorescein Diacetate;
SMBC: Soil Microbial Biomass Carbon; WSC: Water Soluble Carbohydrate POM : Particulate Organic Matter

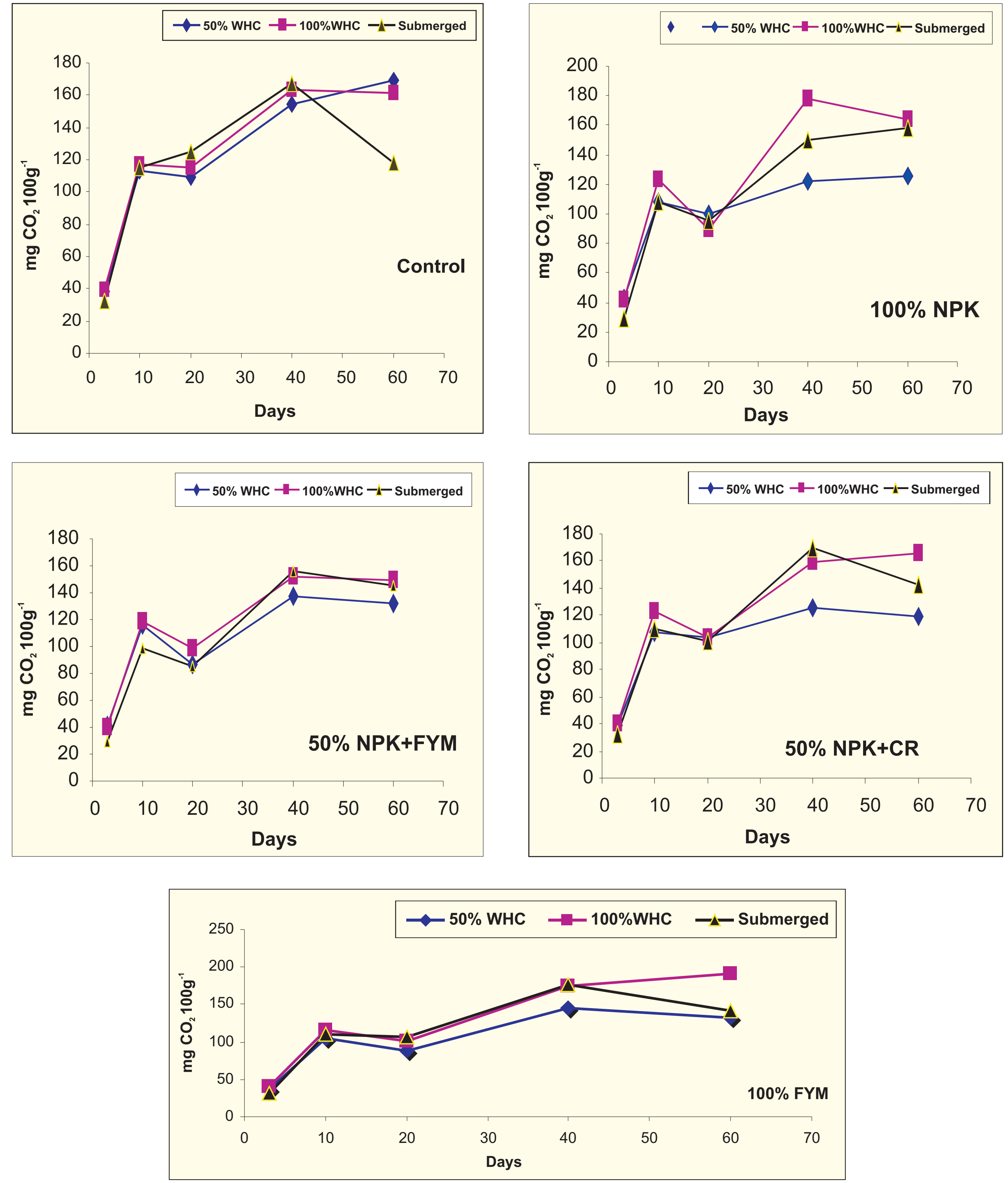


Fig. 4.6.3. Long-term effect of fertilizer, manure and crop residues on carbon mineralization (mg CO_2 $100g^{-1}$ soil) in different hydrological regimes

4.7 Microbial Diversity and Biofertilizers

4.7.1 Improving yields and nutrient uptake of selected crops through microbial inoculants in Vertisols of Central India

The project is aimed at utilizing the culturable bacterial isolates of vertisols of Central India in soybean, chickpea and wheat rhizosphere, possessing improved nutrient transforming ability and with competitive antagonist ability, to promote plant growth, survive at high temperatures and low soil moisture and use them for preparing consortia of beneficial organisms which can promote greater grain yields under farmers' field situations. During 2008-09, further work on the strains isolated in previous years were done and the main findings are summarized below.

Database of plant growth promoting rhizobacteria (PGPR): Of the 510 bacterial isolates initially made from the rhizosphere of soybean, chickpea and wheat in vertisols of Madhya Pradesh and from vermicompost, vermicast samples 81 were short-listed as promising PGPR's (16% of the isolates). A data base of their physiological and biochemical attributes has been prepared.

Oligotrophy of rhizobacteria: Initially 6 out of the 403 bacterial isolates (on 8 different media) were found to be obligate oligotrophs (1.5 %) and 9 obligate copiotrophs (2.2%). 96% isolates were facultative in their mode of nutrition. Upon storage (one year) at 4°C, the obligate copio- and oligotrophs became facultative and grew on nutrient rich media (nutrient agar) as well as diluted media (1/100 and 1/1000) and on ultra-pure agar.

HCN production

A new media formulated with mannitol, glycerol and 0.5% yeast extract gave more sensitive detection of HCN as compared to YEMA, King's or Nutrient agar medium.

Diversity of rhizobia

The intrinsic antibiotic resistance (IAR) pattern of 32 nod+ rhizobial isolates of soybean isolated from 20 districts of various geographical region of M.P. towards 18 antibiotics was evaluated. All the nod+ soybean rhizobia were largely resistant to Nalidixic acid, Trimethoprim, Vancomycin, Novobiocin and Polymyxin-B. Dendrogram of the IAR pattern showed a lot of diversity and soybean rhizobia clustered into 6 distinct groups at 75% level of similarity (Fig. 4.7.1). The standard strains of *B. japonicum* USDA 110 (S49) and *B. elkanii* USDA 31 (S51) and 22 soybean isolates formed a major cluster (Group 1) which account for 65 % of the total isolates.

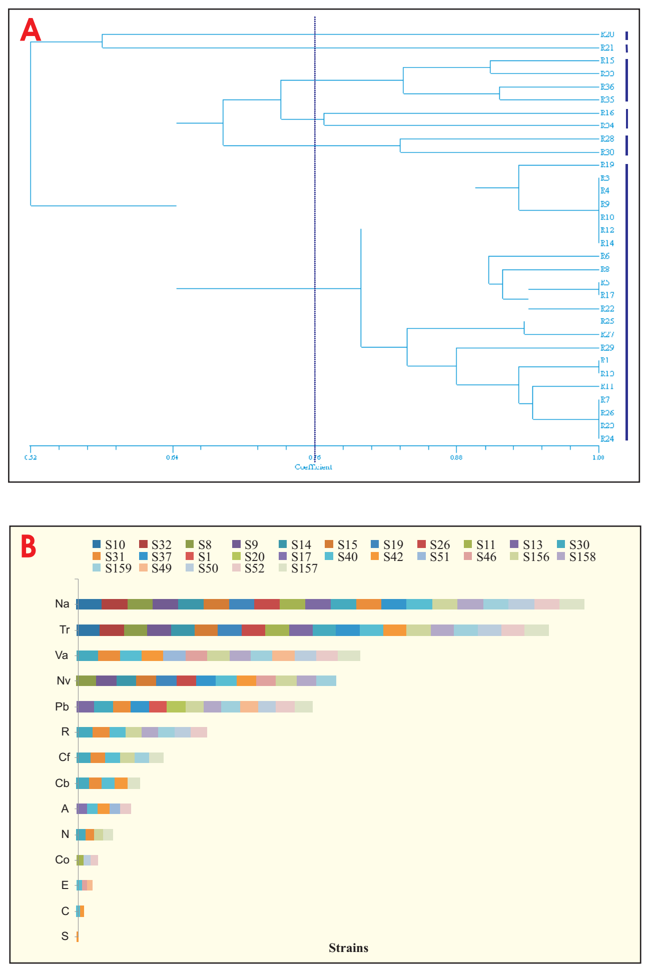


Fig. 4.7.1. (A) Dendrogram of diversity and (B) Antibiotic resistance pattern of soybean rhizobia

Microbial Diversity in 'Haveli' fields of Madhya Pradesh

In soils, submerged during monsoon, 11 new isolates of *Pseudomonas* and 11 of *Rhizobium* (lentil, pea and chickpea) were made from five sites in Jabalpur and Narsinghpur districts. Soils were sampled at four stages and analyzed. Organic carbon, mineral and total N, available P and K, microbial biomass carbon, soil N mineralization, dehydrogenase, acid and alkaline phosphatase, and D-glucosidase were reduced at second stage (*i.e.,* about 20-25 days after submergence) in comparison to first stage *i.e.* before submergence. At third stage *i.e.* after release of water from the fields and their cultivation for sowing of rabi crops, all the parameters improved significantly (over stage 1) due to which the rabi crops (mostly legumes) benefited, resulting in profuse nodulation in chickpea, lentil and pea crops.

Microbial Diversity in `Diara' and `Tal' Lands

In continuing work on submerged lands- Diara and Tal lands of Bihar, 10 new strains of Azospirillum, 6 of Azotobacter, 6 of Pseudomonas, 4 of Rhizobium (Lentil and Broadbean) and 5 strains of *Bacillus sps*. were added (RAU, Bihar).

New PGPR for Hill Soils

A highly efficient P-solubilizing, IAA and siderophore producing *Bacillus circulans* effective in inhibiting *Dematophora necatrix* (causative agent of white rot of apple) was identified from Bharmour, Chamba. A multi-functional, carbendazim tolerant (2000μg ml^{-1}) plant growth promoting rhizobacterial (PGPR) strain *Bacillus subtilis* was isolated from tomato seedlings.

Microbial Diversity in Haryana Soils

In rhizosphere of various cropping systems from diverse agro-climatic zones in Haryana, maximum number of morphotypes were obtained on LB media (56) followed by Pikovaskaya (41), malate (40) and Jensen's medium (33). The counts ranged from 106-107 cfu g^{-1}. Genomic DNA of various culturable bacteria was amplified with Bac 16S rRNA gene primers and RFLP analysis was done with MspI restriction enzyme. Dendrogram of 23 isolates showed 56% similarity among the different isolates on LB media. Soil community DNA was amplified using Bac 16S rRNA primer. Further, attempts are underway to standardize DGGE for studying the total microbial diversity.

Establishment of Cyanobacteria in Rice Soils

Inoculation of a combination of four cyanobacteria showed maximum nitrogen fixing ability (ARA). PCR based amplification profiles were generated for the four cyanobacterial strains using nine repeat sequence primers. Among them, three primers - STRR 1a, STRR mod and HIP TG proved discriminative and were useful in analyzing the establishment of the inoculated cyanobacterial strains in soil microcosms. (IARI, Delhi)

Organics Influence on Microbial Community and Nitrogen Transformation Genes

In a 100 year old permanent manurial trial (TNAU, Coimbatore) organic manured soil had higher organic C, N, total culturable bacteria, fungi and diazotrophs than the one in which only chemical inputs (100% NPK) were added. Differences in molecular level diversity of bacterial communities in both the soils were done by genome analysis. The V1 + V2 domain of 16S rRNA with a size of about 335 bp was amplified by PCR and further cloned in *E. coli*. For V1 and V3 regions, the amplification was not up to the level for cloning. The variability between the organic farming soil and chemical fertilizer applied soil is higher in the V1 + V2 domain. The transformants obtained are under screening for variability and will be analyzed through DGGE in further studies.

MIXED BIOFERTILIZERS

Bacillus on Rice

Nitrogen-fixing Bacillus strain TNAUB3 isolated from rice roots was field evaluated in a consortium with Azophos on rice var. ADT 43. Inoculation in the presence of 100% NP gave rice yield of 5432 kg ha^{-1} which was 15% higher over control. Inoculation with 75% NP gave rice yield of 5096 kg ha^{-1} which was 7.5 % higher than 100% NP (TNAU, Coimbatore).

PSB inoculation of Sali Rice

The PSB isolates 5W, 28 and 24 are now being extensively used as phosphatic biofertilizer for rice based cropping system in Assam. When inoculated along with Azospirillum in presence of 10 kg P_2O_5 as rock phosphate on rice var. *Ranjit* with 50% P application, yields were comparable to recommended doses of P (AAU, Jorhat).

Organics for Rice Production

In an evaluation of different organic nutrient inputs *viz., Azolla caroliniana, Sesbania rostrata,* enriched compost, Azolla compost, Azorhizobium and biofertilizers in combination with 50% recommended NP on organic rice production, Azolla dual culturing followed by in situ incorporation of *Sesbania rostrata* gave the highest grain yields (AAU, Jorhat).

INM Package for Rice Based Cropping System

Application of Biofertilizer enriched compost at 1 t ha^{-1} along with 50 % recommended doses of N and P gave the highest rice yield of 3.9 t ha^{-1}. *Toria* responded even better under 25% NP (10.5 q ha^{-1}) coupled with enriched compost (2 t ha^{-1}) (AAU, Jorhat).

Bionutrient package for Rice in Bihar

A microbial based bionutrient package consisting of *Azospirillum*, enriched mycostraw (spent residue + *Pseudomonas* sp.) and tobacco waste based cyanobacteria was formulated and tested on rice crop. Inoculation increased the colonization of root by *Azospirillum*, higher ARA activity of rice roots and of phototrophic nitrogen fixers in vivo. Grain yield was in the following order: 100% NPK + bionutrient package (40.0 q ha^{-1}) > 100% NPK (36.1 q ha^{-1}) > 50% NPK + BP (35.2 q ha^{-1}) > BP (30.3 q ha^{-1}) > 50% N (28.90 q ha^{-1}) > control(19.2 q ha^{-1}). Bionutrient package could substitute about 50% of the nutrients. The soil organic carbon content was increased by 6.3, 8.5 and 10.6% due to bionutrient package application alone or alongwith 50% or 100% NPK respectively. (RAU, Bihar)

Maize

Maize rhizosphere in vertisols was dominated by *Azospirillum*. Inoculation of AZS 711 + PSB+ PFM1 with 100% RDF gave maximum cob yields of maize (6703 kg ha^{-1}) which was significantly higher by 12.2 % over 100% RDF (ANGRU, Amaravathi).

Sorghum

Application of 100% RDF alongwith co-inoculation of Azospirillum and PSB on sorghum gave highest grain yield (2647 kg ha^{-1}). Fodder yield of sorghum improved materially in 100% RDF alongwith dual inoculation. Interaction effect was also reflected on N uptake by sorghum crop (MAU, Parbhani).

Pigeonpea

Inoculation in the presence of 100% RDF increased the *Rhizobium*, free diazotrophs, PSB and total bacterial population to the maximum extent along with highest nodulation (42 plant^{-1}) and available P content which was significantly higher than 100% RDF. Heavy colonization of arbuscular mycorrhizal fungi was found on pigeon pea roots. The treatment of 50% RDF with inoculum mix gave higher grain yields than 100% RDF. Inoculation along with 100% RDF gave maximum grain yield (2465 kg ha^{-1}) which was 28.8% higher over 100% RDF (ANGRU, Amaravathi).

Chickpea

Application of 100% RDF along with co-inoculation of *Rhizobium* and PSB on chickpea produced maximum grain yield (1955 kg ha^{-1}), which was 20% higher over uninoculated. Yield attributes, N and P uptake were also improved. However, 75 % RDF and biofertilizers improved the weight of nodules as compared to 100% RDF (MAU, Parbhani).

Soybean

Application of 100% RDF along with co-inoculation of *Bradyrhizobium* and PSB on soybean gave highest grain yield (2161 kg ha-1), which was 18% higher over uninoculated. About 22-38 kg ha^{-1}N was fixed in soil by Bradyrhizobium seed inoculation by soybean. There was significant improvement in soil microbial population by 75% RDF with dual inoculation of biofertilizers (MAU, Parbhani).

Groundnut

Mixed biofertilizers were developed for groundnut, combinations of mutually compatible strains of PGPR (*Pseudomonas sp*. C185*; Pseudomonas sp*. ACC3), PSB (*Pseudomonas sp*. ACC10 and *Bacillus megaterium*) and rhizobia (NRCG 22 and TAL 1000) and tested in field conditions. In rabi-summer 2008 inoculation enhanced pod yield by 11-21%. Maximum increase was obtained with mixture of PSM and groundnut rhizobia. In kharif 2008, application of PGPR, PSB and rhizobia resulted in 8% enhancement in pod yield (NRCG, Junagadh).

Inoculation of Rhizobium (GNB714) + PSB + PGPR with 100% RDF recorded highest nodulation, available phosphorus and gave good build up in various microbial groups and pod yield (1785 kg ha^{-1}) which was about 19% greater than the uninoculated crop grown with 100%RDF (ANGRAU, Amaravathi).

Safflower

Application of 100% RDF alongwith co-inoculation of *Azotobacter* and PSB significantly increased growth and yield attributes of safflower and produced maximum seed yield (2012 kg ha^{-1}), which was 17% higher over uninoculated. There was significant improvement in microbial population by 75% of RDF with dual inoculation of biofertilizers at rosette stage of safflower (MAU, Parbhani).

BIOFERTILIZER TECHNOLOGY

Liquid Inoculants Technology

Liquid inoculants coated seeds could be stored up to 24 hrs for sowing whereas carrier based inoculums coated seeds have to be sown within 4 to 8 hrs. A dose of 4-5 ml of liquid inoculums having a population of $3x10^9$ cells per ml is enough to coat one kg seed. Liquid biofertilizer entrapped into granular form was prepared for easy application and is under evaluation on black gram (ANGRAU, Amaravathi).

Delivery System for Inoculants

To identify suitable delivery system(s) for the consortium of beneficial bacteria various consortia were applied either through irrigation water or seed treatment or furrow application through carriers like talcum, kaoline, FYM, soil, charcoal, etc. Application of bacterial consortium in furrows through talcum powder as carrier resulted in significant enhancement of pod yield (15%) (NRCG, Junagadh).

DIVERSIFICATION OF BIOFERTILIZERS

Tropical Vegetables

Field experiments were conducted with Spine Gourd and Sweet Potato at Bhubaneswar (Soil pH 5.7), Broccoli at Keonjhar (pH 6.7) and Capsicum at Kendrapara (pH 6.2) districts of Orissa during *kharif* and *rabi* 2008-09. Spine Gourd (seedlings produced from cuttings) responded positively to fertilizer application, soil amelioration and bio-inoculation (*Azotobacter*+*Azospirillum*+ PSB - 1:1:1 inoculated and incubated with FYM). Soil amelioration with paper mills sludge alone resulted in 21% increase, bio-inoculation alone by 33% and two together by 46%

compared to the yield of 36.2 q ha^{-1} obtained with 100% NPK dose. In sweet potato bioinoculation with 50% NPK gave tuber yield (19.4 t ha^{-1}) that was at par with 100% NPK (19.6 t ha^{-1}). Integration of bio-inoculation with 75% NPK dose yielded significantly higher (10%) tuber yield (21.4 t ha^{-1}). In Broccoli, use of BIs yielded 34% higher broccoli curds (21.4 q ha^{-1}) compared to the absolute control yield (16 q ha^{-1}). However, its integration with 75% and 100% NPK dose of chemical fertilizers yielded 53 and 39% higher yields of curds compared to the yield of 79.6 and 96.7 q ha^{-1} respectively. The Capsicum crop in Kendrapara district yielded 28% higher fruits due to integration of BIs with 100% NPK dose (93 q ha^{-1}) (OUAT, Bhubaneshwer).

Temperate Vegetables

Inoculation of a *Rhizobium leguminosarum* strain that could also solubilize insoluble phosphate and was highly tolerant to carbendazim (1000µg ml^{-1}) at three locations in Himachal Pradesh gave an increased yield of pea by 9% over 100% N dose due to rhizobial inoculation alone (YSPHUT, Solan).

Biocontrol in Apple

Inoculation of *Bacillus megaterium* on grafted apple plants in nursery resulted in increase in root and shoots length, root and shoot dry weight of one year old plants from 18 to 25%. These treated plants were distributed to farmers in Himachal Pradesh for further evaluation at different locations (YSPHUT, Solan).

4.8 Amelioration of Contaminated Soils

4.8.1 Developing database on extent of soil and water contamination in India

Soil and water pollution in Pithampur (Dhar) Industrial Area : a case study

Environmental quality is one of the major issues and concerns worldwide. Of particular importance is the protection and sustainability of valuable soil and water resources. In modern economies, various types of activity, including agriculture, industry and transportation, produce a large amount of wastes and new types of pollutants. With increasing human population, concentrated animal production areas and expanding industries, safe disposal of by-product materials is becoming a greater challenge. Often, agricultural, industrial and municipal by-products are applied to land. While they can be beneficial to plants and soils, there can be negative impacts on soil and water quality. Therefore, a geo-referenced survey was undertaken during May 2008 from Pithampur, Dhar (Madhya Pradesh) industrial area, which is the largest industrial center in Madhya Pradesh (Fig. 4.8.1). The areas receiving the effluents discharged from various industries (textile, biochemical processing, food processing, automobiles etc.) and fields situated near industries were selected for soil and water/effluents sampling and 42 soil and 39 water/effluents samples were collected. The collected soil and effluents/water samples were processed and analyzed for heavy metals and other chemical parameters.

Fig. 4.8.1. Industrial effluents in local nallah at Pithampur Industrial Area

The result showed that the water of wells and tube wells in Cheerakhani and Silotia villages near to the industrial area is categorized as high salinity EC (1.91 4.07 mS cm^{-1}) and sodium hazard (SAR > 10) and about 82 % of the samples have potential for severe Cl^- (>10 me L^{-1}) hazard permitting their use as irrigation in tolerant crops. The EC of some of the tube well water of polluted villages have gone up more than 2.5 m S cm^{-1} indicating that effluents of industrial area have contaminated the ground water. The ground water samples of polluted area contained, on an average, 84.2 µg L^{-1} Cr, 3.7 µg L^{-1} Pb and 1.2 µg L^{-1} Cd. Surface soil samples of ground water polluted area of Cheerakhani and Silotia villages had, higher EC (3.4 times) and SAR (3.1 times) (Fig. 4.8.2). The soils of polluted villages (Cheerakhani and Silotia) showed considerable accumulation of Na^+, Cl^-. The soil receiving polluted ground water also high in chromium (83-252 mg kg^{-1}) and manganese (710 -1341 mg kg^{-1}).

Fig. 4.8.2. Salt accumulation in soils at Cheerakhani and Silotia villages in Pithampur receiving polluted irrigation water

Mercury Pollution in India (Survey report)

A global warning has been sounded. A recent meeting of the Governing Council of the United Nations Environment Program (UNEP) concluded that the global risk to humans and animals from the release of mercury into the environment is so high that immediate international action is needed to identify groups at risk and to reduce human-generated mercury releases.

Mercury occurs as a result of both natural and anthropogenic sources in our environment. The cycle involves different forms and types of mercury as a result of both chemical and biological reactions in aerobic and anoxic microenvironment. Mercury distribution in the environment has been a focus of scientific attention because of the potential health risks posed by mercury exposure. The atmosphere is the dominant transport vector of mercury to most ecosystems. Most of the mercury found in the atmosphere is elemental mercury vapour, which circulates in the atmosphere for up to a year, and hence can be widely dispersed and transported thousands of miles from likely sources of emission. Most of the mercury in water, soil, sediments, or plants and animals is in the form of inorganic mercury salts and organic forms of mercury (for example, methyl mercury). Organic mercury, mostly methyl mercury (MeHg) the most toxic species is bioaccumulating in the biota and subsequently biomagnified in the aquatic food chain, especially in fish. The major sources of mercury pollution in India are chlor-alkali industries, industrial processes in thermal power plants, steel and cement industries, coal fired power and heat production, mercury-containing products such as thermometers, blood pressure equipment, pesticides, dental amalgam, and waste incineration processes. Plastic industry (mercury is used as a catalyst), pulp and paper industry, medical instruments and electrical appliances, certain pharmaceutical and agricultural product accounting for additional consumption of mercury. India consumes 510 million tonnes of coal in 2007-08 in various thermal power plants, steel industries and cement productions (www.mjunction.in/market_news/**coal**_1/**india**s_200809_**coal**_**consumption**.php). Coal contains mercury ranges between 0.01 to 1.1 ppm (average 0.25 ppm Hg) and its combustion as a source of energy is often sited as significant source of mercury emission (100-110 t Hg). Mercury levels are reported to be extremely high in the working environment of these industrial processes including thermometer factories. Mercury contamination in water in India is verging on alarming situation due to discharge of industrial effluents containing mercury ranging from (0.058-0.268 mg l^{-1}) against 0.001 mg l^{-1}. as per WHO and Indian standards (Table 4.8.1). Mercury levels in water near caustic chlorine industry has been reported as high as 0.176 ± 0.0003 mg l^{-1}. in water and 596.67 ± 25.17 mg kg^{-1} dry wt. soil against the prescribed limit of 0.001 mg l^{-1}. in water and 0.05 mg kg^{-1} in soil (R C Srivastava, 2002, co-chairperson of the Mercury Assessment Group, UNEP; http://www.cseindia.org/dte-supplement/global-warming.htm).

Table 4.8.1. Level of Mercury in Industrial Effluents

Sl. No.	Industrial effluents location	Hg concentration (mg l^{-1})
1	Industrial Area, Panipat (Haryana)	0.268
2	Barsai Road, Panipat (Haryana)	0.074
3	Machua Village,Vatva (Gujarat)	0.115
4	Lali Village,Vatva (Gujarat)	0.211
5	Chiri Village, Vapi (Gujarat)	0.096
6	Sarangpur Village, Ankleshwar (Gujarat)	0118
7	Bapunagar, Ankleshwar (Gujarat)	0.176
8	Pocharam Village, Patancheru (Andhra Pradesh)	0.058
	Permissible limit (industrial effluent), India	0.01

Source: Down to Earth, August 31, 1999

The mercury consumption in Indian caustic chlorine companies is at least 50 times higher than the global best companies. They alone contribute to about 40% of the total mercury pollution in the country. As much as 44% of mercury consumed by mercury cell companies are released into environment through unknown sources. On an average, 47 g mercury is lost in the production of 1 tonne of caustic soda in the Indian caustic- chlorine industry. This mercury loss is based on the total caustic soda production, irrespective of the production process. The average specific mercury loss from mercury cell plants in India is about 142 g MT^{-1} NaOH produced. More than 1,000 tonnes of mercury remains in the inventory of industry and 8 to 10% is the annual replenishment. For producing 0.5 million tonnes caustic soda, the total annual consumption of mercury in Indian caustic-chlorine industry is about 70 - 100 tonnes (http:// www. cseindia.org/dte-supplement/who-responsible.htm).

A case study on mercury pollution in soils nearer to the chlor-alkali industries suggest that the mercury content

Table 4.8.2. Mercury content in soil samples collected within and outside the caustic soda industries

Name of caustic soda industries	Distance from mercury cell	Mercury content (ppm)
Hukumchand Jute Industries	Near the mercury cell room	0.028
(GMMCO Ltd.), Amlai, M.P.	Within the plant but away from the mercury cell room	0.054
	1 km away from the plant premises	0.174
Bihar Caustic & Chemicals	Near the HCl tank	0.006
Ltd., Daltonganj	500 m away from the plant premises	0.016

Source: Down to Earth, October 31, 2003

in the soil outside the plant premises were higher (Table 4.8.2) than that within the plant. Mercury has a long retention time in soils. As a result, mercury that has accumulated in soils may continue to be released to surface waters and other media for long periods of time, possibly hundreds of years.

Technologies and practices to control mercury pollution

The chlor-alkali plants and paper industries using mercury cell as the electrolytic cell are the main cause of mercury pollution. The mercury cell chlor-alkali plant is reported to discharge mercury in wastewater in the range of 0.08-2mg l^{-1}. The phase out of this obsolete technology is very slow. The government and the industry should both play a proactive role in phasing out these obsolete technologies. The units owned by the public sector, which produce chlorine using mercury cell technology, should lead the way in the phase out in the interim. Other industries discharging mercury-contaminated wastewaters include mining, smelting, tars and asphalt, coke ovens, textiles and those manufacturing cements, catalysts, paints, pesticides, pharmaceuticals, and batteries. The maximum limit for the presence of mercury in the industrial effluents, as per Indian Standards, is 0.01 mg l^{-1}. The pollution can be substantially reduced either by the use of some other metal electrodes (titanium substrate insoluble anodes) and electrolytic cell (Electrolytic cells) in the chlor-alkali plants or by the effective treatment (Micro-organism based technology mercury resistance strains of *Pseudomonas*; use of low cost Resins - grafted coconut husk; precipitation of mercury by a more reactive metal, such as Al, Fe, Cu, Zn etc., and also as mercuric sulphide using sulphide reagents) of the effluents from these polluting industries. Controlling mercury emissions through end-of-pipe techniques, such as exhaust gas filtering, is appropriate for raw materials with trace mercury contamination, including fossil-fueled power plants, cement production etc. (www.toxicslink.org/docs/06035_publications-1-33-3.pdf and www.envisnioh.org/**Mercury-**Exposure/and/effects.pdf).

4.9 Recycling and Rational Usage of Different Waste in Agricultural Soils

4.9.1 Investigation on the effect of continuous use of sewage water as irrigation on the swell-shrink soil quality

Nutrient potential of sewage water in soybean wheat cropping system in Vertisol

Response of soybean to sewage water application

Field experiment has been initiated in IISS farm to study the nutrient potential of sewage water. Tenth crop of soybean (var. JS 335) was grown on rainfed during kharif (with RDF) with uniform RDF doses and the eleventh crop of wheat (var. WH-147) was grown after soybean during rabi with 6 irrigations of 5 cm each (including one pre-sowing irrigation). Wheat (var. WH-147) was grown with two irrigation treatments

Table 4.9.1. Residual effect of sewage irrigation on different growth and yield attributes of soybean

	W_1	W_2	(% change)
Plant height (cm)	67.5	105.1	56
Total dry wt. (g plant^{-1})	19.9	35.8	80
No. of branches	5.2	7.2	38
Leaf area (cm^2 plant^{-1})	1971	2783	41
Grain Yield (g m^{-2})	85.1	136.5	60
Straw Yield (g m^{-2})	318.5	708.3	122
Test wt. (g 100 seed^{-1})	7.3	7.5	3
Oil content (%)	20.0	20.1	0.6

(W1: ground water and W2: sewage water) and four nutrient treatments (T_1: 0, T_2: 100%, T_3: 50% and T_4: 50% of recommended doses of NPK+ FYM @10 t ha^{-1}) with three replications. Recommended dose of fertilizer for wheat was 120 kg N, 26 kg P and 50 kg K ha^{-1}. Soybean was grown after wheat crop with recommended dose of fertilizers.

Plant height, no. of branches plant^{-1}, leaf area plant^{-1} were 56, 38 and 41% higher in the plots previously irrigated with sewage water (in wheat) as compared to those previously irrigated with groundwater. Residual effect of sewage irrigation to previous wheat crop has also been found as increases in the grain yield (60%) and straw yield (122%). There was no significant change in the test weight of soybean seed and its oil content (Table 4.9.1).

Available major nutrient status in the soils during soybean growth period

Soil samples were collected from surface layer of the plots during flowering stage of soybean crop. Soils, after processing were analyzed for available major nutrient contents. Average available N, P and K contents in the previously sewage irrigated plots were about 167, 49 and 14% higher than soils previously irrigated with groundwater (Fig. 4.9.1).

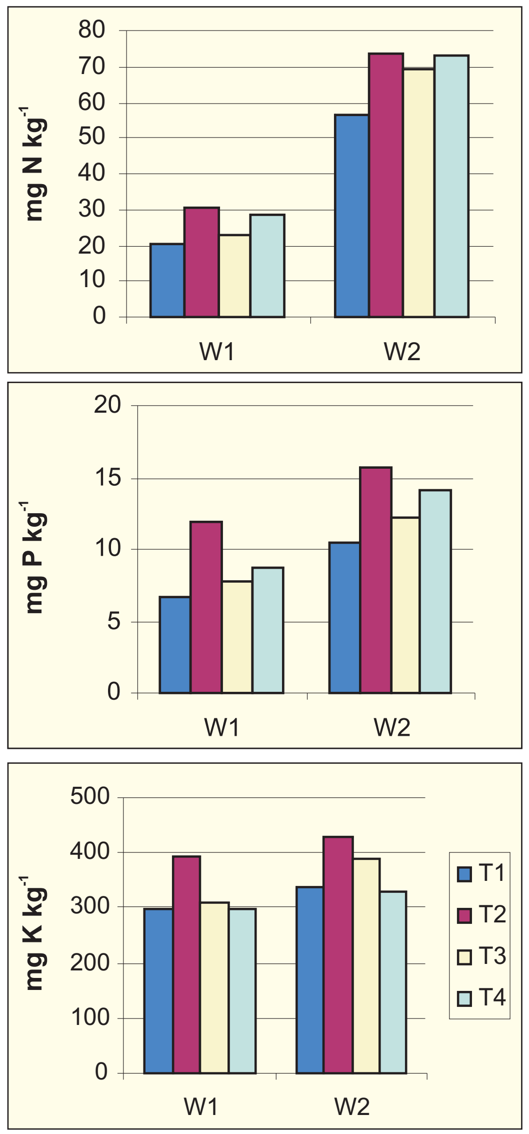


Fig. 4.9.1. Effect of irrigation and fertilizer treatments on available N, P and K content (mg kg^{-1}) in soil

Contents of micronutrients in wheat grains collected from farmers fields of sewage grown area

Composite samples of surface soil and wheat grain were collected from wheat growing farmers' fields of sewage-irrigated area (village: Raslakhedi) as well as from nearby groundwater irrigated area (village: Sagwani) near Bhopal city. The soil samples and grain samples were processed and analyzed for available Zn, Cu, Fe and Mn contents. Significantly higher content of available Zn (245%), Cu (16%) and Mn (42%) was observed in the sewage irrigated soils; however no significant differences was observed in case of available Fe content (Fig. 4.9.2). Such increases in available Zn and Cu were not reflected in their contents in wheat grain. Average contents of Fe and Mn in wheat grains of sewage irrigated area were about 10 and 16% higher as compared to those in groundwater irrigated area (Fig. 4.9.3).

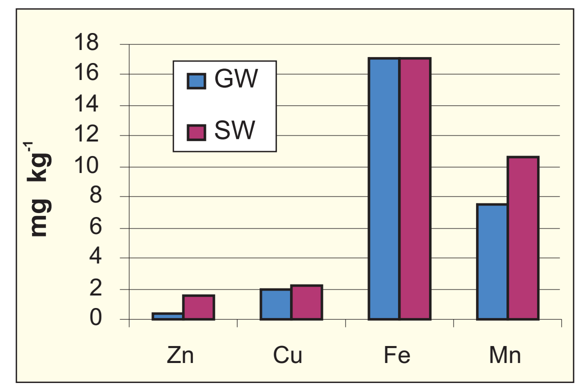


Fig. 4.9.2. Changes in available micronutrients status in soils of farmers' fields due to long-term sewage irrigation

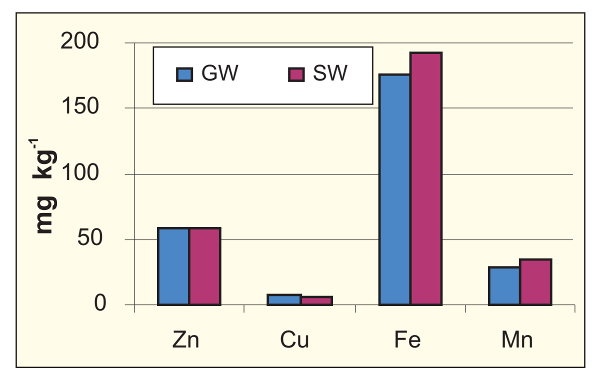


Fig. 4.9.3. Contents of micronutrients in wheat grain collected from farmers' fields

4.9.2. Developing quality indices of urban waste composts

Determination of lead and cadmium concentration limits in agricultural soil and MSW compost through an approach of zero tolerance to food contamination

Information on cumulative loading limits (CLL) of heavy metals for agricultural soils is essential for taking policy decisions with respect to their unavoidable additions in crop lands and thereby protecting the environment. A screen house pot experiment (in separate batches for Cd and Pb) have been conducted on a representative light textured acidic soil (Haplaquept, pH: 4.95, clay: 14.7%) using spinach crop with the objective of determining CLL of Pb and Cd applied through MSW composts (Fig. 4.9.5). In this approach of the study, the CLL for Pb and Cd has been defined as the maximum amount of heavy metal additions in the soil, which do not increase their concentrations in the edible food crop above the background level (*i.e.,* concentration range found in the crop grown in uncontaminated area).

Lead and Cd were applied at graded levels of application doses from 0.4 to 150 mg Pb kg^{-1} and 0.02 to 20 mg Cd kg^{-1} soil. All the treatments were replicated four times. Half of the heavy metal additions were provided through their inorganic (nitrate) salts directly to soil and remaining amounts were added through heavy metal enriched MSW compost collected from Vijaywada city. The MSW compost was applied to soil @ 50 g kg^{-1} and mixed thoroughly. Spinach crop was grown for 50 days in the pot containing 5 kg treated (for 60 days) soils. At the end of growing period, leaves were harvested, processed and analyzed for Pb and Cd. In order to determine the background concentration level, leaf samples of spinach crop and soil samples were collected from 30 farmers' field from the experimental area and were analyzed for Pb and Cd.

The upper limit of background metal concentration was calculated as:

$C_{ul} = \bar{x} + 3*\sigma$ .... (1) or 4.9.1

Where, $\bar{x}$ is the mean value of metal concentration in spinach leaf in control treatment (Pb_1 or Cd_1) of screen house experiment and σ is standard deviation of the metal concentrations in spinach leaf from farmers' fields. Uptake response slope (UR) was calculated for the best fit regression line (passing through origin) obtained for soil-Pb or soil-Cd ('x' axis) and tissue-Pb or tissue-Cd ('y' axis). Maximum concentration of metals allowed in soil and CLL for these metals were calculated as:

Maximum concentration of metal allowed in soil = C_{ul}/UR .... (2) (4.9.2)

CLL = C_{ul} / UR metal concentration in uncontaminated soil ...... (3) (4.9.3)

Effect on metal concentrations in plant tissue

Tissue-Pb concentration as well as Pb-uptake correlated significantly (r = 0.917*** and 0.817**) with soil-Pb. Tissue-Cd concentration as well as uptake correlated significantly (r = 0.972*** and 0.900*** respectively) with soil-Cd up to 16 mg Cd kg^{-1} level of addition (Fig. 4.9.4).

Cumulative loading limits for Pb and Cd

Lead and Cd content in spinach leaf samples collected from farmers' fields varied from 0.6 to 6.6 and from trace to 3.8 g g^{-1} with mean values of 2.9 and 0.5 g g^{-1} and standard deviation (σ) values of 1.39 and 0.74 g g^{-1}, respectively. Upper limits of background concentration (C_{ul}) for Pb and Cd in spinach leaf for uncontaminated area were calculated using the equation (4.9.1), as 7.11 and 2.52 g g^{-1} respectively.

Uptake response slopes (UR) for Pb and Cd were computed as 0.084 and 7.524, respectively. Maximum

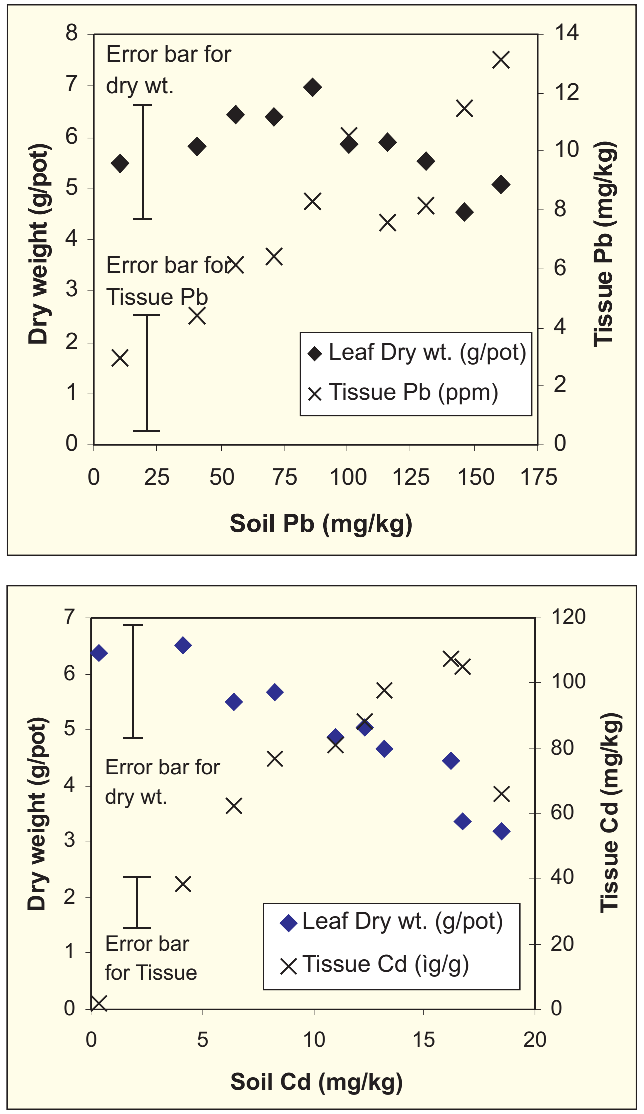


Fig. 4.9.4. Effect Pb and Cd concentrations in soil on their concentrations in spinach leaf tissue as well as on dry weight of above ground biomass

concentrations of metals in the experimental soil that might not contaminate spinach leaves were calculated using equation (4.9.2), as 85.7 mg Pb kg^{-1} and 0.55 mg Cd kg^{-1}. Cumulative Loading Limit for Pb and Cd were calculated using equation (4.9.3), as 73.73 mg Pb kg^{-1} soil and 0.33 mg Cd kg^{-1} soil respectively, which are equivalent to about 170 kg Pb ha^{-1} and 0.8 kg Cd ha^{-1}, respectively.

On the basis of computed CLL values, maximum

Fig. 4.9.5. Cadmium had higher adverse effect on growth of spinach compared to lead

permissible Pb and Cd concentrations in the compost were computed as 170 mg Pb kg^{-1} and 0.8 mg Cd kg^{-1} respectively, assuming cumulative allowable MSW compost application rate in crop land as 1000 Mg ha^{-1} during the 100 years of recycling programme.

As the experimental soil is acidic in nature and contains lower levels of clay, organic matter, oxides of Fe, its metal immobilizing capability is expected to be low. Hence, the regulatory limiting values, viz., maximum concentration limit and cumulative loading limit for agricultural soil as well as maximum permissible concentrations of Pb and Cd in MSW compost determined for such a sensitive situation, (*i.e.,* low metal fixing capacity of soils and growing crops with high uptake capacity) can protect the food crops from their contamination in all other agroecological situations in India.

Effect of lead on microbial activity in soils

Heavy metals have considerable influence on microbiological activities in soil. For the purpose of understanding role of Pb on soil microbial activity, a laboratory incubation study was conducted on two contrasting soils; heavy textured mild alkaline swell-shrink soil of Bhopal and light textured acidic alluvial soil of Coochbehar. Soils were incubated with Pb loading rates of: 0 (absolute control, without MSW compost), 0.4 (Pb_0), 30 (Pb_1), 60 (Pb_2), 90 (Pb_3), 120 (Pb_4), and 150 (Pb_5) mg Pb kg^{-1} soil, half of which was added through MSW compost and remaining was added directly to soil. Treated soils were incubated for 180 days at alternate wetting & drying condition at 25°C and were periodically analyzed for different indicators of microbiological activity *viz.,* soil respiration, activities of dehydrogenase, acid and alkaline phosphatase.

Effect of Pb contamination on dehydrogenase activity

Application of Pb did not have any significant effect on dehydrogenage activity (DHA) up to 30 days period. In acid soil, application of lower doses of Pb (≤ 90 mg kg^{-1}) maintained higher DHA compared to treatment of uncontaminated MSW compost (Pb_0) (Fig. 4.9.6). Application of higher doses of Pb (>120 mg kg^{-1}) decreased DHA significantly in both soils, the adverse

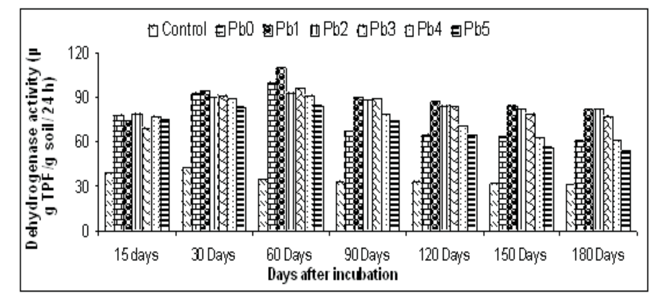


Fig. 4.9.6. Effect of Pb contamination on dehydrogenase activity of acidic alluvial soil

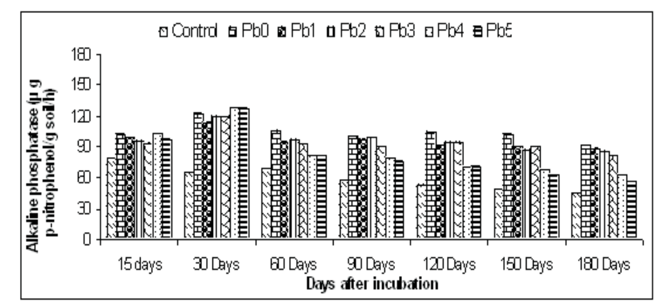


Fig.4.9.7. Effect of Pb contamination on alkaline phosphatase activity of acidic alluvial soil

effect being more in acid soil compared to black soil.

Effect of Pb contamination on alkaline phosphatase activity

In acid soil, Pb contamination did not have significant effect on alkaline phosphatase activity (AlkPA) upto 30 days of incubation (Fig. 4.9.7). During subsequent period, however, Pb contamination (particularly at higher doses) had adverse effect on the activity of this soil enzyme. In black soil, however, it did not have any significant effect on this enzyme.

Effect of Pb contamination on acid phosphatase activity

Contamination with Pb at higher doses (≥120 mg kg^{-1} soil) had significant decreasing effect on acid phosphatase activity (AcPA) after 90 days of incubation (Fig. 4.9.8). In black soil, however, Pb contamination, even at higher doses did not have

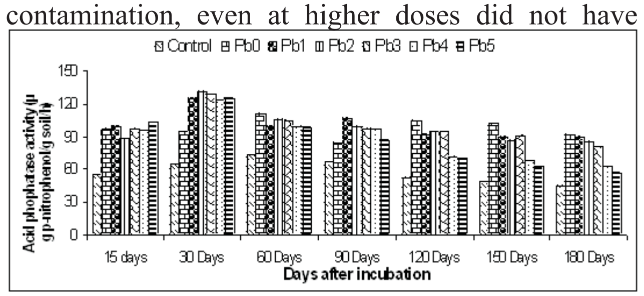


Fig. 4.9.8. Effect of Pb contamination on acid phosphatase activity of acidic alluvial soil

Effect of Pb contamination on soil respiration

Lead contamination resulted in increased soil respiration (CO_2 evolution) during initial period (30 to 45 days of incubation). However, at later days, it did not have any significant effect on soil respiration in both acid and black soil.

4.9.3. Impact of Linear Alkylbenzene Sulphonate (LAS) and Sodium Tri poly phosphate (STPP) present in detergent on crop and soil quality

The dye, methylene blue, in aqueous solution reacts with anionic-type surface active materials to form a blue colored salt. The salt is extractable with chloroform and the intensity of color produced is proportional to the concentration of MBAS (methylene blue active substances).

LAS & STPP content in sewage in Bhopal and some of the major cities of Madhya Pradesh

A survey was conducted to have a estimate of detergent pollution from four cities of Madhya Pradhesh *viz.* Bhopal, Gwaliar, Jabalpur and Bhopal, based on MBAS activity and STPP content in the samples collected and questionnaire filled by the different income categories of respondents. Among the four cities, Indore had the highest content of LAS and STPP (Fig. 4.9.9)

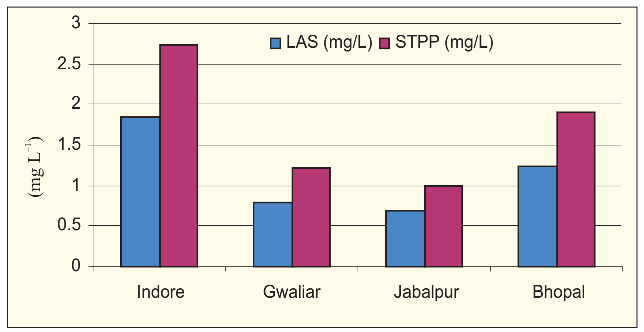


Fig. 4.9.9. LAS and STPP distribution in four cities of MP based on water bodies

The LAS content in residential washout water samples was high (5.04 ppm) as compared to that in water bodies (3.15 ppm). Based on the washout samples from different income group, the average LAS content in MIG (Medium income group) was the highest (6.64 ppm) and the least(1.30 ppm) in LIG (Low income group). On the contrary, the average phosphate content was the highest (12.87 ppm) in HIG (High income group) and the lowest (2.37 ppm) in LIG. Similar trends have been found, except Jabalpur, where HIG is not using very costly detergents. HIG & MIG are polluter of LAS and HIG and LIG in STPP category (Fig. 4.9.10).

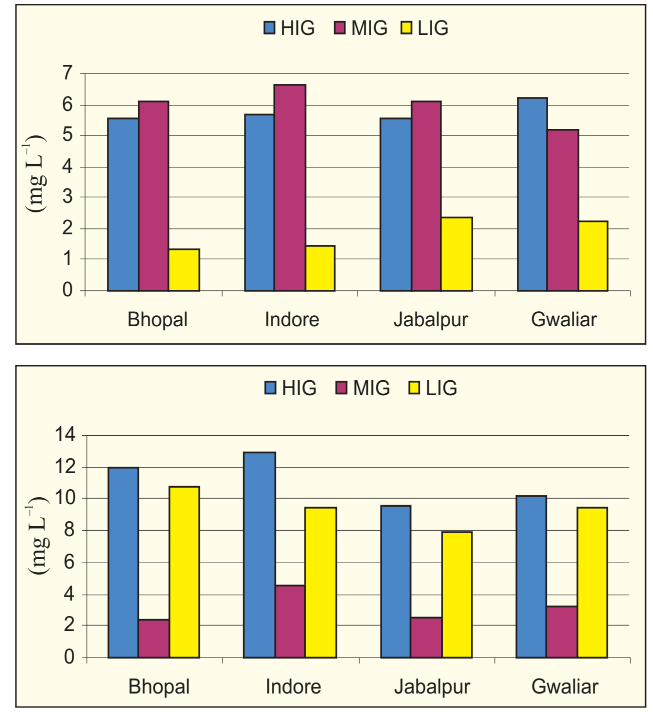


Fig 4.9.10. LAS and STPP distribution in different income group from four cities of MP based on washout samples and questionnaires.

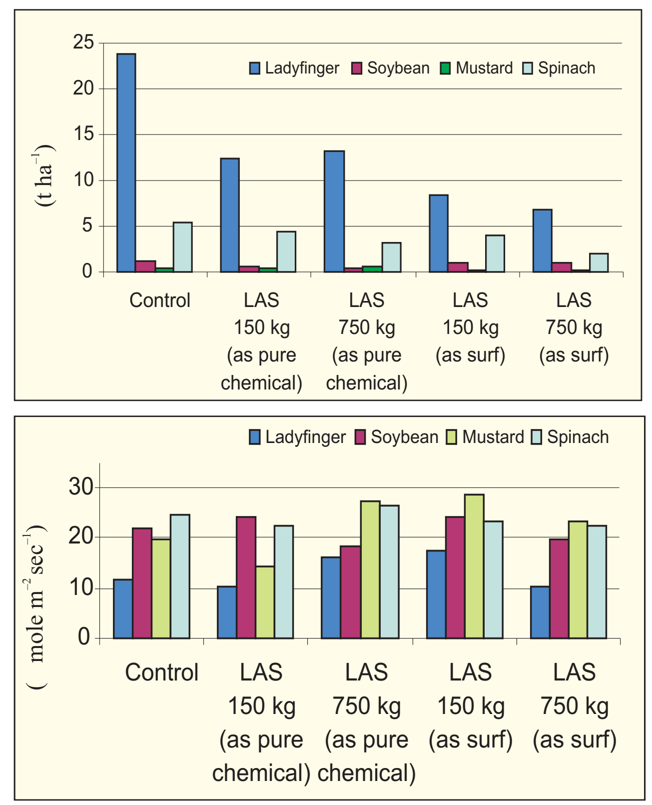


Fig. 4.9.11. Effect LAS (pure chemical and detergent Surf) on productivity and photosynthesis in selected crops.

Effect of Soil application of LAS on Crop Productivity and Biochemical Properties of Soil

During the crop growth period, nitrate reductase activity, chlorophyll a/b ratio, photosynthetic rate were measured before and after flowering. At maturity, yields were recorded. Overall, all the LAS levels showed inhibitory effect on yield level, except in mustard, which seemed to be resistant and even showed increase in yield over control (Fig. 4.9.11).

Pure LAS was found to be less toxic compared to surf applications. Overall the spinach was found to be having highest activities (Fig. 4.9.12).

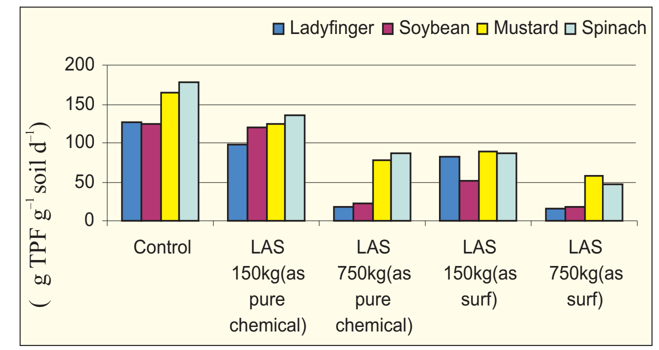


Fig. 4.9.12. Effect of LAS addition in soil on soil dehydrogenase activity with different field crops

LAS & STPP accumulation and biodegradability in long-term sewage treated plots

Estimation of LAS from detergent pollution has been undertaken in the on-going long-term sewage irrigated experiment. The soil samples were collected after five years of continuous application of sewage water and ground water. The results showed that methylene blue active substances were present both in the ground water and sewage water irrigated soils. It was possibly due to the presence of different substances in agricultural soil, such as organic sulfonates, sulphates, carboxylates, phenols, inorganic thiocyanates, cyanates, nitrates and chloride which reacted with methylene blue. However, content of MBAS in sewage-irrigated soils were higher than groundwater irrigated soils. Sewage water irrigated soils has more LAS and STPP (mg kg^{-1} soil) than ground water irrigated soils (Fig. 4.9.13 & 4.9.14).

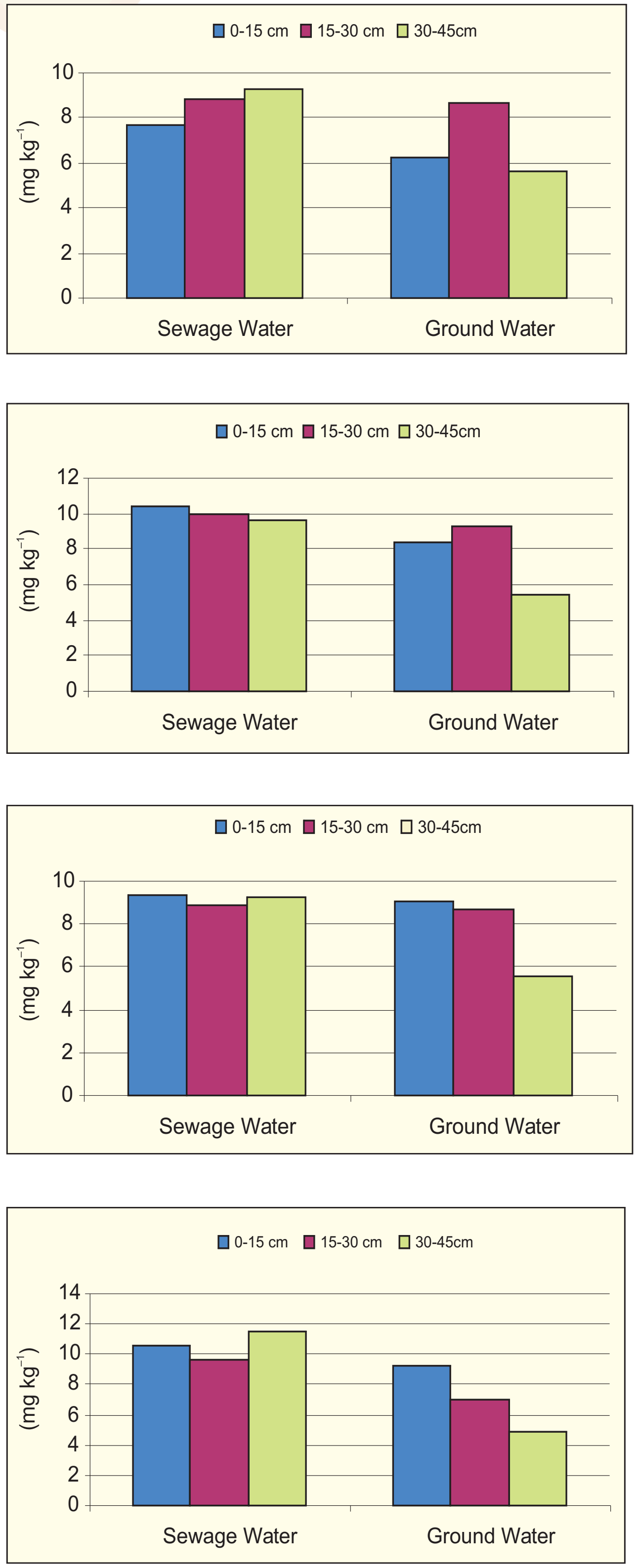


Fig. 4.9.13. LAS concentration from long-term sewage application field at different soil depth.

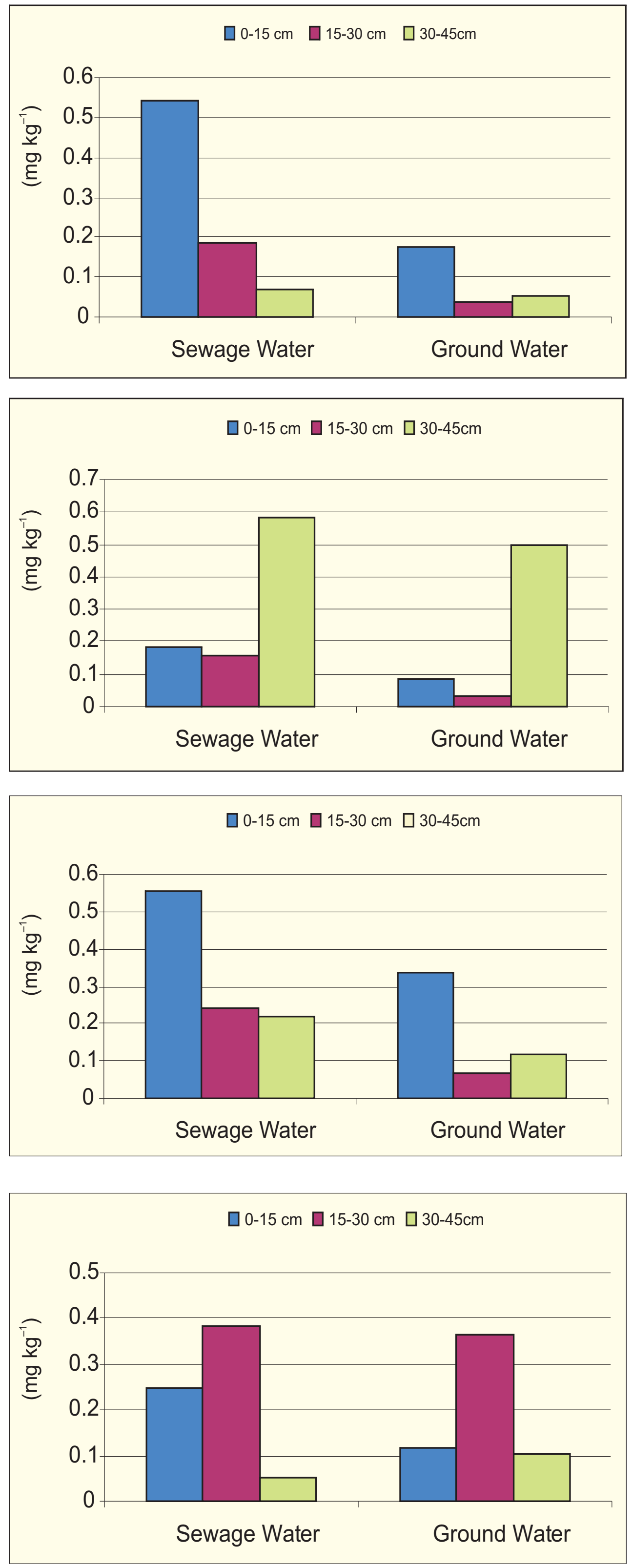


Fig. 4.9.14. STPP concentration from long-term sewage application field at different soil depth

4.10 Organic Farming

Performance of soybean under organic farming system

Field experiment was conducted for the fifth year with three management practices *viz.* 100 % organic, 100 % chemical and integrated nutrient management (50: 50) with four soybean based cropping systems in strip plot design. In organic treatment, well composted cattle dung manure @ 4 t ha^{-1} on dry weight basis (which could supply 30 kg N ha^{-1}) along with rock phosphate @ 100 kg ha^{-1} was applied. In chemical treatment, 30-26.2-16.6 kg ha^{-1} of NPK were applied through fertilizers. In integrated nutrient management, 50 % of nutrients through organic and 50% nutrients through chemical fertilizers were applied. Soybean (JS-335) seed was treated with *Rhizobium* + PSB inoculation and Dhaincha (*Sesbania aculeate*) was planted around the field as a border crop. Plant protection measures like soil application of *Trichoderma viride* and *Beauveria bassiana* and spraying of Neem oil (Azadiractin 0.03 %), NPV, use of pheromone traps and keeping bird perches were adopted in organic management.

Fig. 4.10.1. Dr. M.S. Gill, Project Director, PDCSR and Dr. A. Subba Rao, Director, IISS observing the growth of soybean under organic management

The results indicated that the organic management practice recorded the highest soybean seed yield (2009 kg ha^{-1}) which was 20.7 % higher than the chemical treatment (1664 kg ha^{-1}) and 9.4 % higher than the integrated nutrient management (1837 kg ha^{-1}). This was due to more number of pods/plant (44.6), higher straw yield (3479 kg ha^{-1}) and better harvest index (0.366) in organic compared to other treatments (Table 4.10.1).

Table 4.10.1. Yield attributes and yields of soybean as influenced by management practices

Management Practice	Pods (plant^{-1})	Seeds (pod^{-1})	100-seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
Organic	44.6	2.83	10.24	2009	3479	0.366
Chemical	38.9	2.88	10.25	1664	3198	0.342
Integrated	40.3	2.86	10.39	1837	3407	0.350
CD (P= 0.05)	2.6	NS	NS	124	NS	NS

Table 4.10.2 Quality of soybean as influenced by management practices

Management practice	Protein	Oil	Ash	Methionine	Cysteine	Tryptophane
		(%)			(g 16 g^{-1} N)	
Organic	35.87	18.42	5.26	1.69	1.51	1.90
Chemical	35.14	17.98	5.20	1.64	1.50	1.86
Integrated	35.44	18.39	5.24	1.66	1.51	1.89
CD (P= 0.05)	0.44	0.28	NS	NS	NS	NS

Quality parameter of soybean *viz*. protein and oil were better in the organic than chemical treatment but was on par with integrated nutrient management. However, ash, methionine, cysteine and tryptophane content were not affected significantly among the nutrient management practices (Table 4.10.2).

The post harvest soil analysis data indicated that organic treatment improved the organic carbon and the available P and K status compared to the chemical and integrated nutrient management. Dehydrogenase activity was higher in organic compared to both chemical and integrated nutrient management. However such significant differences were not observed with regard to alkaline phosphatase due to management practices (Table 4.10.3).

Organic nutrient management recorded higher gross returns; net return and benefit cost ratio compared to either chemical or integrated nutrient management (Table 4.10.4).

Table 4.10.3. Soil characters as influenced by management practices

Management Practice	Organic carbon (%)	Soil available nutrients (kg ha^{-1})			Dehydrogenase (g TPF g^{-1} soil d^{-1})	Alkaline phosphatase (g PNP g^{-1} soil h^{-1})
		N	P	K		
Organic	0.70	181.4	27.37	609	99.6	59.8
Chemical	0.56	175.5	20.29	579	89.3	50.3
Integrated	0.64	180.5	23.45	594	90.4	57.5
CD (P= 0.05)	0.04	NS	2.22	14.2	6.2	NS

Table 4.10.4. Economics of soybean grown under different nutrient management practices

Management Practice	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit : cost ratio
Organic	34,232	10,540	23,692	3.24
Chemical	28,542	11,660	16,882	2.44
Integrated	31,436	10,940	20,496	2.87

Survey of certified organic farms in different states

A survey was conducted in Maharashtra, Karnataka, Tamil Nadu (including Pondicherry) Kerala and Uttarakhand involving 10 certified organic farms in each state. The objectives of the survey were to compare the production potential and economics of organic farming and to evaluate the soil quality in comparison to the conventional farming. These farms are currently being certified by NOCA, Pune in Maharashtra, APOF, Bangalore in Karnataka, Control Union (Skal), Indocert, Cochin, IMO, Bangalore and Lacon quality in Tamil Nadu and Kerala and UOCB, Dehradun in Uttarakhand. Replicated soil samples were brought from each certified organic farm and comparable soils from nearby conventional farms for in depth analysis of different soil quality parameters. On an average, the mean land holdings of each certified organic farm was found to be 12.7 hectares. On an average, these farms are under certified organic farms from the last 6 years. The average number of cattle possessed by each organic farm is around 11-12. Different crops grown under these certified organic farms and their productivity levels in comparison to conventional farms were given in the Table 4.10.5.

Table 4.10.5. Productivity of crops (t ha^{-1}) in organic vs. conventional farming

State	Crop	Organic farming	Conventional farming	Per cent increase (+) / decrease (-) in organic farming
Maharashtra	Vegetables	11.0	13.0	-15.3
	Fruit crops	11.4	13.6	-16.1
	Rice	2.0	2.5	-20.0
	wheat	1.2	1.5	-20.0
Karnataka	Soybean	0.9	1.1	-18.2
	Chickpea	0.8	0.8	0.0
	Fruit crops	8.0	9.0	-11.1
	Groundnut	1.2	1.4	-14.2
	Sugarcane	120	140	-14.3
Tamil Nadu & Pondicherry	Cotton	0.6	0.8	-25.0
	Cashew	1.3	1.0	+30.0
	Banana	25.0	30.0	-16.6
	Mango	8.0	6.0	+33.3
	Guava	20.0	23.0	-13.0
	Coconut	28,250 nuts	28,750 nuts	-1.7
	Rice	5.0	6.0	-16.6
Kerala	Pepper	1.38	1.40	-1.4
	Banana	23.6	27.2	-13.2
	Coconut	31,000 nuts	30,500 nuts	+1.6
	Coffee	1.23	1.31	-6.1
	Turmeric	22.5	25.0	-10.0
Uttarakhand	Rice	3.77	3.82	-1.3
	Wheat	3.12	3.92	-20.4
	Potato	12.0	15.0	-20.0
Mean				-9.2

On an average, the productivity of crops in organic farming is lower by 9.2 % compared to conventional farming. There was a reduction in the average cost of cultivation in organic farming by 11.7 % compared to the conventional farming. However, due to the availability of premium price (20 to 40 %) for organic produce in most cases, the average net profit was 22.0 % higher in organic compared to the conventional farming (Table 4.10.6).

Table 4.10.6. Economics of crop production in organic vs. conventional farming

State	Crop	Cost of cultivation (Rs ha^{-1})			Net returns (Rs ha^{-1})		
		Organic farming	Conventional farming	Per cent increase (+) / decrease (-) in organic farming	Organic farming	Conventional farming	Per cent increase (+) / decrease (-) in organic farming
Maharashtra	Vegetables	25,000	26,000	-3.8	25,000	29,000	-13.8
	Fruit crops	70,000	78,000	-10.2	50,000*	47,000	+6.4
	Rice	10,000	11,500	-13.0	20,000*	18,000	+11.1
	wheat	8,000	9,000	-11.1	10,000*	9,000	+11.1
Karnataka	Soybean	7,200	7,800	-7.7	9,000	10,350	-13.0
	Chickpea	6,700	7,250	-7.6	4,700	4,750	-1.1
	Fruit crops	20,000	23,500	-14.9	84,000*	64,500	+30.2
	Groundnut	13,000	14,500	-10.3	17,000	23,000	-26.0
	Sugarcane	55,000	60,000	-8.3	1,01,000	1,08,000	-6.5
Tamil Nadu & Pondicherry	Cotton	10,000	10,000	0	11,000*	10,000	+10.0
	Cashew	12,500	14,000	-10.7	13,500*	6,000	+125.0
	Banana	60,000	80,000	-25.0	2,40,000*	1,70,000	+41.2
	Mango	25,000	30,000	-16.6	1,35,000	90,000	+50.0
	Guava	20,000	25,000	-20.0	80,000	90,000	-11.1
	Coconut	30,000	34,000	-11.7	1,11,250	1,09,250	+1.8
	Rice	25,000	20,000	+25.0	37,500*	40,000	-6.2
Kerala	Pepper	36,500	40,200	-9.2	88,600*	44,300	+100.0
	Banana	61,000	75,000	-18.6	1,94,000*	1,45,000	+33.8
	Coconut	50,000	60,000	-16.6	1,66,000*	1,20,000	+38.3
	Coffee	40,000	54,000	-25.9	75,000*	48,000	+56.2
	Turmeric	87,000	1,40,000	-37.8	1,30,000*	85,000	+52.9
Uttarakhand	Rice	18,000	20,700	-13.0	28,800*	17,750	+62.2
	Wheat	20,000	23,000	-13.0	17,500*	16,000	+9.3
	Potato	20,000	18,000	+11.1	28,000	42,000	-33.3
Mean				-11.7			+22.0

* Premium price (20-40% high) available to organic produce

The soil quality parameters in both organic and conventional farms in different states were given in Tables 4.10.7 and 4.10.8. The results indicated that on an average, there was an improvement in soil physical, chemical and biological parameters in organic farming compared to the conventional farming indicating an improvement in soil health in organic farming.

Table 4.10.7. Soil quality parameters as affected by organic and conventional farms

Parameters	Kerala		Tamil Nadu		Uttarkhand	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
BD (Mg m^{-3})	1.18	1.27	1.24	1.28	1.22	1.25
pH	5.96	5.64	7.71	7.57	7.42	7.40
EC (dS m^{-1})	1.74	1.18	2.85	2.98	5.87	5.85
O.C. (%)	1.55	1.44	1.28	0.84	0.81	0.66
Avail N (kg ha^{-1})	244.4	209.1	183.9	171.4	257.2	246.5
Avail. P (kg ha^{-1})	16.61	13.52	18.02	15.05	36.63	31.60
Avail. K (kg ha^{-1})	337.0	314.7	477.4	411.5	389.2	351.8
Dehydrogenase						
(g TPF g^{-1} soil 24 h^{-1})	53.9	29.8	53.6	39.8	104.0	64.7
Alkaline Phosphatase						
(g PNP g^{-1} soil h^{-1})	77.2	66.2	89.9	76.6	85.3	61.3

Table 4.10.8. Soil quality parameters as affected by organic and conventional farms

Parameters	Maharashtra		Karnataka		All States Average	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
BD (Mg m^{-3})	1.18	1.27	1.24	1.28	1.22	1.25
BD (Mg m^{-3})	1.24	1.28	1.27	1.30	1.23	1.27
pH	5.99	6.01	7.28	6.52	6.86	6.62
EC (dS m^{-1})	0.12	0.12	0.17	0.13	2.15	2.05
O.C. (%)	1.49	1.11	0.98	0.65	1.22	0.94
Avail N (kg ha^{-1})	215.9	150.8	181.2	150.0	216.2	185.4
Avail. P (kg ha^{-1})	10.41	6.60	32.04	36.70	22.72	20.69
Avail. K (kg ha^{-1})	529.4	537.9	422.6	290.8	431.0	381.3
Dehydrogenase						
(g TPF g^{-1} soil 24 h^{-1})	85.3	66.0	118.1	71.6	82.9	54.4
Alkaline Phosphatase						
(g PNP g^{-1} soil h^{-1})	67.1	54.9	59.8	42.8	57.8	45.0

4.11 Crop Adoptability to Climate Change

4.11.1 Diagnosis and Management of Emerging Physiological Disorders of Cotton, Wheat and Soybean in Black Soils of Central India under Changed Climatic Scenario

The physiological, biochemical and nutritive response of plants grown in black soils of central India to some of the changes in climate such as sudden wilt in soybean, senescence of wheat and leaf reddening of cotton was studied in field, pot culture and hydroponics.

Wheat senescence

The total green plus yellow leaf weight and area were on par in (senescent) and NS (non senescent) lines (Fig. 4.11.1A). However, NS lines had greater number, weight and area of green leaves that of S lines and vice-versa for yellow leaves. The root length was longer in S lines but the root volume and weight was less compared to NS lines (Fig. 4.11.1B). The greater number of branching roots and root hairs contributed to the larger volume and weight of NS lines. The rate of water and nutrient uptake was faster in case of NS lines compared to S lines. The nutrient contents in different parts of S and NS lines differed significantly. Both root, green and yellow leaves of S lines were deficit in N, K, Zn, Mn and Fe. The root properties such as low density root hairs and weight observed in S lines could have limited the nutrient uptake. The photosynthesis (Pn) of flag leaf did not differ between the S and NS lines. But the Pn of second and subsequent leaves from top declined in both S and NS, with the decline being steeper in the former lines. Thus, the early senescence observed in S lines could be ascribed to the limited uptake of N, K, Zn, Fe and Mn as a consequence of poor root structure. The early senescence in addition to the reduced photosynthesis resulted in poor grain yield of S lines.

Fig. 4.11.1. Non-senescent and senescent wheat lines at panical initiation (A) plant growth and (B) rooting pattern

Cotton

Amongst the cotton hybrids variability was seen in the occurrence of leaf reddening. Leaf reddening was more in RCH 2 Bt hybrid while it was less prevalent in Bunny hybrid. The occurrence was aggravated under soil moisture depletion, flooding, dry weather, high temperature and plants possessing heavy boll load. Reddening starts from the margin and gradually spreads to the base of the leaf lamina (Fig. 4.11.2). Soil and reddened plant samples collected from Nagpur and Bhopal were analysed for major and micronutrient content. Red leaf plant contained 13, 9.5, 33 and 36 less K, Fe, Mn and Mg, respectively compared to green leaf plants. Maximum decline in these nutrients was seen in leaf followed by stem and roots.

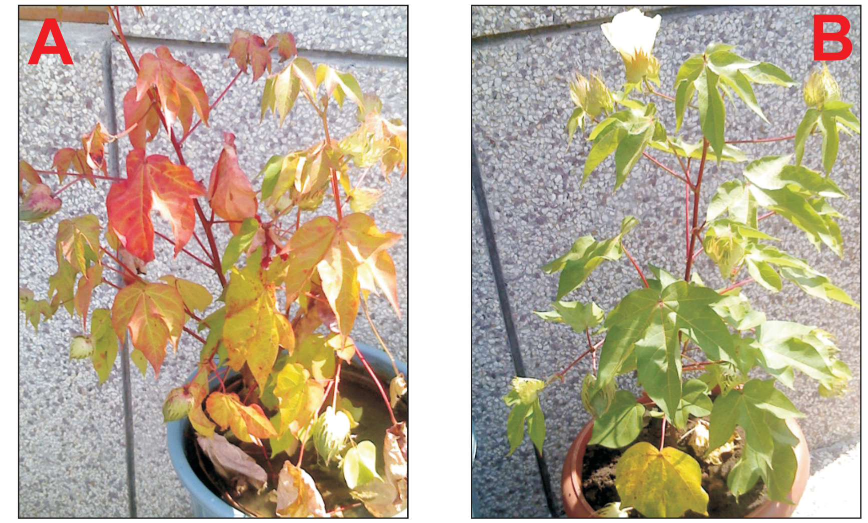


Fig. 4.11.2.Leaf reddening in cotton (A) reddened plant (B) Normal plant

Soybean

A short duration fast growing soybean variety JS-9305 wilted under prolonged moisture stress condition (Fig. 4.11.3). The wilting was sudden and the whole crop collapsed and got devastated within a few days (Fig. 4.11.4). During the same period, another popular variety JS-335 remained healthy and was growing normal. Morphological and physiological investigations revealed that the poor regulation of water use under soil moisture depleted condition caused the wilting in JS-9305 (Fig. 4.11.5). The better stomatal regulation and the consequent moisture conservation on the other hand enabled JS-335 to adapt and survive under adverse environment. Further, it was observed that JS-335 had higher water use efficiency compared to JS-9305. This study suggests that the stomatal regulation is one of the most important traits that need to be incorporated while evolving newer varieties for stress tolerance/resistance so as to make them to adapt to the anticipated drought due to climate change.

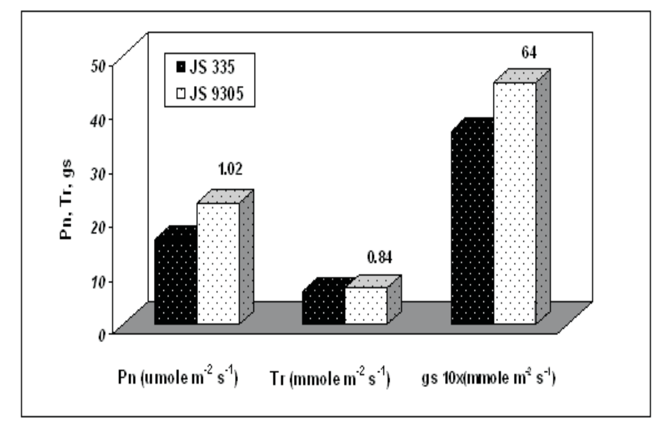


Fig. 4.11.5. Photosynthesis (Pn), transpiration (Tr) and stomatal conductance (gs) measured in the healthy plants (just before wilt initiation) of soybean varieties JS 335 and JS 9305 in 2008 (Values above the bars represent CD at 5%)

Fig. 4.11.3 Field view of soybean varieties JS 335 and JS 9305 during early Sept. 2008

Fig. 4.11.4. Wilting of soybean variety JS 9305 before (left) and after (right) pod initiation

4.12 On-farm Research and Impact Assessment

4.12.1. Ailing Agricultural Productivity in Economically Fragile Region of India: An Analysis of Synergy between Public Investment and Farmers' Capacity

Since mid-Nineties, India has been targeting a more than 4 per cent growth rate in Indian agriculture, but the actual growth rate has not turned out to be even half of this target. The present study aims at to examine the status of different kind of infrastructures and its effect on input use and agricultural productivity in three most poor states- Bihar, Madhya Pradesh and Orissa- of the country.

Value of output from agriculture (VOA)

From analysis of value of output from agriculture (VOA) in the selected states, it has been observed that growth in total VOA at 1993-94 prices has been abysmally low *viz.* 0.90 and 0.64% for M.P. and Orissa, respectively during 1990-2002 as compared to national average growth of 2.02% (Table 4.12.1). In Bihar, agriculture has shown significant resilience with 4.79% growth even after recurrent floods and drought. Among crop groups, cereals, pulses and oilseeds in these states have shown either very slow growth or negative growth during the period under study. Most of the positive growth has come from fruits and vegetables sector.

Table 4.12.1. Growth rates in value of output from different crop groups in selected states during 1990-2002 at 1993-94 prices

(per cent per annum)

State	Cereal	Pulses	Oilseeds	Fruits & Vegetables	Total Agriculture
Bihar	2.568	-1.530	1.051	9.741	4.789
M. P.	-0.798	3.000	2.284	5.916	0.876
Orissa	-2.520	-10.981	-11.802	4.663	-0.636
All India	1.259	-0.351	-0.233	5.432	2.023

Production trends of major crops in selected states

The production performance of major crops occupying more than 80 per cent of gross cropped area (GCA) in 3 selected states has been examined for two periods- period I (1970-1989) *viz.* post-green revolution period, during which foodgrains production in many parts of the country have leapfrogged and period II (1990-till date) *viz.* post economic liberalization period, when the domestic economy got direct link with the global economy. During this second period, two new states Jharkhand and Chhattisgarh were carved out from Bihar and M.P., respectively. Though, for comparison purposes, the results of Bihar and M.P. in the study include the data of Jharkhand and Chhattisgarh.

From Fig. 4.12.1, it can be observed that except in wheat, area under all the crops has declined in Bihar during Period II. Although, the decline in area have been compensated by increase in yield of all the crops in Period II. Among all the foodgrain crops, rice & maize performed exceptionally well with more than 2% annual growth during 1990-2005. Though, growth in yield of most of the crops has decelerated during 2nd period, and in case of wheat, it became negative.

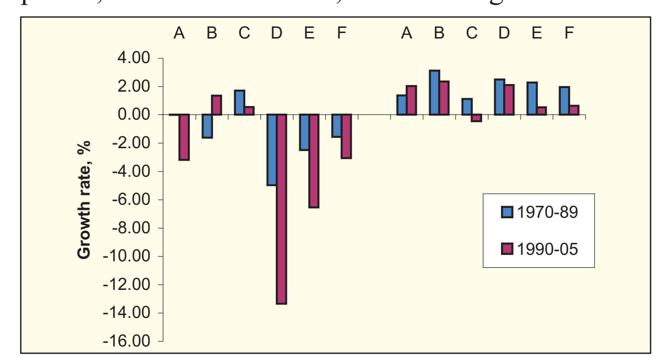


Fig. 4.12.1. Production performance of major crops in Bihar (A- Rice, B- Maize, C- Wheat, D- Other Cereals, E- Gram, F- Other pulses)

In Madhya Pradesh state, soybean was introduced in early eighties and proved to be a wonder crop. Area under soybean has increased exponentially at the expense of jowar, sesamum, even groundnut (Fig. 4.12.2). In fact, area under all the crops has increased due to increase in GCA. Similarly, yield of maize, wheat and soybean during later period were appreciably high. However, except in maize, no crop exhibited robust growth in yield of 2%.

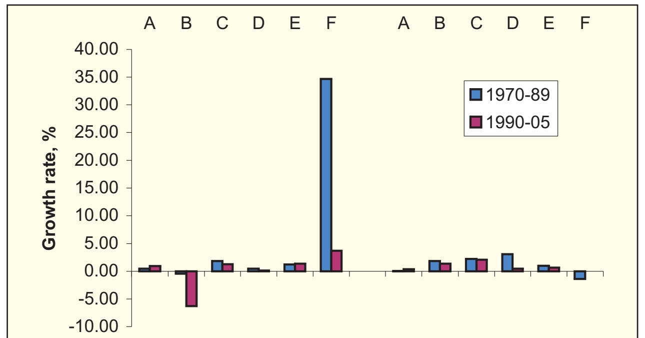


Fig. 4.12.2. Production performance of major crops in M.P. (A- Rice, B- Jowar, C-Maize, D- Wheat, E- Gram, F- Soybean)

From perusal of Fig. 4.12.3, it can be observed that rice is the most dominant crop in Orissa state. In fact, except rice, no single crop occupy >2% of GCA. Further, area under most of the crops are declining. More surprisingly, yield of rice has marginally increased during 2^{nd} period, but growth in yield for all crops after 1990s was found to be negative. This means, agriculture in the state is in real crisis, where about 75% of rural population depends on it and maximum death due to starvation has been reported in the recent past.

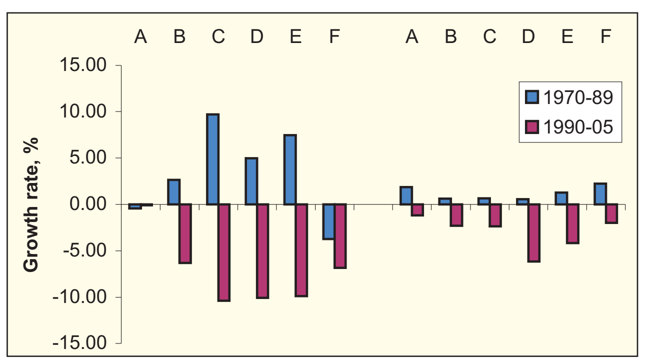


Fig. 4.12.3. Production performance of major crops in Orissa (A- Rice, B- Ragi, C- Groundnut, D- Other pulses, E- Edible oilseeds, F- Small millets)

Growth of factors affecting agriculture

In order to find out the reasons for the stagnation or deceleration in crop productivity of food crops in 3 states, trend of critical factors used in agriculture has been analysed and tried to link these changes to output growth in various periods. It was hypothesised that the level of agricultural output over time was affected by area, inputs like irrigation, fertiliser, prices, technology and infrastructure. Year to year changes in agricultural output were also influenced by weather, particularly monsoon rainfall.

In these states, in fact, irrigation has not made much headway as percentage of GCA irrigated is as low as less than 30% in M.P. and Orissa. In Bihar, although, percentage irrigated area is about 60% but reliability of irrigation is under question. It is well known fact that across the region, proportion of area under surface irrigation is shrinking while that of by groundwater irrigation is expanding. Under such circumstances, in states like Bihar, M.P. and Orissa, where electricity for irrigation purposes is quite erratic and unreliable, farmers depend on diesel engine for drafting of groundwater.

Under spiraling crude oil prices, groundwater irrigation has proved to be uneconomical proposition and therefore it became one of the most limiting factors for increasing crop productivity.

Furthermore, consumption of chemical fertilizers in these states is very low- 35-45 kg ha^{-1} in M.P. and Orissa and 95 kg ha^{-1} in Bihar (Fig. 4.12.4) as compared to other states like Andhra Pradesh, Haryana, Punjab, Tamil Nadu, etc. Low doses of plant nutrients without supplementing with organic manures accordingly are also important factors for low productivity.

Similarly, disbursement of institutional credit in these poor states (Rs. 1800-2500 ha^{-1}) has remained laggard till mid-1990s, while developed states enjoyed more than double of this credit amount. Poor credit disbursement for agriculture in the poor states worked as double edged weapon- on one hand, due to poor economic condition, farmers in these states are not able to use capital intensive inputs like fertilizer, irrigation or plant protection measures, on the other hand, it hampered in realization of higher crop production, thus left with very low investible surplus.

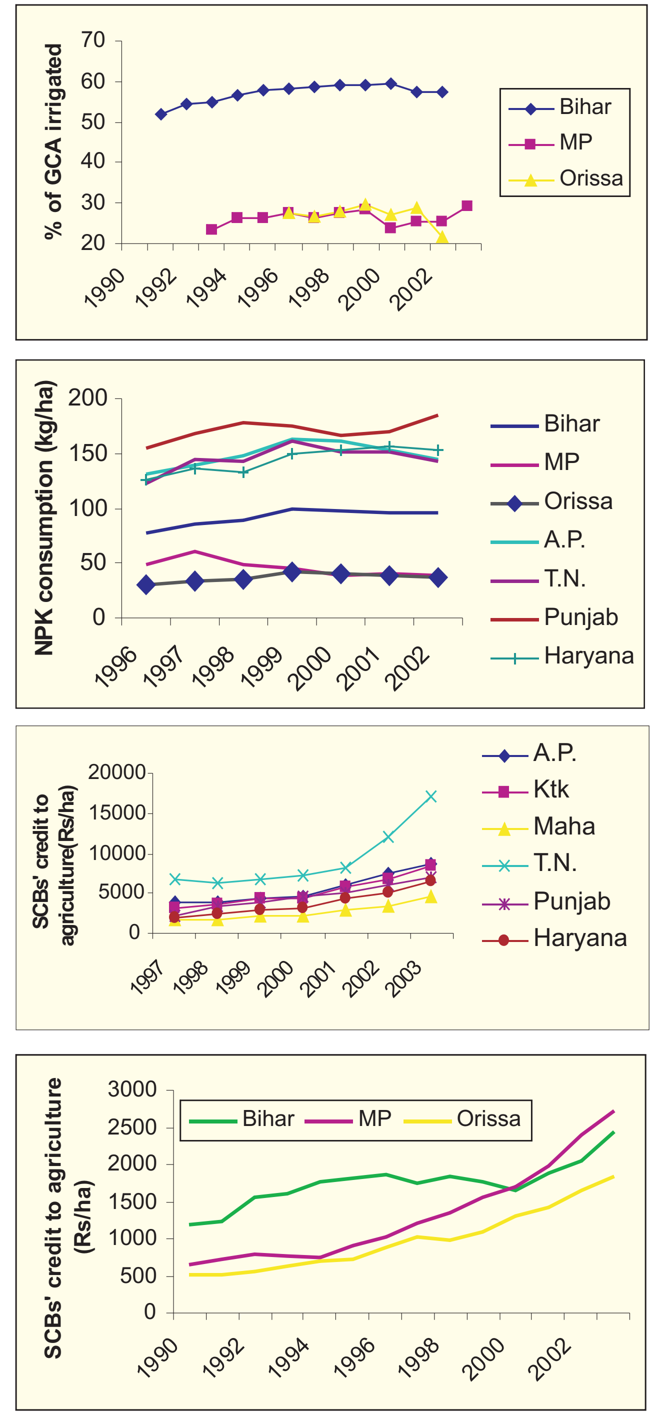


Fig. 4.12.4. Status of critical inputs' use in selected states

Public expenditure in agriculture

Trend of public expenditure (includes expenditure on crop husbandry, soil & water conservation, food storage & warehousing and agricultural research & education) by the state governments in agriculture during 1990-2004 given in Fig. 4.12.5 shows that MP has highest expenditure on agriculture and allied activities, while Bihar has the lowest. In fact, over the years, growth in expenditure by the Government has declined in Bihar. Similarly, in the state of Orissa, investment in agriculture increased significantly after mid-1990s. However, most surprising, most of these expenditures were incurred on revenue account, which only 10-15% of total expenditures were meant for creation of assets. It is very interesting to note that although total expenditure on agricultural development as well as share of this expenditure in total value of agricultural output is the lowest and declining in Bihar state as compared to other two states.

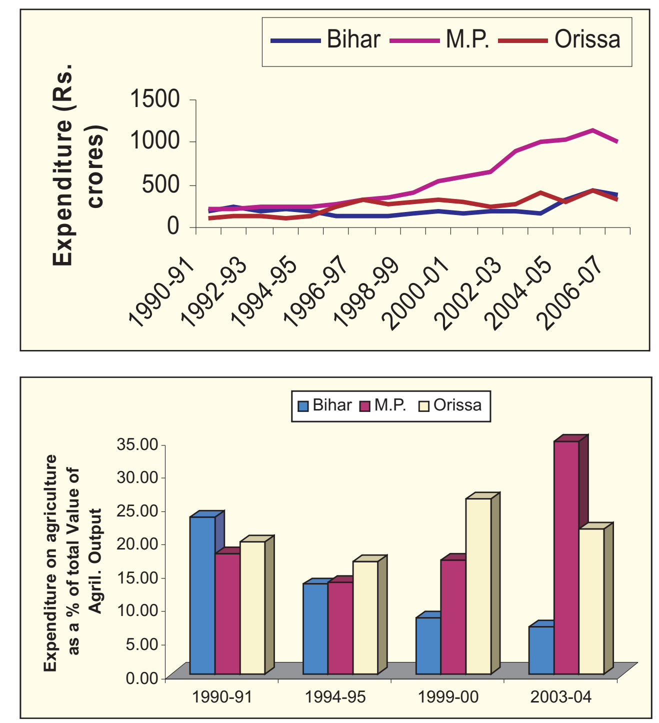


Fig. 4.12.5. Public expenditure on agricultural development

From the aforesaid discussion, it appears that in the selected states, resource poor farmers are not only struggling due to their own poor economic capacity but also due to the inappropriate institutional support from the Governments in terms of assured supply of critical inputs like fertilizer, irrigation, farm credit and public investment.

4.12.2 Demonstration of effect of integration of broad bed furrow (BBF) and balanced fertilization on growth and productivity of soybean-wheat system on waterlogged fields in Vidisha district

About 20-25% of cultivable land in Vidisha district is left uncultivated by farmers during *kharif* season due to prolonged waterlogging condition. Even though farmers sow some waterlogged fields with soybean, the yields are negligible due to poor establishment of soybean. Most of the fields in this district were also deficient in available N, P, S, and Zn but high in available K. Therefore, three demonstration field trials were conducted in Rangai village, Vidisha district to demonstrate the beneficial effect of integration of Broad Bed Furrow (BBF) with balanced fertilization or integrated nutrient management (INM) on soybean wheat system. The beneficial effect of integration of BBF with balanced fertilization (100% NPKSZn) or INM on soybean seed yield was compared with that of flat-on grade (normal) with balanced fertilization or INM on waterlogged fields which could not be cultivated in most of the years.

During *kharif* season, the results of demonstration trials showed that the integration of BBF with INM produced higher soybean yield by 83%, 78% and 96% at site 1, site 2 and site 3, respectively over the integration of flat land (normal) with INM. Whereas, the integration of BBF with balanced fertilization with inorganic fertilizers produced 73%, 82% and 75% higher soybean yield over the integration of flat land (normal) with balanced fertilization at site 1, site 2 and site 3, respectively. The pooled data of 3 sites showed an increase of about 92% in soybean seed yield with integration of BBF with INM on waterlogged fields over that of integration of flat land with INM (Table 4.12.2).

During *rabi* season, wheat was grown on flat land with INM, balanced fertilization and farmers' practice of nutrient management. On plots those had BBF in *kharif* season, INM and balanced fertilization produced 18% and 24% higher wheat yield, respectively over the farmers' practice (Table 4.12.4).

Economics of BBF and nutrient management in soybean-wheat system grown on waterlogged fields has been computed. The economic evaluation in

Table 4.12.2. Soybean grain yield (kg ha^{-1}) as affected by the integration of nutrient management and land treatments on waterlogged fields. (Mean of 3 Sites)

Land Treatment (LT)	Nutrient Management (NM) Options			Mean
	FP	BF	INM	
Flat (Normal)	1017	1159	1246	1141
BBF	1585	2047	2322	1985
Mean	1301	1504	1784	
LSD (5%)	LT	NM	LTx NM	
	481	309	487	

FP: Farmers' Practice; BF Balanced Fertilization; INM-Integrated Nutrient Management

soybean showed that a farmer can get a net income of about Rs.12000/- and a B:C ratio of 0.96:1 with the integration of BBF with INM on water-logged fields (Table 4.12.4). During *rabi* season, cultivation of wheat on plots those had BBF in *kharif* produced a net income of about Rs.59000/- with balanced fertilization through inorganic fertilizers and a net income of Rs.56000/- with integrated nutrient management (Table 4.12.4). If soybean-wheat system grown on water-logged fields considered as a unit, a farmer can get a net income of Rs.68121/- and B:C ratio of 3:1 with the adoption of BBF and INM in soybean and INM in wheat (Table 4.12.5). These results have clearly indicated fact that the farmers can cultivate water-logged fields with soybean with BBF and INM in *kharif* and wheat with INM in *rabi* which facilitate higher cropping intensity and net income to the farmers in Madhya Pradesh.

Table 4.12.3. Economics of nutrient management in soybean grown on BBF plots (Mean of 3 sites)

Treatment	Mean yield (kg ha^{-1})	Gross income (Rs ha^{-1})	Total cost (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
FP	1068 (±70)	17088	11353	5735	0.51
BF	1331 (±251)	21296	12369	8927	0.72
INM	1533 (±267)	24528	12520	12008	0.96

FP: Farmers' Practice; BF Balanced Fertilization; INM-Integrated Nutrient Management, * Figures in paranthesis are standard deviations.

Table 4.12.4. Economics of nutrient management in wheat grown on plots those had BBF in *kharif* season (Mean of 3 sites)

Treatment	Mean yield (kg ha^{-1})	Gross income (Rs ha^{-1})	Total cost (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
FP	3977 (±184)	56424	10173	46251	4.55
BF	4931 (±272)	70178	11180	58998	5.28
INM	4690 (±284)	66620	10507	56113	5.34

* Figures in paranthesis are standard deviations.

Table 4.12.5. Economics of nutrient management (NM) in soybean-wheat system grown on waterlogged fields with BBF and NM in k*harif* and NM in *rabi* (Mean of 3 sites)

Treatment	Mean yield (kg ha^{-1})		Gross income (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
	Soybean	Wheat				
FP	1068	3977	73512	21526	51986	2.4
BF	1331	4931	91474	23549	67925	2.9
INM	1533	4690	91148	23027	68121	3.0

4.12.3 Follow up trials on validation of fertilizer prescription equations (AICRP on STCR)

The collaborative centres of the soil test crop response have generated several fertilizer prescription equations for applying to crops to attain the desired target yields. Later, these would be validated either on the university farm or on the farmers' fields. In the sixty front line demonstrations of Rice conducted by Raipur revealed that soil test based fertilizer recommendations of STCR targets were found to get higher yields than the farmers' practice and the general fertilizer recommendations in both inceptisols and vertisols of Raipur, Durg, Dhamtari, Bilaspur, Raigadh, Jangir, Rajnandgarh, Kawardha and Korba districts. The wheat FLD's (2) organized by New Delhi centre at Sonepat, Haryana revealed that the net profit in the STCR treatments ranged from 27, 345 to 28, 765 Rs. At Hyderabad, in follow up trials on farmers' fields it was observed that in turmeric trial at Jagtial, Karimnagar district the relative income at 45 q target was Rs. 5134/- over RDF and the B.C. ratio was 2.2 while it was 1.8 with blanket dose. Similarly, in groundnut, about Rs. 9440 to 13,211 ha^{-1} income was obtained with STCR target yield of 30 q ha^{-1} over farmers' practice. At Palampur, some of the generated equations also were tested on farmers' fields. The trials of Toria revealed that B:C ratio was higher (10.77) with STCR target yield dose than the farmers' practice CC (6.93) and GRD dose (8.23).

Table 4.12.6 Work accomplished by some cooperating centres of AICRP on STCR during the period under report

Centre	FAE	IPNS	MLT	FLD	LTD	Cropping sequences
Pusa	Sesame			Rice (3)		Rice-Wheat
	Mustard			Sesame (1)		Rice-Winter Maize
				Pigeonpea (2)		Rice Potato+ winter Maize
				Cauliflower (2)		Potato-Onion
				Wheat (4)		
				Winter maize (3)		
				Mustard (6)		
				Linseed (1)		
				Lentil (1)		
				Gram (1)		
Coimbatore		Beet root	Hill wheat		Rice-Rice	
		Beet Root				

contd...

Centre	FAE	IPNS	MLT	FLD	LTD	Cropping sequences
Hyderabad	Red gram		Turmeric	Groundnut (Clay loam)		
			Ragi	Sunflower (Alfisol)		
				Groundnut (Alfisol)		
				Sesame (alfisol)		
				Bengalgram (vertisol)		
Palampur		Turmeric		Maize (5)	Maize-wheat	Soybean-Wheat
		Garlic		Soybean (6)		Rice-Wheat
		Peas		Toria (6)		
Rahuri		Bt-Cotton				
		Sugarcane				
		Pre-seasonal				
		Sugarcane				
		Caster				
		Gram				
New Delhi	Maize	Maize		Maize		
	Wheat	Wheat		Blackgram		
				Greengram		
				Wheat (2)		
Raipur		Hybrid Rice		Rice (60)		Rice-Wheat
		Rainfed Rice				
		Chickpea				
		Cauliflower				
Bangalore		Dryland	Sunflower			
		Ragi				
		Carrot				
		Ragi		Groundnut		Paddy-Ragi
		Sugarcane		Maize		
		Ratoon				
		Paddy				

FAE: Fertilizer adjustment equation; IPNS:Integrated Plant Nutrient System ; MLT: Multi Location Trials
FLD : Front Line Demonstration ; LTD: Long-term Demonstration

Technology Dissemination Events

Farmers' Day

A Farmers' Day was organized at Rangai village, Vidisha district under ACIAR project on 16 September 2008. About 100 farmers from Rangai and surrounding villages, project scientists from India and Australia, Dr. Christian Roth, ACIAR, Australia, Ms. Simrat Labana, ACIAR, New Delhi and Dr. Michael Webb, ACIAR Reviewer, Australia have participated in the Farmers' Day. Both the host and non-host farmers visited the demonstration trials of NADEP compost heaps. Farmers were very much attracted by the soybean trials on Broad Bed Furrow (BBF) with Balanced Fertilization on waterlogged fields. Host farmer, Shri Ram Manohar Verma, explained the advantages of integration of BBF with Balanced Fertilization on soybean crop growth as compared to flat field (normal field) with Balanced Fertilization. The BBF maker-cum-seed drill was also demonstrated to the farmers during the farmers' day. Farmers have shown keen interest to procure the BBF maker-cum-seed drill from the local fabricator.

Farmers' Day at Rangai village, Vidisha district

ACIAR Project Scientist visiting a compost pit at Rangai village

Farmers and Scientists observing the root growth of soybean in BBF plots

Farmers' visits to the Institute

Dr. A. B. Singh coordinated the visits of farmers and agriculture officers to the institute (Table 5.1) and explained the technologies generated in the institute particularly on vermicomposting, phospho-sulpho-nitro composting, organic farming and organic pomegranate production technologies.

Table 5.1 Farmers' visits to the Institute

S.No	Department	Number of participants	Period
1	Agriculture Officers of Uttar Pradesh	25 Officers	19/8/2008
2	Agriculture Officers and Extension Officers from Govt. of Maharashtra Deptt. of Agriculture Shrirampur, Ahmednagar	35 Officers	26/8/208
3	Shajapur, Madhya Pradesh	30 Farmers	09/09/2008
4	Agriculture Development Office, Sagar, Madhya Pradesh	25 Farmers	22/09/2008
5	Agriculture Development Office, Khandwa, Madhya Pradesh	30 Farmers	12/12/2008
6	Assistant Director of Agriculture Extension, Tonk, Rajasthan	40 farmers	17/12/2008
7	Kisan Welfare and Agriculture Development Office, Indore, Madhya Pradesh	30 farmers	09/01/2009
8	Assistant director of Agriculture Extension, Daulpur, Rajasthan	50 Farmers	21/01/2009
9	Office of Assistant Director of Horticulture, Sagar, Madhya Pradesh	20 Farmers	29/01/2009
10	Office of Assistant Director, Shivpuri, Madhya Pradesh	30 Farmers	18/02/2009
11	Chamunda Agricultural Technology Training Management Agency (ATMA), Dewas	25 Farmers	27/02/2009
12	Kisan Welfare and Agriculture Development (ATMA Project), Shajapur, Madhya Pradesh	75 Farmers	12/03/2009

Dr. N.R.Panwar coordinated an exposure visit of 34 farmers from Ratlam and 36 farmer's from Amarwada, Chindwara district of Madhya Pradesh on 19 February and 7 March 2009 respectively. During field and institute museum visits, the technologies generated in the institute were explained.

Display of Institute Technologies in Kisan Mela

The technologies developed at the institute were made available to the farmers, watershed functionaries and representatives from line departments through *"Kisan Mela"* organized by various State/Central Agricultural Departments. Live demonstration was given to visitors in the farmer fairs on vermicomposting (Pit and Heap method), phosphocomposting (Pit and Heap method) and NADEP composting etc. The Institute publications containing the user friendly technologies were also sold in the farmers' fairs. Institute's scientist participated in the following *Kisan Melas* during the period under report (Table 5.2).

Table 5.2. Institute technologies displayed at different Kisan Melas

Name	Venue	Period
Drs. Brij Lal Lakaria and N.R. Panwar	Directorate of Agriculture, Hoshangabad	May 28-June 1, 2008
Drs. A.B.Singh and S.Ramana	Directorate of Agriculture, Sironj, Distt. Vidisha, Madhya Pradesh	May 31-June 3, 2008
Dr. R.H. Wanjari and Sh.O.P. Shukla	DWSR, Jabalpur	March 8, 2009

Transfer of technology at Krishi Mela, Hoshangabad

Transfer of Technology

Training on vermicompost, phospho-sulpho-nitro compost and organic farming to the farmers of the Sagonikala, Dobra, Adampur and Koluva villages. Around 100 farmers from adjoining villages participated in the training, arranged by Madhya Pradesh, Vigyan Sabha on 18/08/2008. Bulletin and pamphlet materials on vermicomposting and organic farming were distributed to the farmers along with on farm practical demonstration of vermicompost preparation. Video films on vermicomposting and organic farming were shown to the farmers during training programme.

One day training on phospho-sulpho-nitro-compost production to the farmers at the village Panchayat Bankot on 29/12/2008, jointly organized by MP Council for Science and Technology and Swami Vivekanand Shiksha Samiti, Madhya Pradesh. Around 150 farmers participated in the training. Bulletin and pamphlet materials on vermicomposting, organic farming and phospho-sulpho-nitro-compost production were distributed to the farmers along with Practical demonstration of phospho-sulpho-nitro-compost preparation on farmer's field. Video films on vermicomposting for biofertilization and organic farming for sustainable agriculture were shown to the farmers during training programme.

The technologies developed at the institute were demonstrated to a group of about 30 farmers and representatives from Chhindwara district (M.P.) on 03rd March, 2009. They were also given training on soil sampling, vermi-composting, NADEP method of composting, manure preparation etc.

Biofertilizer Interventions in Tribal Areas

Efficacy of a bionutrient package consisting of 50% NPK (Urea, SSP, MOP), FYM 5 t/ha and biofertilizers (*Azotobacter, Azospirillum* and PSB) was demonstrated on soybean, maize, kodo, kutki and niger in 5 farmer's fields in Tehsil Kurai, Seoni district, M.P. and compared with Farmers practice (FP- 50% N P through DAP). The yield increase was 17, 25, 40, 20 and 18% in soybean, maize, kodo, kutki and niger. The absolute increment for the crops (kg ha^{-1}) was 240, 550, 175, 50 and 80 kg ha^{-1} respectively. (JNKVV, Jabalpur)

Research and Demonstrations on *Azolla*

Highest *Azolla* biomass production was recorded during November to February both under semi and permanent structures (10-15 fold increase). During May-September the biomass production was 8-10 folds. The variation was due to increase in temperature that reached more than 38°C in the month of July. Comparing the two structures, the semi-permanent had slight edge over permanent structure in maintaining better growth. (AAU, Jorhat)

Demontrations on Oilseeds

Biofertilizers costing Rs.3,70,000 were produced and sold to the farmers from university counter at Parbhani. Nine frontline demonstrations were conducted during the year 2008-09 on farmer's field on efficacy of mixed inoculation of *Bradyrhizobium* and PSB in soybean. Soybean seed yield in farmers fields varied from 1420 to 2642 kg ha^{-1}. There was an average increase of 24% in yield due to inoculation. (MAU, Parbhani)

Bionutrient package Demonstrations in Bihar

Evaluation of the package in eight farmers of Samastipur, Muzaffarpur and Vaishali districts showed 32% increase in grain yield in resource poor farmers and 11-14 % increase in grain yield in resource rich farmers who also applied chemical fertilizers. There was an increase of 20% in grain yield of broad bean (11 q ha^{-1} in farmer's practice and 13.2 q ha^{-1} in biofertilizer treated plot).

6. EDUCATION AND TRAINING

6.1 Training Attended

Name	Programme	Venue	Period
Dr. S. Ramana	MDP Workshop on "Policy Prioritization, Monitoring and Evaluation (PME) Support to Consortia based Research in Agriculture (Under NAIP- L&CB Project)"	NAARM, Hyderabad	June 17-21, 2008
Dr. Ranjit Kumar	Management Development Programme on "Performance Assessment of Agricultural Research Organizations"	NAARM, Hyderabad	September 16-20, 2008
Drs. Tapan Adhikari and R.H. Wanjari	FTIR training programme	Perkin Elmer (India) Pvt. Ltd., Mumbai.	September 17-19, 2008
Drs. R. S. Chaudhary, D.D.Reddy, K.B.Hebbar and Blaise Desouza	Intellectual property and Technology management	CIAE, Bhopal	November 27-29, 2008
Drs. K. Ramesh and S.K. Behera	Efficient use of on farm and off farm resources for sustainable crop production in organic farming	Indian Institute of Soil Science, Bhopal	December 1-8, 2008
Drs. S. Kundu and Tapan Adhikari	Procurement Procedures of the World Bank-NAIP	IISR, Lucknow	February 9-10, 2009

6.2 Training Organized for students

Name of the Institution / College	Name of the Trainee and Degree Programme	Coordinating Scientist & Division at IISS	Duration of the Training	Training Programme
Amity Institute of Biotechnology Noida, Uttar Pradesh,	Miss Parul Rajput, B. Tech. Biotechnology,	Dr. A.B.Singh	August 2-16, 2008	Techniques in Biochemical Analysis
Barkatullah University, Bhopal	Mr. Muzaffar Ahmad Bhat, Research Scholar, Department of Applied Aquaculture & Zoology	Dr. A.B.Singh	December 2008 to February 2009 in Biochemistry	Analytical Techniques used

6.3 Students Guided

Name of the Institution / College	Name of the Student and Degree Programme	Coordinating Scientist	Duration	Title of the Dissertation
Department of RPEG, Barkatullah University, Bhopal	Mr. Tariq Ahmad Qureshi, M. Sc. Environmental Science	Dr.K.B.Hebbar	Three months	Adoptation of wheat to climate change: Genotypic variability in morphological and physiological traits associated with growth and yield.
	Mr. Imtiyaz Ahmad Shah, M. Sc. Environmental Science	Dr.K.B.Hebbar	Three months	Adoptation of wheat to climate change: Genotypic variability in root traits and nutrient uptake
	Mr. Rouf-ur-Rafiq, M. Sc. Environmental Science	Dr.A.K.Biswas	Three months	Potassium supplying power of a black soil amended with spent wash and post-methanation effluent.
	Mr. Javed Ahmad Lone, M. Sc. Environmental Science	Dr. Ajay	Three months	Linear alkylbenzene sulphonate behaviour in vertisol in relation to detergent pollution
	Mr. Malik Mubashir Ahmad, M. Sc. Environmental Science	Dr. T. Adhikari	Three months	Effect of nickel on selected soil enzyme activities and plant growth
	Mr. Shanaz Nazir, M. Sc. Environmental Science	Dr. N.R. Panwar	Three months	Soil enzymatic and basal respiration response to the addition of lead contaminated municipal solid waste compost in acid and alkaline soils
Jawaharlal Nehru P.G. College, Bhopal	Mr. Sajad Ahmed Seikh, M.Sc. (Biotechnology)	Drs. J.K. Saha and N.R. Panwar	Three Months	Effect of Pb contaminated municipal solid waste compost on soil biological and biochemical (enzymatic activity) properties in acid soil"

Name of the Institution / College	Name of the Student and Degree Programme	Coordinating Scientist	Duration	Title of the Dissertation
	Mr. Shadab Aga, M.Sc. (Biotechnology)	Drs. N.R. Panwar and J.K. Saha	Three Months	Effect of Cd contaminated municipal solid waste compost on soil biological and biochemical (enzymatic activity) properties in acid soil"
	Mr, Manoj Kumar Singh M.Sc. (Biotechnology)	Dr. Tapan Adhikari	Three months	Characterization of different soils collected from different parts of North Bengal
Barkatullah University, Bhopal	Miss. Manta Narware	Dr. A.K. Biswas	Three months	Tolerance of Pongamia Pinnate to Nickel in a Vertisol
	Miss.Marry V.Toppo	Dr. A.K. Biswas	Three months	Tolerance of Pongamia pinnate to chromium in a Vertisol.
	Miss. Alankrita Dashora M.Sc. (Bioscience)	Dr. Tapan Adhikari	Three months	Tolerance of *Pongamia pinnata L.* to cadmium in a Vertisol & Effect of Copper Nano particle on germination of Mustard seed
	Miss. Aradhana Sharma M.Sc. (Bioscience)	Dr. Tapan Adhikari	Three months	Tolerance of *Pongamia pinnata L.* to lead in a Vertisol & Effect of Zinc Nano particle on germination of Mustard seed
Vellore Institute of Technology, Vellore	Mr. Arijit Biswas M.Sc. Applied Microbiology	Drs. D.L.N.Rao and A.K. Biswas	Six months	Physiological effects of zinc stress on soil bacteria
JNKVV, Jabalpur	Ms. Sunita Tirkey, M.Sc., JNKVV, Jabalpur.	Dr. Sanjay Srivastava acted as research guide	-	Fertilizer requirement based on soil tests for garlic grown in vertisols of M.P.
Barkatullah University, Bhopal	Mr. Nishat Sharma M.Sc. Student	Dr.A.B.Singh and Dr.S.Ramana	Three months	Biochemical quality evaluation of soybean seed under different nutrient management systems

7.1 Awards

Dr. K. Sammi Reddy, Senior Scientist, Dr. A. Subba Rao, Director, and Dr. Muneshwar Singh, PC (LTFE): received the FAI Golden Jubilee Award for Excellence in the Field of Development of Fertilizer Best Management Practices.

Dr. K. Sammi Reddy receiving the FAI Golden Jubilee Award from Mr. Atul Chaturvedi, Secretary, Ministry of Fertilizers and Chemicals, Govt. of India.

Dr. Sangeeta Lenka, Scientist, Soil Physics, received the Jawaharlal Nehru Award for Postgraduate Agricultural Research for the year 2007 for outstanding research in the field of Soil Science, NRM and Agronomy.

Dr. Sangeeta Lenka, receiving Jawahar Lal Nehru award from Minister of state for Agriculture

7.2 Best Poster Awards

The poster entitled "Impact of organic farming system on soil quality a case study" by Panwar, N.R. Ramesh, P., Singh, A.B. and Ramana, S. was awarded the best poster in the poster session of the International Symposium on Natural Resource Management in Agriculture at Agricultural Research Station, (RAU, Bikaner), Durgapura, Jaipur during 19-20 December 2008.

Mr. Javed Ahmed Lone received the Best Young Scientist Award based on the paper presented on "Linear Alkyl Benzene Sulphonate Behaviour in Vertisols in Relation to Detergent Pollution" by Javed Ahmed Lone and Ajay in the National Seminar on Science Education and Attraction of Talent for Excellence in Research organized at Sant Hirdaram Girls College, Bhopal, during 21-22 February 2009.

7.3 Recognitions

Dr. D.L.N.Rao, Network Coordinator (Biofertilizers) was nominated as Member, Institute Management Committee, NRC on Seed Spices, Ajmer.

Dr. Y. Muralidharudu, Project Coordinator (STCR) acted as Chairman Technical Session II on Fertility during Annual Convention of Indian Society of Soil Science at UAS, Bangalore held on 30 November 2008.

8. LINKAGES AND COLLABORATIONS IN INDIA AND ABROAD

The institute has strengthened linkages with ICAR institute and SAUs located throughout the country, the international agencies, and the extension & development agencies. Linkages have been strengthened by organizing workshops/ meetings of AICRP projects in which scientists of co-operating centers located at SAUs or ICAR institutes have participated. Efforts have also been made to strengthen research collaborative activities with SAUs through guidance of PG/Ph.D students by the institute scientists.

The Indian Institute of Soil Science has established research linkages and collaborations with other ICAR institutes and State Agriculture Universities (SAUs) through its network of NAIPs and AICRPs/Networks and their cooperating centers. All the three AICRPs and one Network Project's co-operating units located at IISS, Bhopal have 56 cooperating centers spread over in almost all the SAUs.

One ACIAR, Australia funded research project on "Integrated manure nutrient management in soybean/wheat cropping systems on vertisols in Madhya Pradesh and Queenland" has been started from July1, 2004. In this project, IISS is collaborating with University of Queensland, Australia and Department of Natural Resources (DNR), Brisbane, Australia.

Three network projects on the following aspects are being operated in the institute.

1. Network project on organic farming (NPOF)
2. Evaluation of efficacy of Granubor II in ameliorating boron deficiency in important field crops under major ecological zones of India.
3. Assessment of quality and resilience of soils in diverse agro-ecosystems.

In a NAIP project on Nano-technology, institute has collaboration with CAZRI, Jodhpur. IISS has collaboration with CRRI, Cuttack in another NAIP project on "Soil Organic Carbon Dynamics and Climatic Change". AMAASS funded research project on "Improving Yields and Nutreint Uptake of Selected Crops through Microbial Inoculants in Vertisols of Central India" was initiated in the year 2008 in collaboration with NBAIM, Mahoo.

Co-operating Centers of AICRPs/Networks located at IISS, Bhopal

S. No	All India Coordinated Research Projects	No. of co-operating centres ICAR	SAUs/SGUs	Total
1.	AICRP on Long Term Fertilizer Experiments to Study Changes in Soil Quality, Crop Productivity and Sustainability (LTFE): Hyderabad, Raipur, New Delhi, Junagarh, Palampur, Ranchi, Bangaluru, Pattambi, Jabalpur, Akola, Parbhani, Bhubaneshwar, Ludhiana, Udaipur, Coimbatore, Pantnagar, Barrakpore.	2	15	17
2.	AICRP for Investigation on Crop Response Correlation (STCR): Hyderabad, Pusa, Raipur, New Delhi, Hisar, Palampur, Bangaluru, Vellanikkara, Jabalpur, Rahuri, Bhubaneshwar, Ludhiana, Bikaner, Coimbatore, Pantnagar, Kalyani, Barrackpore.	2	15	17
3.	AICRP on Micro and Secondary Nutrients and Pollutants in Soil and Plants: Hyderabad, Pusa, Anand, Hisar, Jabalpur, Akola, Bhubaneswar, Ludhiana, Coimbatore, Pantnagar, Lucknow.	-	11	11
4.	Network Project on Biofertilizers (BNF): Jorhat, New Delhi, Hisar, Jabalpur, Parbhani, Amarawathi, Bhubaneshwar, Junagarh, Coimbatore, Pusa, Solan.	2	9	11
	Total	**6**	**50**	**56**

9. LIST OF PUBLICATIONS

9.1 Research Papers

Bandhopadhyay, K.K., Misra, A.K., Ghosh, P.K., Hati, K.M., Mohanty, M. and Singh, R.K. 2009. Assessment of critical soil water potential for emergence of wheat, chickpea and linseed seedlings in relation to water stress in a Vertisol. *Journal of Indian Society of Soil Science* 56(3): 267-275.

Bhattacharyya, R., Prakash, Ved, Kundu, S., Srivastava, A. K. and Gupta, H. S. (2009) Soil aggregation and organic matter in a sandy clay loam soil of the Indian Himalayas under different tillage and crop regimes. *Agriculture, Ecosystems and Environment*, (DOI: 10.1016/j.agee.2009.03.007).

Hati, K.M., Swarup, A., Mishra, B., Manna, M.C., Wanjari, R.H., Mandal, K.G. and Misra A.K. (2008). Impact of long-term application of fertilizer, manure and lime under intensive cropping on physical properties and organic carbon content of an Alfisol. *Geoderma*, 148 (2): 173-179.

Hebbar, K.B., Venugopalan, M.V., Seshasai, M.V.R., Rao, K.V., Patil, B.C., Prakash, A.H., Kumar, V., Hebbar, K.R., Jeyakumar, P., Bandhopadhyay, K.K., Rao, M.R.K., Khadi, B.M. and Aggarwal, P.K. (2008). Predicting Cotton Production Using Infocrop-cotton Simulation Model, Remote Sensing and Spatial Agro-climatic data. *Current Science*, 95(11): 1570-1580.

Jeevandas, Anupama, Singh, R.P. and Kumar, Ranjit (2008) Concerns of groundwater depletion and irrigation efficiency in Punjab agriculture: A micro-level study. *Agricultural Economics Research Review*, 21(2): 191-199.

Kundu, S., Bhattacharyya, R., Prakash, Ved and Gupta, H. S. (2008). Carbon Sequestration Potential of Inceptisols under Long-term Soybean-Wheat Rotation in Sub-temperate Rainfed Agro-ecosystem of North-West Himalayas. *Journal of Indian Society of Soil Science* 56 (4): 327-331.

Lenka, Sangeeta, Singh, A.K., Lenka, Narendra Kumar (2009). Water and nitrogen interaction on soil profile water extraction and ET in maize-wheat cropping system. *Agricultural Water Management*. 96 (2); 195-207.

Mandal, B., Majumdar, B. Adhya, T. K., Bandhopadhyay, P. K., Gangopadhyay, A., Sarkar, D., Kundu, M. C., Guptachoudhary, S., Hazra, G. C., Kundu, S., Samantaray, R. N. and Misra, A. K. (2008). Potential of double cropped rice ecology to conserve organic carbon under Subtropical Climate. *Global Change Biology*, 14:- 2139 -2151.

Mishra, P.K., Mishra, Sumit, Selvakumar, G., Bisht, J.K., Kundu, S. and Gupta, H.S. (2009). Coinoculation of Bacillus thuringeinsis-KR1 with *Rhizobium leguminosarum* enhance plant growth and nodulation of pea (*Pisum sativum L.*) and lentil (*Lens culinaris L.*). *World Journal of Microbiological Biotechnology*. 25: 753-761.

Muneshwar Singh, Mohan Singh, and B. Kumrawat (2008). Influence of nutrient supply system on productivity of soybean, wheat and soil fertility of Vertisols of Madhya Pradesh. *Journal of Indian Society of Soil Science*, 56: 436-441.

Ramana, S. Ramesh, P, Panwar, N. R. and Singh, A.B. 2008. Physiological and biochemical changes in soybean as affected by organic, chemical and integrated nutrient management practices. *Indian Journal of Plant Physiology,* 13 (2): 130-136.

Ramana, S., Biswas, A.K., Ajay, Singh, A. B. & Subba Rao, A. (2008) Tolerance and bioaccumulation of cadmium and lead by gladiolus. *National Academy Science Letters*, 31 (11&12): 327-332.

Ramana, S., Biswas, A.K., Ajay and Subba Rao, A. (2008) Phytoextraction of lead by marigold and chrysanthemum. *Indian Journal of Plant Physiology,* 13 (3): 297-299.

Ramesh, P., Panwar, N. R., Singh, A.B. and Ramana, S. (2008). Effect of organic manures on productivity, soil fertility and economics of soybean (Glycine max) durum wheat (Triticum durum) cropping system under organic farming in Vertisol. *Indian Journal of Agricultural Sciences,* 78: 1033-1037.

Ramesh, P., Panwar, N. R., Singh, A.B. and Ramana, S. (2008). Effect of organic manures on productivity, nutrient uptake and soil fertility of maize (*Zea mays*) - linseed (Linum usitatissimum) cropping. *Indian Journal of Agricultural Sciences,* 78(4):351-354.

Ramesh, P., Panwar, N. R., Singh, A.B. and Ramana, S. (2008). Effect of organic nutrient management practices on production potential, nutrient uptake, soil quality, input use efficiency and economics of mustard (*Brassica juncea*) *Indian Journal of Agricultural Sciences*, 79(1):40-44.

Saha, J. K., Panwar, N., Srivastava Ajay, Biswas, A. K., Kundu, S. and Subba Rao, A. (2009). Chemical, biochemical, and biological impact of untreated domestic sewage water use on Vertisol and its consequences on wheat (*Triticum aestivum*) productivity. *Environmental Monitoring and Assessment*. (DOI: 10.1007/s10661-009-0756-5).

Sammi Reddy, K., Mohanty, M., Rao, D.L.N., Singh, M., Dalal, R.C., Subba Rao, A., Pandey, M and Menzies, N (2008). Nitrogen mineralization in a Vertisol from organic manures, green manures and crop residues in relation to their quality. *Agrochimica* (Italy) LII (6): 377-388.

Sammi Reddy, K., Singh, M., Tripathi, A.K., Subba Rao, A. and Sudhir, K. (2008). Contents and depth distribution of nitrogen fractions in Kandic Paleustalf soil following long-term cropping with fertilizer and farmyard manure applications. *Agrochimica* (Italy) LII (6): 337-351.

Selvakumar, G., Joshi, P., Nazim, S., Mishra, P. K., Kundu, S. and Gupta, H. S. (2008). Exiguobacteriun acetylicum strain I P (MTCC 8707) a novel bacterial antagonist from the North Western Indian Himalayas. *World Journal of Microbiological, Biotechnology,* (DOI 10.1007/s 1127 008 9874 4).

Singh, A.B., P.Ramesh, N.R. Panwar and S. Ramana. (2008). Nutritional quality of soybean, wheat and chickpea and soil biological properties as influenced by different organic manures. *Indian Journal of Agricultural Sciences*, 78: 781-784.

Singh, A.B., Saha J.K. and Ghosh, P.K. (2008) Effect of nutrient management practices on soybean (*Glycine max*) - chickpea (*Cicer arietinum*) cropping system for improving seed yield, quality and soil biological health under rainfed condition. *Indian Journal of Agricultural Sciences*, 78 (6): 485-489.

Singh, Alka, Vasisht, A.K., Kumar, Ranjit and Das, D.K. (2008) Adoption of Integrated Pest Management Practices in Paddy and Cotton: A Case Study in Haryana and Punjab. *Agricultural Economics Research Review*, 21(2): 221- 226.

Srivastava, S.K., Kumar, Ranjit and Singh, R.P. (2009) Extent of Groundwater Extraction and Irrigation Efficiency on Farms under Different Water-market Regimes in Central Uttar Pradesh. *Agricultural Economics Research Review*, 22(1): 87- 97.

9.2 Books/Bulletins

Aggarwal, P.K., Hebbar, K.B., Venugopalan, M.V., Rani, S., Bala, A., Biswal, A. and Wani, S.P. (2008) Quantification of yield gaps in rainfed rice, wheat, cotton and mustard in India. Global theme on Agroecosystems Report No.43, ICRISAT, A.P., India.

Ilamurugu, K., Natarajan, T., Balchander, D. and Rao, D.L.N. (2008) Research-Adoption-Impact Analysis of Biofertilizers in Tamilnadu. AINP on BF Bulletin, TNAU, Coimbatore, pp 62.

Kachhave, K.G., Adsul P.B. and Rao, D.L.N. (2008) (Eds.) Frontline demonstrations on biofertilizers for oilseeds. AINP on BF Technical Bulletin MAU, DEE. no 30/2008, pp 20.

Kundu, S. and Saha, J.K. (2008) Information Brochure, NAIP Sub-project 'Assessment of Quality and Resilience of Soils in Diverse Agro-ecosystems', Indian Institute of Soil Science, Bhopal, pp.1-8.

Kundu, S. and Saha, J.K. (Editors) IISS Newsletter, July-December, 2009, Volume 11, No.2, Indian Institute of Soil Science, Bhopal, pp.8.

Patnayak, S.K. and Rao, D.L.N. (Eds) Biofertilizers for tropical vegetables. AINP on BF Bulletin, OUAT, Bhubaneswer, pp 20.

Prasad, S.N., Singh, R.K., Kumar, Ashok, Parandiyal, A.K., Ali, Shakir, Somasundaram, J., Sethy, B. K., Sharda, V. N. (2008) Natural Resource management for sustainable Development in Western India, Allied Publishers Private Ltd, New Delhi: 1-263.

Ramesh, P. and Subba Rao, A. (Eds.) (2009). Efficient use of on-farm and off-farm resources in organic farming, Indian Institute of Soil Science, Bhopal, 190.

Rao, D.L.N. (2008). Biofertilizer Research Progress (2004-07). All India Network Project on Biofertilizers, IISS, Bhopal, pp 105.

Rawat, A.K., Dwivedi, B.S. and Rao, D.L.N (2008) Biofertilizer based nutrient management for tribal areas of Madhya Pradesh. AINP on BF , JNKVV, Jabalpur, pp 6.

Rawat, A.K., Khatik, S.K., Rao, D.L.N. and Saxena, A K. (2008). Soybean rhizobial inoculants survey in Madhya Pradesh. AINP on BF Bulletin, JNKVV, Jabalpur, pp 33.

Saha, J.K., Panwar, N.R., Singh, M.V. and Subba Rao, A. (2008). Quality indices of municipal solid waste compost for safe use in agriculture. Technical Bulletin No. 6. Indian Institute of Soil Science, Bhopal, 44.

Saha, M.N., Singh, Muneshwar, Wanjari, R.H., Majumder A., Ghorai, D., Saha, A. R. and Majumdar, B. (2008) Soil Quality, Crop Productivity and Sustainability of Jute - Rice - Wheat Cropping System after 36 Years of Long Term Fertilizer Experiment in Inceptisols. AICRP-LTFE, Indian Institute of Soil Science (ICAR), Nabibagh, Bhopal. p. 1-88.

Sammi Reddy, K. (2008) (Ed.) IISS at a Glance. Indian Institute of Soil Science, Bhopal.

Subba Rao, A., Blaise D'Souza, Sammi Reddy, K., Tripathi, A.K., Lal, Brij, Panwar, N. R. and Kumar, Ranjit (2008). IISS Annual Report (2007-08). Indian Institute of Soil Science, Bhopal. pp.1-120.

Subba Rao, A., Sharma, A. K. and Sammi Reddy, K (2008) Soil Science Research in India (A Bibliography of IISS Scientists' Research Contribution 1988-2008), Indian Institute of Soil Science, Bhopal. p. 90.

9.3 Book Chapters

Adhikari, Tapan (2009). Nickel in Soil Environment. In: Nickel in relation to Plants. (Ed. Barket Ali, S. Hayat, and A. Ahmad). ISBN: 978-81-7319-899-1. Narosa Publication House, New Delhi.

Ajay (2009). Scope of medicinal crops in organic farming. In "Efficient use of on-farm and off-farm resources in organic farming". (Ramesh, P. and A. Subba Rao, Eds). pp.163-178.

Biswas, A.K. (2009). Utilization of off-farm wastes on soil and environmental quality. In "Efficient use of on-farm and off-farm resources in organic farming". (Ramesh, P. and A. Subba Rao, Eds). pp. 179-190.

Kundu S. (2009). Conceptual frame work of soil quality: Its' importance in organic farming. In "Efficient use of on-farm and off-farm resources in organic farming". (Ramesh, P. and A. Subba Rao, Eds). pp75-81.

Mayee, C.D. and Blaise, D. (2009). Organic Farming. In: PERI-URBAN AGRICULTURE - Agriculture by Twenty20 and Beyond (Ed. S. Masood). S.B. Nangia APH Pub. Co. New Delhi, pp. 38-52.

Panwar, N. R. and Ramesh. P. (2009). Sources, availability and characterization of inputs in organic farming. In: Efficient use of on-farm and off-farm resources in organic farming (Eds. P.Ramesh and A.Subba Rao). Indian Institute of Soil Science, Bhopal, 25-37.

Panwar, N.R. (2009). Computation of carbon management index (CMI): As a measure of soil quality. In "Efficient use of on-farm and off-farm resources in organic farming". (Ramesh, P. and A. Subba Rao, Eds). pp.146-148.

Ramesh, P. (2008). Organic Farming Research in Madhya Pradesh. In: Organic Farming in Rainfed Agriculture, Opportunities and Constraints (Eds. B.Venkateswarlu, S.S. Balloli and Y.S.Ramakrishna). Central Research Institute for Dryland Agriculture, Hyderabad, pp. 12-20.

Ramesh, P. (2009). Organic farming research in India: Case studies on crop productivity and soil fertility. In: Efficient use of on-farm and off-farm resources in organic farming (Eds. P.Ramesh and A.Subba Rao). Indian Institute of Soil Science, Bhopal, pp. 149-162.

Ramesh, P., Singh, Mohan and Subba Rao, A. (2008). Organic Farming: Its relevance to the Indian context. In: Organic Farming: A Global Perspective (Ed. Subir Ghosh). The ICFAI University Press, Hyderabad, pp.166-185.

Sammi Reddy, K. (2009) Nutrient release characteristics of organic manures in relation to their quality. In: Efficient Use of On-farm and Off-farm Resources in Organic Farming (Eds. Ramesh, P and Subba Rao, A.), Indian Institute of Soil Science, Bhopal. pp.139-145.

Sethy, B.K., Ali, Shakir and Somasundaram, J. (2008). Potential of Rainwater Harvesting For Sustainable Agricultural In South-Eastern Rajasthan. In: (Eds. Prasad Et Al) "Natural Resources Management For Sustainable Development In Western India" CSWCRTI, Research Centre, Kota, Rajasthan, Allied Publishers Private Ltd, New Delhi, pp.57-64.

Singh, A.B. and Subba Rao, A. (2009). Recycling of Biodegradable Organic Wastes by Selected Composting Techniques. In: Efficient Use of On Farm and off- Farm Resources in Organic Farming (Edited by P Ramesh and A Subba Rao), Indian Institute of Soil Science Bhopal, pp. 38-52.

Singh, A.B., Ramesh, P. and Subba Rao, A. (2009). Assessment of produce quality in different nutrient management systems. In: Efficient use of on-farm and off-farm resources in organic farming (Eds. P.Ramesh and A.Subba Rao). Indian Institute of Soil Science, Bhopal, 99-115.

Somasundaram, J., and Chauhan,V. (2008). Impact of different land uses on cracking pattern of black soils in south-eastern Rajasthan. In: Natural Resources Management for Sustainable Development in Western India. (Eds: Prasad et al.) CSWCRTI, Research Centre, Kota, Allied Publishers Private Ltd , New Delhi, pp.105-108.

Subba Rao, A. and Ramesh, P. (2009). Soil fertility management in organic farming. In "Efficient use of on-farm and off-farm resources in organic farming". (Ramesh, P. and A. Subba Rao, Eds). pp.14-24.

9.4 Reviews/Popular Articles

Lal, Brij, Panwar, N.R. and Behara, S.K. (2008). Mrida parikshan vidhi avam upyogita. Mera Gaon mera desh. 39: 8.

Subba Rao, A. and Sammi Reddy, K (2008). Soils: Deterioration in Physical, Chemical and Biological Qualities. The Hindu-Survey of Indian Agriculture 2008, M/s. Kasturi and Sons. Ltd. Chennai, 105-108.

9.5 Invited / Lead Papers Published

Manna, M.C., Wani, S.P., Rego, T.J., Sahrawat, K.L., Bhattacharyya, T., Ramesh, V., Bandhopadhyay, K.K., Rupa, T.R., Singh, P., Pathak, P. and Padmaja, K.V. (2008). In: Global Theme on Argoecosystems (R. no 41), ICRISAT, pp 1-60.

Rao, D.L.N. and Sharma, P.D. (2009) Policy Interventions for Promotion of Biofertilizers in Indian Agriculture. In: Balanced and Integrated Nutrient Management-Key Policy Issues. S. P. Sharma et al (eds), CSHP Agricultural University, Palampur, pp 47-54.

Subba Rao, A. and Srivastava S. (2009). Fortified, customized and 100% water soluble liquid fertilizers in agriculture. In. Policy issues on balanced and integrated nutrient management (Eds. SP Sharma, PD Sharma, PP Biswas, K Sanjay, RP Sharma and Narendra K Sankhyan. CSK HP Agricultural University, Palampur (HP), 103-116.

Rao, D.L.N. (2008) Microbial Diversity, Biofertilizers and Soil Health. Keynote address delivered at the International Conference on "Microbial Biotechnology: Diversity, Genomics and Metagenomics" the University of Delhi during 18-20 Nov 2008.

Rao, D.L.N. (2008) Policy Interventions for Promotion of Biofertilizers in Indian Agriculture. Delivered theme paper at Min. of Agric. Seminar on "Policy Initiatives for Promotion of Balanced Fertilization and Integrated Nutrient Management" at CSHPKV, Palampur, April 2008.

Rao, D.L.N. (2008) Role of Microbes as Nutrient Mobilizers. Delivered a synthesis paper at Brain storming session on Agricultural Sustainability through Microbial Biotechnology-Novel and Innovative Concept at National Academy of Agricultural Sciences (NAAS) on 11 Nov 2008.

10. LIST OF APPROVED ON-GOING PROJECTS

Programme I: Nutrient Management and Fertility Improvement

(A) In-house Projects

1 Long-term Evaluation of Integrated Plant Nutrient Supply Modules for sustainable productivity in Vertisol.

Muneshwar Singh, K. Sammi Reddy, A.K. Biswas, A.B.Singh & R.S. Chaudhary

2 Development of potassium management strategies for Alfisol in view of lessons learnt from long term fertilizer experiments.

R.H.Wanjari, Muneshwar Singh, Sanjay Srivastava, and N. Vasuki and S. B Yogananda (GKVK, Bangalore)

3 Development of region-specific databases on nutrient resources in agriculture and user friendly intelligent data retrieving systems for rational and efficient nutrient management.

S. Srivastava, A.Subba Rao, D. Damodar Reddy, S. Ramana, N.R.Panwar, Y. Muralidharudu and Abhishek Rathore

4 Long-term effect of fertilizer and manure application on carbon pool dynamic in a Vertisol under soybean-wheat system.

Brij Lal, Muneshwar Singh, K.Sammi Reddy, A.K.Biswas, R.S.Chaudhary and A.B.Singh

5 Investigations on phosphorus fraction in diverse organic manure and their effects on phosphorus speciation and availability in contrasting soils.

D. Damodar Reddy and Brij Lal Lakaria

6 Development of web enabled statistical software for analysis of data of AICRP on STCR.

Abhishek Rathore, Y.Muralidharudu, A.Subba Rao, V.K.Gupta and Rajender Prasad (IASRI, New Delhi)

7 Transformation and phyto-availability of zinc and boron in selected bench mark acid soils amended with lime and farmyard manure.

Sanjib Kumar Behera and M.V.Singh

(B) Externally Aided Projects

8 Integrated Manure Nutrient Management in Soybean/Wheat cropping systems in Vertisols in M.P. (ACIAR Project)

A. Subba Rao (Project Leader), K. Sammi Reddy (Operational Leader), D.L.N. Rao, Muneshwar Singh & M. Mohanty

9 Development of suitable methodology for soil fertility using GIS and GPS tools for precise fertilizer recommendations based on spatial variability. (ICAR Cess Fund)

K.N. Singh, A.K. Tripathi, N.S. Raju, Abhishek Rathore and A. Subba Rao

10 Development of methodology using RS, GPS & GIS for delineating area of a district in different fertility zones. (MP COST)

K.N. Singh, Abhishek Rathore A.K.Tripathi and A.Subba Rao

11 Ailing Agricultural productivity in economically fragile region of India: An analysis of synergy between public investment and farmer's capacity. (ICAR Cess Fund Award)

Ranjit Kumar

12 Network on evaluation of efficacy of Granubor II in ameliorating boron deficiency in important field crops under major ecological zones of India. (Contractual Research Project)

M.V. Singh and R.H. Wanjari

13 Boom Flower (Nitrobenzene 20% EW)-its influence on growth, Physiology, nutrient uptake and yield of tomato plant. (Contractual Research Project)

K.B.Hebbar, D.Damodar Reddy, Ajay and S.Ramana

14 Nano-Technology for Enhanced Utilization of Native Phosphorus by Plants and Higher Moisture Retention in Arid Soils. (NAIP)

Tapan Adhikari, A.K.Biswas and S. Kundu

15 Understanding the mechanism of variation in status of a few nutritionally important micronutrients in some important food crops and the mechanism of micronutrient enrichment in plant parts. (NAIP)

M.V.Singh, S.K.Behera, Muneshwar Singh, K.B.Hebbar, P.C.Mishra and Tapan Adhikari

16 Evaluation of Allwin wonder and Allwin top for their effects on maize productivity and soil fertility. (Contractual Project).

K.Ramesh and S. Ramana

Programme II: Management of Soil Physical Components

(A) In-house Project

17 Study of Long-term tillage management with differential nitrogen on soybean-wheat cropping systems in Vertisols.

A.K. Misra, K.M. Hati and R.K.Singh

18 Tillage and manure interactive effects on soil aggregate dynamics, soil organic carbon accumulation and pass flow in Vertisols.

Sangeeta Lenka, A.K.Misra, M.C.Manna, D.D.Reddy, K.M Hati, R.K.Singh, S.K.Rautray and B.K.Garg.

19 Tillage effects on weed dynamics in soybean-wheat system on Vertisol

Blaise D'Souza,, R.H.Wanjari, D.D. Reddy and R.K. Singh

Programme III: Soil Qualities for Sustainable Productivity

(A) In-house Project

20 Studies on the effect of organic nutrient sources on yield and quality of pomegranate

A.B. Singh, D.L.N. Rao and A.K.Tripathi

21 Development of composting techniques for recycling of municipal solid waste

M.C.Manna and A.B.Singh

22 Quality assessment of crops under different nutrient management system in long-term experiment

A.B.Singh, P.Ramesh, Muneshwar Singh, A.K.Tripathi and A.Subba Rao

23 On farm Production and evaluation of vermicompost and enriched compost

A.K.Tripathi

(B) Externally Aided Projects

24 Improving yields and nutrient uptake of selected crops through microbial inoculants in Vertisols of Central India (AMAAS)

D.L.N. Rao and M.C. Manna

25 Soil organic carbon dynamics and climatic changes and crop adaptation strategies. (NAIP)

M.C.Manna, S. Ramana, K. Sammi Reddy, A.K. Tripathi, Muneshwar Singh and K.N. Singh

Programme IV: Minimizing Environmental Pollution

(A) In-house Project

26 Investigation on effect of continuous use of sewage water as irrigation on swell-shrink soil quality

J.K. Saha, A.K. Biswas and Ajay

27 Nutrient dynamic and production sustainability of cropping sequences under organic farming system in Vertisols

P. Ramesh, A.B. Singh, S. Ramana and N.R. Panwar

28 Developing quality indices of urban solid waste composts

J.K.Saha, N.R.Panwar and M.V.Singh

29 Impact of Linear alkylbenzene sulphonate (LAS) and sodium tri poly phosphate (STPP) present in detergent on crop growth and soil quality

Ajay, J.K. Saha and M.V Singh

30 Developing database on extent of soil and water contamination in India

N.R.Panwar, Abhishek Rathore, Tapan Adhikari, S.Ramana, A.K.Biswas, J.K.Saha, S.Srivastava and S.Kundu

31 Diagnosis and Management of Emerging Physiological Disorders of Cotton, Wheat and Soybean in Black Soils of Central India Under Change Climatic Scenario

K.B.Hebbar, N.R.Panwar, S.Ramana, Ajay, P.Ramesh and S.Kundu

32 Phyto-extraction of Cr by some floriculture plants.

S. Ramana, A.K. Biswas and Ajay

(B) Externally Aided Projects

33 Network Project on Organic Farming(ICAR)

P. Ramesh, A.B.Singh, S. Ramana and N.R. Panwar

34 Assessment of quality and resilience of soils in diverse agro-ecosystems (NAIP)

S.Kundu, A.Subba Rao, Muneshwar Singh, Y.Muralidharudu,, J.K.Saha, A.K.Biswas, A.K.Mishra, A.K.Tripathi, K.Sammi Reddy, N.R.Panwar, R.H.Wanjari, K.M.Hati, K.N.Singh and T.Adhikari

11. CONSULTANCY, CONTRACTUAL SERVICES, PATENT, COMMERCIALISATION OF TECHNOLOGY

Drs. K.B. Hebbar, D. Damodar Reddy, Ajay and S. Ramana undertaken a contractual research project entitled "Boom Flower (Nitrobenzene 20% EW) its influence on growth, physiology, nutrient uptake and yield of tomato plant" with M/s. Dev Crop Sciences, Chennai.

Drs. M.V. Singh and R.H. Wanjari undertaken research project entitled "Evaluation of efficacy of Granubor II in ameliorating boron deficiency in important field crops under major ecological zones of India" with M/s Rallis India Limited, Chennai.

12. IRC, IMC, RAC, IBC, IPC, IJSC

(Institute Research Council, Institute Management Committee, Research Advisory Committee, Institute Building Committee, Institute Purchase Committee, Institute Joint Staff Council Committee)

Institute Research Council

1.	Dr. A. Subba Rao	Director	Chairman
2.	Dr. A.K. Misra	Head, Division of Soil Physics	Member
3.	Dr. Y.Muralidharudu	PC (STCR)	Member
4.	Dr. Muneshwar Singh	PC (LTFE)	Member
5.	Dr. D.L.N. Rao	PC (BNF)	Member
6.	Dr. P. Ramesh	Pr.Scientist	Member
7.	Dr. K.N. Singh	Pr.Scientist	Member
8.	Dr. M.C. Manna	Pr.Scientist	Member
9.	Dr. A.B. Singh	Pr.Scientist	Member
10.	Dr. A.K. Biswas	Pr. Scientist	Member
11.	Dr. Ajay	Senior Scientist	Member
12.	Dr. J.K. Saha	Pr.Scientist	Member
13.	Dr. R.S. Chaudhary	Pr.Scientist	Member
14.	Dr. A.K. Tripathi	Senior Scientist	Member
15.	Dr. K. Sammi Reddy	Senior Scientist	Member
16	Dr. D. Damodar Reddy	Pr.Scientist	Member
17	Dr. Sanjay Srivastava	Senior Scientist	Member
18.	Dr. Tapan Adhikari	Sr.Scientist	Member
19.	Dr. Kuntal M. Hati	Sr.Scientist	Member
20.	Dr. S. Ramana	Sr.Scientist	Member
21	Dr. K.B. Hebbar	Pr.Scientist	Member
22.	Dr. R.H. Wanjari	Scientist (Sr.Scale)	Member
23.	Mr. M. Mohanty	Scientist (Sr.Scale)	Member
24.	Dr. Abhishek Rathore	Scientist (Sr.Scale)	Member
25.	Dr. N.R. Panwar	Scientist (Sr.Scale)	Member
26.	Dr. Brij Lal Lakaria	Sr.Scientist	Member
27.	Dr.S.Kundu	Head, Division of ESS	Member
28.	Dr. (Mrs.) Sangeeta Lenka	Scientist	Member
29	Dr. Sanjib Kumar Behera	Scientist	Member
30	Dr. Blaise Desouza	Pr.Scientist	Member
31	Dr. K. Ramesh	Sr. Scientist	Member
32	Dr. M.V.Singh	PC (MSN)	Member Secretary

The first Institute Research Council (IRC) meeting during the period under report was held on 9-11 June, 2008 under the chairmanship of Dr. A. Subba Rao, Director IISS, Bhopal. At the outset, Member Secretary of IRC, Dr. M. V. Singh, Project Coordinator (Micronutrients) pointed out that IRC is an important forum to help the scientists in planning and reviewing the research work to fulfill the objectives and mandate of the Institute.

The Chairman in his opening remarks welcomed the members and requested all the Heads of Divisions to send the progress reports of technical staff regularly, for effective monitoring of their duties.

He reiterated all scientists to work with devotion and sincerity. Scientists were asked to submit one page progress report to the Technical Cell well before the IRC Meeting. All together the progress of 25 on-going research projects and 2 new research proposals were reviewed.

In his concluding remarks, Dr. M.V.Singh, Secretary IRC has suggested the members to improve the presentation quality. He has requested the scientists to carry out patentable research which will be more deliverable.

The Chairman, IRC in his concluding remarks observed that the expectations from the ICAR and other peers on our institute are very high. Therefore, he requested the scientists to think sincerely how deep we are going into the subject as scientist and try to improve the research work to the international competence level. He also observed that no new technologies are coming out from the research projects of the institute. He has asked the scientists to submit two to three pages scientific achievements of high caliber, if any. He suggested the scientists to get analyzed soil and plants samples from other organizations on payment basis wherever facilities are not available in our institute. He once again reiterated that each scientist should have at least one project as PI. The Chairman has appreciated all the scientists who have presented the progress in the IRC.

The second IRC meeting was held on November 20-24, 2008 under the chairmanship of Dr. A. Subba Rao, Director. The chairman pointed out that research output must be in line with the expectation of RAC and QRT. He also remarked that work load is highly skewed towards some scientists while many are not having sufficient work load and asked those scientist to undertake more research work to justify their time. Total 19 In-house projects and 11 Externally Aided Projects were discussed. Two research projects were declared completed by the IRC. Three new research proposals were approved in this IRC Meeting. In concluding remarks, the chairman suggested that new project proposals must cover the following areas;

(i) Use of nano-technology in nutrient use efficiency and remediation of contaminated soils.

(ii) Precision farming using digital and space technology.

(iii) Climate change and mitigation strategies,

(iv) Agro-biodiversity

(v) Carbon sequestration and carbon credits.

All the Heads of the Divisions were advised to take necessary measures to bring non-functional equipments into working condition. They were also asked to maintain a work done register for all the technical staff indicating the date-wise duties performed by the technical staff.

Institute Management Committee (IMC)

Representation	Name	Designation
Director of the institute	Dr. A. Subba Rao	Chairman
Institute's scientists	Dr.S.Kundu, Head, ESS Division	Member
	Dr.R.S.Chaudhary, Pr.Scientist	Member
	Dr.D.Damodar Reddy, Pr.Scientist	Member
Asst. Finance & Accounts Officer of the Institute	Shri Rajesh Dubey	Member
Administrative officer of the Institute	Shri Kumar Vivek	Member Secretary

Institute Management Committee (IMC) meeting was held thrice on September 9, 2008, December 3, 2008 and January 30, 2009. During the first meeting, the chairman elaborated on-going activities to the IMC members. The IMC recommended to procure the urgently required equipment that were mentioned in XIth Plan EFC, renovation of footpath of main roads in the institute campus, deepening of tubewells in the wake of drought situation, reappropriation of funds from other heads to establishment charges. The IMC also approved the recruitment of computer programmer on direct recruitment basis. Subsequently, the council examined the IMC proceeding and approved the proposals cleared by the IMC.

In the second IMC meeting, the proposals for procuring urgently needed equipment, digging of two new tubewells, civil works on water harvesting and conservation structures, deepening of farm ponds, construction of building for two labs, remaining boundary wall and threshing floor have been approved. Subsequently, ICAR has approved the IMC proposals and authorized the Director to undertake these proposals subject to the approval in the XIth Plan EFC.

The IMC has approved the proposals of replacement of staff car and jeep which are twenty years old from the non-plan budget in the third IMC meeting. ICAR, New Delhi permitted the institute to replace the said vehicles with the non-plan budget. As a result, the old staff car was replaced by new staff car successfully.

Research Advisory Committee (RAC)

The composition of RAC w.e.f. Jan 25, 2008 is as follows

1.	Dr. J.S.P. Yadav	Chairman
2.	Dr. R.K. Gupta	Member
3.	Dr. P.K. Chhonkar	Member
4.	Dr. P.D. Sharma	Member
5.	Dr. Biswapati Mandal	Member
6.	Dr. A. Subba Rao	Member
7.	Dr. P.K. Aggarwal	Member
8.	Dr. Y. Muralidharudu	Member Secretary

The 14th Meeting of the RAC (first meeting of the fifth RAC since inception of the institute) was held on 18-19 September, 2008 under the chairmanship of Dr. J.S.P.Yadav.

At the outset Dr. A.Subba Rao, Director, Indian Institute of Soil Science welcomed the members. The chairman in his initial remarks highlighted the need for focusing research on frontier areas at IISS, Bhopal. He traced the history of the institute and mentioned that a few years prior to establishment of IISS, Bhopal in 1988, a Working Group (of which he was Convener) was constituted by ICAR to recommend the site of location as well as the mandate for the Institute. The Group had expressed very high expectations from the

Institute. Initially, high yielding fertilizer responsive crop varieties were given more importance during Green Revolution era in mid 1970s. But indiscriminate and unscientific management led top soil deterioration, low nutrient use efficiency, deficiency of some nutrients, and decline in factor productivity and sluggish agricultural growth rate. As a consequence, the situation has changed and there is a need to give greater importance to soil over the crop variety, to fully exploit the yield potential of the crop varieties, as the yield level of even most high yielding crop varieties can not be realized if the soil is not in good health. Under the changed situations, the scenario is now to give priority to soil over the crop varieties alone. Hence, it is imperative to improve the soil health for increasing productivity, as the net cultivated area has hovered around 140 M ha for last 38 years, and there is no hope of further increase in the cultivated area. Besides, many prime farm lands are being diverted to non-agricultural uses and per capita land availability is declining. Proper land use planning and periodic monitoring of soil health have become imperative. There is a need for more strategic and basic research at IISS, Bhopal to achieve this objective. The Institute is lucky to have four related AICRP/Network projects and therefore, has enough opportunity to validate its technologies at multilocations across the country representing major eco-systems and to come out with well proven recommendations.

Dr. A.Subba Rao, Director, IISS presented the achievements of the institute during his presentation. He mentioned that the institute has published over 107 international research articles. The institute has also handled 10 NATP projects and now initiated four NAIP projects. He also mentioned that the institute has developed 18 technologies which include INM on cotton, pulses and soybean-wheat system, wheat residue management, GIS based fertility mapping, bentonite sulphur efficiency, efficient use of water in soybean-wheat system, identified species of vermicompost, safe use of distillery effluents, bioremediation, organic farming etc. In addition to the above, training on composting technology and soil testing are also being organized. He drew the attention regarding the constraints of the manpower and technical support. In the end, he requested the RAC to identify the critical gaps and to make recommendations.

Later, Project Coordinators/Network Coordinator/ HODs presented the research achievements of their respective projects. Subsequently, the RAC gave the following comments:

AICRP on Micronutrients: Current status of micronutrient deficiency in different states, methodology for soil fertility mapping, methodology for delineation of polluted soils needs attention. The DTPA method was originally developed for neutral and non-calcareous soils. The use of this method in other soils including calcaresous and acid soils may be made with caution. Information on extent of multi nutrient deficiencies in the country is needed.

AICRP on Long-term Fertilizer Experiment: Physical, chemical and microbiological properties need to be determined wherever not being done at present. Statistical analysis for splitting of treatments should be paid due to attention. Scientific reasons should invariably be given for explaining the differences observed in the effect of same treatment in respect of different crops and sites. Many cropping systems have been studied for last several years and no significant changes are observed in the effects of the treatment(s) in some cases. It will be worthwhile that this issue may be critically examined and discussed in the workshop to decide as to how long a particular experiment is to continue further, and if a change in the cropping system is needed, the appropriate alternative systems/treatment combinations may be suggested.

AICRP on STCR: The yield levels based on soil test in STCR and LTFE centers at a particular locality need to be compared critically. How to make soil testing laboratories made more effective and how to achieve transfer of technology are to be examined.

Division of Soil Physics: The work done in the Physics Division on conservation tillage is commendable. To transfer the technology to farmers' fields, the main constraint is management of weeds in Vertisols and therefore, management technology developed may be demonstrated on the farm. Besides, the members have also suggested for further studies on other soil types.

Division of Soil Chemistry and Fertility: Considerable research has been conducted on cotton at CICR, Nagpur and elsewhere. In view of this, it is to be examined whether such studies on cotton will serve any useful purpose at IISS.

Division of Soil Biology: More work is needed on soil biology, especially on soil bio-diversity.

After considering various presentations and discussions the following future lines of work have been suggested by the Hon'ble RAC,

1. Enhancing the use efficiency of inputs like nutrients, water and energy employing modern tools like nanotechnology.
2. Identifying quantitative parameters for developing indices for assessing and categorizing different degrees of soil quality/ soil health with a view to enhance soil health.
3. Development of eco-friendly remedial measures for efficient recycling of solid and liquid wastes.
4. Anticipatory research on soil-related problems arising from impending climate change.
5. Identification and quantification of agriculturally useful microorganisms in different agricultural ecosystems.
6. Rhizosphere studies for increased mobilization of nutrients in soil-plant system.
7. Quantification of carbon sequestration under different land uses and cropping management systems.
8. Isolation and identification of tolerant microbial strains for abiotic streses management.
9. Exploiting the synergistic interactions among the nutrients as well as between nutrient and water under different management/productions systems.
10. Soil management for improving physical conditions for sustaining high crop productivity.
11. Studies on nutrient deficiencies and heavy metal toxicities in soil-plant-animal continuum.
12. Establishment of quality standards/ specifications for organic manures and locally available amendments.

Preparation of geo-referenced soil fertility maps of selected districts.

Institute Building Committee

1	Dr. A. Subba Rao, Director	Chairman
2	Dr. M. V. Singh, PC (MSN)	Member
3	Dr. Muneshwar Singh, PC (LTFE)	Member
4	Dr. Y. Muralidharudu, PC (STCR)	Member
5	Dr. A. K. Misra, Head, Division of Soil Physics	Member
6.	Dr. S. Kundu, Head, Division of ESS	Member
7.	Dr. D. L. N. Rao, PC (AINP on BNF)	Member
8.	Shri Rajesh Dubey, Assistant Finance & Accounts Officer	Member
9.	Shri. Kumar Vivek, Administrative Officer	Member Secretary

Institute Purchase Committee

1	Dr. R.S. Chaudhary, Pr.Scientist	Chairman
2	Dr. K. Sammi Reddy, Sr. Scientist	Member
3	Shri. Rajesh Dubey, Assistant Finance & Accounts Officer	Member
4.	Shri. Kumar Vivek, Administrative Officer	Member

Institute Joint Staff Council

1	Dr. A. Subba Rao, Director	Chairman
2	Shri. A. S. Rajput, Assistant	Administrative
3	Shri. O. P. Shukla, T-2, Mechanic	Technical
4	Shri. Harish Kumar Barmaiya, Lab Attendant	Supporting

13. PARTICIPATION OF SCIENTISTS IN CONFERENCES/ MEETINGS/WORKSHOPS / SYMPOSIA

Name	Programme	Venue	Period
Dr. K. Sammi Reddy	National Conference on Open Access to Scientific Publications: Policy Perspective, Opportunities and Challenges	CSIR, India Habitat Centre, New Delhi	March 24, 2009
Dr. S. Srivastava	National Seminar on customized fertilizers, HPKVV, Palampur.	CSKHPKV, Palampur.	April 9 -11, 2008
Dr. Y. Muralidharudu	National Seminar on Customized fertilizers	HPKV, Palampur	April 9-14, 2008.
Dr.D.L.N.Rao	Seminar on Policy Initiatives for Promotion of Balanced Fertilization and Integrated Nutrient Management	CSHPKV, Palampur	April 2008
Dr.K.M.Hati	International Symposium on Water Harvesting - Bringing green revolution to rainfed areas	TNAU, Coimbatore	June 23-25, 2008
Dr. Y. Muralidharudu	Participated the QRT meeting and to attend the presentation of Coimbatore, Vellanikkara Centre.	Coimbatore	July 7-8, 2008
Dr. Y. Muralidharudu	Participated in QRT meeting organized and to attend presentation	MPKV, Rahuri	June 31-July 1, 2008
Dr. Y.Muralidharudu	Presentations during QRT meeting by STCR centre, Uttarakhand, Kalyani and West Bengal	Lucknow	August 2, 2008
Dr.J.K.Saha	1st Meeting of Technical group to look into the feasibility and all technical and scientific aspects of organic fertilizers and biofertilizers included in the FCO 1985	ICAR, New Delhi	August 18, 2008
Dr.R.H. Wanjari	Launching Workshop of NAIP on Assessment of quality and resilience on soils in diverse agro-ecosystems	Indian Institute of Soil Science, Bhopal	September 6-7, 2008

Dr.Y.Muralidharudu	National Seminar on Natural Resource Management for livelihood security	NBSS&LUP, Nagpur	September 12, 2008
Dr. N.R. Panwar	National Seminar on Non - biological Contaminants in Food, Feed and Their Safety Standards	India International Centre, New Delhi	September 23-24, 2008
Dr. Ajay	Golden Jubilee Conference on Challenges and Emerging Strategies for Improving Plant Productivity	IARI, New Delhi	November 12-14, 2008
Drs. Y. Muralidharudu, M.C. Manna and A. B. Singh	Annual Convention of Indian Society of Soil Science	UAS, Bangalore	November 27-30, 2008
Dr.D.L.N.Rao	49th Annual Conference of AMI	Delhi	November 2008
Dr.K.Sammi Reddy	FAI Annual Seminar	FAI, The Ashok, New Delhi	December 4-6, 2008
Drs. K. Sammi Reddy, Brij Lal Lakaria, K. Ramesh and Tapan Adhikari	International Conference on Nanotechnology in Indias Future	2nd Bangalore Nano at Grand Ashoka, Bangalore	December 11-13, 2008
Dr.N.R.Panwar	International Symposium On Natural Resource Management in Agriculture	Agricultural Research Station, Durgapura, Jaipur	December 19-20, 2008
Drs.S.Kundu, A.K. Biswas and Tapan Adhikari	Launching workshop of NAIP sub -project Nano technology for enhanced utilization of native phosphorous by plant and higher moisture retention in arid soils	CAZRI, Jodhpur	December 23-24, 2008
Drs.Ajay and Tapan Adhikari	96th Session Indian Science Congress	North-eastern Hill University, Shillong	January 3-7, 2009
Dr.Ranjit Kumar	Fifth Biennial Conference of Indian Society for Ecological Economics (ISEE) on Environmental Governance	Gujarat Vidyapeeth, Ahmedabad	January 21-23, 2009
Dr.Y.Muralidharudu	National Symposium on Vegetable Oils Scenario: Approaches to meet the growing demands	ANGRAU, Hyderabad	January 29-30, 2009
Drs. A. Subba Rao, K.Sammi Reddy, D. Damodar Reddy, Brij Lal Lakaria, K. Ramesh, K.M.Hati, Y. Muralidharudu and J. Somasundaram	4th World Congress on Conservation Agriculture	NAAS, New Delhi	February 4 - 7, 2009
Drs. S. Kundu and Tapan Adhikari	Workshop for consortia partners on Procurement Procedures of the World Bank- NAIP	IISR, Lucknow	February 9-10 2009
Dr.K.Ramesh	International conference on challenges and opportunities in Agro-meteorology	Indian Meteorological society, New Delhi	February 23-25, 2009
Dr.J.K.Saha	2nd Meeting of Technical group to look into the feasibility and all technical and scientific aspects of organic fertilizers and biofertilizers included in the FCO 1985	Krishi Bhavan, New Delhi.	February 27, 2009

14. WORKSHOP/SEMINARS/SUMMER INSTITUTES/ GROUP MEETINGS/ FARMERS' DAY / WOMEN'S DAY ORGANIZED AT THE INSTITUTE

14.1 Workshops/ Group Meetings/ Seminars

Review Workshop of ACIAR Project

Final Review Workshop of the ACIAR project entitled "Integrated manure nutrient management in soybean/wheat cropping systems on Vertisols in Madhya Pradesh and Queensland" was organized during 15-17 September 2008 at IISS, Bhopal. The project Scientists from IISS, Bhopal and BAIF Research Foundation, Bhopal, India; University of Queensland & Queensland Department of Natural Resources, Brisbane, Australia, Dr. Christian Roth, Programme Manager, ACIAR, Canberra, Australia; Ms. Simrat Labana, Assistant Country Manager, ACIAR, New Delhi had participated in the workshop. During the workshop, Dr. Michael Webb, Soil Scientist, CSIRO, Brisbane, Australia has reviewed the work done under the project and appreciated the research outcomes. He has recommended for conducting another 100 baby trials (Demonstration trials) in new villages for popularization of the INM technology among the farmers during 2009-2010. Therefore, the ACIAR has extended the project period up to June 30, 2010 for conducting these trials with the unspent funds of the project.

AICAR team visiting the field trials

Launching Workshop of NAIP Project

NAIP sub-project entitled "Assessment of Quality and Resilience of Soil under Diverse Agro-ecosystems" (under component 4) was launched on 7th September 2008. The total budget of the project is Rs. 276.65 lakhs. IISS, Bhopal is the consortium leader while BCKV (Kalyani), PAU (Ludhiana), CRIDA (Hyderabad) and NBSS & LUP (Nagpur) are the co-operating centers. Dr. N.N. Goswami, Ex-Vice Chancellor (CSAUA & T, Kanpur) was the chief guest. Dr. N. Panda Ex-Vice Chancellor (Sambalpur University) and Dr. M. Velayutham, Ex-Director (NBSS & LUP, Nagpur) graced the occasion.

Dignitaries attending the Launching workshop of NAIP sub-project

Seminar /Workshops outside the Institute

AICRP on STCR conducted two regional workshops cum seminars on soil testing on 21 - 22 May 2008 at Rahuri and 15 - 17 July 2008 in Hyderabad.

Group Meeting of All India Network Project on Soil Biodiversity-Biofertilizers

The group meeting of the All India Network Project on Biofertilizers was held during September 11-13, 2008 at the Y.S. Parmar University of Horticulture and Technology. It was inaugurated by Hon. Minister for Health and Family Welfare of H.P. Govt., Dr. Rajeev Bindal. The vice-chancellor of YSPUHT, Dr. K.R. Dhiman, Dr. P.D. Sharma ADG (Soils) and Dr. A. Subba Rao, Director, IISS graced the occasion. Dr. D.L.N.Rao, Network Coordinator presented the salient achievements and the XI plan programme. There were 4 technical sessions where the progress and future programmes of the centres was discussed. The annual report of the project, 4 bulletins and 1 folder was released.

Inaugural meeting of the Group Meeting of AINP-Soil Biodiversity-Biofertilizers

Model Training Course (MTC)

An eight-day Model Training Course (MTC) sponsored by Ministry of Agriculture, Department of Agriculture & Cooperation, New Delhi. on "Efficient use of on-farm and off-farm resources for sustainable crop production in organic farming" was organized at IISS, Bhopal during 1-8th December, 2008. Eighteen candidates from different State Agriculture/ Horticulture Departments, State Agricultural Universities and ICAR Institutes were participated in this training program. Dr. P. Ramesh, Principal Scientist was the Course Director of the training program.

14.2 WINTER SCHOOL

ICAR sponsored Winter School on "Farmers Resource based site specific integrated nutrient management and on-line fertilizer recommendations using GIS and GPS tools" of 21 days duration was organized at IISS, Bhopal from January 3-23 2009. Dr. Y. Muralidharudu and Dr.K.Sammi Reddy were the Course Director and Course Co-Director, respectively. A total of 22 participants from ICAR institutes and Agricultural Universities attended the training programme. Dr.D.N.Sharma, Director of Agriculture, Govt. of Madhya Pradesh inaugurated the winter school. Dr.M.M.Pandey, Director, CIAE was the guest of honour at the inauguration.

About 57 lectures including Theory and Practicals were delivered to the trainees. These lectures were categorized into the six modules, viz., (i)Soil fertility scenario, fertilizer use and Agril. Production in the country (ii) Concepts of STCR and SSNM (iii) INM and its use of higher efficiency (iv) Farmers' resource based site specific INM (v0 Role of GIS and GPS tools in soil fertility mapping and on-line fertilizer recommendations. (vi) Issues and challenges of soil testing. During the course, 8 invited speakers from outside organizationViz, IARI, New Delhi, DOR, Hyderabad, NBSS& LUP, Nagpur, NIC, Pune, TNAU, Coimbatore and CIAE, Bhopal delivered lectures and shared their views with the trainees.

During the valedictory function, Dr. A.K.Singh, DDG (NRM), ICAR was the chief Guest and Dr.S.P. Shukla, IFFCO advisor was guest of honour. Dr.A. Subba Rao, Director, IISS presided over the function. In the feed back, the trainees appreciated the programme and said that course schedule was well planned and the programme was slightly tight. Finally, the participants received certificates from the Chief Guest.

Inaugural function of the Winter School

Participants of Winter School

Dr. A.K. Singh, DDG (NRM) distributing certificates

14.3 EVENTS

Independence Day/Republic Day: All the staff members and their families celebrated the Independence day and Republic day with great enthusiasm.

Children participating in running competition on the Republic Day

IISS staff participating in musical chair competition on the Republic Day

International Women's Day: International women's day was celebrated on March 9, 2009. The function was graced by Chief Guest Dr.Rashmi Jha, Medical Officer, District Ayurvedic Hospital. Her speech highlighted the importance of nutrition and balanced diet for children and women. Other guest speakers for the function were Mrs.Young, Principal, People Public School and Smt. A. Bhulakshmi Devi. Various competitions viz., Rangoli, musical chair, Antakshri were held to bring forth talent of women participant. Prizes were distributed to winners of competition. The function concluded with vote of thanks by Dr.(Mrs.) Sangeeta Lenka, Chairperson Women Cell.

Chief Guest Dr.Rashmi Jha, Medical Officer, District Ayurvedic Hospital and other dignitaries on the occassion of International womens day

Institute Foundation Day

Institute celebrated its 20th foundation day on April 16, 2008. The function was graced by Chief Guest Dr. J. Venkateshwarlu, Former Director, CAZRI, Jodhpur. On this occassion Chief Guest relased Institute publication and delivered a lecture

15. DISTINGUISHED VISITORS

Dr. Neal Menzies, Professor, and Dr. F. P. C. Blamey, University of Queensland, Brisbane, and Dr. Ram Dalal, Senior Principal Scientist, Queensland Department of Natural Resources & Water, Brisbane, Australia: Visited IISS, Bhopal during 11-17 September 2008 to participate in the Final Review Workshop of ACIAR Project (SMCN/2002/032).

Dr. Christian Roth, Programme Manager, ACIAR, Canberra, Australia and Dr. Michael Webb, Soil Scientist, CSIRO, Brisbane, Australia: Visited IISS during 15-17 September 2008.

Shri A. K. Upadhyay, Additional Secretary to the Government of India, Department of Agricultural Research & Education (DARE) and Secretary, Indian Council of Agricultural Research (ICAR) visited the institute and addressed the staff members on 28/11/2008.

16. PERSONNEL

(Appointments, Promotions, Transfers, Retirements etc.)

Appointments

Sh. Kumar Vivek, Administrative Officer, joined the institute on April 30, 2008.

Dr. M.C. Manna, Pr. Scientist joined as HOD, Soil Biology

Dr. K. Ramesh appointed as Sr. Scientist (Agronomy) on September 4, 2008.

Dr. J. Somasundaram appointed as Sr. Scientist (Soil Physics) on December 22, 2008.

Promotion

Dr. A.K. Biswas, Senior Scientist promoted to Principal Scientist w.e.f August 23, 2007.

Dr. J.K. Saha, Senior Scientist promoted to Principal Scientist w.e.f. August 31, 2007.

Dr. Abhishek Rathore, Scientist promoted to Scientist (Sr.Scale) w.e.f. December 16, 2006.

Dr. N.R. Panwar, Scientist promoted to Scientist (Sr.Scale) w.e.f. April 16, 2007.

Mr. Thomas Joseph, Personal Assistant promoted to Private Secretary to the Director w.e.f. February 1, 2009.

Smt. Babita Tiwari, UDC, promoted to assistant on May 15, 2008

Transfer

Dr. S. Elamathi, Scientist (Sr. Scale) transferred to Allahabad Agricultural Institute, Allahabad on May 31, 2008.

Supernnuation

Shri. K. Chandrabhanu, Private Secretary to the Director retired on January 31, 2009.

17. INFRASTRUCTURE DEVELOPMENT

17.1 Technical Cell

Strengthened the technical cell by procuring Colour Photocopier, Air Conditioner etc. Achievements of the Technical Cell during the report period are;

Compiled and submitted 2 scientist-wise Six Monthly Progress Reports, 4 Quarterly Reports, 4 Quarterly Performance Reports and 12 Monthly Reports for the Cabinet Secretariat.

Compiled and Edited IISS Annual Report (2007-08)

Prepared the "IISS at a Glance".

Compiled/ prepared and submitted the replies to 20 Audit *Paras* given by the External Audit Party for the financial year 2007-08.

Prepared the XI Five Year Plan EFC Memo of IISS, which has been approved by the ICAR, New Delhi.

Compiled the material for DARE Annual Report.

Involved in preparation of Agenda Items for IRC Meetings and IRC Proceedings.

Prepared Action Taken Reports (ATR) on the recommendations of Directors' Meeting, Regional Committee Meetings and QRT recommendations.

17.2 Statistics and Computer Application Section/ARIS Cell

Software Developed

A software "Soil Test Crop Response (STCR) Based Fertilizer Recommendation System" is an application software developed using principles of web technologies. The application gives an easy and user-friendly mechanism to prescribe major fertilizers in various districts of different states of the country based on soil type, crop, crop variety and target. The application takes care of the location specific information while prescribing the fertilizer rates. The calculation for recommendation of fertilizer is based on the STCR equations. The Database contains information on soil type, crops, crop variety, range of achievable target, available nutrient in the soil, climatic zone. MS-Access is used to design and manage the database repository and proper care has been taken for the issues related to data ambiguity, inconsistency, redundancy, data loses. User-interfaces have been developed using ASP and ADO techniques.

Updating PERMISNet Database

ICAR has developed an application software, Personnel Management Information System Network (PERMISNet), to maintain the activities and records of its various institutes/research centers and their employees. The records are to be updated on monthly basis. ARIS Cell is doing the work regularly.

Maintenance of IT and Communication Systems

The ARIS Cell is looking after the Information Technology and Communication related activities of the institute. The ARIS Cell is looking after the institute LAN equipped with 256 kbps FTDMA Broadband VSAT connections. It is maintaining the e-mail server and Proxy server configured with LINUX Network Operating System. All divisions and sections are connected to the Internet through proxy server. Scientists and staff are having individual email accounts. It also takes care of the maintenance of computers, printers and other electronic peripherals.

ARIS Cell is also taking care of the internal communication needs of the institute by providing intercom telephone connection to all divisions and section through EPABX system. It also facilitate the Audio-Visual presentation need of the institute,

Updating Institute Website

The ARIS Cell is also maintaining the Institute website (www.iiss.nic.in). The site contains complete information about the institute R&D and other activities. It is updated from time to time as per the requirement of the institute. Recently the WebPages have been redesigned and the home page is given below. RTI Act 2005, Photo Gallery, Latest News, Forthcoming events, other information, Search engine etc. have been incorporated in the present form to make

17.3 Farm Development

The farm section undertook the following developing activities:

1. An extensive geo-hydrological survey was undertaken to find out the underground water resources beyond 200 feet keeping in view of the serious shortage of water due to repeated drought conditions in the last four years.

2. As per the survey report, 2 number of tube wells were dug up up to a depth of 600 feet and 400 feet each, to generate additional water resources.

3. Purchase of 2 number of submersible pumps with suitable 3 phase specifications are fitted to extract the water from the newly dug tube wells.

4. Certified seed production program was taken up in the collaboration with National Seed Corporation (NSC), Bhopal to generate farm resources.

5. Initiated the work on deepening of farm ponds to improve the water storage capacity and lining of silpaulin film to reduce the seepage losses from the storage ponds.

17.3 Civil Works Undertaken

Deepening of the farm ponds

Construction of threshing floor

17.4 Library

During the period of report, the Institute Library has acquired total documents categorized as listed in the table

Table 17.4.1. Books and Journals procured during 2008-09

Documents	Addition during 2008-09	Total Holding
Books	33	2370
Bound Journals	877	2507
Annual Reports	121	1417
Foreign Journals	-	30
Indian Journals	-	44
Gifted Books	19	467

The library is well maintained with the facilities of Document Lending Service, Reference Service, Reprographic Services. The Library has procured the Library Automation Software TLS, in which the bibliographic data of the books were imported from the existing software. In the field of digitization, the library is providing all the databases available on CD to its user online on their desktop. During the period of report, library became an active member of CeRA. The electronic resources and facilities provided by the CeRA are being used actively by the institute scientists.

DETAIL OF MANPOWER

SL. NO.	DIVISION/CELL/LAB/ UNIT/SECTION	PRESENT DESIGNATION	DATE OF JOINING ICAR	DATE OF JOINING IISS	DATE OF JOINING IN PRESENT DESIGNATION
I	*DIRECTOR'S CELL*				
	Dr. A. Subba Rao, FNAAS	Director	27.07.89	27.07.89	05.02.04
	Mr. Thomas Joseph	PS to Director	18.09.89	18.09.89	02.02.09
	Mrs. Geeta Yadav	Personal Assistant	26.12.95	26.12.95	16.03.04
	Mr. Sanjay Narayan Gharde	Lab Attendant/SSS	01.09.93	15.06.99	15.06.99
II	*DIVISION OF SOIL PHYSICS*				
	Dr. A. K. Misra	Pr. Scientist & Head	14.03.86	23.03.90	08.05.06
	Dr. R. S. Chaudhary	Pr. Scientist	10.11.93	08.12.99	08.06.07
	Dr. Blaise D' Souza	Pr. Scientist	27.07.94	22.12.07	22.12.07
	Dr. Kuntal Mouli Hati	Sr. Scientist	27.12.96	27.12.96	27.12.00
	Dr. J. Somasundaram	Sr. Scientist	12.11.01	22.12.08	22.12.08
	Mr. Manoranjan Mohanty*	Scientist, Sr.Scale	10.11.99	10.11.99	10.11.04
	Dr. R. K. Singh	Scientist, Sr.Scale	25.01.93	16.10.02	07.09.98
	Dr. Sangeeta Lenka	Scientist	08.01.07	18.05.07	18.01.07
	Mr. R. K. Mandloi	Tech. Officer (T-6)	19.06.89	19.06.89	01.01.05
	Mr. P. K. Chouhan	Field Asstt. (T-4)	15.02.93	15.02.93	15.02.08
	Mr. Darash Ram	Lab. Attendant/SSS	15.03.90	15.03.90	17.01.01
III	*DIVISION OF SOIL CHEMISTRY & FERTILITY*				
	Dr. D. Damodar Raddy	Pr. Scientist & I/c Head	25.07.94	25.09.95	11.06.07
	Dr. K. Sammi Reddy	Sr. Scientist	05.08.91	24.07.92	05.08.00
	Dr. Sanjay Srivastav	Sr. Scientist	22.03.96	02.09.96	10.03.03
	Dr. B.L. Lakaria	Sr. Scientist	01.10.97	15.01.07	01.10.06
	Dr. K. Ramesh	Sr. Scientist	04.09.08	04.09.08	04.09.08
	Mr. Deepak Kaul	Tech. Officer (T-6)	29.12.88	29.12.88	01.10.04
	Mr. T. Ayodhya Ramaiah	Personal Assistant	29.12.80	15.07.96	15.10.99
	Mr. K. S. Raghuvansi	Field Asstt. (T-3)	29.12.88	29.12.88	29.12.03
	Mr. Sanjay Katinga	Lab Attendant/SSS	20.06.89	20.06.89	17.01.06
IV	*DIVISION OF ENVIRONMENTAL SOIL SCIENCE*				
	Dr. S.Kundu	Pr. Scientist & Head	22.08.86	01.07.07	24.12.07
	Dr. P. Ramesh	Pr. Scientist	05.12.89	10.09.99	05.12.06
	Dr. K.B.Hebbar	Pr. Scientist	25.07.94	12.07.07	12.07.07
	Dr. A. K. Biswas	Pr. Scientist	21.01.92	11.01.93	02.07.09
	Dr. J. K. Saha	Pr. Scientist	21.01.92	02.01.93	31.08.99
	Dr. Ajay	Sr. Scientist	12.04.93	31.08.99	31.08.99
	Dr. Tapan Adhikari	Sr. Scientist	22.03.96	07.11.96	22.03.05

SL. NO.	DIVISION/CELL/LAB/ UNIT/SECTION	PRESENT DESIGNATION	DATE OF JOINING ICAR	DATE OF JOINING IISS	DATE OF JOINING IN PRESENT DESIGNATION
	Dr. Nav Raten Panwar	Scientist, Sr. Scale	16.04.03	18.08.03	16.04.07
	Mrs. Seema Sahu	Tech. Officer (T-6)	14.04.87	24.01.89	01.04.07
	Mr. S. K. Rai	T-2	15.06.89	15.06.89	21.05.04
	Mr. Kalicharan	Lab. Attendant/SSS	01.09.93	15.06.99	15.06.99
V	*DIVISION OF SOIL BIOLOGY*				
	Dr. M. C. Manna	Pr. Scientist & I/c Head	21.01.92	11.01.93	19.03.07
	Dr. A. B. Singh	Pr. Scientist	22.03.99	22.03.99	22.03.07
	Dr. A. K. Tripathi	Sr. Scientist	05.08.91	25.07.92	05.08.00
	Dr. S. Ramana	Sr. Scientist	06.02.97	06.02.97	06.02.06
	Dr. Ranjit Kumar	Sr. Scientist	31.10.00	01.05.07	01.05.07
	Mr. Vinodbabu Pal	Tech. Officer (T-5)	15.02.93	15.02.93	10.02.05
	Mr. Vinod Choudhary	Lab Asstt. (T-2)	14.06.89	14.06.89	28.10.00
	Mr. Bhoi Lal	Lab Attendant/SSG.II	13.11.95	13.11.95	28.08.06
VI	*STATISTICS AND COMPUTER APPLICATION SECTION*				
	Dr. K. N. Singh	Pr. Scientist & In-charge	05.08.91	24.12.98	24.12.98
	Mr. N. S. Raju*	Scientist	08.12.99	08.12.99	08.12.99
	Mrs. Kavita Bai	Sweeper/SSS	20.12.88	20.12.88	17.01.01
VII	*PROJECT COORDINATING UNIT*				
	(a) Micronutrients				
	Dr. M. V. Singh	Project Coordinator	08.09.75	28.04.88	14.08.01
	Dr. Sanjib Kumar Behera	Scientist	08.01.07	18.05.07	08.01.07
	Mr. Sahab Siddque	Tech. Officer (T-5)	05.10.92	05.10.92	19.12.04
	Mr. Jai Singh	Field Asstt (T-4)	22.05.90	22.05.90	22.05.05
	Mr. Venny Joy	Stenographer (Gr.III)	14.02.91	23.03.98	14.02.91
	Mr. Harish Kumar Barmiya	Lab Attendant/SSS	14.03.90	14.03.90	28.08.06
	(b) STCR				
	Dr. Y. Muralidharudu	Project Coordinator	31.12.77	25.11.05	25.11.05
	Dr. Abhishek Rathore[$]	Scientist (SS)	16.12.02	16.12.02	16.12.06
	Mrs. Yojana Meshram	Personal Assistant	12.05.97	12.05.97	20.03.09
	Mr. Janak Singh	Khalasi/SSS	08.09.97	08.09.97	08.09.97
	Mr. Ram Bharose	Lab Attendant/SSS	08.11.96	08.11.96	08.11.96
	(c) LTFE				
	Dr. Muneshwar Singh	Project Coordinator	11.07.89	11.07.89	18.08.05
	Dr. R. H. Wanjari	Sr. Scientist	07.01.99	07.01.99	07.01.03

SL. NO.	DIVISION/CELL/LAB/ UNIT/SECTION	PRESENT DESIGNATION	DATE OF JOINING ICAR	DATE OF JOINING IISS	DATE OF JOINING IN PRESENT DESIGNATION
	Mr. A. K. Mishra	Lab Attendant/SSS	01.09.93	10.06.99	10.06.99
	(d) AINP on Biofertilizers				
	Dr. D. L. N. Rao	Pr. Scientist & Network Coordinator	29.07.78	25.06.98	25.06.98
	Mr. Bhanwar Singh Yadav	Messenger/SSS	01.09.93	23.01.99	23.01.99
VIII	*CENTRAL LAB*				
	Dr. A. K. Tripathi	Sr. Scientist & In-charge	05.08.91	25.07.92	05.08.00
	Mr. Vinodbabu Pal	Tech. Officer (T-5)	15.02.93	15.02.93	10.02.05
	Mr. Jagannath Gour	Lab. Attendant/SSS	20.07.92	20.07.92	20.07.04
IX	*TRAINING-CUM-REFERRAL SOIL TESTING LABORATORY*				
	Dr. Y. Muralidharudu	Project Coordinator	31.12.77	25.11.05	25.11.05
	Mr. Ram Bharose	Lab Attendant/SSS	08.11.96	08.11.96	08.11.96
X	*LIBRARY, INFORMATION AND DOCUMENTATION UNIT*				
	Mr. A. K. Sharma	Doc. Officer (T-7)	02.02.90	12.08.94	12.08.94
	Mrs. Nirmala Mahajan	Tech. Officer (T-6)	15.03.93	15.03.93	15.03.08
	Mr. Arun Bhojraj Mate	Lab. Attdt/SSS	15.06.99	15.06.99	15.06.99
XI	*ARIS CELL*				
	Dr. S. Srivastava	Sr. Scientist & In-charge	22.03.96	02.09.96	22.03.03
	Mr. Babulal	Watchman/SSS	08.11.96	08.11.96	08.11.96
XII	*TECHNICAL CELL*				
	Dr. K. Sammi Reddy	Sr. Scientist & In-charge	05.08.91	24.07.92	05.08.00
	Ms. Kirti Singh Bais	Stenographer (Gr.III)	05.05.97	18.03.02	05.05.97
XIII	*FARM SECTION*				
	Dr. P. Ramesh	Pr. Scientist & In-charge	05.12.89	10.09.99	05.12.06
	Mr. V. B. Andurkar	Farm Supdt. (T-9)	11.11.77	05.05.89	01.01.02
	Mr. D. R. Darwai	Field Asstt. (T-4)	23.01.93	23.01.93	23.01.08
	Mr. C. T. Wankhede	Electrician (T-4)	03.08.92	03.08.92	03.08.07
	Mr. O. P. Shukla	Tractor Mechanic(T-2)	22.04.89	22.04.89	01.01.99
	Mr. Hukum Singh	Field Asstt. (T-2)	30.12.88	30.12.88	30.10.00
	Mr. Bhagwat Prasad	Beldar/SSS	24.01.92	24.01.92	17.01.01
	Mr. Lalaram Sahu	Beldar/SSS	24.07.92	24.07.92	24.07.92
	Mr. Rakesh Sen	Beldar/SSS	08.09.97	08.09.97	08.09.97

SL. NO.	DIVISION/CELL/LAB/ UNIT/SECTION	PRESENT DESIGNATION	DATE OF JOINING ICAR	DATE OF JOINING IISS	DATE OF JOINING IN PRESENT DESIGNATION
XIV	***ADMINISTRATION SECTION***				
	Mr. Kumar Vivek	A.O.	21.12.98	30.04.08	21.12.98
	Mr. Rajesh Dubey	A. F. & A. O.	21.12.88	26.11.98	26.11.98
	Mr. P. S. Sunil Kumar	Assistant	30.01.89	30.01.89	26.02.02
	Mr. Anupam S. Rajput	Assistant	14.03.90	14.03.90	26.02.02
	Mr. M. S. Hedau	Assistant	31.10.95	31.10.95	29.11.07
	Mrs. Babita Tiwari	Assistant	30.05.96	30.05.96	15.05.08
	Mr. Anurag	Security Supervisor	29.09.97	29.09.97	13.08.08
	Mr. Bansilal Sarsodia	U. D. C.	10.09.97	10.09.97	29.11.07
	Mr. Heeralal Gupta	U. D. C.	23.12.88	23.12.88	23.08.08
	Mr. Somnath Mukherjee	L. D. C.	30.09.99	30.09.99	30.09.99
	Mr. Jineshwar Prasad	L. D. C.	13.12.88	13.12.88	22.05.99
	Mr. O. P. Yadav	L. D. C.	19.12.88	19.12.88	10.06.99
	Mr. L. N. Chouksey	Messenger/SSS	17.12.88	17.12.88	17.01.01
	Mr. Dharm Raj Singh	Messenger/SSS	01.09.93	14.06.99	14.06.99
	Mr. Subhash Khare	Sweeper/SSS	20.04.89	20.04.89	28.08.06
	Mr. Amerjeet Singh	Watchman/SSS	08.11.96	08.11.96	08.11.96
	Mr. Pramod Raut	Beldar/SSS	21.07.92	21.07.92	20.07.04
	Mr. S. K. Batham	Messenger/SSS	19.12.88	19.12.88	17.02.96
XV	***VEHICLE SECTION***				
	Mr. Deepak Kaul	T-6 & In-charge	29.12.88	29.12.88	01.10.04
	Mr. Sukhram Sen	Driver (T-2)	25.01.91	25.01.91	29.06.01
	Mr. Naresh Yadav	Driver (T-3)	23.09.87	03.05.99	29.06.06

* On Study Leave $ On Deputation