



I I S S Annual Report 2009-10



वार्षिक प्रतिवेदन Annual Report 2009-10



Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal - 462 038 (M.P.) India



भारतीय मृदा विज्ञान संस्थान
INDIAN INSTITUTE OF SOIL SCIENCE

वार्षिक प्रतिवेदन
ANNUAL REPORT
2009-10



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

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PREFACE

Soil is a biogeochemical and dynamic natural resource that supports all critical components that comprise terrestrial ecosystems. It has been called Earth's living skin. There has been renewed interest in soil and soil science in recent years as the recognition that biogeochemical processes that occur at the Earth's surface influence global climate change, land degradation and remediation, the fate and transport of nutrients and contaminants, soil and water conservation, soil and water quality, food sufficiency and safety, global carrying capacity, and many other issues pertinent to the stewardship and conservation of land and water resources. Population pressure and associated changes in land use place an increasingly high burden on the global soil resource. In some areas of the Earth we have approached irreversible soil conditions that threaten the existence of future generations. Understanding the long-term implications of decreased soil quality and addressing the aforementioned challenges will require new information based on advances and breakthroughs in soil science research that need to be effectively communicated to stakeholders, policy makers, and the general public.

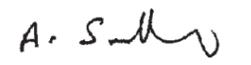
The present report addresses some of the above issues under twelve thematic areas including basic, strategic and applied research of National and International importance. The knowledge of physical, chemical, and biological processes that interact across a large range of spatial and temporal scales is covered under fundamental research which is basic to agriculture. Research involved multiscale approaches from the nanotechnology to the landscape levels to address issues related to biogeochemical reactions and processes in the environment, nutrient availability, loss, land use and degradation, regional climate change, food security, and water quality. There have been several issues of national importance like biofortification of grains with micronutrients and soil quality and human health. The report also noted the importance of farmers' participatory research, on farm trials, Balanced Fertilization, Integrated Nutrient Management and Front Line Demonstrations under AICRPs and ACIAR project. Further, this report presents a glimpse 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 2009-10" of the Indian Institute of Soil Science.

I wish to express my sincere appreciation to the Head of Divisions and Project Coordinators for timely compilation of data of the respective areas of research. I also extend my gratitude to the scientists and other staff members of the Institute for their 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, Blaise Desouza, K.Sammi Reddy, A.K.Tripathi, Pramod Jha and S.R.Mohanty for their sincere efforts 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. S.Ayappan, Secretary, DARE & Director General, ICAR and Dr. A.K.Singh, Deputy Director General (NRM), ICAR, New Delhi for their constant support and encouragement for the successful conduct of the research.

Bhopal
July 2010


(A. Subba Rao)
Director

1. कार्यकारी सारांश

मृदा उर्वरता मूल्यांकन एवं डेटाबेज

- जी.आई.एस., जी.पी.एस. और जी.एस.का प्रयोग करते हुए जिले के विभिन्न उर्वरता क्षेत्रों का नक्शा बनाने और निश्चित उर्वरक अनुशंसाओं की क्रियाविधि का मानकीकरण किया गया। एन.डी.वी.आई. मान और पोषक तत्व मान के बीच विभिन्न प्रकार के कर्व की फिटिंग दर्शाती है कि केवल उच्च क्रम वाले पोलीनोमियल्स अर्थपूर्ण पाए गए। नाइट्रोजन के लिए जनवरी माह में पांचवे क्रम के पोलीनोमियल के लिए औसत एन.डी.वी.आई. का औसत सर्वाधिक अर्थपूर्ण (0.55) पाया गया। इसी प्रकार फास्फोरस एवं पोटैश के लिए फरवरी और दिसम्बर माह में पाँचवे क्रम के पोलीनोमियल के लिए औसत एन.डी.वी.आई. का औसत सर्वाधिक (क्रमशः 0.74 और 0.40) अर्थपूर्ण पाया गया।
- म.प्र.के होशंगाबाद एवं गुना जिलों में जमीन में विद्यमान पोषक तत्वों एवं एन.डी.वी.आई. मान के बीच सम्बन्ध ज्ञात करने के लिए एक अध्ययन किया गया। विभिन्न पोषक तत्व मान एवं एन.डी.वी.आई. मान के बीच विभिन्न प्रकार के कर्व के पोलीनोमियल पर अर्थपूर्ण रूप से सम्बन्ध पाया गया। नाइट्रोजन के लिए होशंगाबाद एवं गुना जिले की एन.डी.वी.आई. मान का औसत क्रमशः जनवरी एवं मार्च के महीने सर्वाधिक अभिप्राय दर्शाता है।
- कृषि के लिए पोषक तत्वों के स्रोत के डाटाबेज को संकलित किया जा रहा है एवं नक्शों की जाँच चल रही है जो कि बाद में प्रकाशित किए जाएंगे। खादों एवं उर्वरकों से पोषक तत्वों की उपलब्धता एवं फसलों द्वारा उर्वरकों का शोषण के डेटाबेज को पूर्ण किया गया है। उपरोक्त को दर्शाते हुए जिला आधार पर नक्शे तैयार किए जाएंगे।

आदाय प्रयोग दक्षता में सुधार

- उच्च ऊर्जा बाल मिल में रॉक फास्फेट (एच.जी. आर.पी. 3 और स्टोन 3) का चूर्णन करके 10-100 नैनोमीटर आकार के नैनो पार्टिकल्स तैयार किए गए। हाइड्रोपेनिक विधि द्वारा उगाये गए पौधों पर नैनो पार्टिकल्स के प्रयोग से जड़ एवं तनों में साधारण रूप से वृद्धि हुई।
- अनुबन्धित परियोजना के अन्तर्गत रसायनों (नाइट्रोबेन्जीन, आलविन टाप और आलविन वन्दर) के परीक्षण परिणाम दर्शाते हैं कि उपज एवं फसलों की वृद्धि पर लाभकारी परिणाम प्राप्त हुआ। इनकी क्रियाविधि एवं पोषक तत्व उपयोग दक्षता पर इनके प्रभाव पर परीक्षण चल रहा है।

दीर्घकालीन उत्पादकता का सतत निरीक्षण

- दीर्घकालीन उर्वरक परीक्षण के परिणाम दर्शाते हैं कि सभी मृदाओं में नाइट्रोजन की कमी है और सभी फसलें नाइट्रोजन प्रयोग के प्रति अपनी अनुक्रिया दर्शाती हैं। लेकिन एल्फीसोल मृदा में केवल नाइट्रोजन का प्रयोग फसलोत्पादन पर प्रतिकूल प्रभाव डालती है। सभी मृदाओं में सभी फसलों में प्रयोग किए गए फास्फोरस की अनुक्रिया दर्शाती है कि मृदाओं में फास्फोरस का स्तर अपर्याप्त है और फास्फोरस उर्वरक प्रयोग अनिवार्य है। जगटियाल की वर्टीसोल मृदा पर धान-धान फसल चक्र प्रणाली और जूनागढ़ की वर्टीसोल मृदा पर मूँगफली-गेहूँ फसल चक्र प्रणाली को छोड़कर सभी फसल चक्रों ने पोटेशियम के प्रति अपनी अनुक्रिया दर्शाई। यह परिणाम दर्शाता है कि लगातार उच्च उत्पादकता प्राप्त करने के लिए पोटेशियम का प्रयोग आवश्यक है और हमें पोटेशियम के आंकड़ों पर सतत निगरानी रखनी चाहिए। उदयपुर में मक्का – गेहूँ फसल चक्र में

केवल गोबर की खाद के द्वारा पोषक तत्वों का प्रयोग एवं बाद में गोबर की खाद का ना.फा.पो. के द्वारा स्थानापन्न उपज को बरकरार नहीं रख सका। इसका आशय यह है कि सवन्मित पोषक तत्व प्रबन्धन, उपज को बरकरार बनाये रखने का सर्वोत्तम तरीका है। एल्फीसोल मृदा का स्वास्थ्य और उत्पादकता बनाए रखने के लिए चूना का प्रयोग आवश्यक है। परन्तु, गोबर की खाद का लगातार प्रयोग उत्पादकता को बरकरार रखने के लिए एक अच्छे सुधारक का काम करता है।

मृदा के भौतिक वातावरण का प्रबन्ध

- परम्परागत भूपरिष्करण (टिलेज) पद्यति की तुलना से संरक्षण भूपरिष्करण जैसे नो टिलेज(एन.टी.) और रिड्यूस्ड टिलेज (आर.टी.) पद्यति में सोयाबीन और गेहूँ की उपज पर कोई प्रभाव नहीं हुआ। परम्परागत टिलेज की तुलना से एन.टी. और बी.टी. में खरपतवार घनत्व अर्थपूर्ण रूप से कम पाया गया क्योंकि उनमें चयनित शाकानाशी का प्रयोग किया गया था।
- प्रारम्भिक फसल बढ़वार की अवस्था में नोरमेलाइज्ड डिफरेंस वेजीटेशन इन्डेक्स (एन.डी.वी.आई.) का एल.ए.आइ. के साथ निकट का सह सम्बन्ध पाया गया। बाद की अवस्थाओं में (एल.ए.आई.>2) ग्रीन एन.डी.वी.आई. और नोरमेलाइज्ड डिफरेंस रेड एज (एन.डी. आर. ई.), एल.ए.आई. और बायोमास के लिए उपयुक्त सूचक पाये गए।

मृदा के रासायनिक अवयवों का सतत परीक्षण

- सन् 1990 के बाद गुजरात राज्य के विभिन्न जिलों से एकत्र किए गए सतह के नमूनों (गन्धक के लिए 6932 और सूक्ष्म पोषक तत्वों के लिए 4277) में गन्धक एवं सूक्ष्म पोषक तत्वों में

प्रतिशत कमी इस प्रकार रही। गन्धक (31.2), लोहा(16.3), मैगनीज(8.4), जस्ता (33.4) और ताँबा (0.2)।

- लुधियाना की ताँबा तत्व की कमी वाली (डी.टी. पी.ए.-ताँबा 0.18 मिग्रा./किग्रा. मिट्टी) मृदाओं पर गेहूँ की 11 प्रजातियों के चयन हेतु परीक्षण किया गया। दानों की अधिकतम उपज का 90 प्रतिशत उत्पादन लेने के लिए गेहूँ के दानों में ताँबा का 4.5 पी.पी.एम. क्रान्तिक स्तर देखा गया। परन्तु इस क्रान्तिक स्तर को विभिन्न मृदाओं में जो ताँबा के स्तर एवं भौतिक रासायनिक गुणों में भिन्न हो, प्रमाणित किया जाय।
- भारत की चयनित बेंचमार्क अम्लीय मृदायें जैसे कि हरिहारापुर (भुवनेश्वर,उड़ीसा), डेबाटोली (रांची, झारखण्ड), राजपुरा (पालमपुर, हिमाचल प्रदेश), और नीलेश्वरम (कासरगोड़, केरला) प्रत्येक से 100 सतही (0-15 सेमी.) नमूनों से निष्कर्षण की स्थिति और मृदा गुणों के साथ सम्बन्ध पर अध्ययन किया गया। इन मृदाओं के विभिन्न गुणों जैसे पी-एच., ईसी, कार्बनिक कार्बन की मात्रा, विनिमेय पोटेसियम, कैल्शियम और मैगनीशियम, डी.टी.पी.ए., मेहलिच-1, मेहलिच-3, 0.1 M एच.सी.एल. और अमोनियम बाई कार्बोनेट डी.टी.पी.ए. (ए.बी.डी.टी.पी.ए.) निष्कर्षक द्वारा जिंक का निष्कर्षण योग्य हिस्सा एवं सम्पूर्ण जिंक की मात्रा का परीक्षण किया गया।
- पौधों के सूक्ष्म पोषक तत्व सम्बन्धी आनुवांशिक भिन्नता का अध्ययन करने के लिए खेत की दशा में 20 अरहर एवं 20 गेहूँ की प्रजातियों का चयन किया गया। अरहर में जस्ता उपयोग दक्षता में काफी भिन्नता देखी गई। अरहर में यह 67-97 एवं गेहूँ में यह 80-97 तक पाई गई।

- लक्षित ए.ई.एस.आर. 10 में मृदा की गुणवत्ता एवं रिजिलिएन्स मापा गया। प्रिंसिपल कम्पोनेन्ट (पी.सी.ए.) का प्रयोग करते हुए प्रमुख मृदा गुणवत्ता सूचक निकाले गए। विदिशा जिले के लिए OxC, OxC/OP मृदा गुणवत्ता के प्रमुख सूचक पाये गये जो कि 43.7% उपज को दर्शाते हैं। सीहोर जिले के लिए TOC, TOC/OP, कुल ताँबा, अविनिमेय पोटेसियम और सिल्ट प्रमुख सूचक पाये गए जो कि 52.3% उपज को दर्शाते हैं।

मृदा की जैविक दशा में सुधार

- भोपाल की वर्टीसोल मृदा में गोबर की खाद के प्रयोग वाले प्लाट में उच्च मात्रा में सक्रिय कार्बन पूल्स जैसे मृदा सूक्ष्मजैविक बायोमास कार्बन (एस.एम.बी.सी.) जल विलेय कार्बन (डब्ल्यू.एस.सी.) और अम्ल हाइड्रोलाइजेबल कार्बोहाइड्रेट (ए.एच.सी.) पाये गए।
- वर्टीसोल में HA - C की मात्रा 34 से 56% पाई गई। यह देखा गया कि गोबर की खाद का अकेले अथवा उर्वरकों के साथ दीर्घकालीन प्रयोग मृदा में HA - C की अधिक मात्रा को धारित करता है। HA - C मुख्यतः एलीफेंटिक कार्बनिक मिश्रण है जो कि एरोमेटिक मिश्रण की तुलना में विघटन के प्रति अधिक सहिष्णु है।
- कार्बन खनिजीकरण रेट कोन्सटेंट तापक्रम के 25 से 45°C बढ़ने से बढ़ता है।
- नमी के बढ़ने पर Q₁₀ मान बढ़ता है लेकिन जलमग्न दशा में निरन्तरता कम हो गई।
- वर्टीसोल मृदा में फंगल श्वसन, फील्ड कन्डीशन एवं 60% WHC पर अधिक पाया गया।
- केवल नाइट्रोजन प्रयोग की तुलना में पन्तनगर

की मृदा में मीथेन आक्सीकरण की सक्रियता फास्फोरस एवं पोटेसियम के प्रयोग करने से अधिक पाई गई।

- अकेले कार्बनिक की तुलना से सवन्मित पोषक तत्व प्रबन्धन उपचार में मृदा की जैविक प्रक्रिया में जैसे डिहाइड्रोजिनेज, एल्केलाइन फास्फेटेज और फ्लोरीसीन डायक्सीटेज की सक्रियता में वृद्धि हुई।
- केवल रासायनिक उर्वरकों के प्रयोग एवं सवन्मित पोषक तत्व प्रबन्धन उपचार की तुलना से कार्बनिक प्रबन्ध प्रणाली में सोयाबीन की सर्वाधिक उपज प्राप्त हुई एवं इसमें सर्वाधिक कार्बनिक कार्बन, सुलभ फास्फोरस एवं पोटाश भी पाया गया।

सूक्ष्म जैविक विविधता और जैव उर्वरक

- वर्टीसोल में सोयाबीन, चना और गेहूँ की वृद्धि में सहयोग के लिए रायजोविया और बहुत ही अच्छी PGPR का एक सम्पूर्ण डेटाबेज तैयार किया गया। 15 उन्नतिशील PGPR एवं 15 उन्नतिशील रायजोबियल प्रजातियों के प्रयोग से सोयाबीन की उपज में 30-55% की वृद्धि हुई।
- वर्टीसोल मृदा में तीन PGPR आइसोलेट्स, बीमारी से ग्रसित प्लाट में फ्यूजेरियम विल्ट को रोकने में प्रभावी पाए गए।
- 10 PGPR ने ओलिगोट्रोफिक वातावरण को छः महीने तक सर्वाइव किया। वर्टीसोल मृदा में ओलिगोट्रोफिक PGPR के प्रयोग से सोयाबीन के दानों की उपज में 24% की वृद्धि हुई।
- सोयाबीन राइजोबिया की कैटाबोलिक विविधता 67% पर 21 क्लस्टर्स दर्शाती है। इसी प्रकार 25% पर 6 क्लस्टर्स आई.ए.आर. और कार्बन

उपभोग दोनों के साथ 90% क्लस्टरस साथ पाए गए।

- ब्रेडीरायजोबियम जैपोनिकम-1SR-33 और बैसीलस मेगाटेरियम-ISP-3 के साथ मध्यप्रदेश की सोयाबीन में 100 प्रदर्शन किए गए। इन प्रदर्शनों में इन प्रजातियों का प्रयोग करते हुए सवन्मित पोषक तत्व प्रबन्ध विधि में संतुलित प्रयोग की तुलना से 18% एवं किसान विधि की तुलना से 54% उपज में वृद्धि हुई।
- नेह रीजन में धान आधारित फसल चक्र में जैव उर्वरकों के साथ गोबर की खाद + रॉक फास्फेट 2 टन/ है. + 25% रासायनिक उर्वरकों के प्रयोग से उपज बरकरार रही।
- वर्टीसोल मृदा में पोषक तत्वों की 75% अनुसंधित मात्रा के साथ ग्लूगोनेसीटी बेक्टर और एजोस्पाइरीलम के प्रयोग से मीठी ज्वार के दानों एवं हरे तनों में अर्थपूर्ण रूप से वृद्धि हुई।
- आन्ध्र प्रदेश में मक्का की फसल संवाहक आधारित निवेशकों के प्रयोग के प्रयोग की तुलना से पी.जी.पी.आर.के तरल निवेशकों का प्रभाव अच्छा रहा।
- गुजरात में मूंगफली में गोबर की खाद को संवाहक के रूप में प्रयुक्त करते हुए पी.जी.पी.आर. और रायजोबियम कन्सोर्टियम को कूँड में प्रयोग अच्छा पाया गया।
- बिहार में किसानों के खेत पर समृद्धि माइक्रोस्ट्रा के साथ पी.जी.पी.आर. ओर साइनोबैक्टीरिया के निवेशन से नाइट्रोजन एवं फास्फोरस की अर्थपूर्ण रूप से बचत हुई और मक्का की उपज में वृद्धि हुई।
- शीत पहाड़ी मृदाओं में मीठी चैरी के लिए एक बैक्यूलस प्रजाति चिन्हित की गई जो कि जैव नियंत्रक के रूप में काम करती है।

अम्लीय मृदा में शकर कन्द, ब्रोकोली और स्पाइन गार्ड फसलों में जैव निवेशन से 25% ना.फा.पो. की बचत के साथ - 2 उपज वृद्धि एवं ना.फा.पो. की रिकवरी में सुधार हुआ। शकर कन्द में कार्बनिक खाद एवं जैव - उर्वरकों के प्रयोग से शर्करा की मात्रा में वृद्धि हुई।

प्रदूषित मृदाओं का सुधार

- पाटनचेरू के औद्योगिक क्षेत्र के भूमिगत जल एवं स्लज जल में भारी तत्वों के प्रदूषण के मूल्यांकन से पता चलता है कि सतही जल में भारी मात्रा में लोहा, मैंगनीज, आर्सेनिक, लैड, जस्ता, बोरोन एवं कोबाल्ट पाया गया। अध्ययन वाले क्षेत्र में प्रदूषित सतही जल भूमिगत जल की गुणवर्त्ता को प्रभावित कर रहा है। कृषि भूमि को फसलोत्पादन के लिए उपयुक्त बनाने के लिए जैव-सुधार तकनीकों को अपनाने की आवश्यकता है।

कृषि मृदाओं में विभिन्न अपशिष्ट पदार्थों की पुनःचक्रण एवं उचित उपयोग

- कृषि मृदाओं में विभिन्न अपशिष्ट पदार्थों के पुनःचक्रण की सम्भावना को देखते हुए कृषि मृदाओं में निकिल एवं क्रोमियम की मात्रा एवं एम.एस. डब्लू. कम्पोस्ट की सीमा पर अध्ययन किया गया। तीन अवयवों विशेषकर मृदा में सूक्ष्म जीवों की सक्रियता, फसलों की वृद्धि पर प्रभाव (जैव-विषालुता) और खाद्यान्न कड़ी संदूषण पर विपरीत प्रभाव के आधार पर मृदा में निकिल एवं क्रोमियम की सुरक्षित मात्रा की गणना के लिए इस अनुसंधान को करने का प्रयास किया गया। खाद्यान्न कड़ी संदूषण एप्रोच के आधार पर मृदा में निकिल की अधिकतम अधिकार योग्य मात्रा निम्नतम (29.5 मिग्रा./किग्रा.) पाई गई और जैव विषालुता एप्रोच द्वारा अधिकतम (153 मिग्रा./किग्रा.) पाई गई। दूसरी तरफ

क्रोमियम के लिए यह सीमा कारक मात्रा जब मृदा सूक्ष्मजीव विषालुता एप्रोच के द्वारा निर्धारित की गई तो यह निम्नतम (34.5 मिग्रा./किग्रा.) पाई गई। उसके बाद क्रमशः खाद्यान्न कड़ी संदूषण एप्रोच (82.5 मिग्रा./किग्रा.) और जैव-विषालुता एप्रोच (176 मिग्रा./किग्रा.) में पाई गई। तीन उपर्युक्त एप्रोच के द्वारा निर्धारित मान मेटल के अधिकतम प्रयोग करने योग्य सम्पूर्ण मात्रा का निम्नतम मान सभी लक्षित जीवों की रक्षा कर सकता है। मेटल प्रदूषण से वातावरण की रक्षा के लिए निकिल 29.5 मिग्रा./किग्रा. एवं क्रोमियम 34.5 मिग्रा./किग्रा. सुरक्षित सीमा मात्रा समझा जा सकता है।

कार्बनिक खेती

- चार सोयाबीन आधारित फसल चक्र प्रणाली में तीन प्रबन्धन पद्धतियों जैसे कि 100% कार्बनिक, 100% रासायनिक एवं सवन्मित पोषक तत्व प्रबन्ध (50:50) का प्रयोग करते हुए लगातार छठवीं साल प्रक्षेत्र परीक्षण किया गया। अनुसंधान के परिणाम दर्शाते हैं कि कार्बनिक खाद के प्रयोग वाले उपचार में सोयाबीन की सर्वाधिक उपज (2009 किग्रा./है.) प्राप्त हुई जो कि रासायनिक उपचार (1664 किग्रा./है.) से 20.7% अधिक एवं सवन्मित पोषक तत्व प्रबन्ध उपचार (1837 किग्रा./है.) से 9.4% अधिक पाई गई। यह अन्य उपचारों की तुलना से कार्बनिक उपचार में प्रति पौधा अधिक फलियां (44.6), अधिक भूसा की उपज (3479 किग्रा./ है.) और अच्छी हारवेस्ट इंडेक्स (0.366) के कारण से हुआ।

जलवायु परिवर्तन के प्रति फसल अनुकूलता

- जलवायु परिवर्तन के प्रति पौधा अनुक्रिया जैसे कि सोयाबीन में सडन बिल्ट, गेहूँ का सीनेस्सेन्स और कपास की लीफ रेडनिंग का अध्ययन

गमला विधि से किया गया। सीनेस्सेन्स विकास से सम्बन्धित क्लोरोफिल का क्षय एक प्रमुख जैव रासायनिक परिवर्तन है। SPAD क्लोरोफिल मीटर रीडिंग का ग्रीन लीफ इन्डेक्स से अच्छा सम्बन्ध है। नियंत्रण उपचार में क्लोरोफिल मीटर रीडिंग लगभग 30 पाई गई और यूरिया के छिड़काव करने पर यह 45 हो गई। बकाया के अन्य उपचारों में यह नियंत्रण एवं नाइट्रोजन उपचार के बीच पाई गई। जो परीक्षण क्लोरोफिल मीटर द्वारा मापे गये उनको मैन्यूअल ओवजरवेशन के साथ कोराबोरेटिड किया गया। क्लोरोफिल की अधिक मात्रा और उससे सम्बन्धित फोटोसिन्थेसिस से उपज पर प्रभाव हुआ। नियंत्रण वाले प्लॉट में यूरिया के छिड़काव से S लाइन की उपज NS लाइन के बराबर ही हो गई। S लाइन के दानों के वजन में अर्थपूर्ण रूप से वृद्धि हुई। अतः गेहूँ की दो विपरीत S और NS लाइन के अध्ययन से यह स्पष्ट है कि यदि गेहूँ की लाइन में सूखा अथवा उच्च तापमान की वजह से सैनेस्सेन्स विकास होता तो पोषक तत्वों के छिड़काव से कुछ हद तक दानों की संख्या अथवा उनके वजन पर सैनेस्सेन्स प्रभाव को कम किया जा सकता है।

खेतों पर अनुसंधान एवं प्रभाव मूल्यांकन

- म.प्र. के रायसेन, विदिशा और राजगढ़ जिलों के छः गाँवों के 98 किसानों के खेतों पर प्रदर्शन परीक्षण के परिणाम दर्शाते हैं कि किसान विधि की तुलना से सवन्मित पोषक तत्व प्रबन्ध मोड्यूल में (50% NPKS + 5 टन/ है. गोबर की खाद + रायजोबियम) सोयाबीन को तथा गेहूँ में 75% NPKS+फासफोरस विलेयक बैक्टीरिया के प्रयोग से सोयाबीन की 52% अधिक उपज प्राप्त हुई। जबकि इसी मोड्यूल से किसान विधि की तुलना से गेहूँ की 28% अधिक उपज

प्राप्त हुई। किसान विधि की तुलना में संतुलित उर्वरक प्रयोग के द्वारा गेहूँ की 42% अधिक उपज प्राप्त हुई।

- अनाज, दलहन, मोटे अनाज, औद्योगिक फसलें, सब्जियां, मसाले, औषधि एवं फलों की लगभग 25 फसलों के लिए अधिकतर सम्बन्धित केन्द्रों द्वारा स्थानीय रूप से उपलब्ध कार्बनिक स्रोतों के प्रयोग से सवन्मित पोषक तत्व प्रबन्धन अनुशंसायें विकसित की गईं।
- विभिन्न प्रदेशों के कृषि-जलवायु क्षेत्रों के दस प्रमुख फसल पद्यतियों के लिए प्रारम्भिक मृदा परीक्षण मान का प्रयोग करते हुए अनुमान समीकरण विकसित किए गए हैं।
- विकसित उर्वरक अनुशंसाओं का कृषि विश्वविद्यालयों/संस्थानों अथवा किसानों के खेतों पर उनके वेलीडेशन के लिए परीक्षण किया गया और यह पाया गया कि प्रस्तावित लक्ष्य का उपज में अन्तराज $\pm 10\%$ पाया गया।
- एस.टी.सी. आर.द्वारा विकसित तकनीकों को प्रदर्शित करने के लिए विभिन्न प्रदेशों के कृषकों के खेतों पर सत्तर अग्रिम पंक्ति प्रदर्शन किए गए। किसान विधि/उर्वरकों का बगैर परीक्षण प्रयोग की तुलना में एस.टी.सी.आर. तकनीक को अपनाने से कृषकों को अधिक उपज के साथ अधिक लाभ: लागत अनुपात/शुद्ध आय प्राप्त हुई।
- सभी अन्य प्रबन्धन पद्यतियों जैसे किसान विधि/बगैर अनुशंसा के उर्वरकों का प्रयोग की तुलना से STCR-IPNS तकनीक के द्वारा मृदा उर्वरता के अनुरक्षण को प्रदर्शित करने के लिए

सात STCR केन्द्रों की पाँच विभिन्न फसल पद्यतियों में दीर्घकालीन प्रदर्शन किए गए।

- एन.आई.सी. पूना के सहयोग से महाराष्ट्र, पंजाब और छत्तीसगढ़ राज्यों में कृषकों के लिए मृदा परीक्षण आधारित अनुशंसायें बनाने के लिए निर्णय सहयोगी प्रणालियों के लिए वेब इनेविल्ड सॉफ्टवेयर प्रोग्राम विकसित किए गए। यह प्रोग्राम भारतीय मृदा विज्ञान संस्थान भोपाल के सर्वर पर स्थापित किए जाएंगे। इससे सभी STCR केन्द्रों के आंकड़ों की आन-लाइन परीक्षण करने एवं PC यूनिट, आई.आई.एस.एस., भोपाल द्वारा निरीक्षण एवं डेटाबेज बनाने में सहायता मिलेगी।
- आर्थिक वृद्धि से लाभ के बँटवारा पर एक दूसरे से जुड़ी हुई असमानतायें गहरा प्रभाव डालती हैं। बिहार, मध्यप्रदेश एवं उड़ीसा – तीन गरीब राज्यों किए गये सामाजिक – आर्थिक अध्ययन के परिणाम दर्शाते हैं कि 50% से अधिक आबादी गरीबी रेखा से नीचे है और अधिकतर कृषि पर निर्भर है। ARIMA मॉडल का प्रयोग करते हुए अगले एक दशक (2005–15) की भविष्यवाणी दर्शाती है कि यदि उत्पादन वातावरण को स्थिर रखा जाय तो इन प्रदेशों में कई फसलों की उत्पादकता कम होगी। खाद्यान्न उत्पादन (और उपज भी) 1–2% वार्षिक दर से बढ़ने की सम्भावना है तथा यह गरीब किसानों के अनाज एवं पोषक तत्व सम्बन्धी सुरक्षा के लिए एक गम्भीर प्रश्न है।

2. EXECUTIVE SUMMARY

Soil Fertility Evaluation and Database

- A methodology was standardized to delineate the different fertility zone of a district for precise fertilizer recommendations using GIS, GPS and RS. Fitting of different types of curves between NDVI values and nutrient values showed that only higher order polynomials were significant. For N the mean of mean NDVI values for the month of January had the highest significant R^2 values (0.55) for 5th order polynomial. Similarly for P and K mean of mean NDVI values for the months of February and December had the highest significant R^2 values (0.74 and 0.40 respectively) for 5th order polynomial.
- A study was conducted at Hoshangabad and Guna districts to predict the relation between nutrient of soil and the NDVI values. Fitting of different types of curves between NDVI values and different nutrient values showed significant relations only at 5th order polynomials. For N, the mean of NDVI values for Hoshangabad and Guna districts showed the highest significance for the months of January and March, respectively.
- The database on nutrient resources in agriculture is being compiled and maps are under scrutiny and will be published subsequently. The database with respect to manure nutrient availability and fertilizer nutrient availability, nutrient uptake by crops was finalized and district wise maps depicting the above were prepared.

Improving Input Use Efficiency

- Rock phosphate (HGRP3 and Stone 3) nano

particles of the size in the range of 10 to 100 nm was prepared by grinding it in a high energy ball mill. Application of nano particles to the hydroponically grown plants marginally increased root and shoot growth.

- The chemicals tested (Nitrobenzene, Allwin top and Allwin wonder) under the contractual projects showed growth and yield promoting effects. The mechanism of action and their influences on nutrient use efficiency are being investigated.

Monitoring Long Term Productivity

- Results of long term fertilizer experiments indicated that nitrogen is deficient in all the soils. All the cropping systems and showed response to applied N. But application of N-alone in Alfisols, had adverse effect on crop productivity. The response of all the crops to applied P across all the soils indicates that, soils are inadequate in P status and P fertilization is essential. All the cropping systems responded to applied K except rice-rice in Vertisols of Jagtial and groundnut-wheat in Vertisols of Junagarh. This suggests that application of K is also mandatory to sustain productivity at higher level. Nutrient application exclusively through FYM in maize-wheat at Udaipur and substitution of NPK against applied FYM could not sustain the yield. This suggests, integrated nutrient management was the best option to sustain productivity. In Alfisols, application of lime is essential to maintain soil health and productivity of these soils. However, continuous use of FYM was found to be better amendment to sustain the productivity.

Managing Soil Physical Environment

- Conservation tillage (CT) system such as no tillage (NT) and reduced tillage (RT) did not influence soybean and wheat grain yields compared to the conventional tillage system.
- Weed density was significantly lowered in NT and RT system compared to the CT because of the usage of selective herbicides.
- Normalised difference vegetation index (NDVI) correlated closely with LAI during initial crop growth stage. At later stages (LAI>2), green NDVI (GNDVI) and normalised difference red edge (NDRE) were found to be suitable indicators for LAI and biomass.

Monitoring Soil Chemical Parameters

- The latest status of S and micronutrients in the soils of different districts of Gujarat on the basis of analysis of surface soil samples after 1990 (6932 number for S and 4277 number for micronutrients) revealed that the percentage of deficiency of S, Fe, Mn, Zn and Cu was to the extent of 31.2, 16.3, 8.4, 33.4 and 0.2, respectively.
- A field experiment was conducted at Ludhiana with a copper deficient soil (DTPA-Cu 0.18 mg kg⁻¹ soil) for screening of eleven varieties of wheat. A critical level of 4.5 µg Cu g⁻¹ in wheat grain was observed to produce about 90% of the maximum grain yield. However, this critical level needs to be verified further by using a wide range of soils differing in their Cu content and physico-chemical properties.
- Status of extractable zinc in selected benchmark acid soils of India and its relationship with soil properties was studied in one hundred surface soil (0-15 cm) samples each from Hariharapur (Bhubaneswar, Orissa), Debatoli (Ranchi, Jharkhand), Rajpora

(Palampur, Himachal Pradesh), and Neeleswaram (Kasargod, Kerala). The soil series were analyzed for soil properties like pH, EC, organic carbon content, exchangeable potassium(K) calcium (Ca) and magnesium (Mg), extractable fraction of Zn by DTPA, Mehlich 1, Mehlich 3, 0.1 M HCl and ammonium bicarbonate DTPA (ABDTPA) extractants and total Zn content.

- In order to study the genetic variability in micronutrients enrichment of plants, 20 pigeon pea and 20 wheat varieties were screened under field condition. Wide variability was observed in Zn use efficiency in pigeon pea. It ranged from 67 to 97 while in wheat it ranged from 80-97.
- Under the targeted AESR 10, the soil quality and resilience of soils were measured. The master indicators of soil quality was derived using principal component analysis (PCA). For Vidisha district OxC, OxC/OP are master indicators of soil quality and experienced 43.7% of the yield variation. In case of Sehore, TOC, TOC/OP, total Cu, non-exch. K, silt are the master indicators and explained 52.3% of the yield variation.

Improving Soil Biological Condition

- The higher concentrations of active C pools such as soil microbial biomass carbon (SMBC), water soluble carbon (WSC) and acid hydrolysable carbohydrates (AHC) were observed in FYM treated plots in Vertisol at Bhopal.
- The HA-C varied from 34 to 56 % in Vertisol. It was observed that long-term application of FYM/or in combination with balanced chemical fertilizer retained greater amounts of HA-C which are mainly aliphatic organic compounds and are more susceptible to decomposition as compared to aromatic compounds.
- C- Mineralization rate constant was

increased with increase in temperature from 25 to 45°C.

- The Q₁₀ value increased with increase in moisture but substantially decreased in submerged condition.
- Soil Fungal respiration was greater under field condition and 60 % MHC in Vertisol.
- CH₄ oxidation activity in Pantnagar soil was stimulated by P and K application compared to only N fertilizer application.
- The soil biological activities in terms of dehydrogenases, alkaline phosphatases, and fluorescein diacetate were substantially improved under integrated nutrient management system as compared to organic alone in Vertisol.
- In organic management system, the highest soybean seed yield was recorded compared to the chemical treatment and integrated nutrient management systems. The highest organic carbon and the available P and K status were also recorded in the organic system compared to the chemical and integrated nutrient management.

Microbial Diversity and Biofertilizers

- A complete database of the most promising PGPR and rhizobia for growth promotion of soybean, chickpea and wheat in vertisols was prepared. 15 elite PGPR and 15 elite rhizobial strains increased the grain yield of soybean in vertisol fields by 30-55%.
- Three (3) PGPR isolates showed early promise for checking *Fusarium* wilt in 'sick plots' in vertisol field.
- 10 PGPR could survive in oligotrophic environments upto 6 months. Oligotrophic PGPR increased soybean grain yield by 24% in vertisol field.
- Catabolic diversity of soybean rhizobia showed 21 clusters at 67% similarity and 6

clusters at 25%. With both IAR and carbon utilization, 90% of the strains clustered together.

- In 100 demonstrations on soybean in Madhya Pradesh using *Bradyrhizobium japonicum*-ISR-33 and *Bacillus megaterium*-ISP-3, grain yield increased with INM option using these strains by 18% over balanced fertilization and 54% over farmer's practice.
- For rice based cropping in NEH region, compost primed with biofertilizers and rock phosphate at 2t/ha along with 25% chemical fertilizers sustained production.
- Grain and green stalk yield of sweet sorghum improved significantly in vertisols at 75% RDF along with inoculation of *Gluconacetobacter* and *Azospirillum*.
- Liquid inoculants of PGPR performed better than carrier based inoculants for maize in A.P. In Gujarat, application of PGPR and rhizobial consortium in furrows through FYM as carrier was found to be superior in groundnut.
- A *Bacillus* sp. was identified as biocontrol agent for sweet cherry in temperate hilly soils.
- Enriched mycostraw along with PGPR and cyanobacteria inoculation in farmer field in Bihar, saved nitrogen and phosphorous significantly and improved maize yields.
- Bioinoculation of sweet potato, broccoli and spine gourd in acid soil saved 25 % NPK besides increasing the yield and improving the recovery of NPK. Total sugar content increased upon organic manuring and biofertilization in sweet potato.

Amelioration of Contaminated Soils

- Assessment of heavy metal pollution in ground water as well as sludge water in Patancheru industrial area revealed a high concentration of Fe, Mn, As, Pb, Zn, B and Co, in surface water. The polluted surface water is strongly influencing the quality of groundwater in the study area to make the agricultural fields suitable for cultivation, bioremediation technologies need to be followed.

Recycling and Rational Usage of Different Wastes in Agricultural Soils

- The Ni and Cr concentration limits in agricultural soil and MSW compost were determined to study the possibility of recycling different wastes in agricultural soils. This experiment attempted to compute safe concentrations of Ni and Cr in soil based on their adverse effect on three components; namely, activity of microorganisms in soil, on growth of plant (phytotoxicity) and food chain contamination. Maximum allowable concentration of Ni in soil was the lowest (29.5 mg kg⁻¹) when determined through 'food chain contamination' approach and the highest (153 mg kg⁻¹) when determined through 'phytotoxicity approach'. On the other hand, such limiting concentration for Cr was minimum (34.5 mg kg⁻¹) when determined through 'soil microbial toxicity' approach followed by 'food chain contamination' (82.5 mg kg⁻¹) and 'phytotoxicity' (176 mg kg⁻¹) approaches. As the lowest value of maximum allowable total concentration of metal can protect all the targeted organisms, the values 29.5 mg Ni kg⁻¹ and 34.5 mg Cr kg⁻¹ can be considered as safe concentration limits in soil for the purpose of environment protection from metal pollution.

Organic Farming

- Field experiment was conducted for the sixth year with three management practices viz. 100 % organic, 100 % chemical and integrated nutrient management (50: 50) with four soybean based cropping systems. The results indicated that the organic management practices 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.

Crop Adaptability to Climate Change

- Plant's response to changes in climate such as sudden wilt in soybean, senescence of wheat and leaf reddening of cotton was studied in pot culture.
- One of the major biochemical change associated with the senescence development is the degradation of chlorophyll. SPAD chlorophyll meter reading had a good association with green leaf index. In control, chlorophyll meter reading was around 30 and with urea spray application it increased to 45. In rest of the treatments, it was in between control and N. Manual observation corroborated with what we had measured through the meter. The higher chlorophyll and the associated photosynthesis had a positive effect on the yield. With urea spray to the control plants, the yield of S lines became on par with NS lines. The grain weight of S lines, otherwise used to be very small had significantly increased. Thus, from this study of contrasting S and NS wheat lines it is clear that if there is a senescence development in wheat lines either due to drought or high

temperature, the senescence effect on grain number or grain weight can be relieved to certain extent by nutrient spray.

On-farm Research and Impact Assessment

- Demonstration trials conducted on 98 farmers' fields in 6 villages of Raisen, Vidisha and Rajgarh districts of M.P. revealed that the INM module (50% NPKS + 5t FYM ha⁻¹+ Rhizobium to soybean and 75% NPKS+PSB to wheat) produced about 52% higher soybean yield as compared to farmers' practice. During rabi season, this INM module produced about 28% higher wheat grain yield as compared to farmers' practice. The balanced fertilization through inorganic fertilizers resulted in 42% higher wheat yield over the farmers' practice.
- Most of the collaborative centres of STCR have generated IPNS recommendations using locally available organic sources for about 25 crops including Cereals, Pulses, Millets, Commercial Crops, Vegetables, Spices, Medicinal and Fruit crops.
- Using initial soil test values, prediction equations have been developed for making nutrient recommendations for ten predominant cropping sequences of different agro-ecological regions in different states.
- The developed fertilizer recommendations have been validated by conducting trials either at SAU/Institute farm or on farmers' fields and it was noticed that the yield variation varied ± 10% variation than the proposed target.
- Seventy frontline demonstrations have been organized by the centres in farmers' fields of villages in different states to demonstrate the developed STCR technology. The farmers' have obtained higher yields with higher BCR/net returns through adoption of

STCR technology over farmers' practice/blanket dose.

- Long term demonstrations have been taken up at seven STCR centres with five different cropping sequences to demonstrate maintenance of soil fertility through the use of STCR-IPNS technology over all other management practices like farmers' practice and blanket dose.
- Decision Supportive Systems for making soil test based recommendations to the farmers by using the web enabled software programme have been developed for the states like Maharashtra, Punjab and Chhattisgarh states in collaboration with NIC, Pune.
- Web-enabled software programme has been prepared and is to be installed at IISS server for making on-line analysis of the data by all the STCR centres and for monitoring and creating database at PC unit, IISS, Bhopal.
- The interlocking inequalities have an important bearing on the distribution of benefits from economic growth.
- The Socio-economic study being carried out in Bihar, Madhya Pradesh and Orissa-the 3 poorest states in India indicated that more than 50 percent of rural population below poverty line (BPL) mostly depend on agriculture. The forecasts for next one decade (2005-15) using ARIMA model shows that the production growth of quite good number of crops are going to be snubbed in these states, if the production environment are kept constant. The foodgrain production (and yield also) is expected to grow between 1-2 per cent annually, posing serious questions for the food and nutritional security of the poor farmers.

3. INTRODUCTION

India is endowed with a 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. Four institute based AICRPs act as a part of the "Network-support-programmes" of the IISS with 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, climate change 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 for 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 nutrients 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, on farmers' fields the technologies generated
- Carrying out diagnostic surveys and
- Strengthening research database on soil and nutrient management to provide a sound base for further 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)

INDIAN INSTITUTE OF SOIL SCIENCE



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	3	4	9	2	3	4	9
2	Soil Chemistry/Fer./Micro	9	7	13	29	8	5	11	24
3	Agronomy	1	2	4	7	1	1	1	3
4	Plant Physiology	1	1	1	3	1	1	1	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	0	0	0
TOTAL		13	17	27	57	12	12	20	44

(b) Technical posts

Designation	Sanctioned	In position
T-1	11	1
T-2	0	4
T-3	9	1
T-4	0	6
T-5	0	2
T-6	0	4
T-7-8	1	0
T-9	0	1
Total	21	18

(c) Administrative posts

S. No.	Designation	Sanctioned	In position
1	Administrative Officer	1	1
2	Asstt. Finance & Accounts Officer	1	1
3	Private Secretary	1	1
4	Personal Assistant	5	4
5	Stenographer Gr-III	5	1
6	Security Supervisor	1	1
7	Assistant	5	4
8	Upper Division Clerk	1	2
9	Lower Division Clerk	7	3
10	SS Gr. - IV	2	0
11	SS Gr. - III	4	1
12	SS Gr. - II	8	7
13	SS Gr. - I	11	14
TOTAL		52	40

3.5 Financial Statement (2009-10)

3.5.1 Closing balance in various projects, externally funded schemes, contractual and consultancy research programmes

PROJE CT CODE	PROJECT DETAILS	OPENING BALANCE AS ON 1.4.2009	FUNDS RECEIVED DURING 2009-10	EXPENDIT URE INCURRED DURING 2009-10	REFUNDS DURING 2009-10	CLOSING BALANCE AS ON 31.3.2010
CONTRACTUAL AND CONSULTANCY RESEARCH PROJECTS						
705	COROMONDEL GROMOR SULPHER	48831		48831		0
706	INSTITUTE RESOURCE GENERATION	108342	495			108837
707	ICAR RESOURCES GENERATION FUND	3038	1155			4193
708	ISS WELFARE FUND	1447				1447
709	ICAR WELFARE FUND	958				958
710	CHEMIE ALLIANCE FORTIFIED BORAX	177300		60842		116458
711	DR DD REDDY GRAMIN VIKAS TRG	170				170
712	DR HEBBAR DEVI CROP SCIENCE	141023	227986	146926		222083
713	DR DD REDDY TRAINING TO STUDENTS OF ALLAHABAD	0				0
714	DR KB HEBBER M/S WINROCK INTERNATIONAL INDIA NE	93122	44120	6707		130535
715	DR K RAMESH M/S SHREE RAMCIDES CHEMICALS P LTD	0	559955	134927		425028
716	DR K SAMMI REDDY TESTING OF UI ON A VERTISOL TOTAL	574231	162030	46791		115239
			995741	445024	0	1124948
EXTERNAL FUNDED SCHEMES						
403	OFS-DR DLN RAO NETWORK ON BF	20000				20000
405	DR KS REDDY ACIAR-ICAR AUSTRALIA	1208527		1136951		71576
406	DR A SUBBA RAO NATIONAL SEMINAR	496		496		0
408	DR DD REDDY TMC-MMI	0				0
410	GOLDEN JUBLEE	80000				80000
411	DR MV SINGH CHOUDHARY DEVILAL	100000				100000
414	REGIONAL WORK SHOP AICRP- STCR					0
415	DR KN SING MAPCOST	-78213	246913	157459		11241
416	FLD STCR ISOPOM DRM NEW DELHI	2000		2000		0
417	FLD STCR IIPR KANPUR	0				0
418	REGIONAL WORKSHOP AICRP-STCR	0				0
419	REGIONAL WORKSHOP AICRP-MSN	0		0		0
420	DR Y MURLIDHARUDU FLD ON OIL SEEDS UNDER ISOPO	0		0		0

PROJE CT CODE	PROJECT DETAILS	OPENING BALANCE AS ON 1.4.2009	FUNDS RECEIVED DURING 2009-10	EXPENDIT URE INCURRED DURING 2009-10	REFUNDS DURING 2009-10	CLOSING BALANCE AS ON 31.3.2010
421	DR KB HEBBER TMC MMI FROM CICR NAGPUR	170759	370000	104176		436583
422	DR P RAMESH MODEL TRAINING COURSE ON EFFICIENT	-20125		-20125		0
423	DR Y MURLIDHARUDU SUMMER/WINTER SCHOOL 21 DA	-3487		-3487		0
424	DR Y MURLIDHARUDU FLD UNDER ISOPOM	100000	200000	280000		20000
425	DR AB SINGH INTERSTATE FARMERS TRAINING TO ATMA -JAMUE BIHAR		90000	90000		0
426	DR AB SINGH INTERSTATE FARMERS TRAINING TO ATMA -BAMETI, PATNA		90000	90000		0
427	DR AB SINGH INTERSTATE FARMERS TRAINING TO ATMA -BANKA		90000	90000		0
428	DR AB SINGH INTER STATE FARMERS TRAINING TO ATMA -CHAMPARAN -BETIA -BIHAR		90000	90000		0
429	DR AB SINGH INTER S TATE FARMERS TRAINING TO ATMA-MAGHEPURA		90000	90000		0
430	DR P RAMESH TRAINING OF DAC CROP PRODUCTION . . . ORG FARMING 8-15 SEPTEMBER 2009		184696	184696		0
431	DR KS REDDY MTC ON EFFICIENT RECYCLING OF MINERAL BY DAC DIR OF EXTN 3-10 NOV 2009		73500	111600		-38100
432	DR TAPAN ADHIKARI GOI MIN OF ENVIRON & FOREST PROJECT ON IMPACT ASSESMEN UNDER LTFE		485000	207125		277875
433	DR AB SINGH WINTER SCHOOL 1-21 DECEMBER 2009 EFFICIENT FARM WASTES UTILIZATION FOR SUTAINABLE		175000	175000		0
434	MUNESHWAR SINGH IPR KS REDDY TRAINING ON SOIL HEALTH AND FERTIITY		563000	2200	560800	0
435	DR AK TRIPATHI RAISEN DISTRICT FARMER TRAINING		30600	30600		0
436	DR Y MURLIDHARUDU PC STCR FLD REMITTED BY IPR KANPUR		136000	136000		0
437	DR Y MURLIDHARUDU DAC REGIONAL SEMINAR CUM TRAINING		100000	66000		34000
438	DR Y MURLIDHARUDU DAC DIGITAL DISTRICT SOIL MAPPING		216000			216000
439	DR Y MURLIDHARUDU DAC REGIONAL TRAINING		38659000			38659000
440	DR Y MURLIDHARUDU DAC REGIONAL TRAINING TOTAL	1579957	42002009	3020691	560800	40000475

PROJ CT CODE	PROJECT DETAILS	OPENING BALANCE AS ON 1.4.2009	FUNDS RECEIVED DURING 2009-10	EXPENDIT URE INCURRED DURING 2009-10	REFUNDS DURING 2009-10	CLOSING BALANCE AS ON 31.3.2010
APCESS FUNDED PROJECTS						
103	DR AK BISWAS-NITRATE CONTAMINA	-2200	2200			0
104	DR KN SING- SOIL FERTILITY MAPING	-254980	222190	-32790		0
105	DR RANJIT SINGH	167287	96975	277919		-13657
	TOTAL	-89893	321365	245129	0	-13657
PLAN NETWORK PROJECTS						
3001	DR P RAMESH ORGANIC FARMING	21336	540000	484577		76759
3002	DR AK MISHRA CLIMATE CHANGE	0	0	0		0
3003	DR DLN RAO AMMAAS	336496	787000	681360		442136
	TOTAL	357832	1327000	1165937	0	518895
AICRP						
2501	PLAN AICRP MSN	-321031	30000000	29651313		27656
2502	PLAN AICRP STCR	37010	25000000	24998282		38728
2503	PLAN AICRP LTFE	146959	20000000	19999027		147932
2504	PLAN NETWORK ON BF	304563	15000000	14998974		305589
	TOTAL	167501	90000000	89647596	0	519905
NON PLAN SCHEME						
2001	NP AICRP MSN	-913447	3746000	3745944		-913391
2002	NP AICRP STCR	407749	2536000	2365803		577946
2004	DR MUNESHWAR SINGH SUMMER SCHOOL	-4380	0	0		-4380
2005	DR DLN RAO WINTER SCHOOL	-252	0	0		-252
2006	DR AK MISHRA SUMMER SCHOOL SOIL ORGANIC CARBO	8502	0	0		8502
IISS PLAN						
	IISS NON -PALN		20000000	19952762		
	TOTAL	-501828	87080000	90045189	0	-331575
	GRAND TOTAL	2087800	221726115	184569566	560800	41818991

3.4.2. RESOURCE GENERATION

S.No	Head of Account	Amount
1	Sale of Farm Produce	996242
2	Sale of Publication and Advertisement	11237
3	Licence Fee	162926
4	Interest earned on Loans and Advances	266635
5	Leave Salary and Pension Contribution	75748
6	Analytical and Testing fee	6000
	a) Training	81825
7	Recoveries of Loans & Advances	1668725
8	Miscellaneous Receipts	89745
	TOTAL	3359083

4. RESEARCH ACHIEVEMENTS

4.1 Soil Fertility Evaluation and Database

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

Fitting of Polynomial: To obtain the relationship between different nutrients and NDVI values of Hoshangabad and Guna Districts.

The k^{th} degree polynomial can be expressed as:

$$\text{Nutrient} = \alpha + \beta_1 X + \beta_2 X^2 + \dots + \beta_k X^k$$

Where, α and β_i 's ($i= 1,2, \dots, k$) are regression coefficients and X's are dependent variables (NDVI's).

Table 4.1.1 Coefficients of the polynomials fitted between available Nitrogen and maximum of maximum NDVI's (X) 2 for the month of January.

		N=176					
Coefficients	K=2	K=3	K=4	K=5	K=6	K=7	
α	-800.865	-7022.288	39324.473	840278.2	21338.341	107323.5	
β_1	1315.003	17066.208	-158799	-4245007	971271.8	-32324.1	
β_2		-9941.379	211401.4	8001669	-5252116	-958091	
β_3			-92343.3	-6669142	1E+007	988062.5	
β_4				2074110	-8531841	1914926	
β_5					2671914	-3500842	
β_6						1483643	
R^2	0.283**	0.425**	0.469**	0.552**	0.553**	0.553**	

Table 4.1.2 Coefficients of the polynomials fitted between available Phosphorus and average of average NDVI's (X) along with R^2 for the month of February.

		N=227				
Coefficients	K=2	K=3	K=4	K=5	K=6	
A	518.973	531.182	512.865	517.086	514.609	
β_1	-1016.926	-1242.286	-391.925	174.516	120.449	
β_2		927.047	-7574.604	-20323.7	-17078.3	
β_3			22298.908	103664.8	64353.462	
β_4				-154319	23757.637	
β_5					-270005	
R^2	0.372**	0.374**	0.392**	0.397**	0.397**	

Table 4.1.3 Coefficients of the polynomials fitted between available Potassium and average of average NDVI's (X) along with R^2 for the month of December.

		N=227				
Coefficients	K=2	K=3	K=4	K=5	K=6	
A	518.973	531.182	512.865	517.086	514.609	
β_1	-1016.926	-1242.286	-391.925	174.516	120.449	
β_2		927.047	-7574.604	-20323.7	-17078.3	
β_3			22298.908	103664.8	64353.462	
β_4				-154319	23757.637	
β_5					-270005	
R^2	0.372**	0.374**	0.392**	0.397**	0.397**	

Fitting of different types of curves between NDVI values and nutrient values showed that only higher order polynomials were significant. For the nitrogen the mean of mean NDVI values for the month of January had the highest significant R^2 value (0.55) for 5th order polynomial. (Table 4.1.1). This shows that the nitrogen of an area of Hoshangabad district can be estimated using 5th order polynomial. Similarly, in case of available phosphorus the

mean of mean NDVI values for the month of February had the highest significant R^2 value (0.74) for the 5th order polynomial (Table 4.1.2). For available potassium the mean of mean NDVI values for the month of december had the highest significant R^2 value (0.40) for the 5th order polynomial (Table 4.1.3). For OC the mean of mean NDVI values for the month of February had the highest significant R^2 value (0.84) for the 5th order polynomial.

Guna District

Table 4.1.4 Coefficients of the polynomials fitted between available Nitrogen and average of average NDVI's (X) for the month of March.

		N = 101			
Coefficients	K=2	K=3	K=4	K=5	
A	273.187	304.216	286.041	-291.812	
β_1	-382.017	-917.327	-332.554	-682.752	
β_2		1758.693	-3978.678	2294.824	
β_3			10896.493	-28480.2	
β_4				65531.281	
R^2	0.281**	0.419**	0.430**	0.430**	

Table 4.1.5 Coefficients of the polynomials fitted between available Phosphorus and average of average NDVI's (X) for the month of March.

		N= 82										
Coefficients	K=2	K=3	K=4	K=5	K=6	K=7	K=8	K=9	K=10	K=11	K=12	
α	17.628	18.914	18.383	17.15	17.52	22.40	30.39	34.86	53.12	65.63	63.63	
β_1	-	-	-30.176	23.49	-1.25	-497.02	-1577.69	-2300.26	-5643.09	-8188.88	-7727.65	
β_2		71.975	-60.467	-742.41	-234.16	14842.53	59915.46	9.80E+04	3.09E+05	4.97E+05	4.56E+05	
β_3			248.110	3254.01	-870.07	-	-	-	-	-	-	
β_4				-	9496.68	196491.27	1.04E+06	1.99E+06	8.52E+06	1.56E+07	1.37E+07	
β_5					-	-	-	-	-	-	-	
β_6						3.30E+06	4.35E+07	1.40E+08	1.31E+09	3.38E+09	2.50E+09	
β_7							-	-	-	-	-	
β_8							8.93E+07	9.62E+08	2.74E+10	1.21E+11	4.76E+10	
β_9									-	-	4.71E+11	
β_{10}									4.00E+10	5.70E+11	-	
β_{11}												1.33E+12
R²	0.237**	0.278**	0.282**	0.292**	0.293**	0.338**	0.384**	0.389**	0.412**	0.415**	0.415**	

Table 4.1.6 Coefficients of the polynomials fitted between available Potassium and maximum of maximum NDVI's (X) for the month of January.

		N = 211					
Coefficients	K=2	K=3	K=4	K=5	K=6	K=7	
a	-2.437	437.833	4689.987	-22620.4	88736.803	-76079.7	
β_1	575.926	-1062.303	-25671.2	186730.9	-910172	1019951	
β_2		1478.703	47458.851	-559890	3696170	5607225	
β_3			-279607	730566.8	-7406506	2E+007	
β_4				-349846	7323435	3E+007	
β_5					-2858223	2E+007	
β_6						-7675240	
R²	0.209**	0.225**	0.257**	0.301**	0.319**	0.320**	

Fitting of different types of curves between NDVI values and different nutrient values showed that only higher order polynomials were significant. For the nitrogen the mean of mean NDVI values for the month of March had the highest significant R² value (0.43) for 4th order polynomial. (Table 4.1.4). This shows that the nitrogen of an area of

Guna district can be estimated using 4th order polynomial. In the case of available phosphorus the mean of mean NDVI values for the month of March had the highest significant R² value (0.41) for the 10th order polynomial (Table 4.1.5). For available potassium the maximum of maximum NDVI values for the month of January had the

highest significant R² value (0.32) for the 7th order polynomial (Table 4.1.6). For EC the mean of mean NDVI values for the months of March had the highest significant R² value (0.52) for the 4th order polynomial. For OC the mean of mean NDVI values for the month of January and March had the highest significant R² value (0.53 and 0.52) for the 6th and 3rd order polynomials respectively. For pH the maximum of maximum NDVI values for the month of March had the highest significant R² value (0.48) for the 8th order polynomial.

Utilization of RS data in the system: NDVI values as required may be obtained for the area through Satellite data (Fig 4.1.1). Using appropriate polynomials for different nutrients the estimate of each nutrient can be obtained. The value of these nutrients can be utilized in the system to obtain the recommendation.

A study was conducted at Hoshangabad and Guna districts to predict the relation between nutrient of soil and the NDVI values. Fitting of different types of curves between NDVI values and different nutrient values showed significant relations only at 5th order of polynomials. For nitrogen, the mean of NDVI values for Hoshangabad and Guna districts showed the highest significance for the month of January and March, respectively. The order of polynomial was 5th and 9th for the districts of Hoshangabad and Guna respectively. In case of available P it showed significant 5th (Feb) and 10th (March) order of polynomial for Hoshangabad & Guna district respectively.

The soil attributes including EC, OC, pH were also computed to find best polynomial order with NDVI values. There was highest significant relation between soil EC, OC, and pH of Guna district at the 6th, 5th and 3rd order polynomials.

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

A close association was found between cattle feed used and nutrient composition of manures thus strengthening the assertions that type of cattle feed could be used in predicting the nutrient composition of manures in different regions. Manure nutrient recovery coefficients values ranged considerably among the crops and across the soils. A representative figure for the recovery of nutrients for different crops was computed. This could be used for modeling the crop yield based on soil test based nutrient recommendations. The nutrient recovery coefficients for maize, bajra, barley, ragi, groundnut, onion, soybean, tapioca, sweet potato, cauliflower, tomato, guar, cabbage have also been compiled and fed to database.

The database with respect to manure availability, manure nutrient availability and fertilizer nutrient availability, nutrient uptake by crops was finalized and district-wise maps depicting the above were prepared. It was found that Indo-Gangetic plain had more dung availability (tonnes/ha) than other parts of the country. Similar trend was seen for fertilizer nutrients also. We have prepared the manure availability based on total district area. The availability based on cultivated area is being compiled.

4.2 Improving Input Use Efficiency

4.2.1 Evaluation of Allwin wonder and Allwin top for their effects on maize productivity and soil fertility

A sponsored project was implemented to evaluate the commercial products viz. allwin wonder and allwin top on Maize for their efficacy on crop nutrition and soil nutrient status. These products

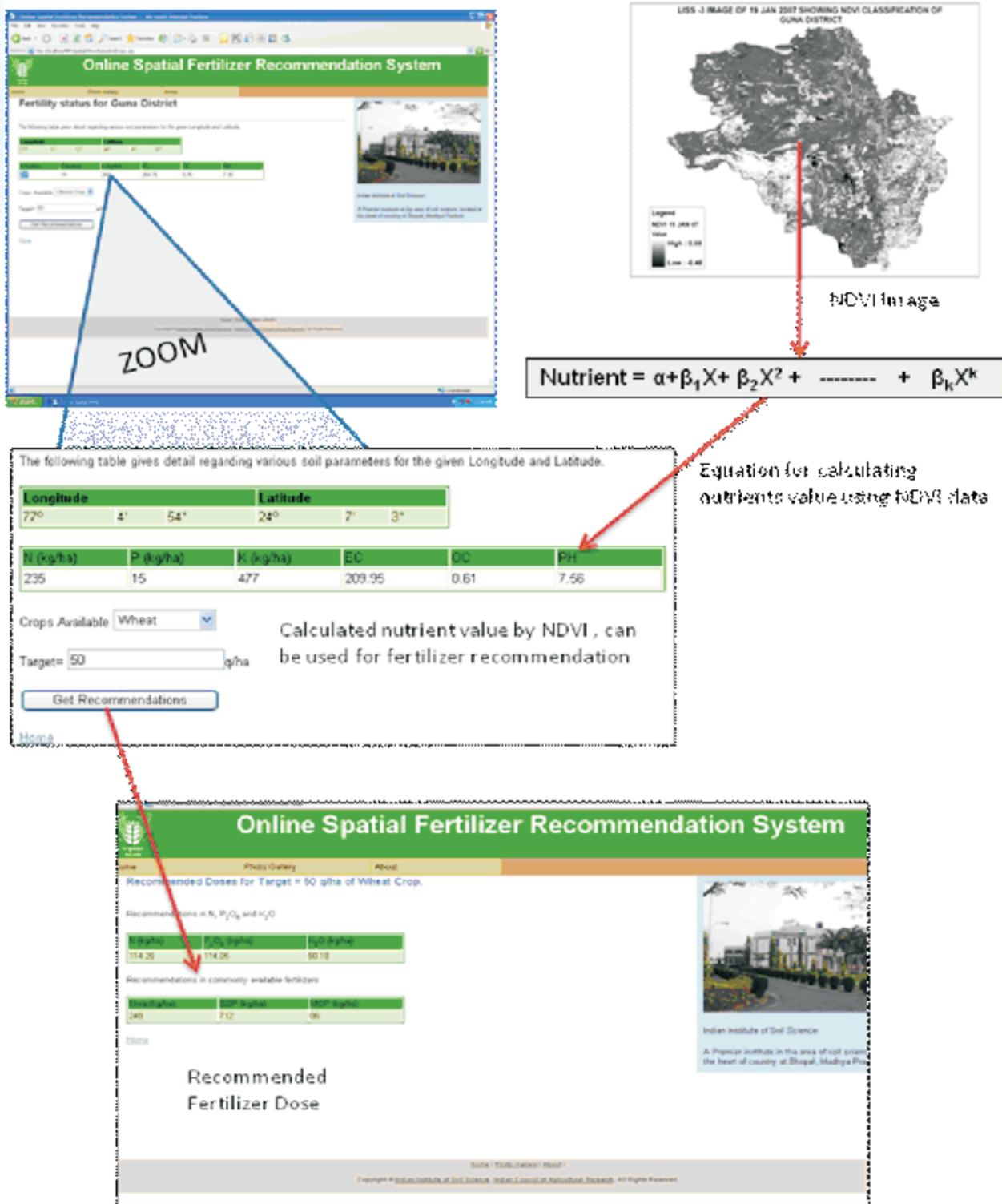


Fig 4.1.1 Obtaining optimum fertilizer doses for fixed target using NDVI values.

are assumed to contain heterocyclic nitrogen compounds and improve crop growth and yield. Allwin wonder contains 19.55% total nitrogen, 0.11% total phosphorus and 11.28% total potassium alongwith 55.7% organic matter. Allwin top contains 26.57% total nitrogen, 3.04% total phosphorus and 4.19% total potassium alongwith 63.4% organic matter. The combined use of 100 % recommended fertilizer with Allwin wonder 2.5 kg/ha and foliar spray of Allwin top 3 times has increased maize yield to the tune of 12-15% over the recommended dose of fertilizers.



Fig. 4.2.1 A View of the Allwin treated maize field

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

The experiments conducted under field and pots involving tomato, Bhenidi and maize showed that Boom Flower (Nitrobenzene 20% EW) @2ml/l or 3ml/l increased the growth and yield significantly. In order to compare the growth promoting effect of (NB), a pot culture experiment was conducted on tomato hybrid Vipul involving a well known growth promoter benzyl adenine (BA 20 ppm) as a treatment along with NB. The experiment involved 3 levels of N (0% N, 75% N, and 100%

N) and control (water spray). One spray of NB and BA was given before transplanting and another 3 sprays were given post transplanting. Both BA and NB spray enhanced growth parameters like height, leaf area, number of branches, shoot, leaf and root biomass significantly over control plants (Fig 4.2.2). Growth enhancement was more under N fertilized pots compared to control pots. Tomato fruit yield increased significantly. With NB spray, the highest yield increase was recorded in 75% N treated pots (46 %) while, with BA it was in 100% N treated pots (45 %). BA and NB treatment did not alter the fruit size (weight), however, the fruit number had significantly increased. Biochemically, plants in chemical treated pots had higher chlorophyll, nitrate reduction, protein and carbohydrate content in comparison with the control plants. Root biomass of chemical treated plants was almost double to that of control plants.



Fig.4.2.2 Effect of Boom Flower (Nitrobenzene 20% EW) and benzyl adenine on the growth of tomato plant. From left NB sprayed plants, centre BA sprayed plant and right control (water sprayed) plant.

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

Phosphatic fertilizers are mainly manufactured from rock phosphate ores. In India, out of 260 million tonnes (MT) of recoverable reserves of rock phosphate approximately 20 Mt only have been estimated to be of high grade which are being

mined by different government agencies for commercial purposes. The depletion of high grade phosphate ores has brought about a search for suitable economically viable technique/process for beneficiating available low grade phosphate reserves. This sub-project made an attempt in synthesizing nano-sized particles of rock phosphate and to see the effect of rock phosphate nano-sized particle on seed germination of selected crops.

Rock phosphate (HGRP3 and Stone 3) nano-particle was prepared by grinding it in a high energy ball mill (Fig. 4.2.3). Milling increased the solubility of rock phosphate by increasing the proportion of X-ray amorphous material and reducing the size of remaining apatite crystals.

Preparation of Nano Rock Phosphate through high energy ball milling

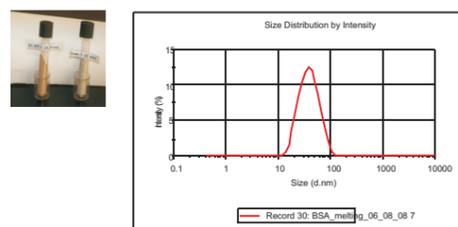


Fig. 4.2.3 Stone 3, Av. Size 42 nm; Intensity 100% (Dynamic Light Scattering)

Rock phosphates were ball milled at ambient temperature and high energy intensities, which induces phase changes through solid-solid reactions. During this milling process repeated collisions between ball and powder continuously exposes new reactant surfaces. After ball milling these rock phosphate particles (HGRP3 and Stone 3) were analyzed by Photon Collision Spectroscopy (Dynamic light scattering techniques) to know the size distribution of the particles. The results pointed out that produced rock phosphate powder is a highly disperse, nano-scaled mixture of small particles, that is crystallites with sizes in the range of 10-100 nm. Maximum portion of HGRP3 is in the size of 28 nm and Stone-3 is in 42 nm (Fig. 4.2.4).

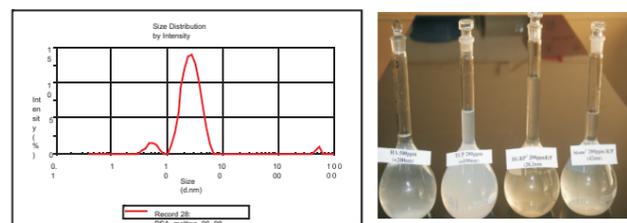


Fig. 4.2.4 HGRP 3, Av. Size 28.20 nm; Intensity 93.1% (Dynamic Light Scattering)

This rock phosphate was characterized by XRD and found that it mainly consisted of calcium apatite, hydroxy apatite, fluoroapatite, plumbogummite, quartz, crystobolite, strengite, variscite etc. (Fig. 4.2.5)

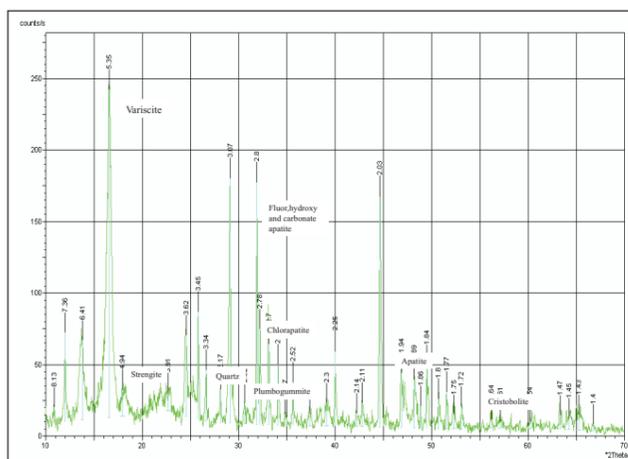


Fig. 4.2.5 Constituents of rock phosphate

Effect on Seed Germination and Plant Growth

Seeds of mustard and soybean were immersed in a 10% sodium hypochlorite solution for 10 min to ensure sterility (USEPA, 1996), then they were soaked in double distilled water, nano-rock phosphate particle and tri-calcium phosphate nano-particle solution for about 4h. One piece of filter paper was put into each 100 mm X 15mm Petri dish, and 5 ml of a test medium was added. Seeds were then transferred onto filter paper. Petri dishes were covered and sealed with tape and

placed in an incubator. After 5 days under room temperature, more than 85% of the control seeds had germinated and developed roots. The germination was halted, seed germination was calculated and seed length was measured.

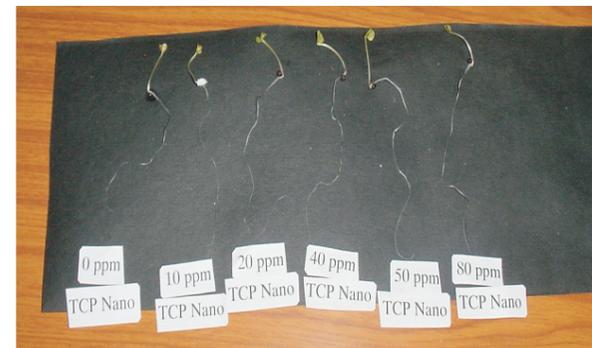


Fig. 4.2.6 Effect of TCP (<100nm) on mustard seed germination

A series of laboratory experiments were carried out to know the effect of rock phosphate nano particle on germination and growth of seeds of soybean and mustard (Fig. 4.2.6). In both the crops, germination was not affected up to 200 ppm P (applied through TCP nanoparticles and RP nanoparticles), and an increasing trend was observed in root growth of the crops (Figs 4.2.7 & 4.2.8).



Fig. 4.2.7 Nano rock Phosphate vs nano HA

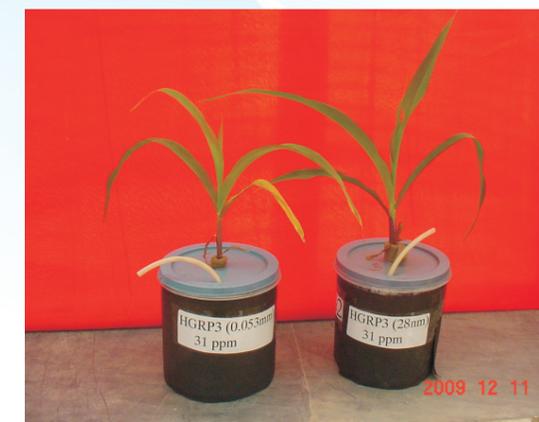


Fig. 4.2.8 Micro (10-40 nm) vs Nano (28 nm) rock phosphate

Results indicated that plant root might have got the unique mechanism of assimilating nano-rock phosphate particle for its growth and development.

4.3 Monitoring Long Term Productivity

4.3.1 Current trends in long term intensive Cropping systems in different soils

Field experiments conducted under AICRP-Long Term Fertilizer Experiments (LTFE) with different crops and cropping systems on various soils, since the last 37 years, produced relevant information on crop productivity, which are summarized as follows.

Rice-wheat: Rice-wheat is grown at three centres viz., Pantnagar (Mollisols), Barrackpore (Inceptisols) and Raipur (Vertisols). The average yield data (2006-07 and 2007-08) presented in Table 4.3.1 revealed higher response of rice and wheat to applied N, P and FYM over and above recommended NPK. However, a little decline in yield in 100% NPK was seen at Pantnagar compared to 100% NP probably due to Zn deficiency. Hidden hunger of Zn is known in 100% NPK due to greater mining of Zn. At Barrackpore, a clear response of rice and wheat to N was noted but crop did not show significant response to applied

P. The poor response of crops to applied P was probably due to low yield level. The increase in yield on application of 150% NPK indicated that the dose of N applied could be less. The low yield levels of both the rice and wheat were due to delay in transplanting of rice due to third crop of jute in sequence. Perusal of yield data of all the three crops (rice, wheat and jute) indicated that continuous absence of S resulted in a decline in productivity. Unlike Pantnagar and Barrackpore, successive addition of N, P and K resulted increase in yield of rice and wheat at Raipur (Fig.4.3.1). But the

decline in maize yield. Poor response of wheat to applied K and S was probably because of supply of these nutrients with irrigation water. Analysis of irrigation water reported to have K and S and wheat is grown with 4 to 5 irrigations, whereas maize is rainfed and only one or two irrigation are applied in case of shortage of rain. Secondly, wheat is deep rooted and draws K and S from the lower layer of soil profile.

Yield data reported in table 4.3.1 showed good response of N, P and K in maize and wheat at

and K was recorded in both the crops. Indications of response to S was also seen. The larger yield in 150% NPK compared to 100% NPK suggest that 100% NPK is more optimum.

Situation at Palampur is all together different from Ludhiana and Udaipur. Continuous application of N alone resulted decline in yield compared to control yield of maize and wheat. However, both the crop responded to applied P and K. But response of both maize and wheat to K was to an order of 12 and 10 q ha⁻¹, respectively. This suggests that K was major growth limiting factor in Alfisols. Application with lime and FYM along with NPK surpassed all other treatments. But the magnitude of effect on yield was more in case of FYM compared to lime.

at Coimbatore (Fig.4.3. 2). However, finger millet did not show any response to N alone in Alfisols whereas, response of K was of very high order in both the crops in Alfisols. This again confirms that in acid soils K is the most limiting nutrient and need more attention to sustain productivity.

Rice-rice : Rice-rice system was practiced at three places viz., Jagtial (Vertisols), Pattambi and Bhubneshwar (Alfisols). In general, rice yields of *rabi* were higher than *kharif* at Bhubneshwar which is due to more sunshine hours during *rabi*. But it was reverse at Jagtial which was due to non availability of canal water in sufficient quantity during *rabi*. Data indicated that there was no response to K in rice during *rabi* at Bhubneshwar. The K content of irrigation water was the cause for



Fig. 4.3.1 Impact of imbalanced and balanced nutrient options on rice under long term fertilizer experiment at IGKV Raipur

response of N and P was less in wheat compared to rice due to low productivity in wheat because of availability of less chilling period. The yield recorded on *in situ* green manuring was comparable with 100% NPK + FYM. But the residual effect of green manuring was not observed in subsequent wheat crop as was noted in FYM treatment. The practice of BGA in rice did not show any additional effect on rice yield. However, little increase in wheat yield was recorded.

Maize-wheat : Maize was grown as a test crop at Palampur (Alfisols), Ludhiana (Inceptisols) and Udaipur (Inceptisols). The yield data presented in Table 4.3.1 indicated response of both maize and wheat to all the three major nutrients (N, P and K). There was no response to Zn but continuous absence of S in fertilizer schedule resulted in a

Udaipur. However, even after 10 years, response to S was not observed either in maize or in wheat. The yield increase with larger dose of nutrients (150% NPK) indicated that the nutrient dose applied was less particularly the N dose which need to be increased to get the potential yield of maize. Udaipur centre had one exclusive organic treatment. The less yield of both maize and wheat in organic treatment even after 10 years compared to inorganic treatment indicated that the productivity can't be sustained through exclusive supply of organic manure, even though amount of nutrients supplied in both treatments were almost similar rather more in organic treatment particularly phosphorus. Perhaps poor release rate of nutrients from FYM especially during late *kharif* and winter is the reason for low productivity. At Delhi centre, response of N, P



Fig. 4.3.2 Effects of balanced fertilizer application on the finger millet at AICRPLTFE TNAU Coimabatore

Finger millet maize : Finger millet-maize was grown on two contrasting soils. In general, yield of finger millet is less in Vertisols of Coimbatore compared to Alfisols of Bangalore. Probably the acid soils are more suited to finger millet. No response of finger millet to lime application in Alfisols supported the hypothesis. Both finger millet and maize responded to applied N, P and K

no response. During *rabi* several irrigations are needed to grow rice crop and water was collected from hill terrain which contained dissolved K. In Vertisols also response of rice to K application was less during *rabi* because of low productivity and K in irrigation water could be another possible reason.

Soybean-wheat: Like finger-millet, soybean-wheat was also grown at two centres having the contrasting soils. In Vertisols of Jabalpur, response of all the three major nutrients was recorded in both soybean and wheat crops. Critical analysis of data revealed very high response of wheat to applied P. Data further revealed that both the crops started showing response to applied K. Thus, result indicated that application of K is essential for sustaining productivity in Vertisol. On the other hand in Alfisols, application of N alone, decreased the yield even less than the control treatment at Ranchi. But application of NP together resulted big jump in yields of both soybean and wheat and application of K further boosted the productivity but the magnitude of increase in productivity on application K was of low order in wheat compared to soybean. Application of lime and NPK over and above FYM improved the productivity. Here also, FYM was found to be superior to lime.

Groundnut -wheat : During the experimental period, the yield of ground-nut was very less because of drought and non availability of irriga-

tion water at the farm. The perusal of yield data of wheat revealed that there was no response of both N and K in wheat probably because of no utilization of nutrients due to poor productivity of previous crop groundnut. It is interesting to note that almost similar yield of wheat in plots received nutrients either through STCR or general recommended dose which suggests that even after 10 years the recommended doses are on par to STCR dose.

Sorghum-wheat : The yield data indicated good response of N, P and K in sorghum-wheat in Vertisols at Akola (Fig. 4.3.3). Higher yield in 150% NPK in both crops demands the revision of the nutrient doses. Till date response of S was visible in either of the crop.

Soybean- safflower : The data presented in Table 4.3.1 indicated very high response of applied N in both soybean and safflower whereas response of P and K was of low magnitude. Data further revealed that both the crops have responded to applied S.

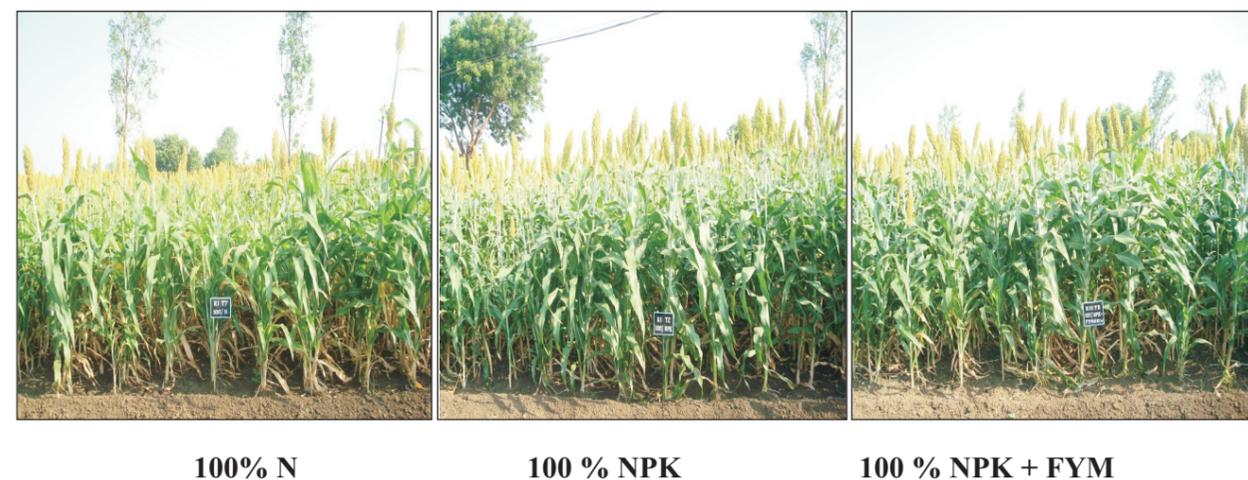


Fig. 4.3.3 Impact of balanced application of nutrients on sorghum growth and productivity at PDKV Akola

Table 4.3.1 Response of different crops to nutrient management practices at LTFE centers

Location	Crop	Control	N	NP	50% NPK	100% NPK	150% NPK	NPK+ Zn	NPK+ FYM	NPK+ S/S	NPK+ HW	NPK + Lime	FYM / BGA/B F
Barrackpore	Rice	1133	1930	2042	1603	1796	2603	1505	2032	1622	2046	-	-
	Wheat	550	1650	1775	1525	1525	2925	1675	2275	1675	1575	-	-
Pantnagar	Jute	322	571	648	691	792	1011	466	1147	619	745	-	-
	Rice	1703	4545	5005	4241	4578	4442	5299	5528	4918 ^S	5200	-	1735 ^{BF}
Ludhiana	Wheat	1298	3389	3806	3196	3553	3435	4346	4795	3826 ^S	4154	-	1379 ^{BF}
	Maize	2251	3145	4361	4034	5001	5188	4822	6286	4599 ^S	5087	-	-
Palampur	Wheat	1794	3625	4154	3647	4400	4850	4454	4872	4410 ^S	4459	-	-
	Maize	705	0	2825	3280	4060	3660	4255	5815	2275 ^S	4605	5015	-
Ranchi	Wheat	425	0	1365	1560	2245	2210	2145	3800	910 ^S	2265	3385	-
	Soybean	406	249	1014	1808	2155	2115	-	2430	703 ^S	2055	2265	-
Bangalore	Wheat	476	575	2736	2173	2893	2987	-	3223	2069 ^S	3018	2966	-
	F. millet	361	410	599	1518	2636	3051	-	2781	2688 ^S	2524	2482	2755 ^{L+FYM}
Pattambi	H. maize	393	267	783	1852	3118	3610	-	3643	2838 ^S	3231	3383	3964 ^{L+FYM}
	Kharif rice	1899	2196	2303	2276	2331	2546	-	3248	-	-	2486	-
New Delhi	Rabi Rice	2004	2609	2763	2785	3028	3190	-	3719	-	-	3143	-
	Maize	1020	1315	1575	1395	1730	2080	-	2080	1890	1770	-	-
Bhubaneswar	Wheat	2170	3135	3760	3230	4110	4765	-	4600	4340	4195	-	-
	Kharif Rice	1215	2080	2270	2360	2560	2590	2315	2900	2305 ^{Zn+S}	2470 ^{Zn+B}	2550	3030 ^{L+FYM}
Rabi Rice	1440	2625	2830	2660	2925	2795	2840	3325	2740 ^{Zn+S}	3000 ^{Zn+B}	2880	3295 ^{L+FYM}	

Table 4.3.1 Response of different crops to nutrient management practices at LTFE centers (Contd..)

Coimbatore	F. millet	1030	1241	1451	1441	1656	1918	1674	2110	1586 ^S	1666	-	-
	H. maize	1980	2530	2610	2165	2905	2959	2925	3301	2833 ^S	2850	-	-
Junagadh	Groundnut	153	158	161	182	192	270	257	325	186 ^{HS}	204 ^{STCR}	185 ^R	296 ^{F25}
	Wheat	2285	2292	3600	3010	3659	3678	3621	4414	3635 ^{HS}	3664 ^{STCR}	3643 ^R	4200 ^{F25}
Udaipur	Maize	1326	1980	2455	-	2814	3133	2924	3322	2868 ^{HS}	-	2938 ^A	1880 ^{F20}
	Wheat	1619	2893	3627	-	3951	4331	4126	4564	4000 ^{HS}	-	4060 ^A	2765 ^{F20}
Raipur	Rice	2401	3743	5395	4299	5538	5870	5494	5645	-	-	5481 ^{GM}	4185 ^{BGA}
	Wheat	905	1320	1977	1514	1895	2336	1956	2389	-	-	1794 ^{GM}	1479 ^{BGA}
Jagtial	KhariRice	3509	4535	6116	5290	6218	6508	6133	6482	6169 ^S	6185	-	4883 ^{FYM}
	Rabi Rice	2726	3635	4893	4175	5081	5486	5098	5306	5041 ^S	5071	-	3762 ^{FYM}
Jabalpur	Soybean	653	853	1030	1129	1305	1464	1188	1624	1086	1266	-	-
	Wheat	1507	1713	4507	4413	5101	5457	4576	5813	4593	4869	-	-
Akola	Sorghum	149	2120	2667	2553	3756	4489	3896	4927	3842 ^{HS}	-	-	1374 ^{F10}
	Wheat	55	1040	1385	1390	2682	3191	2782	3379	2511 ^{HS}	-	-	300 ^{F10}
Parbhani	Soybean	1847	2544	2893	2487	3070	3425	3144	3378	2987 ^S	2891	-	2853 ^{F10}
	Safflower	1236	1469	1547	1691	1818	2010	1828	1999	1740 ^S	1842	-	1516 ^{F10}

Denotation : F= 50% NPK + 10 t ha⁻¹ FYM at Junagadh, F¹⁰ = FYM 10 t ha⁻¹ at Jagtial, F²⁰ = FYM 20 t ha⁻¹ at Udaipur, F²⁵ = FYM 25 t ha⁻¹ at Junagadh, BF= Biofertilizer alone, R= 50% NPK+ Rhizobium, A= 100% NPK+ Seed treatment with Azotobacter, GM= 50%NPK+ Green Manuring at Raipur, BGA= 50%NPK+ BGA at Raipur, L+FYM = lime + FYM at Raipur, L+FYM = lime + FYM at Raipur, +S= 100% NPK(+S) at Ranchi, -S= 100% NPK(-S), STCR= NPK as per soil test.

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

IPNS modules and glucose equivalent carbohydrate carbon

Five years soybean-wheat cropping system involving different INM interventions revealed the highest glucose equivalent carbohydrates in surface soil. The content of glucose equivalent carbohydrates varied between 93.2 and 138.9; 78.7 and 114.6 and 41.7 and 61.2 mg/100g soil in 0-7.5, 7.5-15 and 15-30 cm soil depth, respectively (Fig 4.3.4). The magnitude of difference between depths was less between 0-7.5 and 7.5-15 cm, however, a sharp decline in glucose equivalent carbohydrates was observed in 15-30 cm soil indicating the effect of added carbon as a result of root activity in the surface plough layer. High carbohydrate carbon was recorded in treatments receiving higher quantities of organic inputs. The highest carbohydrate content was recorded in treatment that received 8 t FYM to soybean and 16 t FYM to wheat followed by treatment that received 20 t FYM to wheat once in four year in addition to 50% NPK to soybean and wheat every year.

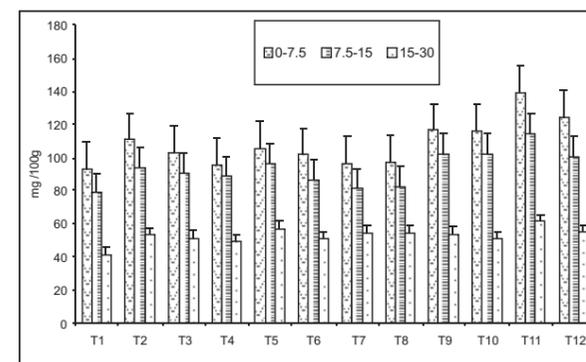


Fig 4.3.4 Effect of IPNS interventions on carbohydrate carbon content of soil

Changes in glucose equivalent carbohydrate and particulate organic matter carbon contents under IPNS systems

Soil aggregates under all the IPNS interventions revealed higher content of carbon in macro-aggregates than micro-aggregates. Carbon content in aggregates of surface (0-7.5 cm) soils ranged between 0.77 and 1.89 per cent in large size macro-aggregates followed by 0.94 and 1.10 per cent in small size macro-aggregates. Carbon content in lower layers was relatively low. Significant changes with respect to carbon content in different aggregates were recorded under the treatments involving wheat residue + 1 t Poultry manure, wheat residue + 5 t poultry manure, only FYM application @16 and 8 t ha⁻¹, 50% NPK annually + 20 t FYM once in four years as well as 50% NPK + 5 t FYM ha⁻¹. Proportion of carbon held in different aggregate size fractions was found to be the highest in macro-aggregates than micro-aggregates. Carbon in soil particulate organic matter (POM-C) was also the highest in surface layer where it varied between 1.5 and 2.85 g kg⁻¹ (Fig. 4.3.5). Higher content of POM-C was recorded under those interventions that received manure additions especially in the form of FYM.

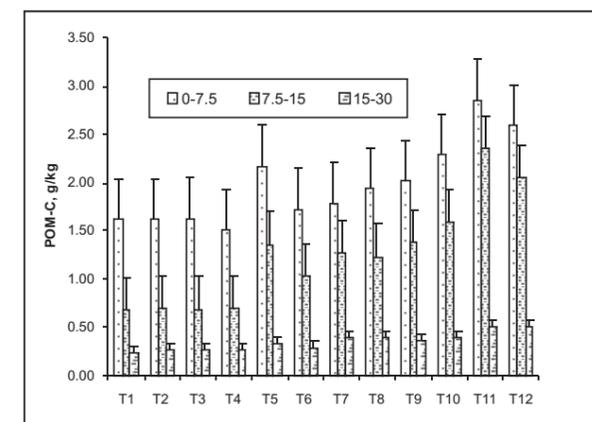


Fig. 4.3.5 Particulate organic matter carbon under different IPNS interventions after five years

4.3.3 Effect of continuous cropping with different manure and fertilizer inputs on soil quality index

A long-term experiment on integrated nutrient management (INM) was initiated in the year 2002 at IISS, Farm. Soil quality index (SQI) was computed in selected treatments of this experiment using deviation method (Dalal and Molooney, 2000) to study the effect of continuous cropping with organic manures, integrated nutrient management and inorganic fertilizers alone on soil quality. Soil physical, chemical and biological indicators were estimated after five cropping cycles of soybean-wheat system in selected treatments whose details are given Table 4.3.2. Data on soil aggregate stability, MWD, pH, EC, Soil Organic Carbon, Available Nutrients (NPKS_{Zn}), Dehydrogenase activity (DHA), Microbial biomass C (MBC) and Labile C were used for arriving SQI. The SQI values varied from 27 in plots those received STCR based fertilizer

dose to 63 in those plots received 24 tonne FYM ha⁻¹yr⁻¹. Relative soil quality index with reference to sole organic treatment was 0.42 in STCR fertilizer based dose, 0.59 in INM involving fertilizers plus FYM, 0.50 in INM with fertilizers plus crop residues. Continuous application of larger quantity of FYM alone maintained better soil quality under soybean-wheat system as compared to INM or fertilizer application alone. During the first 5 years, application of FYM alone produced significantly lower crop yields as compared to integrated nutrient management or STCR based inorganic fertilizers alone. But after five years, application of FYM alone @ 24 t FYM ha⁻¹ year⁻¹ started producing soybean and wheat yields at par with that of INM or STCR based fertilizer dose. But availability of larger quantities of FYM is a major constraint. Therefore, INM involving fertilizers and FYM may be a better option for producing higher crop yields and maintaining better soil quality.

Table 4.3.2 SQI, RSQI and grain yield in selected treatments

S. No.	Treatments		Soil Quality Index (SQI)	Relative Soil Quality Index (RSQI)	Mean yields up to 2007 (kg ha ⁻¹)		Mean yields after 2007 (kg ha ⁻¹)	
	Soybean	Wheat			Soybean	Wheat	Soybean	Wheat
1	25-30-20*	70-30-30*	26.7	0.42	1405	3627	1796	3085
2	12.5-15-10 +5 t FYM	70-30-30	36.8	0.59	1559	4139	1897	3245
3	12.5-15-10 +WR**	35-15-15+ Gly***	31.3	0.50	1288	3229	1633	3281
4	8 t FYM	16 t FYM	62.7	1.00	1424	3692	1778	3470

*N-P₂O₅-K₂O kg/ha; **-Wheat residue recycling; ***-Glyricidia equivalent to 50% of N dose to wheat

4.4. Managing Soil Physical Environment

4.4.1 Interactive effect of tillage and manure on soil aggregate dynamics, SOC accumulation and bypass flow in vertisol

The present study is carried out at IISS, Bhopal to assess the interactive effect of tillage, manure-C inputs on soil productivity, aggregate dynamics and moisture retention during *kharif* and *rabi* seasons in soybean-wheat system. The experimental layout was split plot with tillage level as the main plot and manure-C level as subplots replicated three times. The fertilizer applied is 30:60:30 and 80:40:20 kg ha⁻¹ for soybean and wheat respectively. N fertilizer applied in split dose with 100% P and K as basal. There were seven FYM-C treatments (t ha⁻¹) viz., T1 (0), T2 (0.5), T3 (1), T4 (2), T5 (2.5), T6 (5), and T7 (10). In the tillage treatments, the two levels were no tillage (NT) and conventional tillage (CT) for both soybean and wheat. Soybean grain yield varied from 21 to 26.7 q ha⁻¹ in 2009.

There was no significant effect of Tillage, FYM-C and their interaction on soybean grain and biomass yield. However, no tillage was found to have 13%

and 19% greater grain and biomass yield respectively as compared to conventional tillage in soybean. Soil moisture content increased by 10% at surface 0-5 cm soil depth in no tillage than conventional tillage in soybean. No significant effect of tillage, FYM-C and their interaction was found on soil moisture content. Wheat grain yield ranged from 38 to 51.24 q ha⁻¹ in 2009-2010 (Table 4.4.1). Effect of FYM-C was significant on wheat grain yield. No tillage recorded 3 and 8% increase in grain and biomass yield compared to CT. No significant effect of tillage, FYM-C and their interaction was found on wheat biomass and thousand grain weight. NT was found to have more macro aggregates than CT. Soil moisture content increased with soil depth. FYM and tillage did not contribute to the soil moisture content at early period of crop growth but they did at later period i.e 120 DAS. The effect of tillage was conspicuous at all soil depth (0-5, 5-15, 15-30 and 30-45 cm). The treatment receiving no tillage was found to retain significantly more moisture than conventional tillage. Soil compaction at wheat sowing from surface to 100 mm depth was 0-280 and 0-237 kPa in no tillage and conventional tillage, respectively.

Table 4.4.1 Effect of tillage and manure on wheat grain and biomass yield and thousand grain weight

FYM-C Treatments	Grain yield (q ha ⁻¹)		Mean	Biomass yield (q ha ⁻¹)		1000 grain weight (g)	
	CT	NT		CT	NT	CT	NT
T1	37.70	43.65	40.67c	82.01	101.19	53.60	53.31
T2	38.36	46.30	42.33c	83.99	104.50	55.65	54.12
T3	43.65	46.30	44.97bc	94.58	101.85	56.26	55.62
T4	51.24	50.29	50.76a	112.43	103.17	57.30	55.65
T5	38.36	42.30	40.33c	88.62	97.20	54.50	54.00
T6	44.31	44.95	44.63bc	97.22	99.84	55.47	54.98
T7	49.60	45.61	47.61ab	101.85	108.04	57.13	55.02
Mean	43.32	45.63	44.47	94.39	102.26	55.70	54.67

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

Conservation tillage systems have a major influence on weed density and dry weight accumulation. In a long-term tillage experiment, weed density and dry weight were observed during soybean cropping season and after soybean harvest. Weed density of monocots (grassy weeds)

Table 4.4.2 Monocot and dicot weed density at 25 and 45 DAS

	Monocot		Dicot		Total	
	25 DAS	45DAS	25DAS	45DAS	25DAS	45DAS
CT	244.3 a*	156.4 a	148.7 a	124.4 a	393.0 a	280.8 a
MB	3.7 b	56.3 b	165.7 b	146.7 a	169.3 b	203.0 a
RT	25.0 b	12.6 b	83.7 c	185.2 a	108.7 bc	197.8 a
NT	18.7 b	34.1 b	59.7 c	168.2 a	78.3 c	202.2 a

*values followed by the same letter in a column are not statistically significant

were significantly lower in the reduced tillage (RT) and no-tillage (NT) plots only at 25 and 45 days after sowing (DAS) soybean compared to the conventional tillage (CT) plots. However, weed density did not differ compared to the mould board (MB) ploughed plots. After soybean harvest, densities of monocot weeds were not significantly different among the treatments (Table 4.4.2).

Treatment differences for the dicot weed densities were significant at 25 DAS and after soybean harvest, but did not differ at 45 DAS. At 25 DAS, the RT and NT plots had significantly fewer dicot weeds than the CT and MB. After soybean harvest, the density was greater in the MB and RT plots than the CT. On the other hand, total weed dry weights accumulated were the highest in the CT plots at all the sampling times than those on the MB, RT and NT plots. Use of herbicides in the RT and NT plots resulted an effective weed control strategy compared to manual and mechanical methods in the CT. Fewer weeds and lower dry

weights in the MB ploughed plots was probably due to soil inversion that resulted in burying the weed seeds to lower soil depths.

Since tillage operations influence weed seed species survival, weed seed distribution in the soil is affected. Weed seed bank was determined using the germination assays at ambient conditions over a period of 3.5 months until there was no flush of

weed seeds. In the top 5 cm soil depth, the MB plough treatment had the least weed seed bank followed by the NT, CT and RT (Fig. 4.4.1).

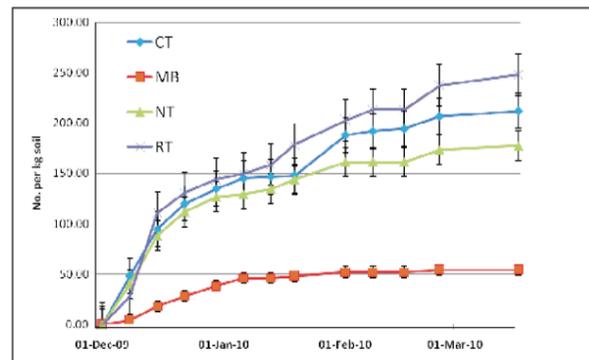


Fig. 4.4.1 Weed seed bank in the 0-5 cm soil depth as influenced by tillage systems

Whereas, a reverse trend was observed for the 5-15 cm soil depth with the MB plough treatments having the highest weed seed bank compared to the other non-inverting tillage treatments (Fig. 4.4.2). Soil inversion in the MB plough plots may have buried the seeds to lower depths.

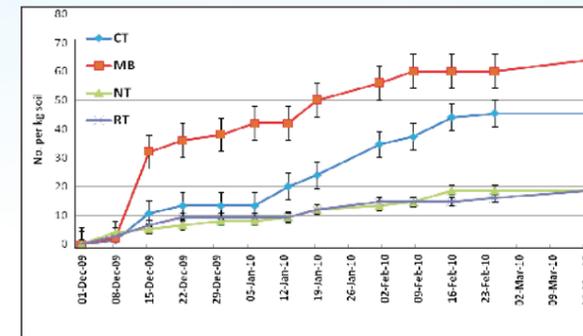


Fig. 4.4.2 Effect of tillage treatments on weed seed bank in the 5-15 cm soil depth

4.4.3 Nitrogen level effect on spectral reflectance, vegetation indices, LAI and yield of maize

To find the effect of nitrogen stress on spectral reflectance and vegetation indices of maize, a field experiment was conducted during the rainy season of 2009. Maize crop (cv. Kanchan101) was grown at four nitrogen levels namely, 0, 50, 100 and 150% of the recommended dose of nitrogen.

The spectral reflectance data from maize crop recorded at major growth stages were used for calculation of two broad band vegetation indices viz. normalized difference vegetation index (NDVI), green-NDVI, and two narrow-band vegetation indices viz. normalized difference red edge (NDRE), modified spectral ratio (MSR). To compare the sensitivity of the vegetation indices to the change in LAI and biomass, the indices were correlated with the corresponding crop LAI and biomass values. The NDVI showed a good correlation with the LAI and biomass at the initial stages but during the full vegetation stage (when LAI value exceeded the value 2) GNDVI and NDRE was found to be a better predictor for LAI and biomass than NDVI. Nitrogen level difference showed a distinct variation in the spectral reflectance of maize canopy in the near infra-red and visible region (Fig. 4.4.3). Spectral reflectance pattern from the maize crop grown under varying nitrogen levels gave an indication that ratio vegetation indices at 550 and 785 nm

wavelength bands are sensitive to the nitrogen stress prediction in maize. The temporal data of leaf area index (LAI) and biomass of maize showed significant variations among the nitrogen levels (Fig. 4.4.4 & 4.4.5). LAI at 39-74 days after sowing was significantly higher in N_{100%} and N_{150%} than that in N_{0%} and N_{50%}. LAI reached its maximum value at 74 DAS. Grain yield of maize increased with increasing nitrogen levels. Maize yield at N₀ level was 3039 kg ha⁻¹ while at N_{150%} it was 5827 kg ha⁻¹.

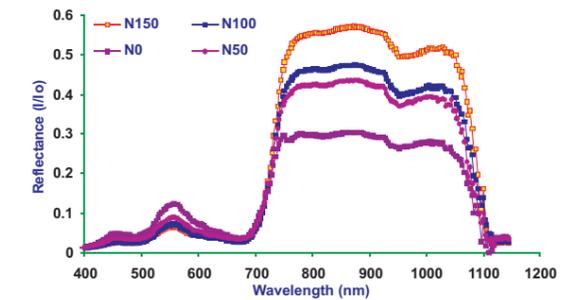


Fig. 4.4.3 Effect of nitrogen levels on spectral reflectance from maize canopy at 77 DAS

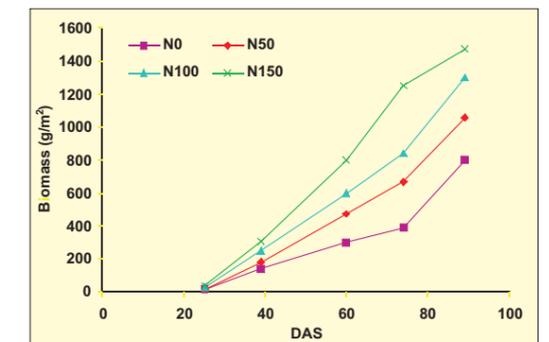


Fig. 4.4.4. Effect of nitrogen levels on biomass yield of maize

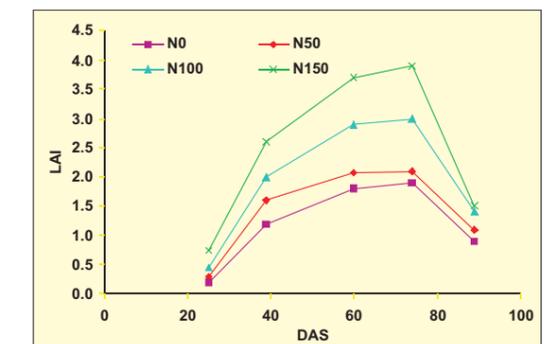


Fig. 4.4.5 Effect of nitrogen levels on leaf area index of maize

4.4.4 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 yield of soybean were not different significantly among the tillage treatments. However, the seed yield of soybean recorded at 150% and 100%

Table 4.4.3 Grain yield of soybean as influenced by tillage treatment and nitrogen levels in 2009

Treatment	N50%	N100%	N150%	Mean
CT-CT	1426	1389	1537	1451 ^a
MB-RT	1574	1630	1704	1636 ^a
RT-RT	1333	1519	1611	1488 ^a
NT-NT	1352	1556	1667	1525 ^a
Mean	1366 ^a	1486 ^b	1565 ^b	

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 1333 and 1704 kg/ha (Table 4.4.3).

Relationship between specific volume and moisture ratio.: The specific volume and soil wetness at 0-7.5 and 7.5-15.0 in CT-CT and NT-NT showed a definite relationship. The specific volume showed negligible change with moisture ratio of 0.16-0.25 and after these ratios the specific volume showed noticeable increase with increase in soil wetness. The specific volume at 7.5-15.0 cm in both tillage treatments increased after moisture ratio of 0.25 where these moisture ratios were 0.16 in NT-NT and 0.20 in CT-CT.

4.5. Monitoring Soil Chemical Parameters

4.5.1 Reassessment and delineation of secondary- and micro-nutrient deficient areas in different districts of Gujarat

The latest status of S and micronutrients in the soils of different districts of Gujarat on the basis of analysis of surface soil samples after 1990 of (6932 number for S and 4277 number for micronutrients) revealed that the percentage of deficiency of S, Fe, Mn, Zn and Cu was to the extent of 31.2, 16.3, 8.4, 33.4 and 0.2 respectively. Accordingly, an increase in the percentage of deficiency is observed in all these

nutrients in comparison to the observation made earlier i.e. before 1990. This could be attributed to the nutrient exhaustion of the soil due to intensive cropping with the increased irrigation facilities, technological advancements, use of high yielding varieties etc. The deficiencies of Fe and Mn are found to be doubled recently. The percentage of deficiency in different districts varied from 12.8-53.3 for S, 0.0- 74.3 for Fe, 0.0-41.5 for Mn, 10.4-80.3 for Zn and 0.0-2.4 for Cu. However, actual Nutrient Index (NI) value indicated medium status for all the nutrients except for Cu which showed a high status and it was 2.06, 2.24, 2.61, 1.97 and 2.98 respectively, for different nutrients.

Critical level of Cu in wheat grain

A field experiment was conducted at Ludhiana with a copper deficient soil (DTPA-Cu 0.18 mg kg⁻¹ soil) for screening of eleven varieties of wheat (PBW 550, WH 542, PBW 527, PBW 509, PBW 502, PBW 343, PDW 291, PDW 274, PDW 233, TL 2098 and TL 1210) with respect to variation in their response to Cu fertilization. The data on grain and straw yield was recorded and the grain samples were analyzed for Cu concentration. The data obtained on grain yield and Cu concentration in grain of different cultivars of wheat was used to estimate the critical level of Cu in wheat grain by plotting it against per cent of maximum yield by using the method of Cate and Nelson. A critical level of 4.5 µg Cu g⁻¹ in wheat grain was observed to produce about 90% of the maximum grain yield. However, this critical level needs to be verified further by using a wide range of soils differing in their Cu content and physico-chemical properties.

4.5.2 Effect of micronutrients through soil and seed treatments for enhancing fertilizer use efficiency in soybean

The experiment was carried out at Regional Research Station, Rudrur, Andhra Pradesh with soybean (variety JS-338) as test crop. The experimental soil is clay loam with slightly alkaline pH 8.3 and normal in soluble salt content. Significant effect of Zn, B and Mo was observed on the pod yield of soybean by all the methods of application except seed treatment with 0.2 % sodium molybdate. Pod yield varied from 1556 to 2225 kg ha⁻¹. Soil application of Zn recorded the maximum yield (2225 kg ha⁻¹) with 43 % response followed by Boron (2012 kg ha⁻¹) with 29 % and Mo (1886 kg ha⁻¹) with 21 % response. Significant effect of Zn, B and Mo was recorded on the stalk yields of soybean at all levels over control except the seed treatment with B and Mo. Among the methods of application, soil application of Zn, B and Mo significantly increased the yields (2032,

1896 and 1896 kg ha⁻¹) over the seed treatments with Zn, B and Mo (1801, 1655 and 1615 kg ha⁻¹), respectively. Total Zinc uptake ranged from 79.88 to 150.54 g ha⁻¹ with the highest uptake in treatments where soil Zinc was applied. Boron uptake ranged from 61.31 to 136.13 g ha⁻¹. Highest B uptake was also recorded in the soil applied boron treatment. Seed treatments along with foliar sprays recorded higher amount of uptake compared to seed treatment alone

4.5.3 Transformation and phyto-availability of zinc and boron in selected bench mark acid soils amended with lime and farm yard manure

Status of extractable zinc in selected bench mark acid soils of India and their relationship among themselves and with soil properties

On a global scale, DTPA is most widely used soil extractant for extraction of plant available Zn, Fe, Mn or Cu in different soil types but other extractants like ethylenediaminetetraacetic acid (EDTA), hydrochloric acid, ammonium bicarbonate-DTPA (ABDTPA), Mehlich 1 and Mehlich 3 etc. are also still very popular. It must be noted that appropriate soil tests are not yet available for all types of agricultural soils around the world. One hundred surface soil (0-15 cm) samples each from Hariharapur (Bhubaneswar, Orissa), Debatoli (Ranchi, Jharkhand), Rajpora (Palampur, Himachal Pradesh), and Neeleswaram (Kasargod, Kerala) soil series were collected and analyzed for soil properties like pH, EC, organic carbon content, exchangeable potassium (K), calcium (Ca) and magnesium (Mg), extractable fraction of Zn by DTPA Mehlich 1, Mehlich 3, 0.1 M HCl and ammonium bicarbonate DTPA (ABDTPA) extractants and total Zn content.

The values of the estimated soil prosperities as well as extractable and total Zn content in soils are presented in Table 4.5.1 & 4.5.3. On an average (considering 400 hundred soil samples together),

Mehlich 1, Mehlich 3, 0.1 N HCl and ABDTPA extracted 2.55, 2.81, 2.78, and 2.06 times more Zn than DTPA extraction. Contribution of soil pH towards the extractable and total Zn is very less. However, contribution of soil organic carbon towards DTPA extractable Zn is higher as compared to Mehlich 1, Mehlich 3, 0.1 N HCl and

ABDTPA extractable Zn. Extracted Zn by different extractants were well correlated with each other (Table 4.5.2). This indicated that the trend of extraction of Zn in acid soils by different extractants used for this investigation was similar although the amount of micronutrients extracted by these extractants differed.

Table 4.5.1 Selected soil properties, extractable and total Zn (mg kg⁻¹) in soils.

Soil parameter	Hariharapur series			Debatoli series		
	Range	Mean	SD	Range	Mean	SD
pH	3.90-6.45	4.90	0.48	4.11-5.89	4.72	0.35
EC(dS m ⁻¹)	0.03-0.16	0.05	0.02	0.03-0.19	0.09	0.03
OC (%)	0.12-1.07	0.29	0.15	0.11-0.85	0.37	0.19
Exch. K (mg kg ⁻¹)	17-172	50.7	30.2	28.5-225	78.0	35.4
Exch. Ca (mg kg ⁻¹)	19-1088	231	215	22.5-735	148	106
Exch. Mg (mg kg ⁻¹)	11-625	155	112	21.7-280	111	66.0
DTPA-Zn	0.04-1.26	0.52	0.24	0.08-5.40	0.60	0.86
Mehlich 1-Zn	0.28-3.36	1.39	0.54	0.48-14.7	1.91	2.35
Mehlich-3-Zn	0.56-3.04	1.41	0.52	0.8-12.4	2.17	1.88
0.1 M HCl-Zn	0.40-3.76	1.75	0.59	0.28-14.9	1.45	2.28
ABDTPA-Zn	0.23-2.59	1.13	0.48	0.46-12.8	1.75	2.08
Total-Zn	8.80-67.5	34.2	11.3	16.0-86.5	34.5	15.2

Table 4.5.2 Corrélation coefficient values (n = 400)

Soil parameter	pH	OC	EC	Exc. K	Exch. Ca	Exch. Mg	DTPA-Zn	Meh.1-Zn	Meh. 3-Zn	0.1 N HCl-Zn	ABDTPA-Zn	Tot Zn
pH	1											
OC	0.12*	1										
EC	-0.08	0.13**	1									
Exc. K	0.22**	-0.12	0.27**	1								
Exch. Ca	0.52**	0.11*	0.13**	0.54**	1							
Exch. Mg	0.47**	0.27**	0.24**	0.38**	0.72**	1						
DTPA-Zn	0.23**	0.47**	0.26**	0.21**	0.39**	0.34**	1					
Meh. 1-Zn	0.23**	0.35**	0.23**	0.20**	0.35**	0.29**	0.82**	1				
Meh. 3-Zn	0.19**	0.18**	0.29**	0.24**	0.36**	0.21**	0.77**	0.85**	1			
0.1 N HCl-Zn	0.24**	0.43**	0.28**	0.14**	0.35**	0.36**	0.85**	0.87**	0.74**	1		
ABDTPA-Zn	0.20**	0.24**	0.25**	0.30**	0.42**	0.32**	0.76**	0.88**	0.85**	0.78**	1	
Tot Zn	0.28**	0.66**	0.05	0.06	0.33**	0.38**	0.47**	0.42**	0.3**	0.43**	0.37**	1

*, ** Significant at 5% and 1% level respectively

Table 4.5.3 Selected soil properties, extractable and total Zn (mg kg⁻¹) in soils.

Soil parameter	Rajpora series			Neeleswaram series		
	Range	Mean	SD	Range	Mean	SD
pH	4.48-5.94	5.04	0.27	4.16-6.28	4.89	0.38
EC(dS m ⁻¹)	0.02-0.19	0.08	0.03	0.01-0.40	0.08	0.06
OC (%)	0.52-2.79	1.24	0.39	0.39-3.46	1.86	0.58
Exch. K (mg kg ⁻¹)	16.5-225	60.6	46.7	8.5-254	39.1	39.2
Exch. Ca (mg kg ⁻¹)	72.4-1115	293	233	27.35-1124	280	163
Exch. Mg (mg kg ⁻¹)	48-635	175	115	21.7-797	191	153
DTPA-Zn	0.28-9.12	1.72	1.29	0.14-10.8	1.49	1.46
Mehlich 1-Zn	0.48-8.08	2.62	1.58	0.48-11.6	2.58	1.85
Mehlich-3-Zn	0.88-8.08	3.15	1.38	0.16-6.24	1.84	1.19
0.1 M HCl-Zn	0.68-8.36	2.75	1.53	0.80-14.2	3.54	2.70
ABDTPA-Zn	0.59-6.65	2.14	1.38	0.34-7.33	1.69	1.11
Total-Zn	33.8-179	62.0	19.6	13.7-122	66.6	21.3

4.5.4 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

A NAIP subproject entitled “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” initiated in a consortium mode with IISS, Bhopal as the lead centre and PAU Ludhiana, GBPUAT Pantnagar, ANGRAU Hyderabad, AAU Anand, RAU Pusa, Bihar Veterinary College, Patna and Lucknow University, Lucknow as the cooperating centres. As per the technical programme, screening of pigeon pea and wheat varieties with respect zinc efficiency has been carried out at IISS, Bhopal.

Twenty varieties of pigeon pea namely C11, ICPL 87119, AKT 8811, PKV Trombay, Hisar Manak, Hisar Paras, Hisar H02-60, Pusa 9, BDN 2, JKM 7, Virsa Arhar-1, SKNP 05-05, GAUT 93-17, DT-23, AAUT 2007-04, GT- 101, T 15-15, BSMR 853, GT 1 and AAUT 2007-10 were grown in zinc deficient soil with control (no zinc), soil application of Zn (@ 20 kg Zn ha⁻¹) and soil application + foliar spray treatments (Fig. 4.5.1). The varieties of pigeon pea differed from one another with respect to grain as well as stover yield. On an average, highest yield of 2891 kg ha⁻¹ grain was recorded in ICPL 87119 whereas it was lowest in PKV Trombay across the treatments. Almost all the varieties responded positively, with respect to grain yield to soil as well as soil + foliar application of Zn. Zinc use efficiency, on grain yield basis of pigeon pea varieties ranged from 67 to 97.

Similarly, twenty varieties of wheat namely C-



Fig. 4.5.1 Pigeon pea varieties in the field

306, DL-803-3, GW-322, GW-366, HD-2864, HD-2932, JW-17, JW-3211, LOK-1, SUJATA HI-627, HW-2004, HW-147, AKW-1071, AKW-381, AKW-4627, HI-1479, HI-1418, HI-8627, HD-4672 & HI-1500 were grown in zinc deficient soil with control (no zinc), soil application of Zn (@ 20 kg Zn ha⁻¹) and soil application + foliar spray treatments. The varieties of wheat differed from one another with respect to grain as well as stover yield. On an average, highest yield of 4145 kg ha⁻¹ was recorded in HI-8627 whereas it was lowest in HI-1500 across the treatments (Fig. 4.5.2) Almost all the varieties responded positively, with respect to grain yield to soil as well as soil + foliar application of Zn. Zinc use efficiency, on grain yield basis of wheat varieties ranged from 80 to 97.



Fig. 4.5.2 Wheat varieties in the field

4.5.6 Assessment of Quality and Resilience of Soils in Diverse Agro-ecosystems

Under the targeted AESR 10.1, two districts namely Sehore and Vidisha were selected. From Sehore district georeferenced soil samples were collected from 140 sites whereas from Vidisha district total 180 samples were collected. Analysis of soils were carried out for physical parameters (Bulk density, aggregate size, moisture retention capacities at 0.3 bar and 15 bar, bulk density, soil texture), chemical parameters (pH, EC, total organic C, fractions of soil organic C, C:N ratio, total N, available N, total P, available P, total K, non-exchangeable K, available K, available S, available Fe, Mn, Zn, Cu, B) and biological parameters (Microbial biomass C, dehydrogenase activity, alkaline phosphatase). Wheat and chickpea yields during *rabi* 2008 -09 and soybean yield during *Kharif* 2009 were recorded and C content of the collected plant samples were measured. Also, CO₂ evolution from field soil was measured by trapping method in alternate months from 3 villages of each district. Principal component analysis (PCA) for minimum data set for identification of master indicators of soil quality was carried out for AESR 10.1. For Vidisha district, the minimum dataset obtained from PCA were TOC, OxC/OP, available K, MWD, total Cu and bulk density whereas for Sehore district OxC, TOC/OP, pH, MWD, total Cu and alkaline phosphatase were identified as component of minimum dataset. When the minimum dataset were correlated with the goal variable (% relative yield), OxC, OxC/OP came out as master indicator of soil quality in Vidisha district and this master indicators explained 43.7% of the yield in Vidisha district. The mean SQI value of Vidisha district was 2.19 and it varied from 1- 4. In case of Sehore district, TOC, TOC/OP, Total Cu, Non ex K, silt appeared to be master indicators and they explained 52.3% of the yield. In Sehore district the mean value of SQI was 2.57 and it ranged between 1.31-3.92.

Table 4.5.4 Optimum & threshold levels of different fractions of Soil Organic Carbon (Sehore)

RY vs		N = 120	Optimum (g kg ⁻¹)	Threshold (g kg ⁻¹)
VL	Y = 15.852X+23.887	R ² = 0.491	3.54	1.64
OxC	Y = 6.548X+16.349	R ² = 0.454	9.72	5.14
TOC	Y = 5.6163X+14.026	R ² = 0.446	11.74	6.40
L	Y = 24.653X+26.622	R ² = 0.445	2.16	0.94
APC	Y = 10.446X+20.866	R ² = 0.375	5.66	2.79
LL	Y = 9.3591X+30.272	R ² = 0.312	5.31	2.11

LL = Less Labile, OxC = Oxidizable Carbon, TOC = Total Organic Carbon, VL = Very Labile, APC = Active Pool of Carbon (L+VL), L = Labile

Table 4.5.5 Optimum & threshold levels of different fractions of Soil Organic Carbon (Vidisha)

RY vs		N = 156	Optimum (g kg ⁻¹)	Threshold (g kg ⁻¹)
LL	Y = 10.742X+32.519	R ² = 0.531	6.28	1.63
OxC	Y = 5.0811X+33.571	R ² = 0.487	13.07	3.233
TOC	Y = 4.0801X+33.886	R ² = 0.458	16.20	3.94
VL	Y = 13.308X+37.582	R ² = 0.420	4.69	0.933
APC	Y = 7.826X+38.478	R ² = 0.410	7.861	1.47
L	Y = 17.403X+41.085	R ² = 0.381	3.385	0.51

LL = Less Labile, OxC = Oxidizable Carbon, TOC = Total Organic Carbon, VL = Very Labile, APC = Active Pool of Carbon (L+VL), L = Labile

Table 4.5.6 Biomass input (kg ha⁻¹), Carbon content (%) and Biomass C input (kg ha⁻¹) to soil through crops in Sehore and Vidisha districts of AESR 10.1

Crops	Items	Biomass input (kg ha ⁻¹)		Carbon content (%)		Biomass C input (g kg ⁻¹)	
		Vidisha	Sehore	Vidisha	Sehore	Vidisha	Sehore
Wheat	Root	2310	2652	33.6	34.8	776	923
	Stubble	251	283	39.2	38.1	99	108
Soybean	Root	738	483	37.3	39.2	275	189
	Stubble	2369	1600	35.6	40.4	844	646
Gram	Root	-	450	-	32.8	-	148
	Stubble	-	1764	-	35.7	-	630
Rice	Root	-	1738	-	34.6	-	601
	Stubble	-	136	-	42.4	-	58
Fym	-	2262	2772	21.07	18.92	476	525

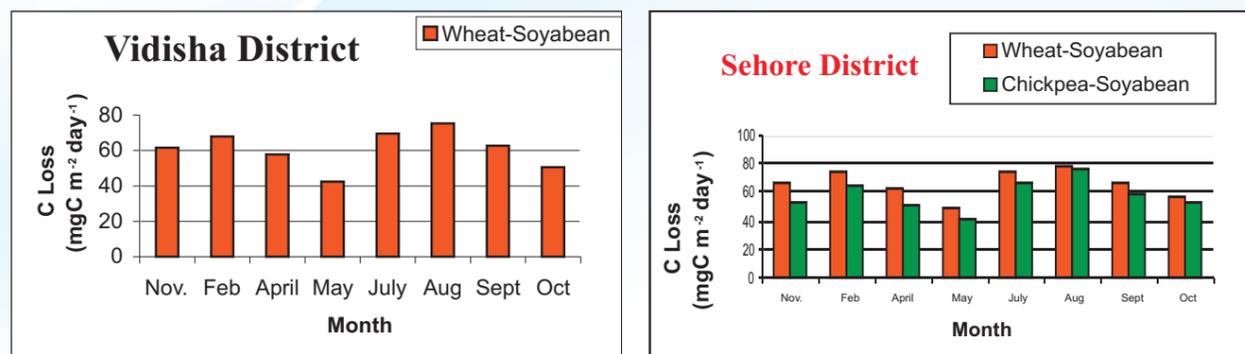


Fig. 4.5.3 Month wise mean loss of Carbon from soil in two districts of AESR 10.1

Table 4.5.7 Annual Loss of C from Cultivated Soils (AESR 10.1) due to Soil Respiration

District	Cropping	SOC Status g kg ⁻¹	Mean Loss			
			mg m ⁻² day ⁻¹		Kg Cha ⁻¹ yr ⁻¹	
Sehore	Soyabean-wheat	5.92	66.12	18-91	241.3	69.02
	Soyabean-chickpea	5.75	58.01	10.56	211.7	38.54
	Pristine	8.98	71.24	14.35	260.0	52.37
Vidisha	Soyabean-wheat	4.33	60.94	13.53	222.43	49.38
	Pristine	7.78	65.38	21.20	238.63	77.38

Table 4.5.8 Balance Sheet of Carbon in AESR 10.1

District	Cropping System	C input Kg Cha ⁻¹ yr ⁻¹	C Loss Kg Cha ⁻¹ yr ⁻¹	
Vidisha	Soyabean-Wheat	2470	222.5	49.4
	Soyabean -Wheat	2391	241.4	69.0
Sehore	Soyabean – Chickpea	2138	211.7	38.5
	Rice - Wheat	2215	-	-

For computing the threshold and optimum levels, different pools of soil organic carbon were correlated with goal variable (% relative yield) and the results are presented in Table 4.5.4 & 4.5.5. The threshold level indicates the level at which 50% of the maximum yield was obtained whereas the optimum level indicates the level at which 80% of the maximum yield was obtained.

For computing the Carbon balance sheet, the annual input of biomass carbon (Table 4.5.6) and annual loss of carbon through soil respiration (Fig. 4.5.3) were

worked out. The mean annual loss of carbon from cultivated soils (AESR 10.1) under different cropping systems is presented in Table 4.5.7. The balance sheet of carbon is given in Table 4.5.8.

In Vidisha, Mean yield of Wheat (n = 156); 2624 kg ha⁻¹ and for Soyabean (n = 156); 1515 kg ha⁻¹, In Sehore, Mean yield of Wheat (n = 118); 3127 kg ha⁻¹, for Soyabean (n = 124); 940 kg ha⁻¹, Gram (n = 22); 885 and Rice (n = 16); 2510.

Root/Shoot ratio for wheat: 0.302, rice: 0.27, Soyabean: 0.19 and Gram: 0.169

4.6 Improving Soil Biological Condition

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

The soil organic matter and its temperature sensitivity have recently received considerable attention especially in its mineralization parameters. The relationships among C-mineralization, biological activities and C pools under different moisture regimes of selected treatments such as control (no fertilizer), 100% of the recommended application of NPK, 50 % NPK+FYM @ 5 Mg ha⁻¹, 50 % NPK+ crop residue (CR) and 100 % FYM were used after 5 cycles of soybean-wheat in rotation. Interactive effect of three temperature situation (25, 35 and 45°C), three hydrological regimes such as 60% moisture holding capacity (MHC), 100 % MHC and submerged condition, and microbiological activities on soil carbon decomposition was investigated and CO₂ efflux and Q₁₀ are expressed by a simple linear model (Table 4.6.1). The increase in CO₂ evolution was noted with increase in temperature and attained

maximum at 40 days of decomposition at 45°C, whereas C-mineralization rate constant (k) increased with increase in temperature from 25 to 45°C from all treatments (Table 4.6. 1). Q₁₀ (e10* K) increased with increased in moisture holding capacity from 60 % MHC to 100 %MHC and decreased under submerged condition except unfertilized control. It was also observed that Q₁₀ was relatively less in submerged condition than 60 and 100 % MHC. Among the treatments, Q₁₀ was the highest in 100% FYM followed by NPK+CR treatment. It was also observed that bacterial respiration was greater in 60% MHC than in submerged condition in all the treatments (Fig.4.6.1). However, under submerged condition the reverse trend was observed (Fig.4.6.2). The water soluble-C and acid hydrolysable - C also followed a similar trend to that of CO₂-C evolution. Thus study indicated that emission of gaseous-C was significantly increased due to exhaustion of the labile pools of carbon which acted as bio-energy under 60% MHC as compared to submerged condition, whereas integrated nutrient management practice of 100% NPK+FYM minimized it.

Table 4.6.1. Effect of moisture and temperature on C- mineralization rate constant (mg CO₂ 100g⁻¹ d⁻¹) and Q₁₀ under different treatments

Treatments	Moisture levels (% MHC)	Temperature			Q ₁₀
		25°C	35°C	45°C	
Control	60	2.3	3.4	2.6	1.10
	100	2.9	3.7	2.9	1.01
	Submerged	2.5	4.1	4.0	1.28
100%NPK	60	2.0	2.0	3.2	1.26
	100	2.2	2.2	4.1	1.36
	Submerged	2.2	2.2	3.8	1.32
50% NPK+FYM	60	1.8	1.8	3.5	1.36
	100	2.1	2.0	4.9	1.55
	Submerged	1.9	1.9	3.8	1.40
50 % NPK+ CR	60	1.8	1.8	4.1	1.50
	100	2.1	2.0	4.6	1.52
	Submerged	2.4	2.4	3.8	1.25
FYM	60	1.7	1.7	3.9	1.50
	100	2.0	2.0	4.5	1.51
	Submerged	2.1	2.1	4.6	1.51

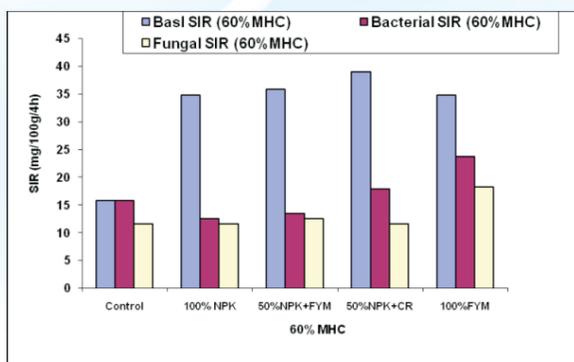


Fig. 4.6.1 Effect of different treatments on basal, bacterial and fungal respiration at 60 % MHC of soil

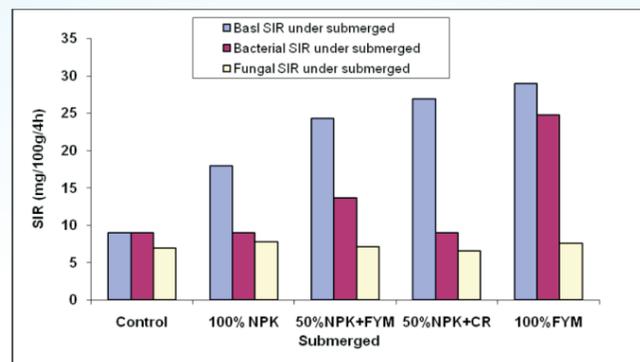


Fig. 4.6.2 Effect of different treatments on basal, bacterial and fungal respiration under submerged soil

4.6.2. Nutritional quality assessment under LTFE Experiment

Soybean samples collected from LTFE Jabalpur and Ranchi centres were analysed for physical, chemical and biochemical parameters. It was observed from the study that the 100-seed weight of soybean varied significantly in different treatments over control. Highest 100-seed weight was recorded with the application of 100% NPK +

FYM compared to other treatments and was the lowest in control. Moisture, carbohydrates and oil percentage in soybean seeds did not vary significantly due to different nutrient treatments but the higher values of above mentioned parameters were recorded in all the nutrient treatments compared to control (Table 4.6.2). Similar results were also recorded in Ranchi LTFE centre (Table 4.6.3).

Table 4.6.2 Nutritional quality of soybean seed (LTFE Jabalpur Centre)

Treatments	100-seed wt.	Moisture (%)	Protein (%)	Carbohydrates (%)	Oil (%)
Control	8.70	9.1	34.83	22.0	18.8
100% N	9.74	8.9	37.34	20.7	19.5
100% NP	10.64	8.9	36.97	21.8	20.3
100% NPK	9.97	9.4	38.37	21.5	20.6
150% NPK	11.21	9.3	39.00	21.1	20.4
100% NPK+ FYM @15 t ha ⁻¹ yr ⁻¹	12.00	9.3	39.16	20.6	20.7
100% NPK-S	10.85	9.3	38.14	21.5	19.3
CD(P=0.05)	0.21	NS	1.17	NS	NS

Table 4.6.3 Nutritional quality of soybean seed (LTFE, Ranchi Centre)

Treatments	100-seed wt.	Moisture (%)	Protein (%)	Carbohydrates (%)	Oil (%)
Control	8.50	9.1	36.4	21.3	18.3
100% N	9.64	9.2	39.0	19.8	19.4
100% NP	10.56	9.1	39.3	20.7	19.7
100% NPK	10.68	9.3	39.8	20.6	19.6
150% NPK	11.30	9.4	40.1	20.2	19.2
100% NPK+ FYM @15 t ha ⁻¹ yr ⁻¹	11.60	9.4	40.4	20.1	19.0
100% N PK+ S	11.20	9.4	40.2	19.9	19.1
CD	0.19	NS	1.48	NS	NS

Different essential amino-acids content in soybean seed did not vary significantly due to different nutrient treatments. But the higher values of S-containing amino-acids (methionine

and cysteine) and tryptophan contents in soybean were recorded due to different nutrient treatments compared to control in both the LTFE centers soybean samples (Table 4.6.4 & Table 4.6.5).

Table 4.6.4. Nutritional quality of soybean seed (LTFE, Jabalpur Centre)

Treatments	Methionine (g/16 N)	Cysteine (g/16 N)	Tryptophan (g/16 N)
Control	1.56	1.58	1.68
100% N	1.68	1.66	1.76
100% NP	1.74	1.70	1.79
100% NPK	1.81	1.74	1.78
150% NPK	1.82	1.76	1.82
100% NPK+ FYM @15 t ha ⁻¹ yr ⁻¹	1.90	1.80	1.84
100% NPK-S	1.78	1.74	1.82
CD (P=0.05)	NS	NS	NS

Table 4.6.5. Nutritional quality of soybean seed (LTFE, Ranchi Centre)

Treatments	Methionine (g/16 N)	Cysteine (g/16 N)	Tryptophan (g/16 N)
Unmanure (control)	1.64	1.57	1.71
100% N	1.72	1.64	1.89
100% NP	1.74	1.62	1.80
100% NPK	1.80	1.66	1.82
150% NPK	1.81	1.67	1.85
100% NPK+ FYM @15 t ha ⁻¹ yr ⁻¹	1.85	1.70	1.83
100% NPK + S	1.84	1.69	1.79
CD (P=0.05)	NS	NS	NS

On the basis of the results obtained in the study, it can be concluded that balanced application of nutrients not only resulted in improvement in protein and amino-acids content but also improved the 100-seed weight of soybean.

4.6.3. Methane (CH₄) production and oxidation in tropical soils under long term fertilizing system

Laboratory incubation studies were conducted to investigate the greenhouse gas, methane (CH₄) metabolism in soils (Pantnagar and Ranchi) under long term fertilizing system. The microbial mediated processes were differentially influenced by the soil factors as well the fertilizer type. Both the soils exhibited similar effect on CH₄ production potential while varied in the CH₄ oxidizing activity and was found that the rate of CH₄ oxidation was higher in Pantnagar than the Ranchi soil. Fertilizer sources like N alone was stimulatory and while applied along with P and K were inhibitory to CH₄ production. CH₄ oxidation activity in Pantnagar soil was stimulated by P and K application than that of only N fertilizer application. Results revealed the differential effect of N, P, K fertilizers on methane production and oxidation in tropical soils under long term application process.

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 (AMAAS).

The project is aimed mainly 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. The main findings during 2009-10 are summarized below.

Database of PGPR and rhizobia:

Of the 510 bacterial isolates, initially made from the rhizosphere of soybean, chickpea, wheat in vertisols of Madhya Pradesh and from vermicompost and vermicast samples and screened for PGPR attributes *in vitro* and *in vivo* on soybean, wheat and chickpea, 81 isolates exhibited PGP activity (16%) (These included 10 oligotrophic isolates). Out of these 81, a further sub-set of 32 isolates were short-listed based on best *in vitro* and *in vivo* PGPR attributes (22 plus 10 oligotrophs) and a data base of their physiological and biochemical attributes has been prepared. The morphological attributes are on colony characters, EPS production, growth rate, gram reaction and sporulation. Physiological attributes are on diazotropy, P Solubilisation, IAA, siderophore production, HCN production, ACC-Deaminase, antifungal activity against *Fusarium oxysporium.f.sp.ciceri* and *Sclerotium rolfsii*. Based on morphological, physiological and biochemical attributes, and analysis of some of them by 16s rDNA analysis, 20 strains were identified and belonged to *Bacillus megaterium*, *B. subtilis*, *B. cereus*, *B. coagulans*, *Microbacterium* sp. A data base of 40 soybean and 18 chickpea rhizobia consisting of the location of the isolates, morphological, physiological and biochemical attributes, nodulation parameters etc has been prepared.

Oligotrophy of rhizobacteria:

Initially 6 out of the 403 bacterial isolates (on 8 different media) studied 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. To ascertain their degree of oligotrophy, 10 isolates which grew on ultra-pure agar (7 original obligate copiotrophs and 3 original obligate oligotrophs) were inoculated in double distilled water (DDW- EC 5.2µS cm⁻¹) and incubated for six months. To check any possible nutrient transfer from the original nutrient agar grown inoculum, 0.1 ml of one month old cultures in DDW were re-inoculated in fresh DDW and grown for one month. Such successive re-transfers into DDW were repeated at the end of 2nd and 3rd month also. The isolates could be maintained in viable state upto 6 months (10⁵-10⁶ cells ml⁻¹). The study is in progress.

Field screening of PGPR

Liquid inoculants preparations of 45 PGPR out of the above short-list of 50 isolates (which included 5 oligotrophs out of the 10) were prepared and inoculated on soybean seeds. The liquid PGPR inoculant had 5 x 10⁸ cells ml⁻¹. The no. of PGPR and *Rhizobium* cells inoculated on the seed ranged from 1.6-2.7 x 10⁵ cells seed⁻¹. Inoculated seeds were sown in 2 x 2 m plots in vertisol field plots at JNKVV, Jabalpur in augmented design and compared with local check and uninoculated treatment in *kharif* 2009. Observations on germination, nodulation, shoot growth and grain yield were recorded. Eleven (11) highly effective PGPR (category 1) improved nodule numbers and mass (by 225 and 285%) and increased the grain yields by 54.8%. Four (4) effective strains (category 2) improved nodule numbers and mass by 156 and 214% and grain yields by 30.9%.

Field screening of PGPB isolates

19 PGPR isolates that also exhibited significant *in vitro* antagonistic activity towards *Fusarium oxysporum f.sp.ciceri* were selected and applied

as seed inoculants on chickpea in vertisol field plots at College of Agriculture, RMSUAT, Sehore in 'sick plots' where inoculum of chickpea wilt was built up over the years. Observations on germination, survival and plant growth were recorded along with grain yield. Out of these, 3 strains were found to be promising.

Diversity of soybean rhizobia

Intrinsic antibiotic resistance

The intrinsic antibiotic resistance (IAR) pattern of 35 nod⁺ rhizobial isolates of soybean isolated from 20 districts of various geographical region of M.P. towards 19 antibiotics was evaluated. Intrinsic antibiotic resistance was sufficiently discriminatory for ascertaining diversity of soybean rhizobia. Dendrogram of the IAR pattern showed a lot of diversity and soybean rhizobia clustered into 5 distinct groups at 67% level of similarity. All the isolates showed a similarity of 56%. The standard strains of *B. japonicum* USDA 110 (R27) and *B. elkanii* USDA 31 (R29) and 22 soybean isolates formed a major cluster (Group 3) which account for 63 % of the total isolates (22 out of 35).

Carbon utilization

The utilization of 35 carbon sources by 36 nod⁺ rhizobial isolates of soybean isolated was evaluated. The carbon sources were, adonitol, L-arabinose, D-arabinose, cellobiose, citrate, dextrose, dulcitol, esculin, fructose, galactose, glycerol, glucosamine, inulin, inositol, lactose, maltose, mannose, melibiose, melezitose, mannitol, α methyl D-glucoside. α methyl-D-mannoside, malonate, ONPG, raffinose, ribose, rhamnose, sucrose, sodium gluconate, Trehalose, salicin, sorbitol, sorbose, xylitol and xylose. The catabolic diversity showed up 21 clusters at 67% similarity and 6 clusters at 25% (Fig 4.7.1). Cluster 6 contained majority (23 out of 35) of the strains which showed only 25% similarity with the

rest. With both intrinsic antibiotic resistance and carbon utilization, 90 % of the rhizobial strains (20 no.) clustered together, thus showing that IAR

and carbon sources utilization criteria are robust criteria for selection of rhizobial strains for competitiveness.

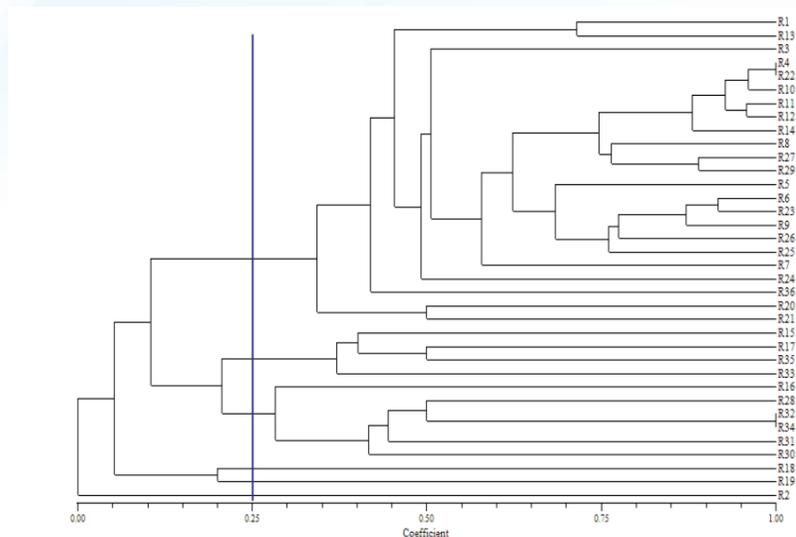


Fig 4.7.1 Dendrogram representing the clustering of soybean rhizobia based on catabolic diversity (carbon source utilization)

MPN of soybean rhizobia in Indian Soils

The most probable number of soybean rhizobia in non-rhizosphere soil was shown from earlier studies to be less than 100 cells g⁻¹ at peak summer as well as at the time of sowing of soybean (onset of monsoon) and built up to 500 cells g⁻¹ at later stages. The only exception was a rhizosphere sample from Vidisha from a very vigorously podding and robust plant that contained more than 3000 cells g⁻¹. In *rabi* season (cool season) even in non-rhizosphere soybean population was 3500-4000 cells g⁻¹ in February. Thus the upper limit can be taken as 4000 and lower limit as 100 cells g⁻¹ as a generalization. This indicated that soybean rhizobia are highly temperature sensitive and there was a mortality of 98% in summer in surface soil (0-15 cm) due to prevailing high temperature. This confirmed our earlier hypothesis that soybean crop requires inoculation with specific rhizobia every year.

Soybean rhizobial populations in other growing regions were also in the above range with the exception of Palampur which was slightly higher due to cool climate. The highest population was recorded in Pantnagar where the crop is regularly inoculated with *Rhizobium* each year.

Field screening of short-listed rhizobial strains in vertisol field

Liquid inoculants preparations of 40 rhizobial strains were prepared and inoculated on soybean seeds. The liquid *Rhizobium* inoculant had 4.5 x 10⁸ cells ml⁻¹. The no. of *Rhizobium* cells inoculated on the seed ranged from 1.6-2.5 x 10⁵ cells seed⁻¹. The inoculated seeds were sown in 2 x 2 m plots in vertisol field plots at JNKVV, Jabalpur in augmented design and compared with local check and uninoculated treatment in kharif 2009. Observations on germination, nodulation, shoot growth and grain yields were recorded. Six (6) highly effective rhizobia (category 1)

improved nodule numbers and mass (by 217 and 230 %, respectively) and increased the grain yields by 54.8%. Nine (9) effective strains (category 2) improved nodule numbers and mass by 144 and 170%, respectively and grain yields by 28.6%.

Field screening of PGPR and *Rhizobium* in vertisol farmers' fields

Soybean rhizobial strain (*Bradyrhizobium japonicum*- ISR-33) and PGPR strain (*Bacillus megaterium*-ISP-3) were field tested in 100 demonstrations conducted by IISS, Bhopal. Detailed observations in five farmer fields in Raisen District showed that soybean seed yield increased with INM option using these strains by 18% over balanced fertilization and 54% over farmer's practice (Fig 4.7.2).

Impact of Research

Bradyrhizobium japonicum ISR-33 and PGPR-*Bacillus megaterium* ISP-3 were supplied for mass production to JNKVV Biofertilizer production centre, Jabalpur. During 2009, 2.13 lakh inoculant packets were prepared with these strains and supplied all over Madhya Pradesh. With a minimum increase of 1 q ha⁻¹ in soybean seed yield due to use of these inoculants, it was estimated that additional increased farm output to the value of 6.3 crores was realized due to the use of these inoculants in M.P.



Fig. 4.7.2 Effect of PGPR and *Rhizobium* inoculation on farmer field in Raisen, Madhya Pradesh. FP=Farmers' practice, BF= Balanced Fertilization, INM= Integrated Nutrient Management.

4.7.2 AINP on Soil Biodiversity Biofertilizers

Diversity of rhizobia

Rhizobial isolates from farmers fields in rice fallow blackgram of East and West Godavari Districts of Andhra Pradesh were at par or better than RBG 314 at ARS, Amaravathi. Three isolates BLG 93, BLG 95 and BLG 97 used as mixed culture along with PSB, gave maximum number of nodules per plant (98/plant) in field. The individual isolates gave 22-28% yield increase whereas the mixed cultures gave 36% grain yield increase over control. In farmers' fields in Anantapur and Tandur, Andhra Pradesh, most probable number of rhizobia in the soils for cowpea and pigeonpea were < 100 cells g⁻¹ at 3 and 2 sites respectively, 100-1000 at 3 and 5 sites and > 1000 at 3 sites each. In groundnut grown in Suarashtra and Kutch, out of 127 isolates of root nodule inhabiting bacteria isolated in YEMA medium, 73 had both *nif* and *nod* genes and work on nodulation, nitrogen fixation, PGPR characteristics and competitiveness traits is under progress. (ANGRAU, Amaravathi; CRIDA, Hyderabad; NRCG, Junagarh)

Abiotic Stress Tolerance

Seven *Azotobacter* sp., six *Azospirillum* sp. and three P Solubilising isolates capable of growth at 45°C were isolated. Three *Azotobacter* isolates (AZT-3, AZT-4 and AZT-13) and two *Azospirillum* isolates ASP-5 and ASP-6 could grow at a matric stress of -12 bars on respective media amended with osmolytes. They could also solubilize zinc. All the isolates were found positive for more than one plant growth promoting attributes. The PSB isolates and one *Azospirillum* isolate also showed antagonism to *M. phaseolina* and *F. ricinii*. (CRIDA, Hyderabad)

Establishment of Cyanobacteria in Rice Soils

Various combinations of four cyanobacterial strains (BF1, *Anabaena torulosa*; BF2, *Nostoc carneum*; BF3 *Nostoc piscinale*; BF4, *Anabaena doliolum* effective in enhancing plant growth, yield, soil fertility and soil enzyme activity were identified in rice. Under net house conditions in an alluvial soil substituting for 50% N was observed (IARI, New Delhi).

Mixed Biofertilizers

Bioinoculants for aerobic Rice

Combined inoculation of AM fungi with Azophos was better than control. Rice grain yield was 7.5 % higher in AM Fungi (colonized root bits + sand based AM inoculum) + Azophos + NP (75%) K (100%). Maximum infection of AM fungi and glomalin content of 0.75 mg were observed at flowering stage. AM inoculation had significant impact on phosphates activity. Application of rhizobacterial inoculants increased the soil urease and dehydrogenase activity of aerobic rice which was maximum at flowering stage. (TNAU, Coimbatore)

PSB inoculation of Rice

Five indigenous PSB isolates gave higher rice grain yield (~24%) over recommended dose under field conditions when inoculated in the presence of 10 kg P₂O₅ as rock phosphate and 50% P. Similarly the MB-C and the key soil enzymes displayed greater activities under the treatments. (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 gave the highest grain yields which were 20% higher over RDF. Biological

parameters viz- phosphomonoesterase and fluorescein diacetate assay revealed similar trend in response to addition of organic inputs. (AAU, Jorhat)

INM Package for Rice Based Cropping System

Application of Biofertilizer enriched compost (primed with biofertilizer agents & rock phosphate) at 2 t ha⁻¹ along with 25 % recommended doses of N and P (full dose of K) increase the rice yield by 23% & 10 % in rice-toria and ricewheat system respectively over recommended dose of mineral fertilizers. Incorporation of either enriched compost or biofertilizer agents (*Azospirillum* & PSB) with consequent reduction of mineral fertilizers exhibited greater MB-C, dehydrogenase, phosphomonoesterase and fluorescein diacetate activities. (AAU, Jorhat).

Sorghum

Application of 100% RDF alongwith co-inoculation of *Azospirillum* and PSB on sorghum gave highest grain yield (2555 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 and improvement in soil microbial population (MAU, Parbhani)

Sweet Sorghum

Significant increase in grain yield and green stalk yield was observed with 75% RDF and dual inoculation of *Gluconacetobacter* and *Azospirillum*. However stem juice (used for bioethanol production) increased with 100% RDF along with inoculation. Significant increase in juice extraction percentage, °brix, reducing and non-reducing sugar content of juice was observed with inoculation of *Gluconacetobacter*. (MAU, Parbhani)

Soybean

Application of 100% RDF alongwith co-inoculation of *Bradyrhizobium* and PSB on soybean gave highest grain yield (2135 kg ha⁻¹), which was significantly higher over uninoculated. Availability of nitrate nitrogen and P in soil was also increased with dual inoculation along with RDF significantly. There was significant improvement in population of bacteria, actinomycets and fungi in soil by 75% RDF with dual inoculation of biofertilizers. (MAU, Parbhani).

Groundnut

Various consortia comprising of compatible strains of PGPR (*Pseudomonas* sp. C185; *Pseudomonas* sp. ACC3), PSM (*Pseudomonas* sp. ACC10 and *Bacillus megaterium*) and rhizobia (TAL1000 and NRCG22) were evaluated on groundnut during kharif 2009. Application of consortium of rhizobia (TAL 1000 and NRCG22) gave maximum pod yield of 1750 kg as compared to uninoculated control pod yield of 1450 kg ha⁻¹ with cultivar Girnar 2. There was also improvement in shelling out-turn, nodule number and nodule dry weight, haulm yield, nitrogen content in kernel and plants when inoculated with consortium of rhizobia and rhizobia with PSM (*Pseudomonas* sp. ACC10 and *Bacillus megaterium*) (NRCG, Junagarh).

Biofertilizer Technology

Liquid Inoculant Technology

Different media compositions were formulated to support the growth of three biofertilizer organisms namely *Azospirillum*, PSB and *Pseudomonas* together in a single medium. The medium, GM3 supported maximum number of cell population of all the three organisms. Further, the studies on shelf life study and suitable packing system is under progress (ANGRAU, Amaravathi).

Field evaluation of Liquid inoculants for maize and pigeonpea

Liquid inoculants performed better than solid carrier based inoculants (+15%) at all fertilizer doses of 50%, 75% and 100% RDF on maize in vertisols. Liquid inoculants of *Azospirillum* + PSB along with 75% RDF gave significantly higher grain yields than 100% RDF alone. In pigeonpea liquid inoculants of *Rhizobium* + PSB with 50% RDF gave maximum number of nodules (78 plant⁻¹) at flowering stage whereas with solid carrier it was 51 plant⁻¹. Visual differences were observed with liquid inoculants over solid inoculants on pigeon pea (ANGRAU, Amaravathi).

Field evaluation of Liquid inoculants for soybean

Field trials with liquid formulations of 40 *Rhizobium* and 45 PGPR strains were conducted on soybean in vertisol field to short-list promising strains. 15 rhizobia and 15 PGPR strains gave 52% av. increase of in grain yield (IISS, Bhopal; JNKVV, Jabalpur).

Delivery systems for inoculants for groundnut

Different delivery systems of application of the consortium of beneficial bacteria (PGPR: *Pseudomonas* sp. C185; *Pseudomonas* sp. ACC3; PSM: *Pseudomonas* sp. C185 + *B. megaterium*; and groundnut rhizobia: TAL 1000 and NRCG 22) were tested in field. The delivery systems included application of the above consortia with irrigation water, as seed treatment and through carriers like soil, talcum powder, kaoline, charcoal, and FYM. Application of bacterial consortium in furrows through charcoal and FYM as carrier and through irrigation water resulted in significant enhancement of pod yield as compared to un-inoculated control. Whereas maximum pod yield of 1740 kg ha⁻¹ was obtained with charcoal carrier, it was 1680 kg when

applied through FYM as compared to uninoculated control (1470 kg ha⁻¹) with cultivar Girnar 2 during *kharif*, 2009 (NRCG, Groundnut).

Biofertilizer enriched Compost

Ninety days old rice straw compost enriched with *Azospirillum* and PSB (@1% broth each containing 10⁸-10⁹ cfu ml⁻¹) and amended with 1% Rock Phosphate (as P) and cured for 1 month showed *Azospirillum* & PSB population increases by 21 and 24%.. C:N ratio stabilized at 8:1. (AAU, Jorhat).

DIVERSIFICATION OF BIOFERTILIZERS

Bacillus biofertilizer for sweet cherry

A highly efficient P-solubilizing *Bacillus* sp. VS9 capable of solubilizing phosphorus, producing IAA and siderophores and inhibiting *Pythium aphanidermatum*, *Rhizoctonia solani* and *Fusarium oxysporum* under *in vitro* conditions was identified for temperate hill soils. The biofertilizer could increase shoot and root biomass, and nutrient uptake significantly (YSPUHT, Solan).

Biofertilizers for tropical vegetables

Bioinoculation of sweet potato in acid soil saved 25 % NPK besides increasing the yield by 8% and improving the recovery of NPK. Similar results were obtained for broccoli and spine gourd. Total sugar content increased upon organic manuring and biofertilization in sweet potato.

4.8 Amelioration of Contaminated Soils

4.8.1 Assessment of heavy metal pollution in groundwater as well as surface water in Patancheru Industrial area, Medak District, Andhra Pradesh, India : A case study (a Survey report)

Patancheru industrial development area, covering

about 120 km² on Hyderabad Mumbai National highway (NH9) in Medak district, Andhra Pradesh, India, is identified as one of the most polluted area by Central Pollution Control Board, New Delhi, and referred to as an area of ecological disaster. The study area forms part of Paddavagu stream, which comes under the catchment of Nakkavagu stream, a tributary of the Manjira River, which is one of the main sources of drinking water to Hyderabad city. About 300 pharmaceutical, heavy engineering, paints, chemical and paper factories established over the last two decades in this area. They generate approximately 8 million liters of effluent water per day, most of which is directly discharged to the natural hydrological system, thereby causing imbalance to the environment (NEERI 1989). There has been no proper waste disposal facilities built in these areas. The combined industrial estates in Bollaram and Patancheru generate a cumulative 8 x 10⁶ l day⁻¹ of effluents which is directly discharged into surrounding land, irrigation fields and surface water bodies. The industrial effluents contain appreciable amounts of inorganic and organic chemicals and their by-products. Most of the industries are small to medium-scale sector and are not having any sewer lines. Many of them do not have proper wastewater treatment plants and they discharge industrial effluents in unlined channels/streams, thereby causing contamination of air, water and soil.

The descriptive statistics of analytical results for both surface and groundwater are shown in Tables 4.8.1 & 4.8.2. pH of surface water varies from 6.4 to 9.8 with an average of 7.9, while, in groundwater it varied from 6.9 to 9.4 (average = 8.1). All the water samples showed neutral to basic and alkaline values. pH did not show significant positive correlation with any trace element in surface and groundwater, while it showed negative correlation with As, B, Fe, Pb

and Zn in surface water, and Ba, Co, Mn and Sr in groundwater. This indicated that influence of pH on trace elements is different in surface and groundwater of the study area, and is a major controlling factor especially in surface water. It was observed that there are some high values of Fe, Mn, As, Pb, Zn, B and Co due to point and non-point sources, which may be attributed to the industrial and agricultural activities. Unlike in surface water samples, the pH in groundwater varied from 6.9 to 9.4 with an average of 8.1±0.7 (1σ) and displays consistency in pH values. However, in surface water, the pH varies from 4.1 to 9.8 with an average of 7.9±1.1 (1σ). The fact

Arsenic levels were found to be almost high in all samples with concentration ranging from 1.8 to 97.3 μg l⁻¹ with an average of 26.3 μg l⁻¹. The high As values up to 15,000 - 30,000 μg l⁻¹ were also reported near the exit of CETP. Paddavagu stream also show high concentration of arsenic varying from 1000 to 4000 μg l⁻¹, which proves that source of arsenic is anthropogenic and not from any surrounding rocks. Organic effluents discharged by the industries can complex with arsenic to form non-degradable metal complexes and they in turn enter the groundwater and migrate along natural hydrological gradient. Arsenic contamination in Patancheru comes mainly from paint,

Table 4.8.1 Descriptive data of surface water analysis (μg l⁻¹) collected from Patancheru Industrial Area, Medak district

Parameters	Mean	Median	Minimum	Maximum
pH	7.9	7.8	6.4	9.8
EC (dS/m)	2.5	1.8	0.5	8.9
Cr	16.0	12.5	3.9	43.8
Mn	73.9	33.9	2.6	219.3
Fe	70.0	71.6	39.1	153.7
Ni	23.4	15.6	4.7	57.4
Zn	81.0	67.3	32.9	326.8
As	26.3	18.9	1.8	97.3
Pb	2.00	1.10	0.30	14.20
Sr	631	518	121	1672

that surface water is either more acidic or alkaline in certain places, and that the trace elements concentrations in those samples are also varying accordingly, indicates that pH is a controlling factor in surface water. This situation suggests a strong variability due to presence of

pharmaceutical, fertilizer and pesticides industries.

Anthropogenic addition of Fe in surface water varying from 39.1 to 153.7 μg l⁻¹ with an average of 70 μg l⁻¹ is low in the area; apparently effluent

waters are only causing its increase in surface water. Fe does not show high concentrations in groundwater suggesting that there is little percolation of Fe from surface to groundwater. Ni concentration varies from 4.7 to 57.4 (average of 23.4 $\mu\text{g l}^{-1}$), Pb varies from 0.3 to 14.2 $\mu\text{g l}^{-1}$ (average of 2.0 $\mu\text{g l}^{-1}$) and Zn varies from 32.9 to 293.9 ppm (average of 81 $\mu\text{g l}^{-1}$). Some sample show high values of Fe, Ni, Pb and Zn, which are near the vicinity of industrial areas. The Sr concentration varies from 121 to

Groundwater contamination can originate above or below the surface of the earth. Infiltration of polluted surface water causes contamination below the surface of the earth. When compared to water in streams and rivers, the movement of groundwater is very slow and hence once the contaminant reaches the groundwater; there is little scope for dilution and dispersion.

The polluted surface water is strongly influencing the quality of groundwater in the study area.

Table 4.8.2 Descriptive data of Ground water analysis ($\mu\text{g l}^{-1}$) collected from Pattancheru Industrial Area, Medak district

Parameter	Mean	Median	Minimum	Maximum
pH	8.1	8.0	6.9	9.4
EC (dS/m)	2.6	1.7	0.7	10.2
Cr	13.3	6.9	2.0	69.7
Mn	75.8	5.6	2.4	11384
Fe	106.7	87.3	34.6	497.2
Ni	69.0	43.0	3.9	264.8
Zn	89.4	57.8	21.4	310.8
As	129.4	19.3	4.2	1139.0
Pb	2.10	0.95	0.30	7.20
Sr	1079	875	134	2681

1672 $\mu\text{g l}^{-1}$ (average = 631 $\mu\text{g l}^{-1}$). Some samples show high values of Sr. High values of Sr up to 1000 $\mu\text{g l}^{-1}$ can be derived from the surrounding acidic rocks having Sr of about 400-500 ppm. Hence Sr contamination is attributed to mixed origin of Sr in the area from anthropogenic and geogenic source.

The ground water contamination is higher in the study area (Table 4.8.2), which may be mainly due to anthropogenic activities or some geogenic also.

Migration patterns of heavy metals released into the environment in the form of untreated effluents by CETP and industries of Patancheru indicate the point source of pollution. Central effluent treatment plant was found to be increasing the concentration of toxic metals in surface and groundwater which was confirmed by high concentration of all the heavy/toxic metals in Peddavagu, adjacent to CETP. The untreated effluents emerging from the industries must be monitored for maintaining the standards

prescribed by the pollution control board for various industries in the region. The chemical analysis of the treated effluent from the CETP was found to contain some toxic metals like arsenic, selenium and manganese. As the CETP receives effluents from various industries in tankers and it is suggested to check for the trace metal and TDS concentrations before letting the untreated effluents into the CETP.

Water streams Nakkavagu, Peddavagu should be lined in the bottom on both sides to prevent the spread of contaminants horizontally and vertically. Some remedial measures should be applied in agricultural fields by removing topsoil and applying bioremediation techniques. Periodical monitoring of the water quality has to be continued to check the rise in TDS concentrations of groundwater.

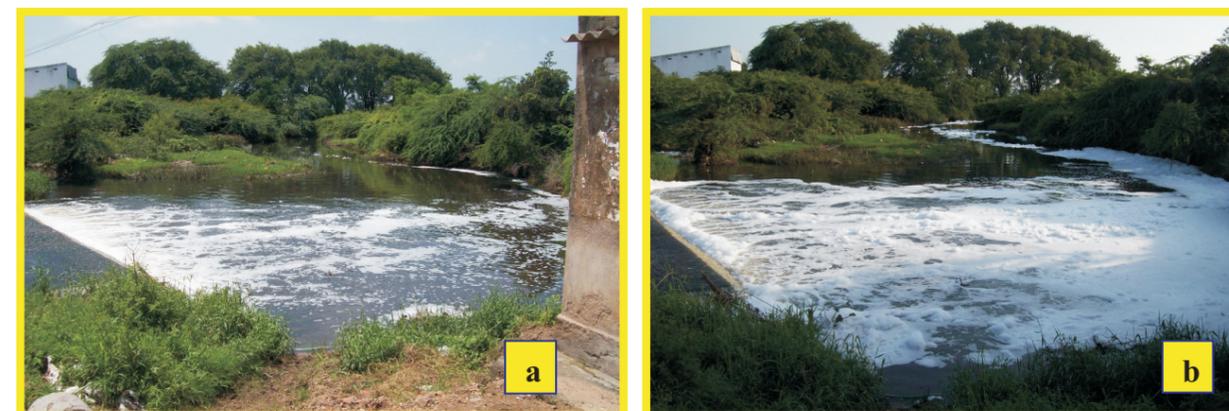


Fig. 4.8.1 Peddavagu stream (sewage canal) (a) Morning view (b) Evening view



Fig.4.8.2 Sewage canal just behind the CETP



Fig. 4.8.3 Application of Paddavagu stream water for irrigation

4.9 Recycling and Rational Usage of Different Waste in Agricultural Soils

4.9.1 Determination of Nickel and chromium concentration limits in agricultural soil and MSW compost through analysis of different limiting pathways

In India, practically no information has been generated in respect of heavy metal concentration limits or cumulative loading limits (CLL) for agricultural soils. Such information is essential for taking policy decisions with respect to unavoidable additions of heavy metal pollutants in crop lands and thereby protecting the environment. This study has been conducted with the objective of determining CLL of Ni and Cr applied through MSW composts in agricultural soil. In this approach, Ni and Cr loadings can be allowed upto the level that is safe for plant growth and soil microbial activity as well as does not contaminate food chain. A screen house pot experiment was carried out on a representative light textured acidic soil using spinach crop.

Nickel and Cr were applied at graded levels of application doses, viz., 0.5 to 250 mg Ni kg⁻¹ and 0.3 to 200 mg Cr kg⁻¹ soil. Half of the heavy metal additions were provided through their inorganic salts (NiCl₂·6H₂O and K₂Cr₂O₇) directly to soil and remaining amounts were added through heavy metal enriched compost. In Cr treated soils, potassium chloride salt was added in such an amount so as to equalize the potassium added through K₂Cr₂O₇ among all the treatments.

Effect of total metal concentrations in soil on their plant available pools:

Dilute CaCl₂ extracts metal mainly from water soluble and exchangeable fractions of soil, which are considered readily available for plant uptake. Dilute CaCl₂ extractable fractions on Ni (Ni_{CaCl2}) and Cr (Cr_{CaCl2}) correlated highly (r = 0.98*** and

0.98***, respectively) with their respective total concentrations (Ni_{Total} and Cr_{Total}) in soil.

Effect of soil Ni and Cr levels on their concentrations in aboveground biomass tissue

Concentration of Ni and Cr in biomass tissue increased with their application up to maximum doses (Fig. 4.9.1). Tissue-Ni (Ni_{Plant}) concentration as well as Ni-uptake by aboveground biomass correlated significantly (r = 0.978*** and 0.863***, respectively) with Ni_{Total}. Similarly, tissue-Cr concentration (Cr_{Plant}) as well as uptake correlated significantly (r = 0.973*** and 0.796** respectively) with Cr_{Total}. Nickel and Cr concentrations in plant tissue were also found highly correlated with their CaCl₂ extractable fractions in soil (Fig. 4.9.2), which shows that CaCl₂ extractable Ni and Cr can be used as indicators of their phytoavailability in contaminated soil.

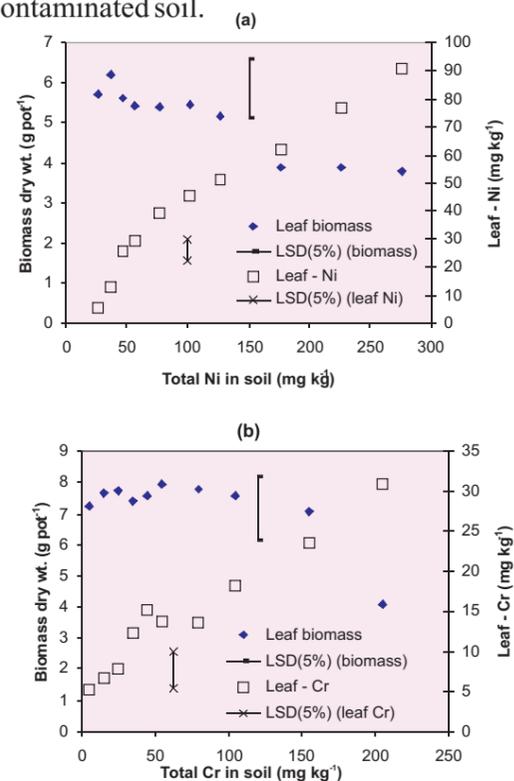


Fig. 4.9.1 Effect of Ni or Cr levels in soil on their concentration in leaf biomass and growth of spinach

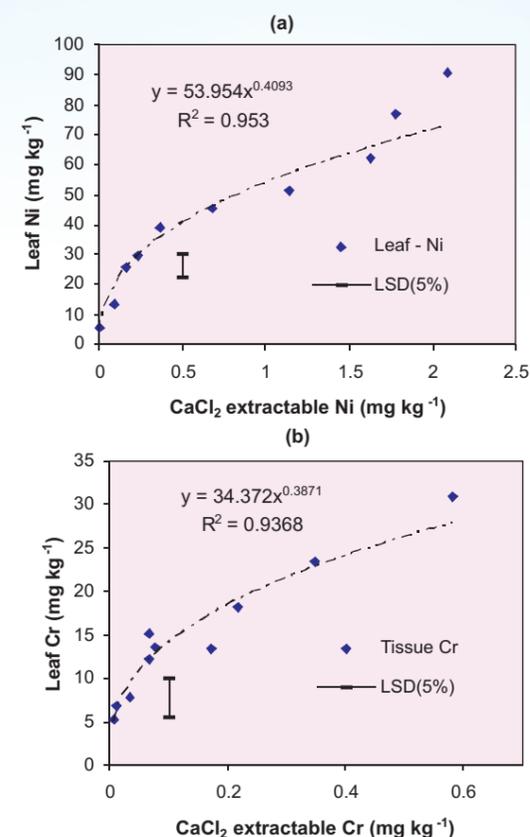


Fig. 4.9.2 Relationship between CaCl₂ extractable Ni or Cr in soil and their concentration in leafy biomass of spinach

Maximum allowable concentration in soil based on food contamination pathway

Results of analysis of spinach leaf samples collected from 30 farmers' fields (of the area from where experimental soil was collected) indicated that Ni and Cr content varied from 1.2 to 5.8 and from 5.5 to 20.8 µg g⁻¹ with mean (µ) values of 2.9 and 14.0 µg g⁻¹ and standard deviation (σ) values of 1.65 and 4.09 µg g⁻¹, respectively. Upper limits of background concentration (C_{ul}) for Ni and Cr in spinach leaf for uncontaminated area were calculated using the equation 'C_{ul} = µ + 3 X σ' as 10.55 and 17.52 µg g⁻¹ respectively. It has been assumed that data on heavy metal concentration in the leaf tissue follow a normal distribution around its mean value.

Best fit equations passing through origin between plant tissue metal concentration and soil metal concentration were:

$$Ni_{Plant} = 0.3572 X (Ni_{Total}) \dots \dots \dots (R^2 = 0.98^{***})$$

$$Cr_{Plant} = 0.2623 X Cr_{Total} - 0.0006 X (Cr_{Total})^2 \dots \dots \dots (R^2 = 0.96^{***})$$

From the above equations, total Ni or Cr concentrations in soil corresponding to C_{ul} were computed as 29.5 mg Ni kg⁻¹ and 82.5 mg Cr kg⁻¹, respectively. These values can therefore, be considered as maximum concentrations of metals in the experimental soil that might not contaminate spinach leaves above background level.

Effect on aboveground biomass growth

Increasing doses of Ni application resulted progressive decrease in above ground biomass from Ni₂ dose onwards (Fig. 4.9.1a). Application of 150 mg Ni kg⁻¹ decreased dry weight of aboveground biomass by about 32%. Application of Cr upto 150 mg kg⁻¹ rate did not result any significant effect on vegetative growth of spinach (Fig. 4.9.1b). However, the highest application dose of 200 mg Cr kg⁻¹ caused significant reduction (43.7%) in dry weight of above ground biomass. Dry weight of leaves significantly and negatively correlated (r = -0.918*** and -0.75**, respectively) with Ni and Cr concentration in leaf tissue, indicating toxic effect of Ni on plant growth due to high Ni absorption by plant.

Relative aboveground biomass growth in respect of control was related to soil Ni and Cr level by following polynomial equations:

$$\text{Relative Yield (\%)} = 0.0002 X (Ni_{Total})^2 - 0.2297 X (Ni_{Total}) + 110.44 \dots \dots (R^2 = 0.89^{***})$$

$$\text{Relative Yield (\%)} = -0.0026 X (Cr_{Total})^2 + 0.3607 X (Cr_{Total}) + 97.25 \dots \dots (R^2 = 0.94^{***})$$

Phytotoxicity threshold concentration of metal is measured in terms of its level in soil at which plant experiences 20% growth retardation. Using this approach, critical toxic level (that reduces aboveground biomass growth of spinach by 20%) of Ni and Cr in soil was computed through above equation as 153 and 176 mg kg⁻¹, respectively.

Effect of Ni and Cr contamination on soil biochemical activity

Nutrient cycling in soil involves biochemical, chemical and physicochemical reactions, with biochemical processes being mediated by mainly microorganisms. In this study, the impacts of Ni and Cr on microbe mediated biochemical activities in soil were studied using two different substrates: 2,3,5-triphenyl tetrazolium chloride (TTC) and fluorescein diacetate (FDA). The reduction of TTC to triphenyl formazan (TPF) is accomplished by dehydrogenase and is considered as complement to respiration measurement and total biological activity. Fluorescein diacetate is hydrolyzed by a number of enzymes, such as proteases, lipases and esterases, whose activity is also considered as a measure of microbial activity in soils.

Results showed that soil enzyme activities, measured using both the substrates TTC and FDA, decreased significantly with increasing levels of Ni in soil (Fig. 4.9.3). The data pair fitted best in following equations:

$$TPF = 206.94 X (Ni_{Total})^{-0.2679} \dots\dots\dots (R^2 = 0.90^{**})$$

$$Fluorescein = 0.0006 X (Ni_{Total})^2 - 0.3115 X (Ni_{Total}) + 74.683 \dots\dots\dots (R^2 = 0.85^{**})$$

$$TPF = 0.0011 X (Cr_{Total})^2 - 0.4155 X (Cr_{Total}) + 75.026 \dots\dots\dots (R^2 = 0.88^{***})$$

$$Fluorescein = 0.001 X (Cr_{Total})^2 - 0.2845 X (Cr_{Total}) + 39.95 \dots\dots\dots (R^2 = 0.83^{**})$$

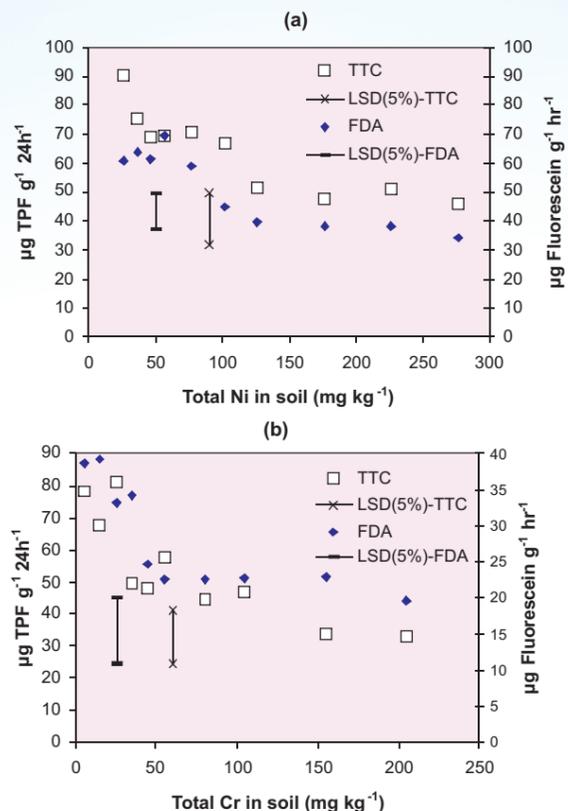


Fig. 4.9.3 Effect of total Ni or Cr levels on biochemical activity in soil measured with substrates TTC and FDA

In the above equations, soil enzyme activities are expressed as production of TPF (μg g⁻¹ soil 24 h⁻¹) and fluorescein (μg g⁻¹ soil h⁻¹) when respectively TTC and FDA were used as substrates.

Critical levels of Ni and Cr in soil was computed in this approach, as the concentrations of these metals in soil which inhibit microbial activity by 20%. Total Ni in soil corresponding to 20% decrease in the enzyme activity (ED₂₀) was computed as 51 mg kg⁻¹ using TTC and 105 mg kg⁻¹ using FDA. Soil Cr level corresponding to ED₂₀ was computed as 34.5 mg kg⁻¹ using TTC and 36.4 mg kg⁻¹ using FDA as substrate. The results thus, show that Cr was more toxic than Ni in terms of inhibiting microbial activity in soil.

This experiment attempted to compute safe concentrations of Ni and Cr in soil based on their adverse effect on three components; namely, activity of microorganisms in soil, on growth of plant (phytotoxicity) and food chain contamination. Maximum allowable concentration of Ni in soil was the lowest (29.5 mg kg⁻¹) when determined through 'food chain contamination' approach and the highest (153 mg kg⁻¹) when determined through 'phytotoxicity approach'. On the other hand, such limiting

concentration for Cr was minimum (34.5 mg kg⁻¹) when determined through 'soil microbial toxicity' approach followed by 'food chain contamination' (82.5 mg kg⁻¹) and 'phytotoxicity' (176 mg kg⁻¹) approaches. As the lowest value of maximum allowable total concentration of metal among the determined values through above three different approaches can protect all the targeted organisms, the values 29.5 mg Ni kg⁻¹ and 34.5 mg Cr kg⁻¹ can be considered as safe concentration limits in soil for the purpose of environment protection from metal pollution.



Fig. 4.9.4 Effect of Ni application in soil on biomass growth of spinach

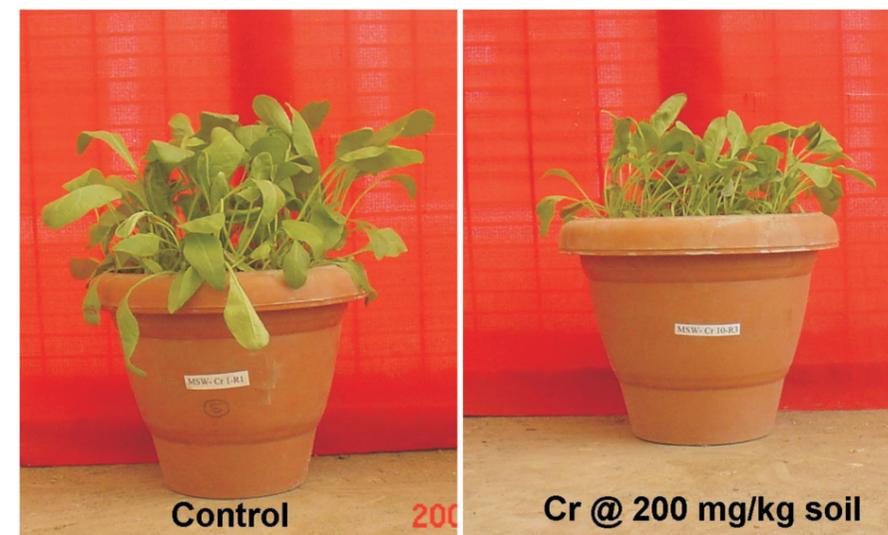


Fig. 4.9.5 Effect of Cr application in soil on biomass growth of spinach

4.10 Organic Farming

4.10.1 Performance of soybean under organic farming system

Field experiment was conducted for the sixth year with three management practices viz. 100 % organic, 100 % chemical and integrated nutrient management (50: 50) with four soybean based cropping systems. 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 (Figure 4.10.1). 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 Organic soybean: Dhaincha as border crop, pheromone traps and bird perches



Fig.4.10.2 Soybean (JS 93-05) at 45 days during drought in organic farming plot



Fig.4.10.3 Soybean (JS 93-05) at 45 days during drought in chemical treatment

The results indicated that the organic management practices 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) (Figs.4.10.2 & 4.10.3). 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 and yield attributes of soybean as influenced by management practices

Management Practice	Pods/plant	Seeds/pod	100-seed weight (g)	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index
Organic	45.1	2.79	11.28	2377	4140	36.7
Chemical	37.4	2.73	10.55	1879	3721	33.5
Integrated	41.1	2.78	11.17	2110	4048	34.2
CD (P= 0.05)	5.5	NS	0.49	248	NS	NS

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

(Table 4.10.2). Dehydrogenase and alkaline phosphatase activity did not show significant differences with regard to management practices (Table 4.10.3).

Table 4.10.2 Soil characters as influenced by management practices

Management Practice	Organic carbon (%)	Soil available nutrients (kg ha ⁻¹)		
		N	P	K
Organic	0.64	232.7	28.26	628
Chemical	0.49	190.3	18.71	583
Integrated	0.55	209.5	23.46	602
CD (P= 0.05)	NS	NS	NS	NS

Survey of organic farms in Tamil Nadu (Theni District)

A survey was conducted in Theni District of Tamil Nadu involving 2 certified organic farms and one progressive organic grower. 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 Kurinji farms, IMO (Bangalore), SNV Horticultural farms is certified by NPOP and EU-02-2007, USDA-NOP, JAS (Japan), EUREPGAP F&V (Fresh) etc. Replicated soil samples were brought from each certified organic farm and

Table 4.10.3 Soil enzyme activity as influenced by management practices

Management Practice	Dehydrogenase (grams TPF g ⁻¹ soil ⁻¹ 24 h)	Alkaline phosphatase (grams p-nitro phenol g soil ⁻¹ h ⁻¹)	Fluorescein di acetate (g fluorescein g ⁻¹ h ⁻¹)
Organic	85.4	138.9	24.3
Chemical	69.0	104.0	20.0
Integrated	75.4	118.5	22.3
CD (P= 0.05)	NS	NS	2.7

comparable soils from nearby conventional farms for in depth analysis of different soil quality parameters.

4.11 Crop Adaptability 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

Plant response to changes in climate such as sudden wilt in soybean, senescence of wheat and leaf reddening of cotton was studied in pot culture.

In our earlier experiments it was observed that the wheat lines selected for early senescence (S) had poor root growth (less root hairs and volume) as a consequence these plants had reduced uptake of water and nutrients. Compared to the nonsenescent (NS) lines, the water uptake was only 17% and some of the nutrients like N, Zn and Mg uptake were only 50, 50 and 28% respectively. In order to study, if the senescence in those lines could be caused by either drought or nutrient limitation, an experiment was conducted involving foliar spray of N, Mg and Zn. In addition to these an additional treatment of hormonal spray

(benzyl adenine) was given to see if there was involvement of hormones in the cause of senescence. In control (no fertilizer) plants, the growth was significantly reduced both in S and NS lines compared to RDF treated pots (Fig 4.11.1). Green leaf production was reduced to almost half in S lines while, it was almost 1/3 rd in NS lines. On the other hand, the yellow leaf production which was otherwise negligible in RDF treated NS lines increased to become on par with S lines in control pots (Fig 4.11.3).

N (3 % urea) spray significantly improved the growth of both S and NS lines (Fig 4.11.2). Green leaf area increased in both the contrasts, but it was on par to RDF level in S lines while, it was less in NS lines. Yellow leaf production became negligible in both lines with N spray. Either ZnSO₄ (0.5%) or MgSO₄ (5%) spray could improve the growth to a certain extent, but they were not effective as that of N. Benzyl adenine on the other hand did not have a significant effect in delaying senescence leaf production (Fig 4.11.3). This data clearly suggested that the early senescence observed in S lines of wheat was because of nutrient limitation and it could be corrected by the foliar spray of limiting nutrients.

One of the major biochemical change associated

with the senescence development is the degradation of chlorophyll. SPAD chlorophyll meter reading had a good association with green leaf index. In control chlorophyll meter reading was around 30 and with urea spray application it increased to 45. In rest of the treatments it was in between control and N. Manual observation corroborated with what we had measured through the meter. The higher chlorophyll and the associated photosynthesis had a positive effect on the yield. With urea spray to the control plants, the yield of S lines became on par with NS lines (Table 4.11.1). The grain weight of S lines, otherwise used to be very small had significantly increased.

Thus, from this study of contrasting S and NS wheat lines it is clear that if there is a senescence development in wheat lines either due to drought

or high temperature, the senescence effect on grain number or grain weight can be relieved to certain extent by nutrient spray.



Fig. 4.11.1 Growth of nonsenescent (left) and senescent (right) wheat lines with nutrient application to the soil



Fig. 4.11.2 Growth of senescent (two pots in left) and nonsenescent wheat lines (two pots in right) without nutrient application to soil. But these plants were given 3 % urea spray when leaf senescence was initiated in S lines

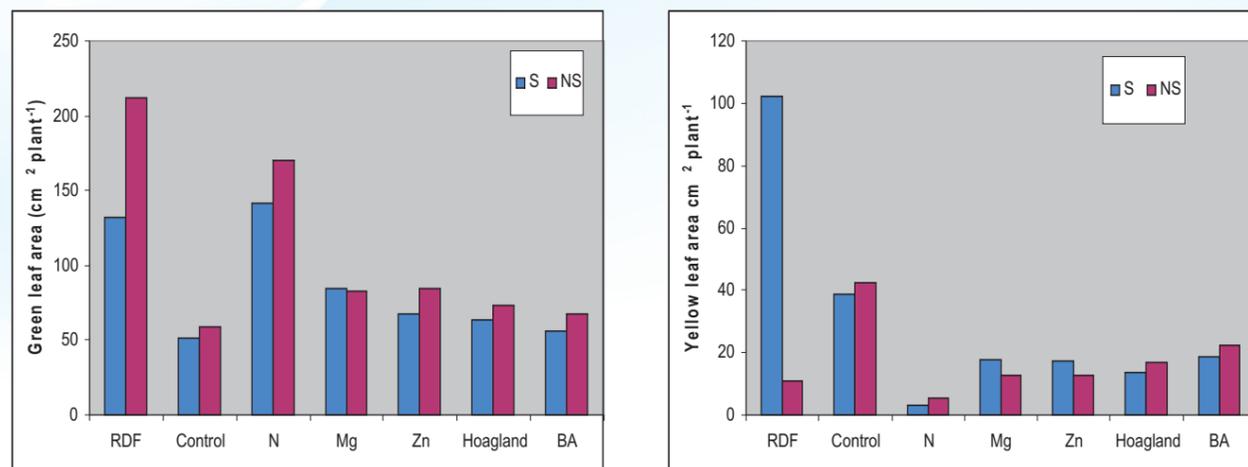


Fig. 4.11.3 Green (a) and yellow (b) leaf area production of senescent (S) and nonsenescent (NS) wheat lines with RDF, control (no fertilizer) and control with spray of different nutrients and hormone benzyl adenine. LSD values Between S and NS lines was 10 for green leaves and 3.5 for yellow leaves.

Table 4.11.1 Biomass, yield and yield attributing characters of senescent (S) and nonsenescent (NS) wheat lines with RDF, control (no fertilizer) and control with spray of different nutrients and hormone benzyl adenine.

Treatments	Spikes plant ⁻¹		Grains plant ⁻¹		100 seed wt (g)		Yield (g plant ⁻¹)		Biomass (g plant ⁻¹)	
	S	NS	S	NS	S	NS	S	NS	S	NS
RDF	10	12	336.75	431.09	2.12	3.47	3.78	13.15	12.02	20.33
Control	3	2	73.73	50.25	2.10	3.07	1.55	1.52	4.71	4.72
N	8	6	196.63	165.64	3.06	3.80	6.01	6.64	14.92	13.80
Mg	3	3	81.48	66.98	2.49	3.41	2.04	2.26	6.63	6.47
Zn	3	3	73.35	66.06	2.58	3.58	1.88	2.36	5.66	6.42
Hoagland	5	4	147.43	111.80	3.01	3.03	4.44	3.38	10.26	7.13
BA	4	4	110.43	95.38	2.19	3.14	2.38	3.00	6.14	6.50
CD at 5%										
Gen	NS		NS		0.12		0.40		0.68	
Treat	1		24.28		0.21		0.75		1.28	
G x T	1		29.34		0.29		1.06		1.81	

4.12 On-farm Research and Impact Assessment

4.12.1 Demonstration of Balanced and Integrated Nutrient Management Technology on farmers' fields

During the year 2009-10, 98 Field Demonstrations (FLDs) on farmers' fields in 6 villages of Raisen, Vidisha and Rajgarh districts of M.P (Table 4.12.1) have been conducted to demonstrate and popularize the INM technology in M.P. In these trials, 2 nutrient management options viz., balanced fertilization (BF) through inorganic fertilizers alone (100% NPKSZn to soybean and 100% NPKS to wheat) and INM module (50%

NPKS+5 t FYM ha⁻¹+Rhizobium to soybean and 75 % NPKS+PSB to wheat) were compared with the farmers' practice (FP). Soybean var JS 335 and wheat var GW 366 were grown in *kharif* and *rabi* seasons, respectively. The quantity of nutrients applied to soybean and wheat in farmers' practice, balanced fertilization and INM options are given in Table 4.12.1. The initial soil fertility status of 98 trial sites showed that all sites were low in available N. About 47% sites were low in available P and 52% were low in available sulphur. Available Zn was low in 60% of the sites whereas 50% of sites were low in organic carbon. About 32% field sites were deficient in four nutrients namely; N, P, S and Zn.

Table 4.12.1. Details of Nutrient Management Options

Nutrient Management Option	Nutrients applied (kg ha ⁻¹)					FYM (t ha ⁻¹)
	N	P ₂ O ₅	K ₂ O	S	Zn	
To Soybean in <i>kharif</i> season						
Farmers' practice	12	30	0	0	0	2
Balanced Fertilization (100%* NPKSZn)	25	60	20	20	5	0
INM (50%** NPKS + 5t FYM+ <i>Rhizobium</i>)	12.5	30	10	10	0	5
To Wheat in <i>rabi</i> season						
Farmers' practice	80	50	0	0	0	0
Balanced Fertilization (100% NPKSZn)	120	60	20	20	0	0
INM (75% NPKS + PSB)	80	45	15	15	0	0

* - 100% of Recommended dose; ** - 50% of the Recommended dose

In *kharif* (monsoon) season, the pooled data of soybean seed yield from 98 sites revealed that the balanced fertilization through inorganic fertilizers produced 32% higher seed yield over the farmers' practice. The INM module (50% NPKS+5 t FYM ha⁻¹+*Rhizobium* to soybean) produced about 52% higher soybean seed yield as compared to farmers' practice. This INM module produced about 15% higher soybean seed yield as compared to balanced fertilization through inorganic

amounts of nutrients in farmers' practice, balanced fertilization and integrated nutrient management (Table 4.12.2). The pooled data of 98 trials indicated that the wheat grain yield ranged from 2500-4750 kg ha⁻¹ under farmers' practice, 3375-6000 kg ha⁻¹ under balanced fertilization and from 2875-5375 kg ha⁻¹ under integrated nutrient management. The mean wheat grain yield of 98 trials showed that the integrated nutrient management produced higher grain yield

Table 4.12.2 Mean Soybean and wheat yields (kg ha⁻¹) as influenced by different nutrient management options (Mean of 98 sites).

Parameter	Farmers' Practice		Balanced Fertilization (100% NPKSZn)		Integrated Nutrient Management	
	Soybean	Wheat	Soybean	Wheat	Soybean	Wheat
Lowest	875	2500	1375	3375	1500	2875
Highest	1663	4750	2125	6000	2750	5375
Mean	1326	3296	1749	4677	2019	4205
Sd (±)	159	439	165	582	243	541

fertilizers alone. The soybean seed yield ranged from 875 kg to 1663 kg ha⁻¹ in farmers' practice, from 1375 kg to 2125 kg ha⁻¹ in balanced fertilization and 1500 kg to 2750 kg ha⁻¹ under integrated nutrient management (Table 4.12.2). During the Farmers' Day, farmers attributed the higher soybean yield under INM to the better pod bearing as compared to that of balanced fertilization. The mean number of pods/plant under INM varied from 30 to 90.

In *rabi* (winter) season, wheat crop (variety GW 366) was grown in the same plots with required

by 28% over farmers' practice. Balanced fertilization (fertilizers alone) increased the wheat grain yield by 42% over the farmers' practice (Table 4.12.2).

4.12.2 Ailing agricultural productivity in economically fragile region of India ; An analysis of synergy between public investments and farmers capacity

Bihar, Madhya Pradesh and Orissa are the 3 states having more than 50 per cent of rural population below poverty line (BPL) and mostly depend on

agriculture. The forecasts for next one decade (2005-15) using ARIMA model shows that the production growth of quite good number of crops are going to be snubbed in these states, if the production environment are kept constant. The foodgrain production (and yield also) is expected

First, it was found that farmers in these two states are selling their main produce to local traders even below the MSP/ procurement price announced by the government due to lack of proper agency to purchase from them. Secondly, even small farmers are hiring labour for all kinds

Table 4.12.3 Inputs used in cultivation of major crops on sample farms in BIHAR (Kg ha⁻¹)

Particulars	Paddy			Wheat		
	Small	Medium	Large	Small	Medium	Large
No. of sample farmers	122	57	21	122	57	21
No. of sample farmers growing paddy	116	52	20	109	52	18
Average area under the crop (ha per farm)	1.02	2.05	4.49	0.70	1.14	2.85
Seed	55.22	55.49	53.36	126.29	124.57	123.04
Organic manure (q ha ⁻¹)	13.42	2.93	5.67	27.02	10.79	8.72
N	83.07	84.44	79.03	94.06	86.19	88.33
P ₂ O ₅	32.97	36.56	37.94	48.10	44.50	53.53
K ₂ O	13.40	14.51	12.98	23.60	15.33	20.26
NPK total	129.44	135.51	129.95	165.76	146.02	162.12
S	0.58	0.99	0.40	0.44	0.44	0.14
Zn	1.10	1.88	0.58	0.83	0.79	0.24
Average no. of irrigation	1.25	1.76	1.37	2.42	2.71	2.61
Yield (q ha ⁻¹)	30.08	27.48	26.80	22.59	22.66	21.14
Total paid out cost (Rs ha ⁻¹)	12372	13585	12821	13942	14374	14929
Operating profit (Rs ha ⁻¹)	7920	4834	4911	6430	6283	4633

to grow between 1-2 per cent annually, posing serious questions for the food and nutritional security of poor farmers.

From survey of 200 farmers from each state during 2007-08, it emerged that the returns from cultivation of major crops (Tables 4.12.3, 4.12.4 & 4.12.5) were un-nerving for at least Bihar and Orissa farmers

of farming activities, which are making their economic situation even worse. Thirdly, the net profit from agriculture as given in Bihar and Orissa is as low as Rs. 15000 to Rs. 21000 per annum, much lower than the standard set for the poverty line. Fortunately, the drought in large part of the country during study period fuelled the price of pulses and oilseeds, thus farmers in M.P.

were able to sell their produce at much higher price than the MSP, making their annual income up to Rs. 72000. Thus, farmers in M.P. have better economic capacity than those of in Bihar and Orissa.

In absence of soil tests facilities in the vicinity or

awareness about its benefits, farmers are applying the fertilizers according to their established knowledge. Infrastructural bottlenecks (unsurfaced rural roads, poor or no electricity supply, etc.) and institutional insensitivity (lengthy procedure or rules practically debarring

Table 4.12.4 Inputs used in cultivation of major crops on sample farms in Orissa state (Kg ha⁻¹)

Particulars	Paddy (kharif)			Paddy (rabi)		
	Small	Medium	Large	Small	Medium	Large
No. of sample farmers	155	29	16	75	13	12
No. of sample farmers growing paddy	155	29	16	48	9	11
Average area under the crop (ha per farm)	0.95	2.39	5.07	0.54	1.16	4.72
Seed	100.51	103.38	94.96	102.85	112.19	88.71
Organic manure (q ha ⁻¹)	23.88	23.78	25.49	24.68	24.30	26.13
N	41.83	49.85	50.74	70.59	69.92	69.53
P ₂ O ₅	15.90	19.12	17.96	38.04	33.51	36.04
K ₂ O	26.24	33.12	30.38	39.41	37.98	38.42
NPK total	83.97	102.09	99.08	148.04	141.41	143.99
S	1.09	1.02	1.34	2.66	1.99	2.45
Zn	1.59	1.44	1.80	2.52	2.01	2.51
Average no. of irrigation	0	0	0	5.64	6.11	7.18
Yield (q ha ⁻¹)	23.74	20.37	20.74	40.26	33.67	38.57
Total paid out cost (Rs ha ⁻¹)	11805	12635	13144	15054	13942	13928
Operating profit (Rs ha ⁻¹)	3397	995	1278	11637	9461	13839

Table 4.12.5 Inputs used in cultivation of major crops on sample farms in M.P. (Kg ha⁻¹)

Particulars	Soybean			Wheat			Gram		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
No. of sample farmers	94	63	43	94	63	43	94	63	43
No. of sample farmers growing soybean	63	40	32	81	61	42	40	30	32
Average area under the crop (ha per farm)	0.90	2.19	5.49	0.80	2.13	4.05	0.54	0.88	3.37
Seed	101.83	107.34	117.95	131.72	137.48	134.85	99.07	105.56	116.98
Organic manure (q ha ⁻¹)	15.11	45.83	61.03	6.88	20.48	14.09	1.18	5.00	1.81
N	14.31	17.42	16.405	108.68	107.91	111.23	16.93	16.84	15.71
P ₂ O ₅	37.665	42.95	44.69	47.60	52.42	47.44	36.02	43.08	42.09
K ₂ O	0.325	0	3.52	4.72	8.04	12.59	0	0	0.31
NPK total	52.3	60.37	64.62	161	168.37	171.26	52.95	59.92	58.11
S	3.08	4.42	6.59	3.93	5.91	2.87	2.63	1.25	1.93
Zn	0.00	0.00	1.30	0.21	0.44	1.21	0.00	0.00	0.00
No. of irrigation	0.11	0.05	0.03	3.08	3.66	3.27	0.82	1.21	0.98
Yield (q ha ⁻¹)	15.96	17.15	15.29	31.45	32.42	31.95	9.99	12.50	10.06
Total paid out cost (Rs ha ⁻¹)	9403	11271	12048	15118	18883	19307	11505	13334	13481
Operating profit (Rs ha ⁻¹)	16720	16235	16525	18368	15812	14105	7484	12833	7798

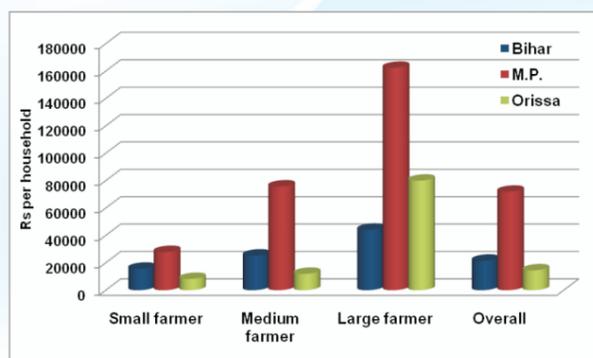


Fig.4.12.1 Farmers' economic capacity in 3 selected states

In the current situation, the government policy to help agriculture in terms of all kind of subsidies - minimum support price/procurement price, fertilizer subsidy, electricity subsidy, interest rate subvention, etc. are helping mainly those farmers who are main user of these schemes (Fig. 4.12.1). The farmers in poor states like Bihar, M.P. and Orissa in general don't participate in government procurement at MSP, use less fertilizer, very least user of electricity; have poor access to institutional credit; thus not getting required benefit of the government schemes. These interlocking inequalities have an important bearing on the distribution of benefits from economic growth. From the above results, it also emerged that the farmers of M.P. state may come out from the vicious circle first among the 3 states under study, if the trend of other production environment continues.

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

Front Line demonstrations of STCR technology on Farmers' fields

Response of a particular crop depends upon both the soil fertility status and also on the status of other nutrient elements in the soil. Full response of crop to major nutrients like N, P and K can not be

realized if any one of other essential nutrients become limiting in the soils. Moreover, the extent of crop response to applied fertilizer nutrients is mainly controlled by the deficiency of one or more nutrients during the plant growth as a result of constant removal by the growing crop or due to less or no application of nutrients. The yield to fertilizer nutrient response ratio (kg grain per kg applied nutrients) has been declining with the time especially in the past two decades due to decontrol of fertilizers. Large number of target yield equations have been generated for different crops including cereals, pulses, oilseeds, vegetables and medicinal and aromatic plants under the All India Coordinated Project on Soil Test Crop Response Correlation Scheme. Ready reckoners have been prepared using the equations for facilitating the users in applying recommended fertilizers based on the soil test values. Demonstrations at the farmers' fields is an effective approach for motivating the farmers for adopting STCR technology by showing its effectiveness. The STCR centres have conducted about sixty (60) front line demonstrations in oilseed crops (2009-10) (Table 4.12.6) on farmers' fields to demonstrate the beneficial value of the STCR technology based on soil test values to the farmers and thereby balanced use of fertilizer application in conjunction with organic manure, biofertilizers, green manuring etc. for achieving the targeted yields. The summary of the activities of cooperating centres of STCR are presented in (Table 4.12.7).

Raipur

Chickpea (Vijay):

The mean yield obtained in five demonstrations on chickpea conducted in Raipur district based on soil test crop response (STCR) target of 1200 kg

Table 4.12.6 Front Line demonstrations using STCR technology in different oilseed crops. No of demonstrations conducted

Centre	Crop	Kharif	Rabi/Summer	Total
Bangalore	Safflower	-	5	5
Palampur	Soybean	6	-	
	Toria	-	6	12
Uttarakhand	Mustard	-	3	3
	Raipur	Safflower	-	5
Pusa	Sunflower	-	5	-
	Soybean	5	-	15
	Sesame	1	-	
Hyderabad	Linseed	-	1	
	Mustard	-	4	6
	Groundnut	-	3	
Jabalpur	Sunflower	-	2	
	Sesame	-	1	6
Bhubaneswar	Linseed	-	1	1
	Groundnut	-	6	0
Hisar	Sesame	-	4	10
	Raya	-	1	1
			Total	59

was 1068 with a mean response ratio of 4.94 and average return per rupee spent on fertilizer was 3.67 as compared to mean yield of 1010 kg/ha mean response ratio of 3.65 with general recommended dose while meagre yield of 718 kg ha⁻¹ was obtained with farmers' practice.

Sunflower (Kargil)

The front line demonstrations organized on five farmers' fields at Raipur district during kharif 2008 based on soil test based approach with INM revealed that the average yield of 2227 kg against the target of 2500 kg /ha with a mean response ratio of 11.45 and a net profit of 3891 Rs. per hectare as compared to mean yield of 1839 kg ha⁻¹ against a target of 2000 kg ha⁻¹ with an yield response of 1038 per kg fertilizer use and net profit

3145 Rs ha⁻¹ while only 1808 kg ha⁻¹, 5.92 and 29.52 of yield, response and profit due to recommended dose and yield of only 1290 kg ha⁻¹ with fertilizer, response ratio of 5.23 and a net profit of 1758 Rs ha⁻¹ with farmers' practice.

Safflower (JSF-1)

The average productivity in five trials of FLDs of Safflower organized at Durg district based on STCR approach along with organic manure was 1393 kg ha⁻¹ with a response ratio of 11.23 and a net profit of 1591 Rs ha⁻¹ while only chemical fertilizer application resulted in 1452 kg ha⁻¹, 6.84 and 18.49 of average productivity, yield response and net profit, respectively. Use of organic manure resulted in less than the inorganic fertilizer due to increase in cost of organic manure (Fig. 4.12.2).

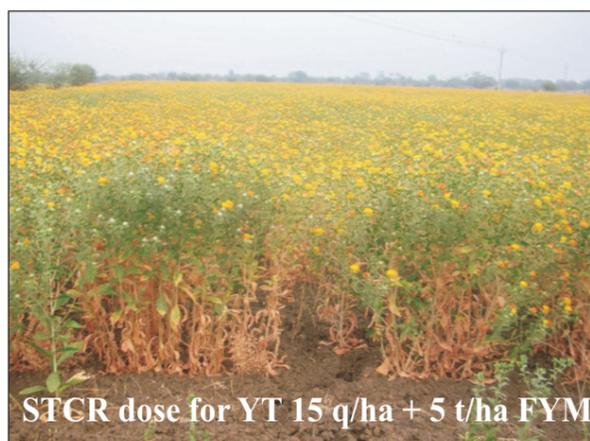
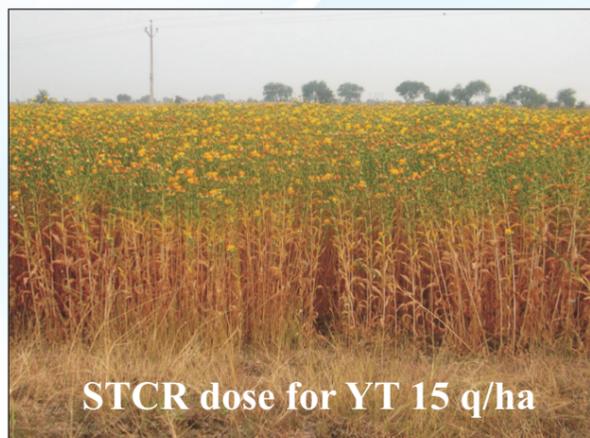


Fig. 4.12.2 Front Line Demonstration Of Mustard Crop At Raipur District

Hisar

Raya (Laxmi)

Five front line trials of Raya Crop to demonstrate the soil test based approach of STCR were organized during rabi 2008-09 in Hisar district. The initial fertility of soil available N was low, available P was medium and available K was high in all five farmers' fields. The fertilizer doses applied in farmers practice as per prevailing practice in farmers' fields of that region. Similarly, fertilizer doses were applied as per the general recommended package of practices. The following target yield equations were used to calculate fertilizer doses of only N & P for the inorganic and IPNS treatments. Since the K status

was high only maintenance dose of K was applied.

$$FN = 10.61 T - 0.95 SN - 0.12 FYM(N)$$

$$FP_2O_5 = 4.73 T - 3.00 SP - 0.10 FYM$$

The fertilizer doses where FYM has been applied, the nutrient amounts of N and P were accordingly reduced from calculated inorganic fertilizer alone treatment. All the recommended package of practice were followed during crop growth and the crop was harvested at maturity. The mean yield of Raya as per farmers' practice was only 1658 kg ha⁻¹. While that of higher target of 22 q ha⁻¹ alone and with IPNS treatment with 22 q ha⁻¹ were 2137 kg ha⁻¹ and 2157 kg ha⁻¹ respectively. However, the per cent deviation obtained in yield of different target treatments was less than 10% than the targeted yields.

Bangalore:

Safflower (A-1)

Four demonstrations of Safflower crop on farmers' fields to show the benefits of balanced fertilization were organized in Chitradurga district during rabi, 2008-09 (Fig. 4.12.3). The available N was in deficient range while the available P and K status were high. As per the prevailing local farmers' practice, fertilizers were applied. The fertilizer doses were applied for STCR target dose according to the target yield equations developed (given below) for safflower crop.

$$FN = 7.49 - 172.25 (O.C), FP_2O_5 = 11.83 - 3.34,$$

$$FK_2O = 4.99 T - 64.87$$

The crop was raised to maturity by adopting recommended package of practices. The Safflower yield data indicated that the lower yields (6.1 to 6.8 q ha⁻¹) were harvested as per farmers' practice while better yields (8.0 to 8.7 q ha⁻¹) were harvested as per soil test based approach. The benefit cost ratios varied from 0.70 to 2.06 in the farmers' practice treatment while it was from 1.84 to 2.71 in target yield treatment.



Fig. 4.12.3 Front Line Demonstration On Safflower At Babbur Village, Chitradura District

Table 4.12.7 Summary of the accomplishments of the cooperative centres of AICRP on STCR during the year 2009-10.

Centre	IPNS	Cropping sequences	Validation trials	Front line demonstrations	Long term demonstrations
Pusa	-	Rice-Wheat Rice-Winter Maize Rice-Potato Rice-Mustard	Wheat (7) Winter maize (3) Mustard (3) Linseed (2) Lentil (3) Chickpea (1) Potato (2) Coriander (1) Cauliflower (2) Cabbage (1)	-	Rice-Wheat
Rahuri	Bt Cotton Aster Pre-seasonal Sugarcane	-	-	Chickpea (10)	-
Bhubaneswar	Cabbage	Rice – Mustard	-	-	-
New Delhi	Wheat Pearlmillet	-	-	Mustard (1)	-
Pantnagar	Cabbage Scented Rice	-	-	-	Rice-Wheat
Bikaner	Lady's Finger Bt Cotton	Clusterbean- Wheat	Bajra	Mustard (10)	-

Centre	IPNS	Cropping sequences	Validation trials	Front line demonstrations	Long term demonstrations
Coimbatore	Wheat Aswagand ha	-	Radish (1) Beetroot (1) Wheat	Groundnut (2) and Sunflower (2)	Rice –Rice
Bangalore	Sugarcane (Ratoon)	Paddy -Ragi	Maize (1) Safflower (1) Ragi (1)	Groundnut Sesame And Safflower	-
Hyderabad	Ragi Muskmelon Soybean	Rice-Maize	Turmeric Groundnut	Chickpea Sesame And Sunflower	-
Palampur	Turmeric	-	Okra (5)	Soybean and Toria (6) Maize (8)	Maize-Wheat
Vellanikkara	Pumpkin Watermelon	-	Ginger (4)	Nendran Banana (3) Salad Cucumber and Rice (3)	-
Jabalpur	Chandrasur, Garlic, Onion	-	Cucumber (4) Rice (4)	Mustard Gram and Wheat	Rice-Wheat
Raipur	-	Rice –Wheat	Soybean	Soybean (5) and Safflower (5)	Rice-Wheat
Kalyani	Radish, Carrot, Amaranthus Bhindi	-	-	Rice and Mustard	-
Barrackpore	-	Jute-Rice –Lentil	Lentil (2) Jute (4) In North 24 paraganas	-	-
TOTAL	26	10	44	71	5

5. TECHNOLOGY ASSESSED/TRANSFERRED

Technology Dissemination Events

Farmers' Day

A Farmers' Day was organized under the ACIAR Project at Dhakna-Chapna village on 9 March 2010. About 100 farmers from Dhakna-Chapna and surrounding villages, project scientists from IISS, BIAF and Dr. Neal Menzies, Australia had participated in the Farmers' Day (Fig. 5.1 & 5.2). Dr. A. Subba Rao, Director, IISS, Bhopal was the chief guest and Dr. Neal Menzies, Project leader, Australia has presided over the function. Host farmers from Rangai, Powanala and Dhakna-

Chapna shared their experiences and success stories of the ACIAR project with non-host farmers. Majority of farmers felt that applying small quantity of FYM (about 5 t/ha) every year in integrated nutrient management to soybean-wheat system is better than applying large quantities (about 18-20 t/ha) of FYM with 3-4 years frequency. Both the host and non-host farmers visited the demonstration trials on "Balanced and Integrated Nutrient Management". Farmers were very much impressed by the has tremendous response of wheat variety GW 366 to balanced and integrated nutrient management.



Fig. 5.1 Project scientists with farmers at an experimental site in Pownala village



Fig. 5.2 Farmers' Day at Dhakna-Chapna village

Farmer's visits

Dr A. B. Singh coordinated the visits of the farmers/scientists/agriculture officers /extension workers to the institute (Table 5.1) and explained

the technologies generated in the institute particularly on organic farming, vermin-composting, phosphor-sulpho- nitro-composting and organic pomegranate production technologies.

Table 5.1 Farmers visit to the institute.

S. No.	Department	Number of participants	Period
1.	Agril Dept., Govt. of Rajasthan, Jhalwar District	39 farmers	19/7/2009
2.	Agril. Dept., Govt of Rajasthan, Seroni district	41 farmers	
3.	Project Director, ATMA and Deputy Director Agriculture Extension, Ajmer, Rajsthan	40 women	09/09/2009
4.	Agriculture Office, Sub Division, Shajapur (M. P.),	30 SC and ST farmers	06/10/2009
5.	Deputy Director Agriculture Extension, Dungurpur, Rajsthan	40 progressive farmers	09/12/2009
6.	Deputy Director Agriculture Extension and Project Director, Dhaulpur, Rajsthan	40 progressive farmers	24/12/2009
7.	BAIF Development Research Foundation Distt. Dhar	16 progressive farmers	30/12/2009
8.	Deputy Director Agriculture Extension, Jaipur	25 progressive farmers	05/01/2010
9.	State Agricultural Research Station, Mokokchung, Nagaland,	15 Agriculture Officers/staff	10/02/2010
10.	Deputy Director Farmer Welfare and Agriculture Development Distt Dhar Madhya Pradesh	50 progressive farmers	10/02/2010
11.	State Department of Agriculture, Goa	4 Agriculture Officers, 10 progressive farmers and Hon'ble speaker, Goa	06/03/2010
12.	Sub Agriculture Director, Barabanki	100 progressive farmers	18/03/2010
13.	Krishi Vigyan Kendra Burhanpur	15 progressive farmers	21/06/2010

Farmer's trainings conducted at the Institute.

Name of the Institute/Organization	Number of trainee	Coordinating Scientist	Duration of the training	Nature of training Imparted
Jamui Distt., Bihar under ATMA Project	25 farmers	Dr. A. B. Singh Dr. A. Subba Rao	6 days (May, 24-29, 2009)	Training on different technologies developed in the institute
Paschim Champaran District, Bihar under ATMA Project	25 farmers	Dr. A. B. Singh Dr. A. Subba Rao	6 days (June, 17-22, 2009)	Training on different technologies developed in the institute
Gaya District, Bihar under ATMA Project	25 farmers	Dr. A. B. Singh Dr. A. Subba Rao	6 days (August, 17-22, 2009)	Training on different technologies developed in the institute
Banka District, Bihar under ATMA Project during	25 farmers	Dr. A. B. Singh Dr. A. Subba Rao	6 days (October, 26-31, 2009)	Training on different technologies developed in the institute
Madhepura-District, Bihar under ATMA Project	25 farmers	Dr. A. B. Singh Dr. A. Subba Rao	6 days (November, 16-21, 2009)	Training on different technologies developed in the institute
M. P. Rajya Krishak Ayog, Bhopal	50 progressive farmers	Dr A. B. Singh Dr A.K. Tripathi	1 day (12/03/2010)	Organic farming, various composting techniques and methodology of soil testing
State Department of Agriculture, Goa	15 farmers 4 Agriculture Officers Hon,ble Speaker Goa	Dr A. Subba Rao Dr A. B Singh	2 days (February, 5-6, 2010)	Organic farming, various composting techniques and methodology of soil testing
Raisen District, Madhya Pradesh under ATMA Project	20 farmers	Dr.A.K. Tripathi Dr. A. B. Singh Dr. A. Subba Rao	5 days (March, 15-19, 2010).	Training on different technologies developed in the institute
Raisen District, Madhya Pradesh under ATMA Project	20 farmers	Dr.A.K. Tripathi Dr. A. B. Singh Dr. A. Subba Rao	5 days (March, 22-26, 2010).	Training on different technologies developed in the institute

Farmer's Trainings conducted by the Institute Scientists

Topic	Resource Person	Organized By	Date
Vermicompost Production and Organic Farming	Dr A. B. Singh	CRDE, Krishi Vigyan Kendra, Sehore	04/10/2009
Vermicompost Production and Organic Farming	Dr A. B. Singh	CRDE Krishi Vigyan Kendra, Sehore.	12/10/2009
Different composting techniques	Dr A. B. Singh	K. J. Education Society, Ravindra Bhawan, Bhopal, Madhya Pradesh	27/3/2010
Organic Farming for Sustainable Agriculture	Dr A. B. Singh	K. J. Education Society, Ravindra Bhawan, Bhopal	28/3/2010
Importance of plant nutrients in agriculture through compost under conventional deep tillage	Dr. M. C. Manna	Punjab National Bank	12/3/10
Preparation of manure through Vermicompost and NADEF Method and importance of Soil Testing for fulfillment of essential plant nutrients	Dr. M. C. Manna	Punjab National Bank	
Organic Farming and vermicomposting, technologies during Crop production management technique training programme,	Dr. A. B. Singh	State Krishi Extension avam Training institute, Bhopal, Madhya Pradesh	3/5/2010

Transfer of Technology

Demonstrations in Maharashtra

10 frontline demonstrations were conducted in farmers' fields on mixed inoculation of *Bradyrhizobium* and PSB in soybean in vertisols.

Large scale commercial production of biofertilizers was undertaken and sold to the farmers. Good response in the use of *Rhizobium*, *Azotobacter*, phosphate solubilizing bacteria and *Azospirillum Biofertilizer* was observed by the farmers of the area (MAU, Parbhani).

Bionutrient package for Rice in Bihar

Application of enriched mycostraw (spent residue or semi decomposed straw + *Pseudomonas* spp) alongwith *Azospirillum* spp. and cyanobacteria to ten farmers fields increased yield from 4-32% depending upon the doses of fertilizer applied by the farmers. All the farmers used the mycostraw developed by them during the cultivation of oyster mushroom. Addition of *Aeschyomene* in bionutrient package further enhanced the saving of nitrogen and phosphorus upto 65-75 percent of recommended dose. Application of *Azospirillum* and PGPR in six farmers fields in rabi maize augmented the yield by 12-15 per cent. (RAU, Bihar)

Demonstrations in Tamilnadu

In Front Line Demonstration trials on groundnut in Tamilnadu, 13-16% increase in pod yield per

ha was observed in farmers fields (TNAU, Coimbatore)

Biofertilizer Production and Demonstrations in Madhya Pradesh

Soybean rhizobial and PGPR strains of IISS were supplied for mass production to JNKVV Biofertilizer production centre. During 2009, 2.13 lakh inoculants packets were prepared with these strains and supplied all over Madhya Pradesh. These inoculants packets were also used in 1000 demonstrations in farmers fields in a TATA-ICRISAT livelihoods project in various districts of M.P; and 100 demonstrations conducted by IISS, Bhopal. Detailed observations (Fig.5.3) in five farmers' fields in Raisen District showed that soybean seed yield increased with INM option with biofertilizers by 18% over balanced fertilization and 54% over farmers' practice. (IISS, Bhopal).



Fig.5.3 Effect of PGPR and *Rhizobium* inoculation on farmer's field in Raisen, Madhya Pradesh. Left=Farmers' practice, Middle= Balanced Fertilization, Right= Integrated Nutrient management.

6. EDUCATION AND TRAINING

6.1 Training Attended

Name	Programme	Venue	Period
Manna, M.C	Workshop on sustainable productivity enhancement initiative in India.	Tata-ICRISAT-ICAR	May 12-13, 2009
Dr K. Sammi Reddy	Short training course on "GIS for Landscape Analysis"	ICRISAT, Hyderabad	July 27-31, 2009.
Manna, M.C.	Workshop on Municipal Solid Waste Management-Finding Opportunities from wastes	Confederation of Indian Industry and ITC center of Excellency for Sustainable Development, Bhubaneswar	August 20, 2009
Dr. K. Ramesh	Training programme on "Methodological workshop on impact assessment of improved agricultural technologies"	NCAP, New Delhi	August 26-28, 2009
Dr. S.R. Mohanty	National Training Programme on Recent advances in molecular identification and characterization of agriculturally important microorganisms	NBAIM, Mau, UP	September 1-21, 2009
Dr J. Somasundaram	Training on "Cyber laws, Information Security and Computers for Scientists and Technologists"	Indian Institute of Public Administration (IIPA), New Delhi	September 7-13, 2009

Name	Programme	Venue	Period
Dr. K. Ramesh	Training programme sponsored by DST on “Advances in Plant-atmospheric interactions”	CRIDA, Hyderabad	22 Oct – 11 Nov, 2009
Dr. KM Hati	Training course on “Scaling up Water Productivity for Livelihood in Agriculture	Water Technology Centre, IARI, New Delhi.	November 2-15, 2009
Manna, M.C.	ICAR, Zonal Technology management Committee workshop	Central Institute for Cotton Research, Nagpur	November 4-6, 2009
R.H. Wanjari Dr. M. C. Manna	Training on Integrated Nutrient Management (INM) to Nagaland State Agricultural Officers	Dimapur Directorate of Agriculture, Nagaland	November 25-27, 2009
Dr. Ranjit Kumar	Training Programme on “Agricultural Policy Analysis”	Council for Social Development, New Delhi	December 7 – 11, 2009.
Dr.R.K.Singh	Short course training on Capacity Building for Integrated Watershed Management	International Crop Research Institute for Semi Arid Tropics (ICRISAT), Hyderabad	December 21-27,2009
Ms. Neenu	Winter School on “Enhancing Input Application Efficiency for Seeds, Fertilizers and Chemicals using Precision Farm Machinery , Decision Support Systems (DSS) and Electronic Controllers for Precision Agriculture in Vertisols”	Central Institute of Agricultural Engineering, Bhopal.	January 1-21 , 2010

Name	Programme	Venue	Period
Dr. Ajay	Training programme on “Greenhouse Gas Emission and its Mitigation in Relation to Soil Organic Carbon(SOC) Pool”.	CRRI, Cuttack.	January 5-25, 2010
Ms. Rashmi	Training programme on “ Ethnic issues and community management for young scientists”	IIFM, Bhopal	January 18-22, 2010
R.H. Wanjari	Kisan Mela–cum-Sangoshthi	Directorate of Weed Science Research, Jabalpur	January 23, 2010
Ms. Rashmi	Training programme on “Finance management and audit sensitization	XIM, Bhubnaeshwar	February 15–20, 2010
Dr.R.K.Singh	Training program on “Enhancing Water Productivity in Agriculture”	Acharya N.G.Ranga Agricultural University, Hyderabad	February 17 to March, 9, 2010
Ms. Rashmi	Training programme on “ Knowledge management”	ISTM, New Delhi	March 3–4, 2010
Dr. Sanjay Srivastava	Training programme on “IT based DSS for Geographical Information System for Rural Livelihood Assessment”	NIRD, Hyderabad	March 11-20, 2010.
Ms. Rashmi	Training programme on “ Introduction to GIS and its application”	NRSA, Hyderabad	March 22–April 16, 2010
Dr. Ranjit Kumar	Workshop on “Sources of Growth in Indian Agriculture- Trends, Challenges and Prospects”	NCAP, N.Delhi	March 27, 2010

Foreign Training Attended

Sangeeta Lenka attended three months foreign training on “Carbon Trading, Carbon sequestration/Climate Change” (Natural Resource Management) under the able guidance of Prof. Keith Paustian, Department of Soil and Crop Sciences, Natural Resource Ecology Lab, Colorado State University, Fort Collins, Colorado,

USA. The training was sponsored by NAIP, ICAR, New Delhi.

Deputation/Foreign visit

Dr. M. V. Singh attended International Plant Nutrition Colloquium (IPNC) held at California, USA during 26 to 30 August 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
Extol Institute of Management, BU	Mr. Kushi Baliyan, M.Sc. Biotech	Dr.M.C.Manna	6 months	Long-term effect of integrated nutrient management on methane emission and soil biological activities in Alfisol.
Extol Institute of Management, BU	Mr. Kesin Paliwal, M.Sc. Biotech	Dr. S.R.Mohanty	6 months	Methanogenesis in tropical soils under long term fertilizer application
Extol Institute of Management, BU	Ms. Nindiya Singh, M.Sc. Biotech	Dr. S.R.Mohanty	6 months	Biogeochemical Processes in soils under long term fertilizer application
BU, Bhopal	Mr. Vinod Verma, M.Sc. Microbiology	Dr. A. B. Singh	10 days	Techniques used in biochemical analysis
Department of Biotechnology, Dr. H. S Gaur University, Sagar (M.P)	Mr. Dilesh Kumar Uikey	Dr. N.R. Panwar	5 months	Effect of different land management practices on soil organic carbon stock in Sehore and Vidisha district of central Madhya Pradesh
Department of Limnology, Barkatullah University, Bhopal	Mr. Javeed Ahmad Lone	Dr. Ajay	6 Months	Characterization of tolerance limit in <i>Spirulina platensis</i> in relation to Linear Alkylbenzene Sulphonate (LAS) an Nano-particles

Name of the Institution / College	Name of the Trainee and Degree Programme	Coordinating Scientist & Division at IISS	Duration of the Training	Training Programme
Jawahar Lal Nehru PG College, Bhopal (Barkatullah University, Bhopal)	Miss Megha Yadav	Dr. N.R. Panwar	3 Months	Effect of different land management practices on soil enzymatic activity in Sehore district of central Madhya Pradesh
	Miss Humera Khanam	Dr. N.R. Panwar	3 Months	Effect of different land management practices on soil enzymatic activity in Vidisha district of central Madhya Pradesh
University Teaching Department, Barkatullah University, Bhopal (M.P)	Miss Saima Shameem	Dr. N.R. Panwar	Three months	Characterization of polluted soils for their physico-chemical properties collected from different parts of central India

7. AWARDS/HONOURS/RECOGNITIONS

7.1 Awards

Dr. K. Ramesh received NAAS Young scientist award for the year 2007-08 for soil, water and environmental sciences



Dr. K. Ramesh receiving NAAS Young scientist award

Dr M. C. Manna received the Fellowship of Indian Society of Soil Science, for the Year, 2009.

Dr. A. B. Singh received the ISAB Fellowship for the year 2009-10 during XI Silver Jubilee Convention of the Indian Society of Agricultural Biochemist, held at BHU, Varanasi.

7.2 Recognitions

Dr. A.B. Singh, Principal Scientist, Soil Biology acted as Chairman Technical Session IV on “Organic Standards for Quality of Produce” during National Seminar on Organic farming for Sustainable Agriculture & Livelihood Security at Raj Mata Vijaya Raje Scindia Krishi Vishwavidyalaya Gwalior held on December, 23-24, 2009

Dr. M.C. Manna HOD, Soil Biology nominated as Co-chairman to evaluate the best poster presentation during National seminar on Agriculture and Global Warming: Challenges and Potentials held at Raj Mata Vijaya Raje Scindia Krishi Vishwavidyalaya Gwalior.

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 IISS has also encouraged interactions by exchanging its Annual Reports with about 194 ICAR Institutes/SAUs. The Annual Reports of other Institutions are also being received in the library for the reference of scientists and for exploration of further collaboration in research projects.

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 Queensland” 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.

Four 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.
4. 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.

In a NAIP project on Nano-technology, institute has collaboration with CAZRI, Jodhpur. There is a collaboration with CRRI, Cuttack in another NAIP project on “Soil Organic Carbon Dynamics and Climatic Change”. AMAAS funded research project on “Improving Yields and Nutrient Uptake of Selected Crops through Microbial Inoculants in Vertisols of Central India” was initiated in the year 2008 in collaboration with NBAIM, Mau.

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, Bhubaneshwar, Ludhiana, Coimbatore, Pantnagar, Lucknow.	0	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

Bandyopadhyay, K.K., Ghosh, P.K., Hati, K.M., and Misra, A.K. (2009) Efficient utilization of limited available water in wheat through proper irrigation scheduling and integrated nutrient management under different cropping systems in a Vertisol. *Journal of the Indian Society of Soil Science* 57(2): 121-128.

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6.5 Invited / Lead Papers Published

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Subba Rao A. and Manna M.C. (2009) Impact of land use and management practices on carbon sequestration in soil. Presented a paper in State level seminar held at MPKVV, Maharashtra during the year, 2009.

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Subba Rao, A., Patra, D.D. and Biswas, A.K. (2009). Soil health and nutritional security role of primary nutrients. Platinum Jubilee Symposium on Soil Science in Meeting the Challenges to Food Security and Environmental Quality at IARI, New Delhi, 22-25 December, 2009.

10. LIST OF APPROVED ON-GOING PROJECTS

Sl.No.	Title of the Research Project
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 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
3	Long-term effect of fertilizer and manure application on carbon pool dynamic in a Vertisol under soybean -wheat systems. Brij Lal, Muneshwar Singh, K.Sammi Reddy, A.K. Biswas, R.S. Chaudhary and A.B.Singh
4	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)
5	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
6	Soil carbon saturation and stabilization in some soils in India. Pramod Jha, Brij Lal Lakaria, Ritesh Saha, S.R.Mohanty, A.K.Biswas and Muneshwar Singh
7	Study on nanoporous zeolites for soil and crop management. K. Ramesh, K. Sammi Reddy and I.Rashmi
8	Efficacy of soil sampling strategies for describing spatial variability of soil attributes. B.N.Mandal, Neenu S, S.Srivastava, and Y. Muralidharudu
(B) Externally Aided Projects	
9	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

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	Boom Flower (Nitrobenzene 20% EW)-its influence on growth, physiology, nutrient uptake and yield of tomato plant. (Contractual Research Project) K.B.Hebbar, Ajay and S.Ramana
13	Nano-technology for enhanced utilization of native phosphorus by plants and higher moisture retention in Arid Soils. (NAIP) Tapan Adhikari and A.K.Biswas
14	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
15	Evaluation of Allwin wonder and Allwin top for their effects on maize productivity and soil fertility. (Contractual Project). K.Ramesh and S. Ramana
16	Testing of UI and NI modified urea fertilizer for higher N use efficiency in maize based cropping system on a Vertisol pomegranate. (Contractual) K. Sammi Reddy and Brij Lal Lakaria
17	GPS and GIS based model soil fertility maps for selected districts for precise fertilizer recommendations to the farmers of India. A. Subba Rao, Y.Muralidharudu, M.V.Singh, Muneshwar Singh, K.N.Singh, R.H.Wanjari, S.K.Behera and A.Rathore
Programme II: Management of Soil Physical Components	
(A)	In-house Project
18	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
19	Tillage and manure interactive effects on soil aggregate dynamics, soil organic carbon accumulation and pass flow in Vertisols. Sangeeta Lanka, A.K.Misra, M.C.Manna, D.D.Reddy, K.M Hati, R.K.Singh, S.K.Rautray and B.K.Garg.

20	Tillage effects on weed dynamics in soybean-wheat system on Vertisol. Blaise Desouza, R.H.Wanjari and R.K. Singh
21	Detection of water and nitrogen stress and prediction of yield of soybean and maize using hyper-spectral reflectance and vegetation indices. K.M. Hati, R.K. Singh, Blaise Desouza and A.K. Misra
22	Participatory assessment of qualitative parameter for categorizing different degrees of soil quality to enhance the soil health and productivity. R.S.Chaudhary
23	Evaluating conservation tillage on various sequences/ rotations for stabilizing crops productivity under erratic climatic conditions in black soils of Central India. J. Somasundaram, Blaise Desoza, R.S. Chaudhary, K.B. Hebbar, Ranjit Kumar
24	Impact of crop covers on soil and nutrient losses through runoff in Vertisol. R.K.Singh, R.S.Chaudhary, J.Somasundaram, I.Rashmi and Blaise Desouza
Programme III: Soil Qualities for Sustainable Productivity	
(A)	In-house Project
25	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
26	Development of composting techniques for recycling of municipal solid wastes M.C.Manna and A.B.Singh
27	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.Su bba Rao
28	On farm Production and evaluation of vermi-compost and enriched compost A.K.Tripathi, M.C. Manna, A.B. Singh and Ranjit Kumar
29	Structural and functional diversity of microbes in soil and rhizosphere. Santosh R. Mohanty, M.C.Manna and Muneshwar Singh
(B)	Externally Aided Projects
30	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

31	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
32	Network Project on Organic Farming A. B. Singh, S. Ramana, N.R. Panwar and K. Ramesh
Programme IV: Minimizing Environmental Pollution	
(A)	In-house Project
33	Investigation on effect of continuous use of sewage water as irrigation on swell-shrink soil quality J.K. Saha, A.K. Biswas and Ajay
34	Developing quality indices of urban solid waste composts J.K.Saha, N.R.Panwar and M.V.Singh
35	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
36	Diagnosis and Management of Emerging Physiological Disorders of Cotton, Wheat and Soybean in Black Soils of Central India Under Changing Climatic Scenario K.B.Hebbar, N.R.Panwar, S.Ramana, Ajay, P.Ramesh and S.Kundu
37	Phyto-extraction of Cr by some floriculture plants. S. Ramana, A.K. Biswas, Ajay and A.B. Singh
(B)	Externally Aided Projects
38	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
39	Impact assessment of continuous fertilization on heavy metals and microbial diversity in soils under long term fertilizer experiment Tapan Adhikari and Sunita Singh

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

Evaluation of Lands Allotted to the Oustees of Omkarshwer Project

Hon'ble High Court, Jabalpur, on appeal from Narmada Bachao Andolan (NBA) gave an order to Indian Institute of Soil Science, Bhopal to assess the suitability of land allotted to oustees of Omkareshwar Project spread over the districts of Harda, Khandwa and Burhanpur and submit its report to the High Court. The Institute very promptly undertook the responsibility and constituted a team of scientists and technical personnel under the leadership of Dr. A.K. Biswas, who inspected every parcel of lands allotted to different farmers in Harda, Burhanpur and Khandwa districts in two phases from 05/04/09 to 09/04/09 and 25/05/09 to 29/05/09. Representatives of NBA and Govt. of M.P. accompanied the IISS team as directed by the Hon'ble High Court. The plots were evaluated for their suitability for agriculture. Land features and soil properties were recorded at the sites and soil samples were also collected and analyzed at the Institute. Out of 146 plots evaluated in two phases, 116 plots were found suitable for agriculture. The reports for the same was prepared and submitted to Hon'ble High Court, Jabalpur within the stipulated time.

The following contractual projects are under operation.

	Title	Project Team	Sponsored by
1.	Boom Flower (Nitrobenzene 20% EW)-its influence on growth, Physiology, nutrient uptake and yield of tomato plant.	K.B.Hebbar, D.Damodar Reddy, Ajay and S.Ramana	Devicrop Sciences, Madurai, TN
2.	Evaluation of Allwin wonder and Allwin top for their effects on maize productivity and soil fertility.	K. Ramesh, S. Ramana and A. K. Biswas	Sree Ramcides Chemicals Pvt. Ltd. Chennai
3.	Testing of UI and NI modified urea fertilizer for higher N use efficiency in maize based cropping system on a Vertisol pomegranate.	K. Sammi Reddy and Brij Lal Lakaria	Potash Research Institute of India (PRII), Gurgaon

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. Y.Muralidharudu	PC (STCR)	Member
3	Dr. Muneshwar Singh	PC (LTFE)	Member
4	Dr. D.L.N. Rao	PC (BNF)	Member
5	Dr. A.K.Misra	Head, Division of Soil Physics	Member
6	Dr. S.Kundu	Head, Division of ESS	Member
7	Dr. M.C. Manna	Head, Division of Soil Biology	Member
8	Dr. A.K. Biswas	Head, Division of Soil Chemistry	Member
9	Dr. A.B. Singh	Principal Scientist	Member
10	Dr. K. Sammi Reddy	Principal Scientist	Member
11	Dr. K.B. Hebbar	Principal Scientist	Member
12	Dr. Blaise Desouza	Principal Scientist	Member
13	Dr. Ajay	Principal Scientist	Member
14	Dr. J.K. Saha	Principal Scientist	Member
15	Dr. R.S. Chaudhary	Principal Scientist	Member
16	Dr. A.K. Tripathi	Principal Scientist	Member
17	Dr. K.N. Singh	Principal Scientist	Member
18	Dr. Tapan Adhikari	Principal Scientist	Member
19	Dr. Sanjay Srivastava	Senior Scientist	Member
20	Dr. Kuntal M. Hati	Senior Scientist	Member
21	Dr. S. Ramana	Senior Scientist	Member
22	Dr. R.H. Wanjari	Senior Scientist	Member
23	Dr. Brij Lal Lakaria	Senior Scientist	Member
24	Dr. Pramod Jha	Senior Scientist	Member
25	Dr. K. Ramesh	Senior Scientist	Member
26	Dr. Ritesh Saha	Senior Scientist	Member
27	Dr. J. Somasundaram	Senior Scientist	Member
28	Dr. S.R.Mohanty	Senior Scientist	Member
29	Dr. Abhishek Rathore	Scientist (Sr.Scale)	Member
30	Dr. N.R. Panwar	Scientist (Sr.Scale)	Member
31	Mr. M. Mohanty	Scientist (Sr.Scale)	Member
32	Dr. Mrs.Sangeeta Lenka	Scientist	Member
33	Dr. Sanjib Kumar Behera	Scientist	Member
34	Ms. I.Rashmi	Scientist	Member
35	Ms. Neenu S	Scientist	Member
36	Dr. B.N.Mandal	Scientist	Member
37	Dr. Asit Mandal	Scientist	Member
38	Ms. Radha T.K.	Scientist	Member
39	Dr. M.V.Singh	PC (MSN)	Member Secretary

The first meeting of IRC was held on 11th, 12th and 16th June, 2009 under the chairmanship of Dr. A. Subba Rao, Director of the Institute. Dr. S. Kundu, Member Secretary, IRC, extended hearty welcome to all participants and requested all the members to present their results briefly and precisely. In his opening remarks chairman pointed out that all the RAC members were happy over the presentations made by the scientists during last RAC meeting and requested all the members to make some good publications in view of the next convention of the Indian Society of Soil Science to be held at IISS Bhopal in 2010. He also asked the scientists to associate themselves as Co-PI is not more than 4 projects and each scientist should have at least one project as P.I. Dr. R. S. Choudhary, Dr. R. K. Singh, Dr. K. Ramesh, Dr. Ajay and Dr. Somasundaram were asked to formulate new research projects on current upcoming issues and deliver seminar before the next IRC meeting. The chairman emphasized that no scientist can earn honor and respect without doing basic research work, therefore, scientists should indulge themselves in search with novel innovative ideas.

Thereafter, PIs of all the in-house and externally funded projects presented the brief achievements of their projects before the house and the suggestion/comments were recorded. The following research projects were declared completed by the house.

- 1). Development of potassium management strategies for Alfisols in view of lessons learnt from long term fertilizer experiments.
- 2). Investigations on phosphorus fractions in diverse organic manures and their effects on phosphorus speciation and availability in contrasting soils.
- 3). Nutrient dynamics and production sustainability of cropping sequences under organic farming system in Vertisols.

- 4). Impact of Linear alkylbenzene sulphonate (LAS) and sodium tri poly phosphate (STPP) present in detergents on crop growth and soil quality.
- 5). Contractual research network on evaluation of efficacy of Granubor II in ameliorating boron deficiency in important field crops under major ecological zones of India.
- 6). Development of suitable methodology for soil fertility using GIS and GPS tools for precise fertilizer recommendations based on spatial variability.

Following two research projects were approved by the IRC:

- 1). Detection of water and nitrogen stress and prediction of yield of maize using hyperspectral reflectance and vegetation indices.
- 2). Evaluation of Allwin wonder and allwin top for their effects on Maize productivity and soil fertility (Sponsored by Sree Ramcides Chemicals PLtd)

Concluding the IRC meeting, the chairman remarked that all the scientists should exercise maximum restraint over commenting on others and extend meaningful co-operation and co-ordination in carrying out research work. In view of the hosting of ISSS convention in 2010, he emphasized that our website has to be updated with new information and bring out some useful publications before the convention.

The second meeting of IRC was held on 11-13 and 23 November, 2009 under the chairmanship of Dr.A.Subba Rao, Director of the Institute. Dr. S. Kundu, Member Secretary, IRC, extended hearty welcome to all the participants and requested all the members to present their results briefly and precisely. In his opening remark chairman extended hearty welcome to all the new members of IRC, namely, Dr. S.R. Mohanty, Dr.Pramod Jha, Dr. Ritesh Saha, Dr. Lenka, Miss Radha,

Miss Neenu, Miss Rashmi, Dr. B. N. Mandal and Dr. A. Mandal. He pointed out that council is now undertaking mid-term appraisal of all the Institutes, hence research has become accountable by the planning commission and agriculture ministry. The chairman emphasized that relevant research has to be done so that the information generated may be utilized for the technology generation and useful to the farmers. The chairman also drew the attention of all the members about the content of the letter sent by the RAC chairman, Dr. J.S.P. Yadav, who once again highlighted the following research thrust areas:

1. Nutrient use efficiency enhancement for sustainable and economic higher productivity.
2. Harnessing management mechanisms for greater soil carbon sequestration in different soils and cropping systems.
3. Quantitative indices for categorization of varying degrees of soil quality/ health for major production systems and agro-environments.
4. Exploiting soil-root interface for higher productivity.
5. Eco-friendly adoptable remedial measures related to soil and water pollution.
6. Anticipatory soil research for coping and

mitigating adverse effect of impending climate change.

Thereafter, PIs of all the in-house and externally funded projects presented the brief achievements of their projects before the house and the suggestion/ comments were recorded. The following research projects were declared completed by the house and the respective PI was asked to submit RPF-III.

- 1) Boom flower (Nitrobenzene 20% EW) its influence on growth, physiology, nutrient uptake and yield of tomato plant (Contractual Research Project).
- 2) Studies on the effect of organic nutrient sources on yield and quality of pomegranate.
- 3) Investigation on effect of continuous use of sewage water as irrigation on swell-shrink soil quality.

Concluding the IRC Meeting, the chairman remarked that all the scientists should exercise maximum restraint over commenting on other's work and extent meaningful suggestion and comments on carrying out research work. In view of the hosting of ISSS convention in 2010, he emphasized that our website has to be updated with new information and bring out some useful publications before the convention.

Institute Management Committee (IMC)

Representation	Name	Designation
<i>Director of the institute</i>	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 on 25 June 2009. During the meeting chairman elaborated on-going activities to the IMC

members. The IMC recommended to procure the urgently required equipment that were mentioned in XI plan EFC.

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 15th meeting of the RAC of the Indian Institute of Soil Science (second meeting of the Fifth RAC since inception of the Institute) was held during 21st – 22nd May, 2009. All the members of RAC were present in the meeting except, Dr. P.K. Aggarwal who could not attend because of other engagement.

- | | | |
|---|----------------------|------------------|
| 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. Y. Muralidharudu | Member-Secretary |

At the outset, Dr. Y. Muralidharudu, member secretary RAC, and Dr. A. Subba Rao, Director, Indian Institute of Soil Science welcomed the RAC members.

Introductory Remarks of the Chairman RAC

Dr. J.S.P. Yadav expressed thanks to the Director, Dr. A. Subba Rao and Member Secretary, Dr. Y. Muralidharudu for arranging the second meeting of the present RAC on May 21 & 22, 2009. He again emphasized the utmost importance of good soil health for ensuring sustainability of higher agricultural productivity, especially in the context of present scenario of wide mismatch between conservation and exploitation of soil resource. The Indian Institute of Soil Science should be alive to the emerging national problems like climate change, low input use efficiency, low soil organic carbon status, soil degradation etc, and to capture this opportunity for making visible significant contributions. The first mandate of the Institute being conduct of basic and strategic research, the scientists should play a leading role in incorporating more soil science component in the research programmes. The scientists should not follow the treaden path and should avoid repetition of past work which has already yielded well-proven results. They should adopt multi-disciplinary team approach in

research, cutting across the divisions. The research findings should have adoptability and replicability to the target areas.

In the rhizosphere, the bacteria living in close contact with the roots, play a key role in improving soil structure and increasing bioavailability of nutrients for plant uptake and therefore, rhizosphere is considered biologically more active than the bulk soil. Organic carbon sequestration has attracted great attention these days as a basic requirement of good soil health. The International Congress on “Global Climate Change Imperatives for Agricultural Research in Asia Pacific” organized jointly by APAARI and JIRCAS on October 21-22, 2008 in Japan, stressed the need of enhancing carbon sequestration in soils through adoption of scientific soil and crop management practices. The Indian Institute of Soil Science should, therefore, evolve scientifically sound soil and crop management practices that can be adopted easily on a large scale by the small and marginal farmers, who are knowledge poor as well as resource poor. Organic farming is developing rapidly at the global level and is reported to be practised in more than 130 countries, occupying about 31 M ha with the trade valued at US \$ 38.6 billion. In India too, organic farming is thriving in many areas, occupying about 5,38,000 ha. India exported organic products worth Rs.3000 million in 2007, and is expected to reach the figure of Rs.40 billion by 2012, equivalent to about 2.5 per cent of current global trade. Though IISS is already conducting research on organic agriculture, it will be advisable to strengthen critical scientific investigation on this aspect to arrive at validated results of practical value relating to soil health enhancement, resource conservation, favorable input: output ratio, quality of produce, food and nutritional security, ecological safety and other relevant issues.

The IISS is planning to organize Annual

Convention of the Indian Society of Soil Science in 2010. It will also perhaps celebrate its Silver Jubilee in 2012. The Institute should take appropriate action well in advance, so that these events are historic landmark and add remarkably to its scientific visibility. The publication “Soil Science Research in India 1988-2008” brought out by IISS is commendable, but it has to be updated further including the concise summary of research done on different aspects like individual nutrients, IPNS, biodiversity, soil quality etc.

Comments /observations made on presentations

Based on presentations made by HODs and PCs, the RAC members made the following observations /suggestions for further work.

1. Soil Physics Division

- ◆ Soil bulk density vs soil moisture content relationship is soil depth dependent. This should be borne in mind while making interpretation of the observed data on the two parameters.
- ◆ Tillage effects are reflected in transient infiltration rate-time data. However, terminal /final infiltration rates tend to converge to a value usually characteristic of least permeable layer/ horizon. The most appropriate time for assessing infiltration rates would be at the end of rainy season. If the purpose is to compare tillage effect on soil porosity or pore size distribution, then soil- moisture characteristics estimated in –situ in the 1-bar range should be a better alternative.

2. Environmental Soil Science Division

- ◆ Urban sewage water is invariably utilized for irrigating vegetable crops grown in suburban areas. Based on data generated on its effect on soil quality (heavy metal

content) and quality of produce, the institute should come out with suitable recommendations/guidelines for safe use of sewage waters for irrigation of major soil types.

- ◆ Plant attributes that promote nutrient use efficiency in general and micronutrients use efficiency in particular, need to be identified for major crops and shared with the concerned crop institutes for subsequent varietal improvement.
- ◆ Soils are used a sink for disposal of contaminants and also for organic C to curb global warming and improve soil fertility. Attempts made by the Division of Environmental Soil Science for using soils as a sink of contaminants is praise worthy. They can continue this work with predominant soil groups where the contaminants are generated for disposal. Along with inorganic, organic' pollutants may also be included. This will help to find good sites for disposal of wastes with favourable economics.
- ◆ Contaminants are omnipresent, and to arrest their spread we need to know the behavior in soil which is the ultimate sink for its disposal and as such, a project entitled “Predicting rate, fate and transport of contaminants in soils and estimating a threshold value” is suggested.

3. Soil Chemistry and Fertility Division

- ◆ Data base generated on organic sources of plant nutrients should be analyzed to estimate the share of organic sources in meeting the requirement of nutrients of the district in question. +
- ◆ Recovery of soil applied Zn is less than 5%. Can we come out with general recommendations for major cropping systems, thereby minimizing the need for

soil testing and promoting use of zinc containing N-fertilizers such as zincated urea? This could be a very good and practicable strategy for accelerating use of zinc as a plant nutrient.

- ◆ ICAR commodity institutes are mandated not only to develop crop varieties but also to produce their nucleus and breeder seed, so that the varieties developed reach the ultimate client. IISS should also fall in line and ensure that the products (mainly biofertilizers, enriched organic manures etc.) are made available with its brand name. Since this would be a resource generation activity, it will not be difficult for the institute to formalize collaboration with cooperating centres which are already engaged in manufacturing Biofertilizers/cultures of agriculturally useful micro-organisms.
- ◆ The division of Soil Chemistry and Fertility has done commendable work on INM and validated their technology conducting large number of FLDs at different locations of the country. They have also inventorised availability of different organic sources of nutrients at the district level. It is suggested that in collaboration with STCR, they come out with bulletins on INM for different cropping systems and agroclimatic regions based on the availability of the organics database generated. They may also put the database on map for easy access to the policy makers, planners and end users.
- ◆ Because of a huge import bill and a possible scarcity of K fertilizers, attempts may be made to mobilize K from difficult available sources to plant available form using microbes through a project say entitled “Increasing plant availability of

K from mineral sources using microorganisms”

4. Soil Biology Division

- ◆ Soil health related issues to be focused including bioremediation.

5. AICRP on LTFE

- ◆ Study may be initiated in all the LTFE sites to find out the critical/threshold values of crop residue/organic C that need be incorporated for maintenance of SOC in soils of the major agroclimatic regions of the country.

6. BF Network Project

1. VAM work with references to fruits and plantation crops may be initiated.
2. Composts enriched with biofertilizers may be explored.

7. AICRP on Micronutrients

The AICRP on Micronutrients and pollutant elements has generated invaluable information and is delineating areas having multinutrient (micro) deficiencies. On the other hand, concerted efforts are being made by DAC for incorporation of specifications for multi(micro) nutrient mixture in FCO. Rationale for such attempts needs to be looked into and necessary scientific inputs may be passed on to the concerned authority.

While growing micronutrient deficiency tolerant varieties, it is commonly observed that the farmers end up with less yield. Economics of cultivation of such tolerant varieties without any micronutrient applied vis-à-vis a susceptible high yielding varieties with micronutrient need to be worked out before recommendation.

8. AICRP on STCR

The AICRP on STCR developed targeted yield equations for a large numbers of crops and cropping systems. Since it will take many years to cover every holding of (110 m) the country, we should try to find something complementarily of soil testing for fertilizer recommendation. Plant led strategy such as chlorophyll meter, color charts, deficiency symptoms may also be put into use, where soil testing facilities are not available. To cut cost for soil testing, attempts may be made to find multinutrient extractants for major soil groups and crops of the country initiating a project say entitled “Searching for a multinutrient extractant for major soil groups and crops”.

1. IISS should extend targeted yield concept to rainfed ecosystems.
2. Prior to recommending optimum nutrients for crops in acid soils there is a need to include liming material for adjustments to soil to a desired pH level and provide Ca and Mg.
3. Nutrient recommendations need to be commensurate with the farmers economic resources.
4. INM modules for major cropping systems and soil types need to be developed.
5. FLDs should be planned with different farm wastes and fertilizers under INM.
6. Improve liaisoning with DAC, FAI and other developmental agencies.

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	Dr. Brij Lal Lakaria	Member
4.	Shri. Rajesh Dubey, Assistant Finance & Accounts Officer	Member
5	Shri. Kumar Vivek, Administrative Officer	Member

Institute Joint Staff Council

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

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

Name	Programme	Venue	Period
Dr. M. V. Singh	First annual workshop of the Component-4 of NAIP	IVRI, Izatnagar, U. P	14-15 th April 2009
Drs. M. V. Singh and S. K. Behera	Launching workshop and first CAC meeting of NAIP sub-project "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"	NBSS & LUP, Nagpur	08-09 th May 2009.
Dr. J. Somasundaram	Tata-ICRISAT-ICAR workshop on 'Sustainable productivity enhancement initiatives in India'	IISS, Nabi bagh, Bhopal	12-13 th May, 2009
Dr. J.K. Saha	Capacity Building training programme of Scientists and Technologists on IPR & WTO related issues	Consumer Unity & Trust Society, Jaipur	25-29 th May 2009
Dr. A.K. Biswas	NAIP workshop	CIAE, Bhopal	May 31, 2009
Drs. A.K. Biswas and Tapan Adhikari	Second meeting of CIC, CAC and CMU of NAIP Sub-project on 'Nano-technology for enhanced utilization of native P by plant and higher moisture retention in arid soils'.	PAU, Ludhiana	June 15-16, 2009.
Dr. K. Ramesh	9th Agricultural Science Congress	National Academy of Agricultural sciences, New Delhi.	June 22-24, 2009

Dr. M. V. Singh	International Plant Nutrition Colloquium (IPNC)	California, USA	26 to 30 August 2009.
Drs. A.K. Biswas and Tapan Adhikari	CAC meeting of NAIP Sub-project on 'Assessment of quality and resilience of soils in diverse agro-ecosystems'	IISS, Bhopal	Sept. 5, 2009
Drs. Muneshwar Singh and R.H. Wanjari	Consortium Advisory Committee (CAC) Meeting of NAIP sub project entitled 'Assessment of quality and resilience of soils under diverse agro-ecosystems'	IISS, Bhopal	September 5 -6, 2009
Dr. D.L.N. Rao	SAARC workshop on "Improving Nutrient Use Efficiency in Agriculture"	CSSRI, Karnal	September 9-10, 2009
Dr.R. S. Chaudhary	National workshop on Agricultural Drainage Technology	CIAE, Bhopal	Sept 15-16,2009
Dr. J. Somasundaram	"Food and Environmental Security through Resource Conservation in Central India: Challenges and Opportunities" (FESCO)	Agra	16-18 th Sept, 2009
Dr. K.B. Hebbar	Interim review Workshop of ATCOM-II	Amaltas, India Habitat centre, Lodhi Road, New Delhi.	October 13, 2009
Dr. K.B. Hebbar	National workshop' towards Preparation of Comprehensive Climate Change Assessment'	Ashoka Hotel, Chanakya puri, New Delhi.	October 14, 2009
Drs. A.K. Biswas and Pramod Jha	Meeting on 'Use of biochar in agriculture'	IISS, Bhopal	Oct.19-20, 2009
Dr. K.B. Hebbar	High level conference on 'Climatic change: Technology Development and transfer'	Vigyan Bhawan, New Delhi.	October 22-23, 2009

Drs. A. Subba Rao Muneshwar Singh and R.H. Wanjari, Y. Muralidharudu	IPI-OUAT -IPNI International Symposium on Potassium Role and Benefits in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damages.	OUAT Bhubaneswar	November 5 -7, 2009
Dr. Ajay	National Seminar Organized by Indian Society of Plant Physiology	IARI, New Delhi	November 5-7 th , 2009
Drs. A.B. Singh, Ranjit Kumar and J. Somasundaram	International Conference on Nurturing Arid Zones for People and Environment: Issues and Agenda for 21 Century	CAZRI, Jodhpur	November 23 - 27,2009
Dr. Ranjit Kumar and S. K. Behera	International Conference on “Nurturing Arid Zones for People and the Environment: Issues and Agenda for the 21 st Century”	CAZRI, Jodhpur	24-28 November 2009.
Drs.Muneshwar Singh and R.H. Wanjari	AICRP LTFE Workshop	IGKV Raipur	December 6 -8, 2009
Drs. A.K. Biswas and Tapan Adhikari	Third meeting of CIC, CAC and CMU of NAIP Sub- project on ‘Nano-technology for enhanced utilization of native P by plant and higher moisture retention in arid soils.	CAZRI, Jodhpur	Dec. 15-16, 2009
Dr. A.B. Singh	National Seminar on Organic farming for Sustainable Agriculture and Livelihood Security	Rajmata Vijayaraje Scindia K.V.V., College of Agriculture, Gwalior	December 23- 25, 2009

Drs. Muneshwar Singh, Y. Murlidharudu, D.L.N. Rao, M.C. Manna, K Sammi Reddy, A.B. Singh, A.K. Tripathi, Tapan Adhikari, J. Somasundaram, Brijlal Lakaria, Pramod Jha and S.K. Behera	74th annual convention of the Indian Society of Soil Science	IARI, New Delhi	December 22-25, 2009.
Dr. A.B. Singh	National Seminar on Organic farming for Sustainable Agriculture and Livelihood Security	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, College of Agriculture, Gwalior	December 23- 25, 2009
Dr.R. S. Chaudhary	National Seminar on Integrated management of water resources with reference to biodiversity and livelihood	ASET, Bhopal	16-17 th Jan, 2010
Dr. J.K. Saha	National Workshop on Repair, Renovation and Restoration (RRR) of water bodies	North-Central Region of Central Ground Water Board at Dr. Hari Singh Gaur Central University, Sagar	4 th & 5 th February 2010
Dr. Blaise Desouza	XIX Biennial workshop of DWSR co-ordinating Centre	IGKV, Raipur	23-24 February 2010

Dr. J.K. Saha	National Brainstorming Workshop on “Preparation of Activity Guide Book for National Children Science Congress 2010-2011’	organized by NCSTC- Network, Dept. of Science & Technology, GOI at B.C. K. V., Mohanpur, W.B.	February 14 -17, 2010
Dr A. B. Singh and A.K. Tripathi	International Conference on “Role of Bio-molecules in Food Security and Health Improvement and XI Silver Jubilee Convention of the Indian Society of Agricultural Biochemists	BHU, Varanasi.	February, 17-20, 2010
Dr. T. Adhikari	International Conference on Nano Science and Nano-Technology (ICONN 2010)	SRM University Chennai	February 24 - 26 th 2010
Dr.R.H. Wanjari	14 th Shri Vasantrao Naik Memorial National Agricultural Seminar	Nagpur	February 27 -28, 2010.
Dr. T. Adhikari	National Seminar on Role of Innovative Environmental Bio-technologies for Greening India	Carrier College Bhopal	March 16-17 th 2010
Dr J. Somasundaram	Workshop on “AGROWEB: Guidelines for Uniformity in Contents of websites of all the ICAR Institutes”	NBPGR	19 th March, 2010.

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

14.1 Workshops / Group Meetings / Seminars

Model Training Course (MTC)

A Model Training Course (MTC) on “Efficient recycling of mineral and by-product nutrient sources for sustainable crop production” was organized at IISS, Bhopal during 2-9 November 2009 for Agricultural and Horticultural Officers of different state Departments. MTC was sponsored by the Department of Agriculture and Co-operation, Ministry of Agriculture, Govt of India, New Delhi. The objective of training programme was to appraise these officers about nutrient potential of the indigenous nutrient sources and to impart knowledge of technologies for their efficient use. Dr. K. Sammi Reddy and Dr. A. B. Singh were the Course Director and Course Co-Director, respectively.

The training programme was inaugurated by an eminent soil scientist and former Director of National Bureau of Soil Survey and Land Use Planning, Nagpur, Dr. M. Velayutham on 2nd November 2009 (Photo 14.1). Seventeen trainees from MP, Maharashtra, Punjab, Assam, Jammu and Kashmir, Tamilnadu, Orissa were attended the training programme (Photo 14.2). The course content was divided into 6 modules which consist of about 30 lectures including theory classes, field visits, and video films. There were 3 guest lectures delivered given by invited speakers. Dr. Pitam Chandra, Director, CIAE, Bhopal presided over the valedictory function and distributed certificates to trainees on 9th November 2009.



Photo 14.1 Dr. M. Velayutham, Former Director, NBSS & LUP, Nagpur inaugurating the MTC



Photo 14.2 Group photo of MTC trainees

Short-term Training to KVK Personnel

A short-term training programme on “Soil Health and Fertility Management” was organized during 12-15 February 2010. Sixty-one KVK personnel from Madhya Pradesh, Chhattisgarh and Orissa states had participated in the training programme. This programme was sponsored by Zonal Project

Directorate Zone VII, Jabalpur. The training programme was inaugurated by Dr.U.S.Gautam, Zonal Project Director, Jabalpur (Photo 14.3 and 14.4). This training programme included 10 practical oriented lectures and field visits. The topics covered in the course are (i) Status of soil health and crop productivity in Madhya Pradesh, Chhattisgarh and Orissa, (ii) Balanced and integrated nutrient management, (iii) Micronutrient Management, (iv) Biofertilizers, (v) Efficient use of mineral and by-product nutrient sources, and (vi) Recycling of organic wastes in agriculture. Dr. A. Subba Rao, Director, IISS distributed certificates to the trainees during valedictory function on 15th February 2010.



Photo 14.3 Dr. US Gautam, Project Director inaugurating the KVK training



Photo 14.4 KVK trainees

AICRPLTFE Workshop

The Workshop of AICRP on LTFE was organized to review research progress of LTFE centre at IGKV Raipur (C.G.) during 6-8th December 2009. The workshop was inaugurated by honourable Dr AK Singh, DDG (NRM), Prof MP Pandey, Vice Chancellor, IGKV, Dr SS Khanna, Ex-Vice Chancellor, IGKV, Dr SS Shaw, DoR, IGKV, Dr RL Pandey, Dean, Dr SS Sengar, Head, Soil Science also graced the function (Photo 14.5 & 14.6). A Souvenir and other six LTFE publications (a LTFE Annual Report 2008-09 + 5 research Bulletins) were released on this occasion (Photo 14.7).



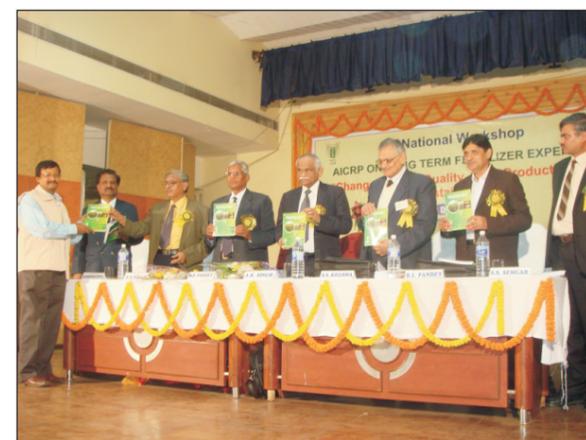
Photo 14.5 Inaugural session



Photo 14.6 Delegates in the workshop



Photo 14.7 Inaugural function of Workshop and release of landmark publication of AICRP LTFE at IGKV Raipur (December 6-8, 2009)



Review workshop of AICRP on STCR

Annual group meeting of STCR Research Workers was organized at Acharya N.G. Ranga Agricultural University from 6th -7th June, 2009 to review the research progress of various cooperating centres. Dr. A.K.Singh, DDG (NRM), ICAR was the chief guest for the group meeting. Dr. P. Raghava Reddy, Vice-Chancellor ANGRAU presided over the inaugural session. Dr. M. Velayutham expert for the meeting Dr. A. Subba Rao, Director, IISS and Dr. G. Lakshmikanta Reddy, Director of Research of the university also participated in the meeting (Photo

14.8). Several technical bulletins, pamphlets in regional languages were also released during the group meeting for the benefit of the researchers, students, industries extension personnel and farming community. The crop wise soil test based recommendations for DOR, DRR, NRCS and CRIDA were handed over to the directors of the institutes by the chief guest. The progress of work carried out and the constraints faced in the execution of the assigned work by the different centres was critically reviewed and the technical programme of the work by different centres for the year 2009-10 was also discussed. (Group Photograph enclosed).



Photo 14.8 Group Meeting of AICRP (STCR) scientists at ANGRAU, Hyderabad

Training on Integrated Plant Nutrient Management

A training programme was organized for the district level agriculture officers of Department of Agriculture, Govt. of Nagaland on Integrated Plant Nutrient Management at IETC Medziphema during 25-27 November, 2009. Thirty one agriculture officers from different districts of Nagaland attended the training programme. During this training programme resource persons from IISS, Bhopal delivered lectures on different aspects of INM. The training was organized by

State Department of Agriculture, Nagaland in collaboration with Indian Institute of Soil Science, Bhopal.



Photo 14.9 Meeting on Use of Biochar in Agriculture

The meeting on Biochar was held on October 19-20, 2009 at IISS, Bhopal under the chairmanship of Dr. A. Subba Rao, Director of the Institute. Dr. S.S. Khanna, Ex Vice-Chancellor, Acharya Narendra Dev University of Agriculture and Technology, Faizabad, and Former Member of Planning Commission, Mr. Persis Bilmoria, CEO and Founder, Earthsoul India Pvt. Ltd., Mumbai, Ms. Priyadarshini Karve, Project Co-ordinator, Appropriate Rural Technology Institute (ARTI), Pune and Mr. Nilesh P. Inamdar, Director Business Development, Patpert Teknow Systems Pvt. Ltd., Mumbai and Dr. G. Venkatesh, Scientist, CRIDA, Hyderabad apart from the IISS scientists attended the deliberations (Photo 14.9).

Launching workshop and first CAC meeting of NAIP sub-project “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”

The launching workshop of the NAIP subproject entitled “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” (C4/C30022) was held at NBSS&LUP, Nagpur on 8th May 2009 along with another NAIP subproject entitled “Georeferenced Soil Information System for Land Use Planning and Monitoring Soil and Land Quality for Agriculture” (C4/C30024). Dr. N. Panda, CAC chairman (Sub project C4/C30024) presided over the session and Dr. A. Badyopadhyay, National Coordinator, Component4, NAIP was the Chief Guest. On that occasion, CAC members viz. Dr. P. N. Takkar (Chairman), Dr. C. Chatterjee (Member), Dr. A. K. Dabadghao (Member), Dr. A. Subba Rao, Director, IISS, Bhopal and Dr. Deepak Sarkar, Director, NBSS & LUP, Nagpur were also present (Photo 14.10). The CCPI along with the associated scientists of all the cooperating institutions participated in the launching workshop as well as in CAC meetings.



Photo 14.10 Inaugural function of “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”

At the outset, Dr. Subba Rao welcomed the dignitaries and delegates to the launching workshop. Dr. Bandyopadhyay, in his inaugural address, emphasized the importance of the subproject with respect to the innovativeness of

research and the partnership involved, which are the main aspects of the NAIP. He said that the subject of the project is of national importance and the objectives of the subproject have to be achieved by active involvement of the partners. Dr. Takkar highlighted the importance of micronutrient in Indian Agriculture and existing micronutrient deficiencies and their importance in soil-plant-animal-human health. In the light of this the subproject is very important and to meet its challenging objectives the participating centers have to work hard. He wished all the best to the consortium partners in their pursuit to achieve the objectives of the subproject. Dr. M. V. Singh, CPI presented overview of the subproject and explained about the thoughts behind the designing of the same.

National Coordinator (Component 4), CAC members, Consortium leader, CPI, CCPI and associated scientists of the subproject participated in the meetings (Photo 14.11). Dr. Badyopadhyay briefed the house about the status of the CAC members and the powers enjoyed by them. CAC members are the partners of the subproject to help and assist the CPI and CCPI in achieving the



Photo 14.11 First CAC meeting of “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” in progress

objectives of the subproject. The CAC members can make financial and technical recommendations and financial re-appropriation within the prescribed limits within the subproject. Chairman asked the consortium leader and CPI to constitute the CIC and conduct meetings at regular intervals. Dr. M. V. Singh, Consortium Principal Investigator presented the technical programme of the subproject before the house. After presentation, a thorough discussion was held on technical programme and following recommendations emerged. The meeting was concluded and Dr. M.V. Singh proposed the vote of thanks.

Twenty seventh workshop of All India Coordinated Research Project on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants

The 27th Workshop of All India Coordinated Research Project (AICRP) on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants were successfully organized at CSK Himachal Pradesh Krishi Vishva Vidyalaya (CSKHPKV), Palampur, Himachal Pradesh from October 6 to 9, 2009. Dr. P. D. Sharma, Assistant Director General (Soil), ICAR, Krishi Bhawan, New Delhi inaugurated the workshop meetings and Dr. Tej Pratap, Vice chancellor, CSKHPKV, Palampur presided over the session. Dr. I. M. Chhibba, former Professor of Soils, Punjab Agricultural University, Ludhiana

Hindi Workshop on “प्रदुषण : समस्या एवम् समाधान” Organized

A one day hindi workshop on “प्रदुषण : समस्या एवम् समाधान” was organized on 19 September 2009 at Indian Institute of Soil Science, Bhopal. During this workshop five important papers were presented namely, (1) Environment and Cancer, (2) Management of Rural Environment, (3) Water Pollution' (4) Swine Flu Causes and Remedies and (5) Economic Aspects of Environmental Pollution.

CAC meeting of NAIP sub-project on Soil Quality and Resilience

The Consortium Advisory Committee (CAC) meeting for the NAIP sub-project “Assessment of Quality and Resilience of Soils in Diverse Agro-ecosystems” was held at IISS, Bhopal on 5th September 2009. The meeting was chaired by Dr. N. Panda, Ex-vice-chancellor, Sambalpur University. Dr. M. Velayutham (Member CAC), Dr. A. Bandyopadhyay (National Coordinator, Component 4), Dr. A. Subba Rao, Dr. S. Kundu and other CCPI's and CoPI's attended the meeting.

Group Meeting

Group meeting was organized for AICRP micronutrients at IISS, Bhopal on dated 23-24 June 2009 and technical programme refinement was discussed to improve nutrient use efficiency and GIS based mapping.

The second CIC meeting of the NAIP subproject entitled “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” (C4/C30022) was held at IISS, Bhopal on 29th October 2009.

Model Training Course (MTC)

Model Training Course (MTC) on “Crop Production and Environmental Sustainability through Organic Farming” was organized at IISS, Bhopal during 8-15th September 2009, which was sponsored by Ministry of Agriculture, Department of Agriculture & Cooperation, Director of Extension, New Delhi. Thirty candidates from different State Agricultural/Horticulture Departments, State Agricultural Universities and ICAR Institutes participated in the training program.



Women's day Celebration

International Women's Day: International women's day was celebrated on March 9,

Events

Independence Day

Independence Day on 15th August 2009 was celebrated at the institute premises. The Staff Recreation Club (SRC) organised recreational activities for children and family members. Mrs. Subba Rao distributed prizes to the participants and winners.



Republic Day

Republic Day on 26th January, 2010 was celebrated at the institute premises. The Staff Recreation Club (SRC) organised recreational activities including racing, poem recitation, songs, drawing competitions for children, and musical chair for the family members of staff. The program was concluded with the distribution of prizes by Mrs. Subba Rao & Dr A. Subba Rao, Director, IISS, Bhopal and Dr. A.B. Singh, President, SRC to the winners on this occasion.



Photo-R.Day

Sports

The ICAR Inter Central Zone Sports Meet was held at NBSS & LUP Nagpur during March, 4-8, 2010. A total of 56 sports persons from the institute participated in various team and individual events in the Central Zone Sports Meet. The sports meet was inaugurated by Dr. Santosh Chaterjee, Chairman Nagpur City Development. At this occasion. Dr. A. K. Singh, DDG (NRM), ICAR, New Delhi, addressed the sports contingents. Mr. P. K. Raut won the gold medal in carrom, Ms. T. K. Radha won third prize in 100 m race, Ms. S. Neenu has got third prize in Javelin throw. Badminton team, table tennis and volley ball team performed well in the tournament. In the team events, the players of our institute played well and exhibited very good discipline and sportmanship. Dr. A.B. Singh Chef-de-Mission and Dr. A.K. Tripathi, Team Manager of the IISS contingent.



Mr. Raut received Gold Medal in Carrom

Felicitation

A farewell program was organized on 30th November, 2009 to felicitate Dr. P. Ramesh, Principal Scientist on his transfer from our Institute to the Directorate of Oilseed Research, Hyderabad.

15. DISTINGUISHED VISITORS

Dr. A.K. Srivastava, Director (Acting) Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora visited May 31 to June 03, 2009.

Dr. A.N. Deshpande, HOD (SSAC), MPKV, Rahuri visited Bhopal on July 15, 2009.

Dr. M. A. Khan, Director, ICAR Research Complex for Eastern Region, B.V. College, Patna visited August 3- 5, 2009.

Dr. Surender K Bansal, Director, PRII visited on September 11, 2009 to monitor the progress of the contractual project on UI inhibitors.

Mr. Satish Menon, Sythite Industries Ltd who deals with spice oils and oleoresin manufacturing visited on September 17, 2009 for discussion on cultivation of mustard.

Dr. M. Velayutham, former Director of NBSS & LUP visited the institute on Nov. 2, 2009 and inaugurated the Model Training Program.

Dr. P.N. Takkar, Founder Director, IISS visited Institute on February 4, 2010 in connection with the CIC/CAC meeting of the NAIP Project.

Shri Pratap Singh Rane, Hon'ble Speaker of Goa along with State Agricultural Officers and 10 farmers visited the institute on February 5, 2010.

Fifteen Agricultural Officers and staff of the State Agricultural Research Station, Yisemyong, Mokokchung, Nagaland visited from February 9-11, 2010.

16. PERSONNEL

(Appointments, Promotions, Joining, Transfers etc.)

New Appointments

Dr. A. K. Biswas joined as Head Division of Soil Chemistry & Fertility on 2nd July, 2009.

Dr. B.N. Mandal joined the institute as Scientist (STCR) on 19th June, 2009.

Ms. T.K. Radha joined as Scientist on 20th June, 2009.

Dr. Pramod Jha, joined the institute in the Division of Soil Chemistry and Fertility as Senior Scientist on 17th July, 2009.

Dr. S.R. Mohanty joined as Senior Scientist on 18th June, 2009.

Dr. Ritesh Saha, joined the institute in the Division of Soil Physics as Senior Scientist on 24th August, 2009.

Miss Rashmi I, joined the institute in the Division of Soil Chemistry and Fertility as Scientist on 27th August, 2009.

Miss Neenu S, joined the institute in the Division of Soil Chemistry and Fertility as Scientist on 27th August, 2009.

Dr. Asit Mandal, joined the institute in the Division of Soil Biology as Scientist on 30th October, 2009.

Promotion

Dr. Ajay, Sr. Scientist promoted to Pr. Scientist w.e.f. August 31, 2007.

Dr. A.K. Tripathi, Sr. Scientist promoted to Pr. Scientist w.e.f. August 5, 2008.

Dr. K.S.Reddy, Sr. Scientist promoted to Pr. Scientist w.e.f. August 5, 2008

Mr. Venny Joy, Steno Gr.III promoted to Personal Assistant w.e.f. October 9, 2009.

Joining

Dr. N.K. Lenka, Senior Scientist from ICAR Research Complex for NEH Region, Umiam, Barapani transferred to Indian Institute of Soil Science, Bhopal and got posted in the Division of Soil Chemistry and Fertility on 9th October, 2009.

Transfer

Dr. P. Ramesh, Principal Scientist, was transferred to Directorate of Oilseed Research, Hyderabad.

Dr. A.K. Sharma, Documentation Officer was transferred to Abiotic Stress Management Institute, Baramati.

Relieving

Dr. D. Damodar Reddy, Principal Scientist, consequent upon his selection as Head of Department in Soil Science and Agricultural Chemistry, was relieved to join Central Tobacco Research Institute, Rajahmundry, A.P. on 16th May, 2009.

17. INFRASTRUCTURE DEVELOPMENT

17.1 Technical Cell

Achievements of the Technical Cell during the report period are;

Compiled and submitted 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 (2008-09)

Compiled/ prepared and submitted the replies to 20 Audit Paras given by the External Audit Party for the financial year 2008-09.

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

Updating PERMISNet Database ICAR has developed 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 also looking after the institute's main server having Linux network operating system.

? Internet & Other Facility: ARIS Cell is equipped with broad band VSAT connectivity by ERNET India, which has been upgraded from 256 to 512 kbps during the reported period. The main server has configured with e-mail server and connected with LAN. All divisions and sections are connected to the Internet through proxy server. Scientists and staff are having individual email accounts. A broad band (BSNL-BB) system has been connected to all the computers in ARIS Cell to provide better facilities the staff. It also takes care of the maintenance of computers, printers and other electronic peripherals.

Internet security for the network computers/servers: Internet Security software (Quick heal 10.0) have been installed to a total 75 computers. Two servers and 75plus network systems were efficiently managed and maintained through AMC/outourcing service engineers from time to time.

EPABX system: 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. Regular updation of EPABX/intercom numbers has been done from time to time.

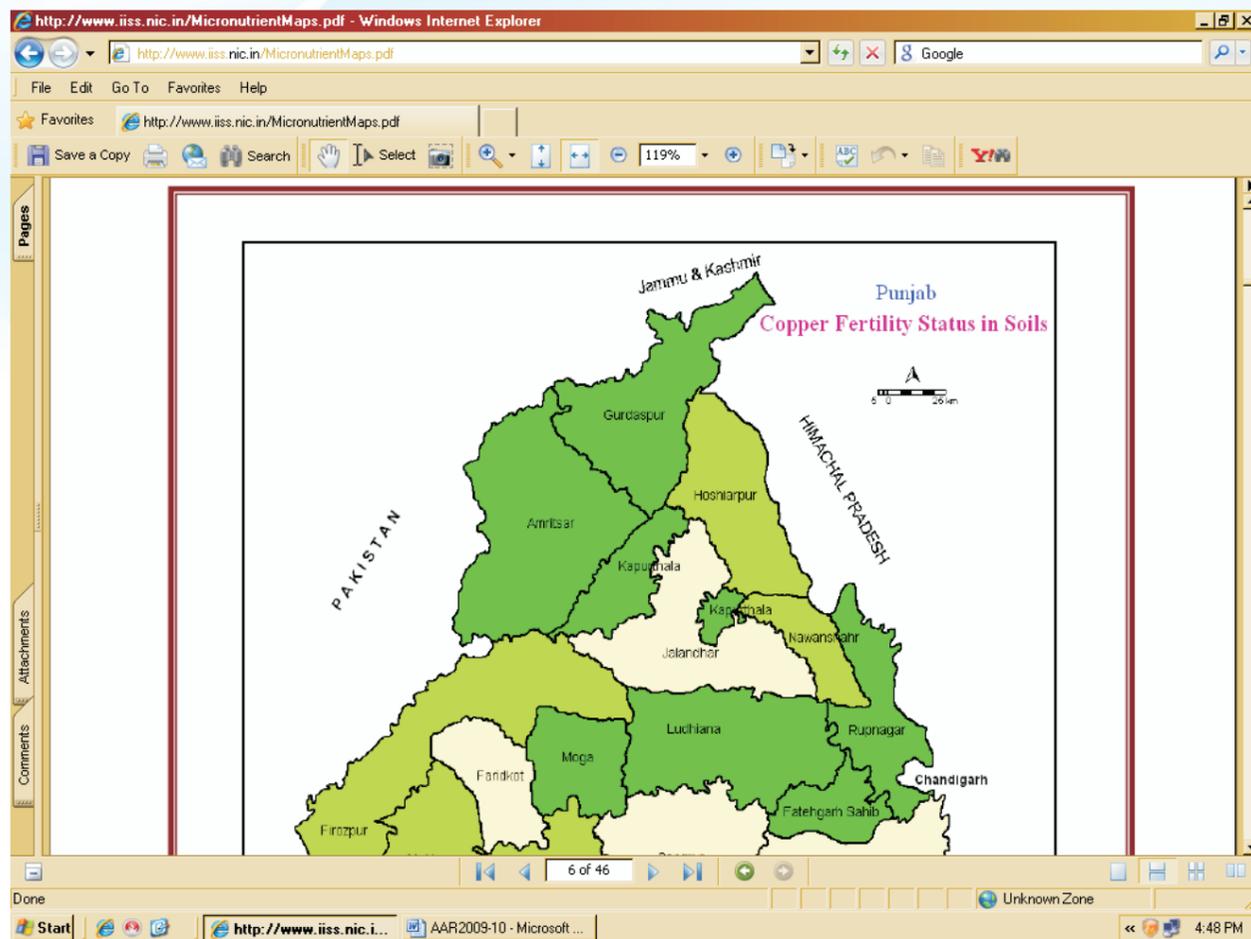
Conference Hall: Well furnished conference hall with fully air conditioned with present state-of-the-art technologies able to accommodate about 130-140 members for various meetings / workshops / seminars.

Updating Institute Website: The ARIS Cell is also maintaining the Institute website (www.iiss.nic.in). The site contains complete information about the institute's

Infrastructure Development

R&D and other activities. It is updated from time to time as per the requirement of the institute. Recently the Web pages have been redesigned, updated and a new outlook of the home page is given below. User friendly soil fertility maps like macronutrients and micronutrients (state & district-wise) have been kept in the website for display. RTI Act 2005, Photo Gallery, Latest News, Forthcoming events, other information, Search engine etc. have been incorporated in the present form to make it more informative.





17.3 Farm Development

In the current year (2009-10) to generate more revenue to the institute, additional area was brought under cultivation to the tune 2-3 ha through intercropping in the orchard crops, in

addition to the utilization of residual moisture from the *Kharif* season.

During the year 2009-10, rotavator was purchased to improve the efficiency in field preparations of the farm.

S.No	Season	Crop	Area (ha)	Yield (q)	Revenue (Rs.)
1	Kharif 2009	Soybean	16	239.27	459156
		Arhar	5.5	84.53	318931
2	Rabi 2009-10	Gram	14.66	267.71	492964

17.4 Library

During the period of report, the Institute library has acquired total documents categorized as listed below:

The Library is well maintained with facilities of document such as lending service, reference

service, reprographic services etc. The library has procured the Library Automation Software TLS, in which the bibliographic data of the books were imported from the existing Software. The Library also exchange the institute publications with the other ICAR Institute, SAUs and renowned Scientists in the field of Soil Science.

Documents	Addition during 2009-10	Total holding
Books	32	2378
Bound Journals	1164	2508
Annual Reports	117	1516
Foreign Journals	32	32
Indian Journals	30	30
Gifted Books	86	553

ANNEXURE I

DETAILS OF MANPOWER

Name	Designation
1. DIRECTOR'S CELL	
Dr. A. Subba Rao, FNAAS, FISSS	Director
Mr. Thomas Joseph	PS to Director
Mrs. Geeta Yadav	Personal Assistant
Mr. Sanjay Narayan Gharde	Lab Attendant/SSS
2. DIVISION OF SOIL PHYSICS	
Dr. A. K. Misra	Pr. Scientist & Head
Dr. R. S. Chaudhary	Pr. Scientist
Dr. Blaise D' Souza	Pr. Scientist
Dr. Kuntal Mouli Hati	Sr. Scientist
Dr. J. Somasundaram	Sr. Scientist
Dr. Ritesh Saha	Sr. Scientist
Mr. Manoranjan Mohanty*	Scientist, Sr.Scale
Dr. R. K. Singh	Scientist, Sr.Scale
Dr. Sangeeta Lenka	Scientist
Mr. R. K. Mandloi	Tech. Officer (T-6)
Mr. P. K. Chouhan	Field Asstt. (T-4)
Mr. Darash Ram	Lab. Attendant/SSS
3. DIVISION OF SOIL CHEMISTRY & FERTILITY	
Dr. A. K. Biswas	Pr. Scientist & Head
Dr. K. Sammi Reddy	Pr. Scientist
Dr. Sanjay Srivastava	Sr. Scientist
Dr. N.K. Lenka	Sr. Scientist
Dr. B.L. Lakaria	Sr. Scientist
Dr. K. Ramesh	Sr. Scientist
Dr. Pramod Jha	Sr. Scientist
Ms. I.Rashmi	Scientist
Ms. Neenu, S.	Scientist
Mr. Deepak Kaul	Tech. Officer (T-6)
Mr. T. Ayodhya Ramaiah	Personal Assistant

Mr. K. S. Raghuvansi	Field Asstt. (T-3)
Mr. Sanjay Katinga	Lab Attendant/SSS
4. DIVISION OF ENVIRONMENTAL SOIL SCIENCE	
Dr. S.Kundu	Pr. Scientist & Head
Dr. K.B.Hebbar	Pr. Scientist
Dr. J. K. Saha	Pr. Scientist
Dr. Ajay	Pr. Scientist
Dr. Tapan Adhikari	Pr. Scientist
Dr. Nav Raten Panwar	Scientist, Sr.Scale
Mrs. Seema Sahu	Tech. Officer (T-6)
Mr. Kalicharan	Lab. Attendant/SSS
Mr. S. K. Rai	T-2
5. DIVISION OF SOIL BIOLOGY	
Dr. M. C. Manna	Pr. Scientist & Head
Dr. A. B. Singh	Pr. Scientist
Dr. A. K. Tripathi	Pr. Scientist
Dr. S. Ramana	Sr. Scientist
Dr. Ranjit Kumar	Sr. Scientist
Dr. Santosh Ranjan Mohanty	Sr. Scientist
Dr. Asit Mandal	Scientist
Mr. Vinodbabu Pal	Tech. Officer (T-5)
Mr. Vinod Choudhary	Lab Asstt. (T-2)
Mr. Bhoi Lal	Lab Attendant/SSG.II
6. STATISTICS AND COMPUTER APPLICATION SECTION	
Dr. K. N. Singh	Pr. Scientist & I/c Section
Mr. N. S. Raju*	Scientist
Mrs. Kavita Bai	Sweeper/SSS
7. PROJECT COORDINATING UNIT	
(a) Micronutrients	
Dr. M. V. Singh	Project Coordinator
Dr. Sanjib Kumar Behera	Scientist
Mr. Sahab Siddque	Tech. Officer (T-5)
Mr. Jai Singh	Field Asstt (T-4)
Mr.Venny Joy	Personal Assistant

Mr. Harish Kumar Barmiya

(b) STCR

Dr. Y. Muralidharudu

Dr. Abhishek Rathore^s

Dr. Baidya Nath Mandal

Mrs. Yojana Meshram

Mr. Janak Singh

Mr. Ram Bharose

(c) LTFE

Dr. Muneshwar Singh

Dr. R. H. Wanjari

Mr. A. K. Mishra

(d) AINP on Biofertilizers

Dr. D. L. N. Rao

Ms. T.K. Radha

Mr. Bhanwar Singh Yadav

8. CENTRAL LAB

Dr. A. K. Tripathi

Mr. Vinodbabu Pal

Mr. Jagannath Gour

9. TRAINING-CUM-REFERRAL SOIL TESTING LABORATORY

Dr. Y. Muralidharudu

Mr. Ram Bharose

10. LIBRARY, INFORMATION AND DOCUMENTATION UNIT

Mrs. Nirmala Mahajan

Mr. Arun Bhojraj Mate

11. ARIS CELL

Dr. J.Somasundaram

Mr. Babulal

12. TECHNICAL CELL

Dr. K. Sammi Reddy

Ms. Kirti Singh Bais

13. FARM SECTION

Dr. K. Ramesh

Lab Attendant/SSS

Project Coordinator

Scientist (SS)

Scientist

Personal Assistant

Khalasi/SSS

Lab Attendant/SSS

Project Coordinator

Sr. Scientist

Lab Attendant/SSS

Pr. Scientist & Network Coordinator

Scientist

Messenger/SSS

Pr. Scientist & I/c Lab

Tech. Officer (T-5)

Lab. Attendant/SSS

Project Coordinator

Lab Attendant/SSS

Tech. Officer (T-6)

Lab. Attdt/SSS

Sr. Scientist

Watchman/SSS

Pr. Scientist & I/c Technical Cell

Stenographer (Gr.III)

Sr. Scientist

Mr. V. B. Andurkar

Mr. D. R. Darwai

Mr. C. T. Wankhede

Mr. O. P. Shuk la

Mr. Hukum Singh

Mr. Bhagwat Prasad

Mr. Lalaram Sahu

Mr. Rakesh Sen

14. ADMINISTRATION SECTION

Mr. Kumar Vivek

Mr. Rajesh Dubey

Mr. P. S. Sunil Kumar

Mr. Anupam S. Rajput

Mr. M. S. Hedau

Mrs. Babita Tiwari

Mr. Anurag

Mr. Bansilal Sersodia

Mr. Heeralal Gupta

Mr. Somnath Mukherjee

Mr. Jineshwar Prasad

Mr. O. P. Yadav

Mr. L. N. Chouksey

Mr. Dharm Raj Singh

Mr. Subhash Khare

Mr. Amerjeet Singh

Mr. Pramod Raut

Mr. S. K. Batham

15. VEHICLE SECTION

Mr. Deepak Kaul

Mr. Sukhram Sen

Mr. Naresh Yadav

* On Study Leave

Farm Supdt. (T-9)

Field Asstt. (T-4)

Electrician (T-4)

Tractor Mechanic(T-4)

Field Asstt. (T-2)

Beldar/SSS

Beldar/SSS

Beldar/SSS

A.O.

A. F. & A. O.

Assistant

Assistant

Assistant

Assistant

Security Supervisor

U. D. C.

U. D. C.

L. D. C.

L. D. C.

L. D. C.

Messenger/SSS

Messenger/SSS

Sweeper/SSS

Watchman/SSS

Beldar/SSS

Messenger/SSS

T-6 & I/c Vhicle Section

Driver (T-2)

Driver (T-3)

^s On Deputation