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2015
International
Year of Soils

वार्षिक प्रतिवेदन Annual Report 2014-15



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Preface



The 68th UN General Assembly has officially recognized the 2015 as the International Year of Soils. This official recognition emphasizes the importance of soils beyond the soil science. However, this also reposes a greater responsibility to Soil Scientists towards not only their usual role of doing research on the management of soil resources but also towards creating an awareness among people on the roles and functions of soils in the sustenance of whole civilization. Soils have supported world civilizations including that of India. India has a total of 329 million hectare of geographical area with 141 million hectare of agricultural land. The entire food grain along-with oilseeds, sugar, fiber, fruits and vegetables has to come from this finite land. Even though the availability of total agricultural land has been constant, the per capita availability is continuously on decline which has put more and more taxation on our soils over the years. Naturally, such a delivery from soils in terms of productivity of crops is only possible if we give due consideration on the improvement and maintenance of the health of the soils. That means we have to have a regular monitoring of our soils.

Presently, the institute has been able to address the challenges / issues which have been depicted in this report traversing the research involving multi-scale approach from the nanotechnology to the landscape level to the biogeochemical reactions and processes in the environment from the nutrients and food security point of view. On a broader sense, this report encompasses the area of soil health and input use efficiency, conservation agriculture and carbon sequestration, soil microbial diversity and genomics, soil pollution, remediation and environmental security. The report has included the work done on integrated nutrient management, balanced fertilization, nutrient enriched compost and manure preparation, farmers' participatory research and demonstration of the technologies at farmers' fields under the aegis of various AICRP centers across the length and breadth of the country.

Some new technologies developed by the institute are: A mini lab named *Mridaparikshak* which can estimate 10 soil parameters viz., pH, EC, organic carbon, available N, P, K, S, Fe, Zn, and B; a novel bio-product prepared from biomass of *Jatropha* (*Jatropha curcas*) which could enhance microbial abundance including heterotrophs, N fixers and P solubilizers; and a bioreactor for accelerated decomposition of vegetable waste. On the basic research front, we identified that Archaea in soil contribute significantly to N₂O production. The functional groups for the biosorption of heavy metals were identified in the cytoplasmic membrane of isolated fungi. From single micronutrient deficiency delineation we have now marched to the identification of simultaneous deficiencies of more than one micronutrient. We found that deficiency of Zn+B in acid soils and Zn+Fe in semi-arid soils is coming up in a big way.

There has been a considerable progress in the studies on GIS/GPS based mapping of soil resources across the country at district level, carbon sequestration, greenhouse gas

emissions, crop modeling and climate change, soil resilience, soil and water quality, bio-fortification with micronutrients and microbial characterization using genomics and metagenomics. Further, this report presents a glimpse of all the important activities undertaken by the institute during the period reported upon. It is thus, a great pleasure for me to bring out the Annual report 2014-15 of the ICAR-Indian Institute of Soil Science.

On this occasion, I take this opportunity to express my sincere appreciation to all the Project Coordinators and Head of Divisions for compiling the information at AICRP/Divisional level. I also extend my gratitude to all the scientists and staff members of the institute for their painstaking efforts in carrying out the research and other developmental activities of institute and for providing the requisite material for compilation of this report.

I express my sincere appreciation to Drs. Sanjay Srivastava, Brij Lal Lakaria, A.K. Vishwakarma, M.L. Dotaniya, Asha Sahu, and Shinogi, K.C. for their dedicated efforts in compiling and editing the report. I also thank Dr. S. Kundu for and giving valuable suggestions, Dr. A.K. Tripathi for editing executive summary in Hindi and Mr. Sanjay K. Kori for Hindi typing.

I acknowledge with deep gratitude and respect to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR and Dr. Alok K. Sikka, Deputy Director General (NRM), ICAR for all round growth and development of the institute that has been possible with their able guidance, encouragement and continuous support. I am highly thankful to Dr. S.K. Chaudhari, Assistant Director General (S&WM), for his active involvement and constructive suggestions in carrying out various activities.

Bhopal
June 2015



(Ashok K. Patra)
Director

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विशिष्ट सारांश

प्रसंग 1: मृदा स्वास्थ्य एवं निवेश उपयोग दक्षता

मृदा उर्वरता मूल्यांकन

- भारतीय मृदा विज्ञान संस्थान द्वारा एक मिनी प्रयोगशाला "मृदापरीक्षक" विकसित की गई है जो मृदा के 10 गुणों का आंकलन करने में सक्षम है। ये गुण हैं – मृदा अभिक्रिया, मृदा लवणता, जैविक कार्बन, मृदा में उपलब्ध नत्रजन, फॉस्फोरस, पोटेशियम, सल्फर, लोहा, जिंक तथा बोरॉन। यह मृदापरीक्षक विशिष्ट मृदाओं व फसलों के अनुरूप उर्वरक अनुशंसाएं भी प्रदान करता है। इससे प्राप्त परिणाम किसान के मोबाइल पर सीधे पहुँच जाते हैं।
- महाराष्ट्र के पुणे व जलगांव तथा तमिलनाडु के डीनडीगल जिलों की मिट्टियों का जी.आई.एस. व जी.पी.एस. आधारित मृदा उर्वरता नक्शा तैयार किया गया जिसमें पी.एच., ई.सी., जैविक कार्बन तथा मुख्य व सूक्ष्म तत्वों का विश्लेषण शामिल था।
- मृदाओं के 97464 नमूनों के विश्लेषण से ज्ञात हुआ कि क्रमशः 43.0, 12.1, 5.4, 5.6 और 18.3 प्रतिशत नमूनों में जस्ता, लोहा, तांबा, मैंगनीज तथा बोरॉन की कमी है। किन्हीं दो तत्वों की कमी विशेषकर जस्ता+बोरॉन की अम्लीय मृदाओं में तथा जस्ता+लोहा की अर्द्ध-शुष्क क्षेत्रों की मृदाओं में कई फसल प्रणालियों में भविष्य के लिए एक चेतावनी के रूप में उभर कर आ रही हैं। इस प्रकार तैयार किए गए सूक्ष्म पोषक तत्वों के नक्शों से इनके प्रति वैज्ञानिक समझ का विकास होगा और ये हमें सूक्ष्म पोषक तत्वों की कमी वाले क्षेत्रों में सूक्ष्म उर्वरकों के वितरण की योजना व निर्णय लेने में सहायक होंगे।
- जोधपुर से प्राप्त ज्योलाइट्स के मध्यम सरन्धता आकृति विज्ञान तथा कणाकार के विश्लेषण से ज्ञात हुआ कि कणों का माप 21.1 से 59.8 नैनोमीटर, लम्बाई 56.7 से 732.8 नैनोमीटर थी। ज्योलाइट्स का बी.ई.टी. पृष्ठीय क्षेत्रफल 10.90 ± 0.03 मी² प्रति ग्राम रहा। मध्यम छिद्रों के पृष्ठीय क्षेत्रफल, एक बिन्दु पृष्ठ क्षेत्रफल, डी.एच. अवशोषण पृष्ठ क्षेत्रफल द्वारा भिन्न-भिन्न छिद्र सतह क्षेत्रफल दर्शाए गए। इन चित्रों के सावधानीपूर्वक विश्लेषण से यह इंगित हुआ कि छिद्रों का आयतन दीर्घ छिद्र क्षेत्र में अधिक है।

परिवर्तित पोषक तत्व उत्पादों का मूल्यांकन

- जिंक ऑक्साइड, कॉपर ऑक्साइड तथा फ़ैरिक ऑक्साइड नैनो सूक्ष्म तत्व उर्वरकों का गेहूँ व मक्का फसल की वृद्धि व उपापचय पर प्रभाव के अध्ययन में पाया गया कि मक्का व गेहूँ फसल की जड़ के विकास में 45 दिन तक कोई दुष्प्रभाव नहीं पड़ा परन्तु बुआई के 30 दिन बाद मक्का के पौधों की वृद्धि प्रभावित हुई। कॉपर नैनो उर्वरक द्वारा मक्का के पौधे अधिक लम्बे हुए जबकि फ़ैरिक ऑक्साइड नैनो उर्वरक का ऐसा प्रभाव नहीं देखा गया। लोहे व जिंक के नैनो उर्वरकों के उपयोग से मध्यम एस.ओ.डी./सी.ए.टी. की गतिविधि तथा कॉपर नैनो उर्वरक द्वारा मध्यम पी.ओ.एक्स. गतिविधि दर्ज की गई जिससे इन नैनो उर्वरकों से पौधों में न्यूनतम तनाव देखा गया।
- मक्का की फसल में नत्रजन उर्वरकों की उच्च उपयोग दक्षता तथा उत्पादकता में बढ़ोत्तरी के लिए यूरिया के विभिन्न परिष्कृत रूपों का मूल्यांकन किया गया। यह पाया गया कि नत्रजन के रूप में यूरिया के विभिन्न उत्पादों द्वारा नत्रजन उपयोग दक्षता में अर्थपूर्ण वृद्धि हुई। नीम लेपित यूरिया द्वारा अधिकतम दाना उपज, डण्डल उपज तथा कुल जैविक उत्पादन प्राप्त हुआ। तत्पश्चात् बाँयोचार लेपित यूरिया तथा पाइन ओलियोरेजिन यूरिया का प्रदर्शन रहा। दाना उपज में नीम लेपित यूरिया, बाँयोचार लेपित यूरिया तथा पाइन ओलियोरेजिन लेपित यूरिया (120 किग्रा. N/हे.) द्वारा साधारण यूरिया की तुलना में क्रमशः 19.0, 9.8 तथा 7.

71 प्रतिशत वृद्धि दर्ज की गई।

- पाइन ओलियोरेजिन लेपित यूरिया उर्वरकों (1.3, 2.5, 3.8 और 5.0 प्रतिशत पाइन ओलियोरेजिन) के मक्का की फसल पर प्रभाव को वर्टीसोल, इन्सेप्टीसोल, अल्फीसोल तथा एरीडीसोल मृदाओं में अध्ययन किया गया। वर्टीसोल मृदा में नत्रजन उपयोग दक्षता 19.3 से बढ़कर 32.8 प्रतिशत हुई, अल्फीसोल मृदा में यह 13.1 से बढ़कर 28.1 प्रतिशत, इन्सेप्टीसोल मृदाओं में 13.9 से 23.8 प्रतिशत और एरीडीसोल मृदा में 10.68 से बढ़कर 20.2 प्रतिशत हुई।
- पाइन ओलियोरेजिन (पी.ओ.आर.), नैनो जिंक ऑक्साइड (<100 नैनो मीटर) और नैनो रॉक फॉस्फेट (48.6 नैनो मीटर) को एक लेपन सामग्री के रूप में प्रयोग करने से नाइट्रोजन डाइऑक्साइड के उत्सर्जन को कम करने का प्रयास प्रयोगशाला में नियंत्रित वातावरण में किया गया। सामान्य दानेदार यूरिया की तुलना में पी.ओ.आर. लेपित यूरिया (5 प्रतिशत) द्वारा मिट्टी में नाइट्रस ऑक्साइड का उत्सर्जन 20.3 प्रतिशत तक कम हुआ। पी.ओ.आर. में 2 प्रतिशत नैनो जिंक ऑक्साइड या 35 प्रतिशत नैनो रॉक फॉस्फेट मिलाने से क्रमशः 45 प्रतिशत तथा 40.1 प्रतिशत नाइट्रोजन ऑक्साइड उत्सर्जन कम हुआ।
- 90 दिन के एक रुष्मायन अध्ययन में मिट्टी में 2, 4 व 6 प्रतिशत सूबबूल बायोचार मिलाने से मृदा के पी.एच. मान में क्रमशः 0.65, 1.35 तथा 2.0 यूनिट की बढ़ोत्तरी दर्ज हुई। बाँयोचार के उपयोग से अमोनियाकल नत्रजन में कमी हुई परन्तु 2 व 4 प्रतिशत बायोचार मिलाने से नाइट्रेट नत्रजन में 3 से 5 गुणा वृद्धि हुई। इसके साथ-साथ इन्हीं दरों पर बाँयोचार मिलाने से कैल्शियम, मैग्नीशियम की सांद्रता में क्रमशः 50, 92 और 138 प्रतिशत वृद्धि तथा विनिमय पोटाश की मात्रा में 5.8, 9.2 व 13.8 गुणा वृद्धि हुई।
- एक निक्षालन अध्ययन में यह पाया कि उर्वरकों के साथ बाँयोचार के प्रयोग से (10 व 20 टन/हे.) 30 से.मी. तक की गहराई तक नत्रजन के निक्षालन नुकसान में क्रमशः 25 व 37 प्रतिशत तक की कमी लाल व काली मिट्टी में देखी गई।

संतुलित एवं एकीकृत पोषक तत्व प्रबंधन

- नत्रजन पोषक तत्व की एस.टी.सी.आर. मात्रा विभिन्न मात्राओं व विभिन्न समय पर मक्का की फसल में डालने से अधिकतम कुल जैविक पदार्थ उपज प्राप्त हुई। नत्रजन की विभिन्न मात्रा को डालने से डण्डल व दाना की उपज में उन उपचारों में अर्थपूर्ण वृद्धि दर्ज की गई जहां बुआई के समय नत्रजन नहीं डाली गई थी तथा कुल नत्रजन को दो टुकड़ों में विभाजित कर बुआई के 20 व 40 दिन बाद दी गई थी।
- मक्का – चना फसल प्रणाली के तहत फसलों की उत्पादकता वृद्धि के लिए वर्टीसोल मृदा में विभिन्न एकीकृत पोषक तत्वों की आपूर्ति हेतु अनेक मापांक के मूल्यांकन के अध्ययन से यह ज्ञात हुआ कि 75 प्रतिशत एन.पी.के. तथा 5 टन देशी खाद डालने से अनाज की अधिक पैदावार हुई। केवल जैविक खाद डालने से फसल की उपज में अर्थपूर्ण कमी देखी गई जबकि आई.एन.एम. मापांक द्वारा जी.आर.डी. के बराबर उपज प्राप्त हुई। समन्वित पौध पोषक मापांकों में देशी खाद आधारित आई.एन.एम. मापांक (75 प्रतिशत एन. पी. के. तथा 5 टन देशी खाद) व तत्पश्चात एस.टी.सी.आर. मापांक उर्वरकों से मक्का की फसल द्वारा नत्रजन, फॉस्फोरस तथा पोटाश तत्वों का अवशोषण, सस्य दक्षता तथा आंशिक कारक उत्पादकता (Partial factor productivity) अधिक रही।
- जैविक खेती व सामान्य खेती पर आधारित अध्ययन में यह पाया गया कि जैविक तकनीक द्वारा अन्य विधियों की तुलना में अधिक उपज प्राप्त हुई। 100 प्रतिशत जैविक प्रणाली व 75 प्रतिशत जैविक पोषण, अभिनव पोषण द्वारा फसल उपज लगभग बराबर रही।

- जैविक पौध पोषण के अंतर्गत सोयाबीन व मक्का की विभिन्न किस्मों का मूल्यांकन किया गया। सोयाबीन की किस्मों RVS-2002-4 तत्पश्चात् JS-97-52 और JS-20-41 का प्रदर्शन श्रेष्ठ रहा। इसी प्रकार मक्का की कंचन किस्म की उपज उच्चतम थी परन्तु स्वीट कार्न की उपज न्यूनतम रही।

संतुलित एवं एकीकृत पोषक तत्व प्रबंधन पर प्रदर्शन

- भारतीय मृदा विज्ञान संस्थान द्वारा विकसित तकनीकों (एकीकृत पौध पोषण प्रणाली, एस.टी.सी.आर. आधारित उर्वरक उपयोग, एकीकृत पौध पोषण प्रणाली के साथ फॉस्फो-सल्फो-नाइट्रो कम्पोस्ट व जैव उर्वरक) के प्रदर्शन किसानों के खेतों पर लगाए गए जिनसे यह पता चला कि ये तकनीकें उन दशाओं में भी प्रभावी हैं जहां प्रक्षेत्र संसाधनों का अभाव भी रहा हो। इन तकनीकों द्वारा किसान पद्धति की तुलना में सोयाबीन-गेहूँ फसल प्रणाली के तहत एकीकृत पौध पोषण प्रणाली से 17.0 प्रतिशत तथा इसी प्रणाली के साथ फॉस्फो-सल्फो-नाइट्रो कम्पोस्ट देने से 22.9 प्रतिशत, एस.टी.सी.आर. आधारित उर्वरक से 18.5 प्रतिशत अधिक सोयाबीन उत्पादन प्राप्त हुई। इसी प्रकार गेहूँ में यह वृद्धि इन तकनीकों द्वारा क्रमशः 9.5, 22.0 तथा 14.8 प्रतिशत अधिक रही।
- मध्य प्रदेश के आदिवासी बहुल अलीराजपुर और झाबुआ जिलों के किसानों के खेतों में प्रदर्शन परीक्षण (सोयाबीन के लिए 6 और मक्का के लिए 4) खरीफ मौसम के दौरान आयोजित किये गये। दोनों फसलों में किसान पद्धति की तुलना में एस.टी.सी.आर. पद्धति का बेहतर प्रदर्शन रहा तत्पश्चात् समन्वित पौध पोषण प्रणाली और उर्वरकों की अनुसंधित मात्रा का प्रदर्शन रहा।
- नैनो रॉक फॉस्फेट लेपित यूरिया मिट्टी में डालने से मक्का फसल में नत्रजन एवं फॉस्फोरस उपयोग दक्षता में सुधार हुआ।
- एस.टी.सी.आर. तकनीक की प्रयोज्यता का परीक्षण करने के लिए विभिन्न फसलों के अन्तर्गत प्रदर्शन प्रयोग मक्का (बैंगलोर), रागी (हीरीयूर), आलू (हिमाचल प्रदेश), सर्द धान व मूंग (जोरहट) की फसल में लगाए गए। इसके साथ-साथ, किसानों के खेतों पर आलू (भुवनेश्वर), सरसों (दियोगढ़), राया (पंजाब) तथा सोयाबीन व तोरिया (हिमाचल प्रदेश) में प्रथम पंक्ति प्रदर्शन लगाए गए।
- आदिवासी उप-योजना के तहत तमिलनाडु और रायपुर में अनेक 'खेत दिवस' आयोजित किए गए। आंध्रप्रदेश के एच.डी. कोटे तालुक में मृदा नमूनों का विश्लेषण किया गया व किसानों को उर्वरक वितरण किया गया।
- झारखंड राज्य के सिंह भूमि व रांची जिलों में लगाए गए खेत परीक्षणों से ज्ञात हुआ कि गेहूँ की फसल में बुनियादी स्लैग डालने से किसानों की पद्धति की तुलना में फसल उत्पादकता में 10 से 12 प्रतिशत वृद्धि हुई। लेकिन अनुसंधित उर्वरकों के साथ बेसिक स्लैग व चूने के संयुक्त उपयोग से उपज में और अधिक वृद्धि दर्ज हुई। आँकड़ों से यह भी विदित हुआ कि चूना व बेसिक स्लैग का फसल उत्पादन पर एक जैसा प्रभाव था। इन मृदा सुधारकों के उपयोग से भूमि के पी.एच. मान में वृद्धि दर्ज हुई जिससे फसलों के लिए पोषक तत्वों की उपलब्धता में वृद्धि हुई व फसल उत्पादन भी बढ़ा।

प्रसंग 2: संरक्षित कृषि, कार्बन स्थिरीकरण एवं जलवायु परिवर्तन

संरक्षित कृषि एवं जलवायु परिवर्तन

- एक मॉडलिंग अध्ययन में एप्सिम मॉडल द्वारा यह इंगित हुआ कि कार्बन डाइऑक्साइड की मात्रा में कोई वृद्धि न होने पर यदि तापमान 1° सेंटीग्रेड बढ़ता है तो गेहूँ की उत्पादकता में 8.4 प्रतिशत की कमी आ जाती है और कुल जैविक पदार्थ उपज में 7.8 प्रतिशत की कमी आई जबकि 4.5° सेंटीग्रेड तापमान में वृद्धि से यह कमी क्रमशः 39

- तथा 37 प्रतिशत थी। इसके विपरीत तापमान में बिना कोई वृद्धि हुए यदि कार्बन डाइऑक्साइड की मात्रा में वृद्धि 350 से 500 पी.पी.एम. होने पर गेहूँ की उपज 14.6 प्रतिशत व कुल जैविक पदार्थ की उपज 15 प्रतिशत बढ़ गई।
- संयुक्त रूप से कार्बन डाइऑक्साइड की मात्रा में 1° सेंटीग्रेड की वृद्धि से गेहूँ की उपज में 5 प्रतिशत की वृद्धि हुई। जबकि 500 पी. पी. एम. कार्बन डाइऑक्साइड व 4.5° सेंटीग्रेड तापमान होने से गेहूँ की उपज 22 प्रतिशत कम हुई जो कि अकेले सिर्फ तापमान में वृद्धि की तुलना में 17 प्रतिशत अधिक थी। गेहूँ की उपज पर कार्बन डाइऑक्साइड व ताममान का संयुक्त प्रभाव ही इस सदी के अंत तक पर्यावरण का असर कहलाया जा सकता है।
 - कम से कम सीमित पानी श्रृंखला (एल.एल.डब्ल्यू.आर. – फसल के विकास के लिए मिट्टी के संरचनात्मक गुणवत्ता का एक सूचकांक) के आंकलन करने के लिए जुताई और खाद के तहत सोयाबीन – गेहूँ फसल चक्र के छः वर्षों के परस्पर प्रभाव प्रतिक्रिया वाले प्रयोग का उपयोग किया गया। कम से कम सीमित पानी श्रृंखला (एल.एल.डब्ल्यू.आर.) की मात्रा ऊपरी 15 से.मी. परत में कम जुताई के उपचार की तुलना में बिना जुताई के तहत कम थी। इससे यह प्रदर्शित हुआ कि बिना जुताई की तुलना में कम जुताई विधि से वर्टिसोल मिट्टी की संरचनात्मक गुणवत्ता में सुधार हुआ है।
 - सोयाबीन – गेहूँ फसल प्रणाली में वर्टिसोल से संचयी नाइट्रस ऑक्साइड और कार्बन डाइऑक्साइड उत्सर्जन क्षेत्र प्रयोग के नौ साल बाद क्रमशः एकीकृत तत्व प्रबंधन > जैविक > एन. पी. के. उपचारों में था। ग्लोबल वार्मिंग की क्षमता एकीकृत तत्व प्रबंधन के तहत सबसे ज्यादा (15,514 किलो कार्बन डाइऑक्साइड प्रति हेक्टेयर) तत्पश्चात् जैविक खाद (13,735 किलो कार्बन डाइऑक्साइड प्रति हेक्टेयर) और अकार्बनिक उपचार के तहत सबसे कम (11,383 किलो कार्बन डाइऑक्साइड प्रति हेक्टेयर) पाई गई।

जड़ वितरण मॉडल

- मृदा में जल व पानी का वितरण असमान रूप में रहता है। पौधों की जड़ों का वितरण ही भूमि से पानी व तत्व को पौधों के लिए उपलब्धता सुरक्षित व सुनिश्चित करता है। विभिन्न प्रबंध तकनीकों के तहत विभिन्न सांख्यिकीय मॉडल का मूल्यांकन किया गया। विभिन्न मॉडल में से क्युबिक मॉडल को इसके अच्छे R^2 (0.82) व कम RMSS (0.051) के आधार पर मध्य भारत की वर्टिसोल मृदा परिच्छेद में जल भार घनत्व के अध्ययन के लिए उपयुक्त पाया गया।

प्रसंग 3: सूक्ष्म जैविक विविधता और जैव प्रौद्योगिकी

जैव विविधता

- जैट्रोफा के राइजोस्फीयर व फाइलोस्फीयर में पोषक तत्वों के चक्रीय प्रक्रिया हेतु संभावित सूक्ष्मजीवों को अलग करने के लिए अध्ययन किया गया। समृद्ध विधि द्वारा विभिन्न क्रियाशील समूह अलग किए गए व उनको चिन्हित किया गया। एक दूसरे अध्ययन में, जैट्रोफा के जैविक पदार्थ से एक अर्क तैयार किया गया जिसके उपयोग से सूक्ष्म जीवों तथा हेट्रोट्रोफस, नत्रजन स्थिर करने वाले व फॉस्फोरस घोलक जीवों की संख्या में वृद्धि दर्ज हुई। यह भी ज्ञात हुआ कि जीवाणुओं की तरह 'आरकिया' भी नाइट्रस ऑक्साइड के उत्पादन में महत्वपूर्ण योगदान करते हैं।
- एक मेटाजिनोमिक अध्ययन से यह प्रदर्शित हुआ कि यूबैक्टीरियल जातियों की अधिकता और विविधता कोपियोट्राफिक बैक्टीरिया की अधिक संख्या, खास जातियाँ तथा कोशिका विभाजन व श्वसन क्रिया में उत्तरदायी जीनों की अधिकता जैविक खेती के तहत मिट्टियों में रहती है।
- एक एच.सी. एच. (हेक्सा-क्लोरो साइक्लो हेक्सेन) से ग्रसित कचरे में से एक आदर्श पैरापीडोबैक्टर इंडीकस जाति नोव. (यूबैक्टीरियल आइसोलेट) चिन्हित करके उसके गुणों का आंकलन किया गया।

- बी. टी. कपास के राइजोस्फीयर में सामान्य कपास की तुलना में 2.5 से 9.8 प्रतिशत अधिक ग्लोमालिन प्रोटीन दर्ज किया गया।
- राजस्थान और हरियाणा के शुष्क व अतिशुष्क क्षेत्रों से लगभग 700 राइजोबियल उपभेदों के तनाव सहनशीलता, परमाणु विविधता और पी.जी.पी.आर. गुणों का चरित्रांकन किया गया। राजस्थान के शुष्क क्षेत्रों में राइजोबिया की अधिकतम संख्या (एम.पी.एन.) 170 से 1000 राइजोबिया प्रति ग्राम मृदा पायी गई।
- अम्लीय मृदाओं से प्राप्त राइजोबिया आइसोलेट्स में बहुत आवश्यक व विचित्र प्रोटीन भिन्नता का अध्ययन प्रोटियोमिक्स विधि से करने पर ज्ञात हुआ कि यूबैक्टीरिया के अनुकूलन में 14 जीन्स अति आवश्यक भूमिका अदा करते हैं।
- हिमाचल प्रदेश की मिट्टियों से गेहूँ, सी बकथान और खुमानी के पौधों के राजोस्फियर से प्राप्त नमूनों से 500 से अधिक राजोबैक्टीरिया पी.जी.पी.आर. गुणों के लिए चिन्हित किये गये।
- मूँगफली के लिए फ्लोरोसेंट स्यूडोमोनास, कपास के लिए जस्ता घोलक बैक्टीरिया, सोयाबीन, चना और गेहूँ के लिए एक्टीनोमाइसिटीस धान, पटसन, आर्द्र व उष्ण सब्जियों व शिमला मिर्च के लिए जैव उर्वरकों तथा उत्तर-पूर्वी पहाड़ी क्षेत्रों में धान के लिए जैविक खादों के प्रदर्शनों से पोषक तत्वों की बचत हुई व अधिक फसल उपज प्राप्त हुई।
- जैव विविधता और जैव उर्वरक पर अखिल भारतीय नेटवर्क परियोजना के विभिन्न केन्द्रों द्वारा उत्पादित जैव उर्वरकों से 113.20 लाख रुपये की आमदनी प्राप्त हुई।
- संस्थान ने जैविक पदार्थों के त्वरित विघटन की तकनीक विकसित की है। सब्जियों के अवशेषों के शीघ्र विघटन हेतु एक जैव-रियेक्टर का निर्माण किया गया जिससे 30 दिनों में एक गंधरहित, भूरी खाद बनाई जा सकी। इस खाद में कार्बन व नत्रजन का अनुपात 14:1, धनायन विनिमय क्षमता 94 सेंटीमोल (प्रोटोन) प्रति किलो ग्राम तथा लिग्निन/सेलुलोज व धनायन विनिमय क्षमता / कुल कार्बन इन्डेक्स क्रमशः 2.4 व 4.56 थी।

प्रसंग 4: मृदा प्रदूषण एवं निराकरण

सूक्ष्म जीवों द्वारा मृदा प्रदूषण निराकरण

- अलग किये गये कवकों की साइटोप्लाज्मिक झिल्ली में विभिन्न क्रियाशील समूहों के अमाइड समूह (-NH), हाइड्रॉक्सिल समूह, (-OH), कार्बोक्सिलेट एनायन्स (-COO), कार्बोनिल समूह (-CO), सी-फ्लोराइड और सी-ब्रोमीन पाए गए। ये सभी भारी धातुओं के अवशोषण के लिए उत्तरदायी पाए गए। ये क्रियाशील समूह चार कवकों-ऐस्परजिलस फ्लेक्स, ऐस्परजिलस टैरस, ऐस्परजिलस अवामोरी और राइजोम्यूकर पसीलस में पाए गए।
- जैविक कवकों की तुलना में मरे हुए कवकों के ऊतकों के जैव अवशोषण अध्ययन फ्रैंडलिच मॉडल द्वारा किया गया। मॉडल की उच्च K मान इंगित करती है कि धातुओं का जैव अवशोषण अच्छा है। सभी कवकों की K मान शीशा के लिए उच्च पाई गई। जैव-फिल्टर को 30 दिन तक 'शहरी ठोस कचरे' में रखने से शीशा का उच्चतम अवशोषण हुआ और इससे कम निकल तथा जस्ता का अवशोषण रहा। यह भी देखा गया कि छः कवकों में से ट्राइकोडर्मा वीरिडी शीशा, निकल, जस्ता व कैडमियम के अवशोषण हेतु सर्वश्रेष्ठ थी। तत्पश्चात् ऐस्परजिलस फ्लेक्स का प्रदर्शन रहा।

मृदा प्रदूषण जांच

- भोपाल शहर के सीमावर्ती क्षेत्रों में नलकूप सिंचित क्षेत्र की तुलना में सिंचाई के लिए सीवेज के पानी के लगातार प्रयोग से कुल कॉपर, कैडमियम, सीसा, क्रोमियम, निकल तथा जस्ता की मात्रा में क्रमशः 2.1, 3.2, 1.4, 1.8, 2.0 और 1.6 गुना वृद्धि हुई है। मिट्टी में 15, 30, 45 और 60 से.मी. गहराई पर मृदा जैविक पदार्थ की मात्रा में नलकूप सिंचित क्षेत्र की तुलना में सीवेज सिंचित क्षेत्रों में क्रमशः 1.6, 1.8, 2.1 और 2.5 गुना वृद्धि हुई।
- पालक के बायोमास में क्रोमियम संदूषण व भारी धातुओं के बीच पारस्परिक क्रिया की जांच की गई। क्रोमियम दूषित मिट्टी (100 मिलीग्राम क्रोमियम/किग्रा. मिट्टी) में 2 मिलीग्राम कैडमियम प्रति किग्रा. मिट्टी में डालने से पालक की जड़ व तना में क्रोमियम की मात्रा में कमी पाई गई। जस्ता डालने से जड़ व तना में क्रोमियम की सांद्रता पर कोई अर्थपूर्ण प्रभाव नहीं पड़ा।

EXECUTIVE SUMMARY

Theme I: Soil Health and Input Use Efficiency

Soil Fertility Evaluation

- A new mini lab named *Mridaparikshak* was developed that can estimate 10 parameters viz., pH, EC, Organic carbon, available N, P, K, S, Fe, Zn, and B. Through *Mridaparikshak* soil test based nutrient recommendations can be obtained for specified targets for selected crops and soils. The test results can be messaged directly to farmers' mobile.
- GPS and GIS based soil fertility maps (macro and micro-nutrients, organic C, pH, and EC) were developed for three districts, viz., Pune & Jalgaon of Maharashtra and Dindigal district of Tamil Nadu.
- Based on the analysis of results of 97464 surface soil samples, on average 43.0, 12.1, 5.4, 5.6 and 18.3% soils are deficient in Zn, Fe, Cu, Mn and B, respectively. The deficiency of two elements, particularly Zn+B in acid soils and Zn+Fe in semi-arid soils is coming up in many cropping systems. Soil micronutrients maps were developed to improve our understanding regarding micronutrients problems. These maps would be helpful in taking policy decisions regarding distribution of micronutrient carrying fertilizer materials to the locations/soils deficient in respective micronutrients.
- Analysis of meso-porosity, morphology and textural characteristics of a commercial Indian zeolite obtained from Jodhpur, Rajasthan revealed that the particles ranged between 21.1 and 59.8 nm, while length was 56.7 to 732.8 nm. BET surface area was found to be $10.9 \pm 0.03 \text{ m}^2/\text{g}$. Different methods of meso pore surface area determination i.e. -BJH desorption surface area, the single point surface area and the DH desorption surface area predicted divergent surface areas for the pores. The porosity distribution through original density functional theory (DFT) has indicated that the total area under pores is $6.89 \text{ m}^2/\text{g}$.

Evaluating Modified Plant Nutrient Products

- The impact of Nano-micronutrient fertilization on growth and metabolism of wheat and maize plants in a hydroponic as well as sand culture system using ZnO, CuO and Fe₃O₄ nanoparticles (NPs) revealed that NPs did not affect the root growth of maize and wheat up to 45 DAS but shoot growth was variably influenced after 30 DAS in maize. Taller plants with more biomass were observed with CuO NP treatment but not with Fe₃O₄ NP treatment. Fe NP and Zn NP treated plants showed moderate level of SOD/ CAT activities and Cu NP treated plants showed moderate POX indicating lower level of stress experienced by NP treated plants.
- Different modified urea materials evaluated for enhancing nitrogen use efficiency and sustaining crop productivity in maize during *Kharif* 2014 showed that maize yield and nitrogen use efficiency (NUE) were significantly different with the application of different

modified urea materials. Application of *neem* coated urea (NCU) recorded the highest grain, stover and total dry matter yield of maize and NUE followed by biochar coated urea (BCU) and pine oleoresin coated urea (PORU). The increase in grain yield was 19%, 9.9% and 7.7% under NCU, BCU and PORU over the prilled urea (PU), respectively at higher levels of nitrogen (120 kg N/ha).

- A study was conducted with maize in Vertisol, Inceptisol, Alfisol and Aridisol to evaluate the efficacy of the pine oleoresin (POR) coated urea fertilizers (coated with 1.3, 2.5, 3.8 and 5% pine oleoresin). Nitrogen use efficiency increased from 19.3% to 32.8% in Vertisol, 13.1% to 28.3% in Alfisol, 13.9% to 23.9% in Inceptisol and 10.7% to 20.2% in Aridisol, as a result of coating urea with pine oleoresin.
- An experiment under laboratory controlled condition was attempted to reduce N₂O emission through use of POR, nano-ZnO (<100 nm) and nano rock phosphate (<48.6 nm) as a coating material. In comparison with normal prilled urea, application of POR (5%) coated urea reduced the N₂O emission in soil to the extent of 20.3%. Further mixing of 2% nano-ZnO or 35% nano rock phosphate particles to POR coating decreased the N₂O emission to 45% or 40%, respectively.

Balanced and Integrated Nutrient Management

- Agronomic interventions through N application into different split doses at varying levels and at different times of application in maize crop showed that total dry matter yield of maize crop was higher with soil test crop response (STCR) equation based fertilizer application while among the varying N rates and time of application, grain and stover yield were significantly higher in the treatments where basal dose of N was skipped and total N was applied in two equal splits (60 kg N/ha) at 20 and 40 days after sowing (DAS).
- A three year field study on evaluation of different integrated plant nutrient supply modules for maize - chickpea cropping sequence for sustainable crop productivity in Vertisol revealed significantly higher grain yield of maize with application of 75% NPK of STCR based dose +5 t FYM. All INM modules were statistically at par with General Recommended Dose (GRD) in terms of maize yield, whereas only organic treatments were significantly lower than GRD. Among the different INM modules, FYM based INM module (75% NPK of STCR based dose +5 t FYM) gave significantly higher N, P and K uptake, agronomic efficiency and partial factor productivity by maize crop followed by STCR based recommended dose of fertilizers.
- The yield of soybean crop in all the cropping systems was higher in organic practices than the integrated and inorganic practices. Among the cropping systems, the yield of soybean was found highest in soybean-mustard cropping system under organic practises. There was not significant difference in yield between 100% organic and 75% organic with innovative practice.
- Performance of organic package of practices (OPoPs) on soybean and maize crops was

studied. Soybean variety RVS-2002-4 was found to produce highest yield followed by JS-97-52 and JS-20-41. In maize, cv. Kanchan recorded maximum seed yield while, cv. sweet corn produced poor yield under OPoPs.

Demonstrations on Balanced and Integrated Nutrient Management

- Demonstration of some technologies (developed by IISS) viz., Integrated Plant Nutrient Supply System (IPNS-I), STCR based fertilizer recommendations, IPNS using Phospho-sulpho-nitro compost (IPNS-II), and biofertilizers (used along with IPNS-I and compost treatments) in the farmers' fields showed that these technologies have the potential to sustain the yield even under constrained on-farm resources. The average increase in yield showed by these technologies over farmers' practice for a period of two years (soybean-wheat cropping system) were 17.0% with IPNS-1, 22.9% with IPNS-2, 18.5% with STCR for the soybean crop and 9.5% with IPNS-1, 22.0% with IPNS-2, 14.8 % with STCR for the wheat crop.
- Demonstration trials (6 for soybean and 4 for maize) have been conducted in farmers' fields of tribal dominated Alirajpur and Jhabua districts of M. P. during *kharif* 2014. In both the crops STCR performed better than farmers practice followed by IPNS & RDF.
- Application of nano rock phosphate coated urea improved the N and P use efficiency in case of maize crop in different soils.
- Follow up experiments were conducted on maize (Bangalore), ragi (Hiriyur), potato (Himachal Pradesh), winter rice (Jorhat), and green gram (Jorhat) to test the applicability of STCR technology. In general, the fertilizer nutrients applied through STCR technology gave higher yields with higher B/C ratios.
- Frontline demonstration on STCR technology were conducted in farmers' fields on tomato (Bhubaneswar), mustard (Deogarh), raya (different agroecoregions of Punjab), soybean and toria (Palampur).
- Several field days were organized under the tribal sub plan (TSP) in Tamil Nadu and Raipur. Soil samples were analyzed and fertilizers were distributed to farmers of Kakanakote forest area of H.D. Kote *taluk* in Andhra Pradesh.
- Field demonstrations in Ranchi and Singhbhum districts of Jharkhand revealed that productivity of wheat enhanced by 10 to 12% over farmer's practice when basic slag was applied as soil amendment. However increase in productivity was further enhanced when basic slag and lime were jointly used with recommended dose of nutrients. Data further indicated that both basic slag and lime are equally effective in terms of yield. The increase in productivity on amending soil with lime or basic slag was due to increase in availability of nutrients as a result of increase in soil pH.

Theme II: Conservation Agriculture, Carbon Sequestration and Climate Change

Conservation Agriculture and Climate Change

- In a modeling study, the APSIM-Wheat model indicated that 1°C increase in temperature with ambient CO₂ concentration, reduced wheat grain yield by 8.4%, and biomass yield by 7.8%, while 4.5°C increase in temperature without elevated CO₂ concentration, reduced wheat grain yield by 39% and biomass yield by 37%. In contrast, elevated CO₂ (from 350 to 500 ppm), with ambient temperature, stimulated wheat grain yield by 14.6% and biomass yield by 15%. Furthermore, the combination of 500 ppm CO₂ concentration and 1°C increase in temperature, increased wheat grain yield by 5%. The combination of 500 ppm CO₂ concentration and 4.5°C increase in temperature resulted in reduced wheat grain yield by 22%, which is 17% higher as compared to the individual increase of temperature alone. This combined effect on wheat yield may be regarded as the predicted climatic effect over the end of the century (RCP 2.6, IPCC AR 5).
- The interactive effect of tillage and manure was used to assess response to least limiting water range (LLWR is an index of structural quality of soil for crop growth) in Vertisol after six years of soybean-wheat cropping cycle. The LLWR values were lower under no tillage as compared to reduced tillage treatments in upper 15 cm layer. This indicates that reduce tillage improves soil structural quality in Vertisol as compared to no tillage.

Root Distribution Modeling

- Water and nutrients are heterogeneously distributed in soil and the distribution of roots markedly affects the ability of a plant to secure these soil-based resources. Hence, it is important to model distribution of root biomass in the soil profile. Different statistical models evaluated and tested under different management practices revealed that the cubic model was the best on the basis of higher R² (0.83), adjusted R² (0.82) and lower root mean square error (0.051). Validation of developed model indicated that this model may be used to study distribution of root mass density in soil profiles in Vertisol of central India.

Theme III: Microbial Diversity and Biotechnology

Harnessing Microbial Diversity

- Experiments were carried out to isolate potential microbial groups involved in nutrient cycling process in the rhizosphere and phyllosphere of *Jatropha curcas*. Using enrichment method different functional groups were isolated and characterized. 16S rRNA gene sequence of the isolates revealed synergism in root and leaf biota. In another experiment, a novel bio-product prepared from biomass of *J. curcas* enhanced microbial abundance including heterotrophs, N fixers and P solubilizers. In another study it was found that Archaea contribute significantly to N₂O production from soil.

- Metagenomics of organic farming soils showed higher eubacterial species richness and diversity, greater numbers of copiotrophic bacteria as well as key species and genes involved in cell division and respiration.
- A novel eubacterial isolate *Parapedobacter indicus* sp. nov. was identified from an HCH (hexa-chloro cyclohexane) dump site and characterized.
- In different cropping systems with cotton, the Bt rhizosphere soil samples had 2.5 - 9.8% more glomalin protein than non Bt samples.
- Nearly 700 rhizobial strains from hyper-arid and arid regions of Rajasthan and Haryana were characterized for stress tolerance, PGPR attributes and molecular diversity. The MPN (maximum probable number) counts of rhizobia of arid legumes in Rajasthan ranged from 170-1000 rhizobia /g soil.
- Several important and unique protein differences amongst the various *Rhizobium* isolates of acid soils analyzed by proteomics showed up-regulation of 14 genes that play a crucial role in adaptation.
- More than 500 rhizobacteria from wheat, seabuckthorn and apricot rhizosphere in Himalayan soils screened for PGPR attributes.
- Several demonstrations were conducted in tribal areas showing the benefits of microorganisms. These demonstrations in different tribal areas included the use of fluorescent pseudomonads for groundnut; zinc solubilising bacteria for cotton; actinomycetes for soybean, chickpea, & wheat; biofertilizer packages for direct seeded rice, jute, tropical and temperate vegetables; capsicum, azolla and compost based organic package for rice in NEH. These demonstrations showed significant yield enhancement and nutrient savings.
- Using the microbial strains of AINP on soil biodiversity and biofertilizers, biofertilizer preparations worth Rs 163.20 lakhs were produced by the project centres.
- A bioreactor was developed for accelerated decomposition of vegetable waste. This bioreactor could produce dark brown compost with no foul odour. The compost had 14:1 C:N ratio, 94 cmol (p⁺)/kg CEC, 0.5 to 2.4% lignin/cellulose ratio, 4.56 CEC/TOC ratio, and 0.5% water soluble carbon after 30 days of decomposition.

Theme IV: Soil Pollution and Remediation

Microbes for Soil Pollution Remediation

- The functional groups viz. amide group (-NH), hydroxyl group (-OH), carboxylate anions (-COO), carbonyl groups (-CO), C-F and C-Br were mainly observed in the cytoplasmic membrane of isolated fungi that were mainly responsible for biosorption of heavy metals. It was found that the four fungi viz., *Aspergillus flavus*; *Aspergillus terreus*; *Aspergillus awamori* and *Rhizomucor pusillus* are having these functional groups. These functional

groups make ligands with heavy metals like Cd, Cu, Ni, Cr and Zn

- The adsorption parameters of Freundlich model were used to study the biosorption capacity of dead fungal cells. Higher values of K indicates higher biosorptive uptake capacity of metal ions. Similarly, higher “1/n” value indicates higher metal adsorption binding affinities towards fungi cell. In the present study K values were higher for all the fungi for Pb. A series of perforated biofilter containing leaving fungal blocks were inserted in the municipal solid waste compost. After 30 days, it was observed that the removal of Pb was maximum by these fungi followed by Ni and Zn. Further, it was observed that among six fungi *Trichoderma viride* performed better for removal of Pb, Ni, Zn and Cd followed by *Aspergillus flavus*.

Soil Pollution

- The continuous use of sewage water for irrigation in the peri-urban areas resulted in build up of total Cu, Cd, Pb, Cr, Ni & Zn by 2.1, 3.2, 1.4, 1.8, 2.0 & 1.6 times more than tube well irrigated fields in Bhopal. The SOC build up at 15, 30, 45 and 60 cm depth was 1.6, 1.8, 2.1 and 2.5 times more, respectively at sewage irrigated fields compared to tube well irrigated field.
- Interaction among heavy metals in the chromium contamination of spinach biomass was investigated. Cadmium application @ 2 mg/kg decreased Cr concentration in root & shoot in Cr contaminated (100 mg Cr/kg) soil. Zinc application had no significant effect on Cr concentration in root & shoot, and its uptake.

1. INTRODUCTION

Food security is one of the great global challenges of the 21st century. Soils, and their continuing ability to support the sustainable intensification of agriculture, will have to play a central and critical role in delivering food security. In order to take up the emerging challenges of increasing food-grain production from shrinking land resources, reorientation of research pursuits addressing the emerging issues like enhancing nutrient and water use efficiency; sustaining soil and produce quality; soil biodiversity and genomics, climate change and carbon sequestration; minimizing soil pollution etc have to be envisaged. To address these issues Indian institute of Soil Science was established on 16th April, 1988 with the mission of “Enhancing Soil Productivity with Minimum Environmental Degradation”. Since its inception, the institute made every effort to attain its mission and received national and international recognitions. The institute activity has been strengthened further by the scientific and managerial activities of All India Coordinated Research Projects/All India Network Project. These four institute based AICRPs act as a part of the “Network-Support Programmes” of the institute with their 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 programme of the Institute on region basis. During the year under report the institute has again made significant scientific contributions in the frontier areas of soil science such as nanotechnology, carbon sequestration and climate change, integrated nutrient supply system (IPNS), biofortification, nutrient transformation and dynamics in soil-plant systems, environmental impact on agricultural production, utilization of solid wastes and waste water, bio and phyto-remediation etc. The salient research findings, infrastructural development, technology transfer, human resource development, awards and recognitions etc are briefly highlighted in the present report.

1.1 Mandate

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

- a) To carry out basic and strategic research on soils especially physical, chemical and biological processes related to management of nutrients, water and energy.
- b) To develop advanced technologies for sustainable systems of input management in soils that is most efficient and least environmental polluting.
- c) To develop expertise and back-stop other organizations engaged in research on agriculture, forestry, fishery and various environmental concerns.
- d) To exchange information with scientists engaged in similar pursuits through group discussions, symposia, conferences and publications.
- e) To collaborate with State Agricultural Universities, National, International and other Research Organizations in the fulfillment of the above objectives, and
- f) To develop database repository of information on soils in relation to quality and productivity.

1.2 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 critical areas:

Programme 1: Soil Health and Input Use Efficiency

- Integrated nutrient management: Indigenous mineral and by-product sources
- Nano-technology
- Precision agriculture
- Crop simulation modeling and remote sensing
- Fertilizer fortification
- Resilience of degraded soils
- Developing a workable index of soil quality assessment imbibing influence of different physical, chemical and biological soil attributes

Programme 2: Conservation Agriculture and Carbon Sequestration vis-à-vis Climate Change

- Organic farming and produce quality
- Efficient and improved composting techniques
- The carbon sequestration research in the context of sustainable management of land and soil resources and conserving deteriorating environment
- Conservation agriculture and carbon sequestration
- Tillage and nutrient interactions
- Crop adaptation to climate change and rhizospheric study

Programme 3: Microbial Diversity and Genomics

- Characterization and prospecting of large soil biodiversity
- Characterization of functional communities of soil organisms
- Testing of mixed biofertilizer formulations

Programme 4: Soil Pollution, Remediation and Environmental Security

- Bio-remediation/ phytoremediation of contaminated soils
- Quality compost production and quality standards
- Waste waters – quality assessment and recycling

1.3 Organizational Set-Up

Divisions

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

Sections

- (i) Statistics and Computer Application
- (ii) Farm Section
- (iii) Vehicle Section

Technical Units/Cells

- (i) Agriculture Knowledge Management Unit (AKMU)
- (ii) Institute Technology Management Unit (ITMU)
- (iii) Library, Information and Documentation Unit
- (iv) Prioritization, Monitoring and Evaluation (PME) Cell
- (v) Right to Information (RTI)
- (vi) Results, Framework and Documentation (RFD)
- (vii) Consultancy Processing Cell (CPC)
- (viii) Official Language Cell (Hindi Cell)
- (ix) Technology Assessment and Transfer Unit (TATU)

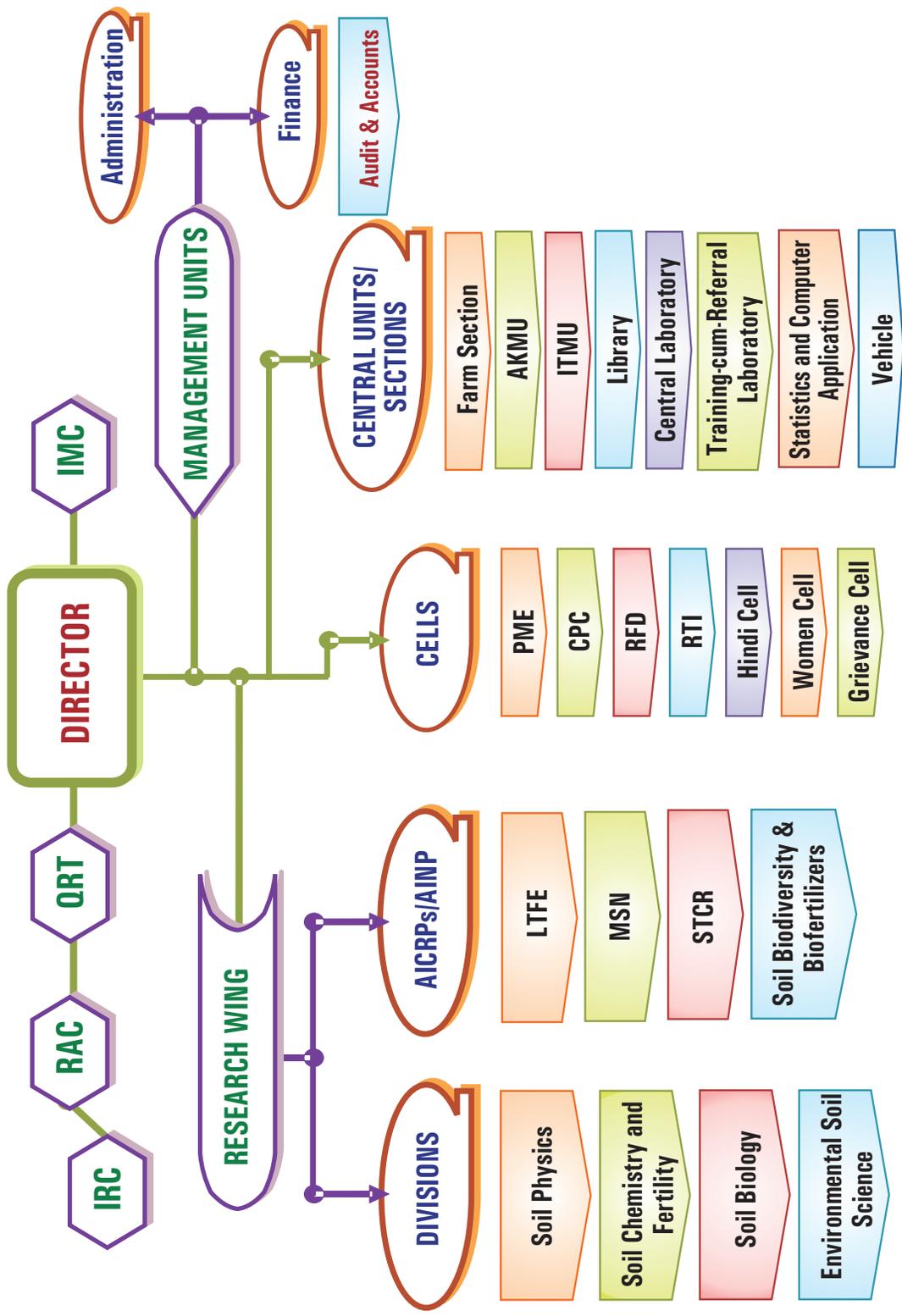
All India Co-ordinated Research Projects (AICRPs)

- (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 (MSN)
- (iv) All India Network Project on Soil Biodiversity and Biofertilizers (BF)

Central Facilities

- (i) Central Laboratory
- (ii) Training cum Referral Laboratory

ORGANIZATIONAL SETUP OF ICAR-INDIAN INSTITUTE OF SOIL SCIENCE



1.4 Manpower

a) Scientific

S. No.	Discipline	Sanctioned				In Position			
		PS	SS	S	Total	PS	SS	S	Total
1	RMP	1	0	0	1	1	0	0	1
2	Agricultural Economics	0	1	1	2	0	0	0	0
3	Agricultural Extension	0	0	1	1	0	0	1	1
4	Agricultural Microbiology	1	1	2	4	1	1	2	4
5	Agricultural Statistics	0	1	2	3	0	0	2	2
6	Agronomy	1	2	4	7	0	2	3	5
7	Computer Application	0	1	0	1	0	0	0	0
8	Plant Biochemistry	0	1	1	2	0	1	0	1
9	Plant Physiology	1	1	1	3	1	1	1	3
10	Soil Science	9	8	16	33	8	8	14	30
	Total	13	16	28	57	11	13	23	47

b) Technical

S. No.	Post	Sanctioned	In Position
1	T-1	11	0
2	T-2	-	0
3	T-3	7	4
4	T-4	-	2
5	T-5	-	5
6	T-6	-	3
7	T-7-8	1	3
8	T-9	-	0
	Total	19	17

c) Administrative

S. No.	Designation	Sanctioned	In Position
1	Sr. Administrative Officer	1	1
2	Finance & Accounts Officer	1	1
3	Asstt. Finance & Accounts Officer	1	1
4	Asstt. Administrative Officer	1	1
5	Private Secretary	2	2
6	Assistant	6	4
7	Personal Assistant	5	3
8	Stenographer Gr-III	2	2
9	Security Supervisor	1	1
10	Upper Division Clerk	2	2
11	Lower Division Clerk	6	3
12	Skilled Supporting Staff	25	20
	Total	53	41

1.5 Finance: Budget statement (₹ Lakhs) for the financial year 2014-15

Institute/AICRPs	Budget			Expenditure		
	Non-Plan	Plan	Total	Non-Plan	Plan	Total
Main Institute	978.00	180.00	1158.00	1006.09	155.84	1161.93
AICRP- LTFE	-	344.00	344.00	-	343.99	343.99
AICRP- STCR	25.73	680.00	705.73	24.36	679.99	704.35
AICRP- MSN	46.32	675.00	721.32	46.37	674.96	721.33
AINP - BF	-	185.00	185.00	-	185.00	185.00
CRP on CA Platform	-	5.00	5.00	-	4.99	4.99
Total	1050.05	2069.00	3119.05	1076.82	2044.77	3121.59

1.6 Resource Generation

S. No.	Head of Account	Amount (₹)
1	Sale of Farms Produce	824991
2	Unspent Balance of Previous Year Grant Capital	3635636
3	Income from Royalty, Sale of Publication and Advertisement	35224
4	Licence Fee	249468
5	Interest Earned on Loans & Advances	1127669
6	Analytical and Testing Fees	34607
7	Interest Earned on Short Term Deposits	1961135
8	Income Generated from Internal Resource Generation	75600
9	Recoveries of Loans & Advances	2796064
10	Miscellaneous Receipts	82928
	Total	10823322

2. RESEARCH ACHIEVEMENTS - MAIN INSTITUTE

Theme I: Soil Health and Input Use Efficiency

2.1 Improving Input Use Efficiency

2.1.1 Study on nanoporous zeolites for soil and crop management

Nano structured materials, such as zeolites, are of great interest owing to the superior gaseous molecule separation properties. Analysis of meso-porosity, morphology and textural characteristics of a commercial Indian zeolite obtained from Jodhpur, Rajasthan was carried out experimentally using a N_2 adsorption isotherm. The detailed surface area, pore volume and pore size were determined from the adsorption–desorption isotherms of nitrogen measured volumetrically at 77° K. To study the reliable pore-size distribution (PSD) both adsorption and desorption curves were used by fitting the data to several well-known adsorption models, i.e., Bruaner-Emmett-Teller (BET) model, Barret, Joyner and Halenda (BJH) model, Dollimore and Heal (D-H) model and the density functional theory (DFT) model. The crystal morphology (550 nm particle-size grains; pore width 19-22 nm) was studied using a JEOL JS 6701F Field emission scanning electron microscope. The sample was examined at 1×10^4 , 5×10^4 and 1×10^5 magnification to determine the dispersion and visibility of crystals and to select an appropriate field. Magnification for morphology have shown the tubular crystals (Plate 2.1.1). The diameter of the particles ranged between 21.1 and 59.8 nm, while length was 56.7 to 732.8 nm. Surface area is an important attribute of zeolites that is useful in catalytic activity. BET surface area was found to be 10.90 ± 0.03 m^2/g . The mesopore surface area studied through -BJH desorption surface area, the single point surface area, the DH desorption surface area have predicted divergent surface area for the pores. An important aim of the porosity analysis is the determination of the pore-size (volume or area) distribution of the Zeolite sample. BJH/DH estimates of pore volume and surface area distributions correspond here to the cylindrical pore model (Fig. 2.1.1). The sample did not contain any micropores as evident from BJH cumulative

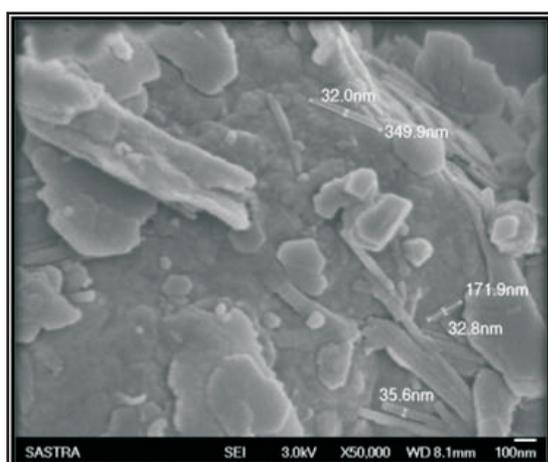


Plate 2.1.1 SEM micrograph at 5×10^4 magnification

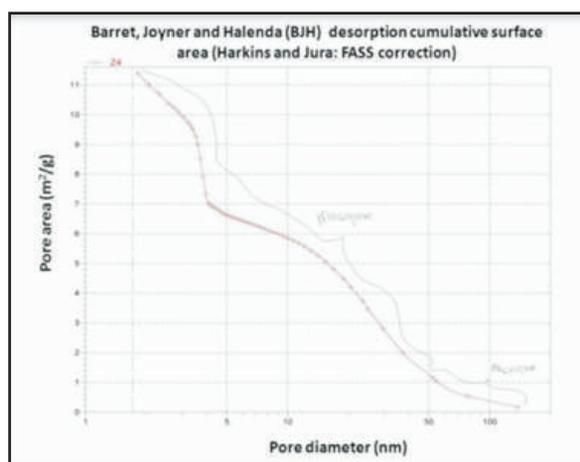


Fig.2.1.1 BJH cumulative pore area

pore volume. Careful analysis of the curves indicated that the decrease in pore volume was more prominent in the macropore region. The porosity distribution through original density functional theory (DFT) has indicated that the total area under pores is $6.89 \text{ m}^2 \text{ g}^{-1}$.

2.1.2 Evaluation of differently coated urea for enhancing nitrogen use efficiency and sustaining crop productivity

Different modified urea materials were evaluated for enhancing nitrogen use efficiency and sustaining crop productivity in maize during *Kharif* 2014. The study showed that maize yield and nitrogen use efficiency (NUE) were significantly different with the application of different modified urea materials. Among different modified urea materials, neem coated urea (NCU) recorded the highest grain, stover and total dry matter yield of maize and NUE followed by biochar coated urea (BCU) and pine oleoresin coated urea (PORU) (Table 2.1.1). The increase in grain yield was 19%, 9.87% and 7.71% under NCU, BCU and PORU over the prilled urea (PU), respectively at higher levels of nitrogen (120 kg N ha^{-1}). The increase in total dry matter yield might be due to slow release of N for longer period during crop growth. The N use efficiencies (Fig. 2.1.2) i.e. agronomic use efficiency (AEn), partial factor productivity (PFPn) and recovery efficiency (REn) also significantly differed with the application of different modified urea materials. The application of NCU showed significant improvement in N use efficiency which was followed by BCU and PORU as compared to PU at both the levels of nitrogen (90 and 120 kg N ha^{-1}) in maize crop.

Table 2.1.1 Effect of different modified urea materials on maize yields

Treatment	Grain yield (t ha^{-1})	Total dry matter yield (t ha^{-1})	Harvest Index
T1 - Absolute control	2.05	4.94	0.42
T2 - N control (N0)	2.35	5.71	0.41
T3 - Prilled urea @ 90 kg N ha^{-1}	3.66	9.04	0.40
T4 - Prilled urea @ 120 kg N ha^{-1}	4.15	10.15	0.41
T5 - Biochar coated urea @ 90 kg N ha^{-1}	3.89	9.69	0.40
T6 - Biochar coated urea @ 120 kg N ha^{-1}	4.56	10.91	0.42
T7 - Zeolite coated urea @ 90 kg N ha^{-1}	3.68	8.83	0.42
T8 - Zeolite coated urea @ 120 kg N ha^{-1}	4.00	10.29	0.39
T9 - Pine oleoresin coated urea @ 90 kg N ha^{-1}	3.72	9.23	0.40
T10 - Pine oleoresin coated urea @ 120 kg N ha^{-1}	4.47	10.52	0.42
T11 - Neem coated urea @ 90 kg N ha^{-1}	3.93	9.68	0.41
T12 - Neem coated urea @ 120 kg N ha^{-1}	4.95	11.35	0.44
LSD ($p = 0.05$)	0.38	0.55	NS
SEm(\pm)	0.13	0.19	NS

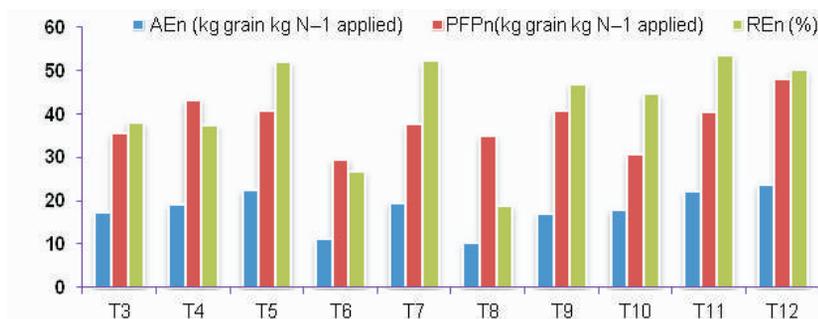


Fig.2.1.2 Nitrogen use efficiencies in maize as influenced by modified urea materials

2.1.3 Evaluation of agronomic interventions for enhancing nitrogen use efficiency and sustaining crop productivity

Agronomic interventions through N application with different split doses at varying levels and at different time of application in maize crop were evaluated during *kharif* season of 2014 for enhancing crop yield and nitrogen use efficiency. The study showed that total dry matter yield of maize was highest with soil test crop response equation based (STCR) fertilizer application; probably due to higher amount of nutrient addition. Also, grain and stover yields of maize were highest in the treatment where basal dose of N was skipped and total N was applied in two equal splits (60 kg N ha^{-1}) at 20 and 40 days after sowing (DAS) (Table 2.1.2). The total dry matter yield of maize was also improved in the treatment where addition of biochar (10 t ha^{-1}) was made. Nitrogen use efficiency significantly differed with the varying rate and time of N application (Fig. 2.1.3). The N use efficiencies were higher in the treatments, where basal dose of nitrogen was skipped and total nitrogen was applied into two or three equal split doses at 20, 40 and 55 DAS, and also in the treatments involving application of biochar.

Table 2.1.2 Maize yield under varying rate and time of N application

Treatment	Grain yield (t ha^{-1})	Total dry matter yield (t ha^{-1})	Harvest Index
T1 - Absolute control	2.22	5.33	0.41
T2 - N control (N_0)	2.55	6.08	0.42
T3 - $\text{N}_{60}\text{-N}_{30}\text{-N}_{30}$ through Broadcast	4.28	10.12	0.42
T4 - $\text{N}_{30}\text{-N}_{30}\text{-N}_{30}$ through Band placement (Basal)	3.91	9.32	0.42
T5 - $\text{N}_0\text{-N}_{60}\text{-N}_{60}$ through Broadcast	4.91	11.14	0.44
T6 - $\text{N}_0\text{-N}_{45}\text{-N}_{45}$ through Broadcast	3.55	8.66	0.41
T7 - $\text{N}_0\text{-N}_{40}\text{-N}_{40}\text{-N}_{40}$ through Broadcast	4.53	10.99	0.41
T8 - $\text{N}_0\text{-N}_{30}\text{-N}_{30}\text{-N}_{30}$ through Broadcast	3.16	8.09	0.39
T9 - $\text{N}_0\text{-N}_{60}\text{-N}_{30}\text{-N}_0$ through Broadcast	3.74	9.14	0.41
T10 - Soil test based N (for 6.0 t ha^{-1} target yield) through Broadcast (175 kg N ha^{-1})	5.31	12.47	0.43
T11 - Biochar (10 t ha^{-1}) + T3	4.87	11.75	0.41
T12 - Biochar (10 t ha^{-1}) + T4	4.03	9.63	0.42
LSD ($p = 0.05$)	0.44	0.81	NS
SEm(\pm)	0.15	0.27	NS

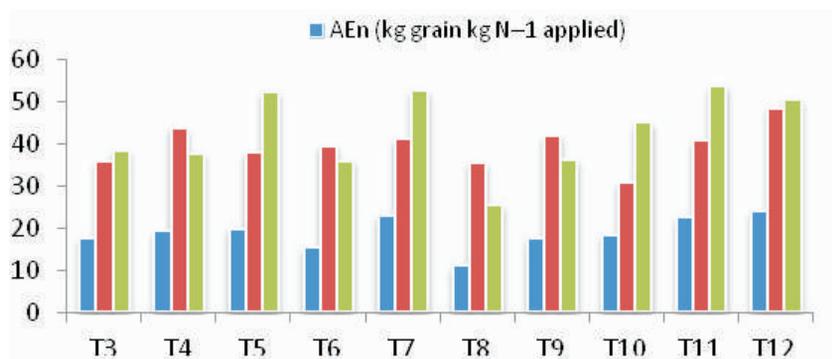


Fig.2.1.3 Effect of time and application of nitrogen on N use efficiencies in maize crop

2.1.4 Nano-particle delivery and internalization in plant systems for improving nutrient use efficiency

The impact of nano-micronutrient fertilization on growth and metabolism of plants viz. wheat and maize was studied under hydroponic as well as sand culture system using ZnO, CuO and Fe₃O₄ nanoparticles (NPs) (Plate 2.1.2). The morphology of nanoparticles was analyzed through Transmission Electron Microscope (TEM). Most of NPs analyzed were within the size range of 50 nm. Plant growth parameters viz. plant height, root length, shoot biomass, root biomass and chlorophyll content were recorded in the nano-micronutrient treated plants. The activity of antioxidant enzymes viz. Super oxide dismutase (SOD), Catalase (CAT) and Peroxidase (POX) were recorded in plants treated with NPs. It was observed that NPs don't affect the root growth of maize and wheat up to 45 DAS but shoot growth was variably influenced after 30 DAS in maize. Taller plants with more biomass were observed with CuO NP treatment but not with Fe₃O₄ NP treatment. Antioxidant enzyme, SOD activity was observed after 30 DAS and CAT & POX activities were observed after 45 DAS. Fe NP and Zn NP treated plants showed moderate level of SOD/ CAT activities and Cu NP treated plants showed moderate POX indicating lower level of stress experienced by NP treated plants. With sub-optimal concentration of micro-nutrients i.e. 50%



Plate 2.1.2 Sand cultured maize grown with Fe, Cu and Zn nanoparticles

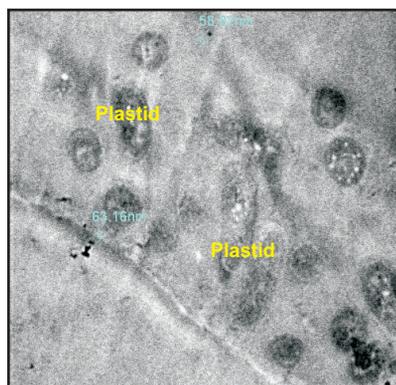


Plate 2.1.3 Integration of Cu-nanoparticle into plant root cells

concentration of NP treatment, higher Fe and Cu content in shoot and higher Cu & Zn in root were observed and highest Cu content was observed in shoot as well as in root. The TEM analysis indicated that the nanoparticles were found to enter the root cortical cells and were found near the plastids of mesophyll cells at the junction of root and stem (Plate 2.1.3).

2.1.5 Evaluation of plant nutrition products for nutrient use efficiency in cereal crops

A field trial comprising wheat variety was undertaken in *rabi* 2013-14 to study the effect of plant nutrition product (NP1) on the nutrient use efficiency of crop. The effect of various combinations of NP1 product and recommended dose of conventional fertilizers on morpho-physiological parameters like growth and yield attributing traits was studied. The nutrient status of the plants was also studied in the various treatments for analyzing the use efficiency. Plant height of wheat was slightly lesser in NP1 treatments, though non-significant, when compared to recommended dose of conventional fertilizers with prilled urea. However, the grain yield and biological yield of the wheat crop was moderately higher in all the NP1 treated plots in comparison to conventional fertilizers. This indicates that the nutritional requirement of plant is met by the single dose of NP1 product application. The yield of crop treated with NP1 product was slightly better and statistically on par

Table 2.1.3 Nitrogen uptake and use efficiency of wheat grown with NFCL-NP1 product

Treatment	Total uptake of N (kg ha ⁻¹)	Recovery efficiency (kg of N absorbed/kg N applied)	Agron efficiency (kg grain/kg N applied)	Physiological efficiency (kg grain/kg N absorbed)	HI of N
T1 = CF 100N + 100PK	93.83	43.64	13.17	30.17	0.86
T2 = CF 75N + 100PK	92.71	42.71	11.95	27.97	0.90
T3 = CF 50N + 100PK	72.43	25.81	6.29	24.38	0.80
T4 = CF 75N ^s + 100PK	73.24	26.48	8.56	32.31	0.84
T5 = NP 100N ^s + 100PK	94.87	44.51	21.49	48.28	0.89
T6 = NP 75N ^s + 100PK	75.56	28.42	16.06	56.50	0.93
T7 = NP 50N ^s + 100PK	71.36	24.92	8.10	32.49	0.74
T8 = NP 75N ^s + 100PK	78.30	30.70	15.17	49.41	0.87
T9 = NP 75N ^s + 0P + 100K	65.18	19.77	3.49	17.64	0.76
T10 = 0N + 100PK	53.39	9.94	3.39	34.08	0.82
T11 = 0P + 100NK	72.07	25.51	4.08	16.01	0.83
T12 = 100NPK by DAP	87.42	38.30	11.11	29.01	0.86
T13 = 0NPK	41.46	0.00	0.00	0.00	0.86
T14 = CF 75% NPK + 5t FYM	90.32	40.72	12.64	31.04	0.79

*NP denotes NFCL_NP1 product; CF denotes conventional fertilizers; DAP denotes Di-Ammonium Phosphate, HI = Harvest Index; 100 NPK = 100% Recommended dose of NPK, 75N= 75% of N dose, 50N= 50% of N dose 0NPK= No fertilizer added N^s=Nitrogen applied as single basal dose

with conventional fertilizers treatments. But, the harvest index of Nitrogen in wheat was slightly better with NP1 treatments indicating that the crop may have better translocation efficiency of stored biomass into economic product (grain). Uptake of N in wheat grain, straw, total uptake and grain N concentration were found to be higher in NP1 treatments than conventional fertilizer treatment. The recovery efficiency (%), agronomic and physiological efficiency of N and P were better under NP1 fertilizer treatment than conventional fertilizer treatment. The harvest index of N was slightly better under NP treatments (Table 2.1.3).

2.1.6 Evaluation of Nano-nutrients product (NUALGI) for improving nutrient use efficiency of crops

A field trial comprising maize hybrid Rasi 4212 and Soybean JS 335 was undertaken in *kharif* 2014 to study the effect of nano-nutrient product (NUALGI) on growth, yield and nutrient use efficiency of crop (Plate 2.1.4). The effect of various combinations of NUALGI nano-nutrient product and conventional recommended dose of fertilizers on morpho-physiological parameters like growth and yield attributing traits in the maize and soybean crop was studied. Soil physico-chemical parameter like pH, EC, organic carbon, available N, P and K were estimated initially. The nutrient status of the plants was also studied in various treatments. In all the treatments involving NUALGI product, a reduction in plant height, plant biomass and leaf area was observed in maize plants when compared to plants treated with recommended dose of conventional fertilizers. However, among the plants treated with Nualgi 50% + GRD 50%, plant height, leaf area and plant biomass were better than Nualgi 100% alone or Nualgi 50%+Sujala 50% (Table 2.1.4). The yield attributes like number of grains per cob, TDM/ plant, cob length, grain weight, stover weight and cob weight/plant were found to be maximum in T3 (GRD100%) treatment followed by T6 (Nualgi 50% + GRD 50%). The grain yield ($t\ ha^{-1}$), straw yield ($t\ ha^{-1}$) and TDM ($t\ ha^{-1}$) of maize crop also followed similar trend. Highest

Table 2.1.4 Effect of NUALGI nano-nutrient product on yield attributes of maize

Treatment	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	HI
T1 Control	2.93	3.24	0.47
T2 Nualgi 100%	2.99	3.26	0.47
T3 GRD 100%	7.35	7.45	0.49
T4 Nualgi 50% Sujala 50%	3.27	3.68	0.47
T5 GRD 50%	5.08	5.59	0.48
T6 Nualgi 50% GRD 50%	5.35	6.33	0.46
LSD ($p = 0.05$)	0.89	0.94	NS

yield was obtained with T3 (GRD100%) treatment followed by T6 (Nualgi 50% + GRD 50%). This indicates that the nutritional requirement of maize is not fully met by the NUALGI product.



Plate 2.1.4 Field view of Maize grown with NUALGI nano-nutrient product

2.1.7 Effect of urea pastilles on crop productivity and nitrogen use efficiency

The experiment was conducted at three different locations viz. Bhopal, Ranchi and Barrackpore in order to evaluate the urea pastilles in terms of agronomic, physiological and soil related parameters under three different soil types viz., Vertisol, Alfisol and Inceptisol, respectively. The performance of urea pastilles was compared with normal prilled urea. Data on biomass yield, grain yield, stover/straw yield, plant biomass yield at different growth stages, SPAD (chlorophyll reading) readings at different growth stages, total soluble solids, starch content, nitrogen, phosphorus and potash content in plant biomass at different growth stages, grain weight, nitrogen uptake by grain and straw, apparent nitrogen recovery and agronomic efficiency of wheat and maize crops and changes in ammoniacal and nitrate nitrogen content of soil were monitored during 2012-2014.

Irrespective of crop and locations, it was observed that application of N was indispensable for obtaining good yield of field crops. It is clearly evident from the data that application of N either through prilled urea or through urea pastilles significantly increased the yield of wheat crop in all the treatments in comparison to control (no N fertilization) at Bhopal in first year, when the experiment was conducted at farmer's field. Highest grain yield of wheat (50.4 q ha^{-1}) was recorded in treatment T3 where N was applied at the rate of 120 kg ha^{-1} through urea pastilles. However, it was statistically at par with the prilled urea.

During *kharif* season of 2013 (Bhopal), no significant difference in grain yield of maize was recorded between N application either through urea pastilles or through prilled urea. Maximum grain yield of 45.77 q ha^{-1} was recorded in treatment T4, where N was applied through the prilled urea (120 kg ha^{-1}) which was at par with the T3 where N was applied through urea pastilles. Application of N through urea pastilles at lower dose (90 and 60 kg ha^{-1}) recorded significantly higher maize grain yield as compared to prilled urea application.

Application of N through urea pastilles significantly increased leaf area of maize crop as compared to prilled urea. Changes in soil ammonium-N and nitrate-N content at different growth stages of maize were recorded during kharif 2013. The maximum ammoniacal N content was recorded in T3 where N was applied through urea pastilles (@120 kg ha⁻¹). Similar trend for nitrate -N was also recorded.

In 2nd year of wheat experimentation at IISS, Bhopal, it was observed that the highest grain yield of 55.6 q ha⁻¹ of wheat was observed in T3 where N was applied at the rate of 120 kg ha⁻¹ through urea pastilles, which was significantly higher than the rest of the treatments (Table 2.1.5). Other than T3, no significant difference in grain yield was observed between prilled urea and pastilles applications.

Similarly 2nd year of experimentation of maize revealed that application of urea pastilles at 120 kg N ha⁻¹ recorded significantly higher leaf area, plant dry biomass weight at different stages of maize growing period. Also plant heights was also found to be maximum in treatment T3 where N was applied through urea pastilles @ 120 kg N ha⁻¹. Grain yield of maize was also found to be maximum (62.2 q ha⁻¹) in T3 which was significantly higher than T4 where N was applied through prilled urea. Other than 120 kg of N application, there was no significant difference in grain yield of maize between prilled and pastille urea application.

Table 2.1.5 Effect of different treatments on agronomic traits of wheat (2013-2014, Bhopal)

Treatment	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	HI
T1 Control	21.6	28.1	0.43
T2 N omission plot	21.5	23.5	0.48
T3 Urea pastilles (120 kg N ha ⁻¹)	55.6	72.3	0.43
T4 Urea prilled (120 kg N ha ⁻¹)	45.7	48.6	0.48
T5 Urea pastilles (90 kg N ha ⁻¹)	51.7	62.5	0.45
T6 Urea prilled (90 kg N ha ⁻¹)	52.5	64.3	0.45
T7 Urea pastilles (60 kg N ha ⁻¹)	40.7	49.5	0.45
T8 Urea prilled (60 kg N ha ⁻¹)	41.3	52.6	0.44
T9 Urea pastilles + FYM (3:1, 120 kg N ha ⁻¹)	53.8	66.3	0.45
T10 Urea prilled + FYM (3:1, 120 kg N ha ⁻¹)	50.8	63.8	0.44
LSD (<i>p</i> = 0.05)	7.22	18.27	NS

2.1.8 Effect of nano rock phosphate coated urea on N and P use efficiency

A pot culture experiment (10 kg capacity pot) was conducted during *kharif* season of 2014 to study the uptake of N and P by maize crop grown on two soils (Alfisol from Betul, M.P. and Vertisol from IISS, Bhopal farm) as affected by the application of urea fortified with variable amounts of nano-rock phosphate (varying from 15 - 35% on mass basis) using pine oleoresin as a coating agent. The

results showed that under uniform dose of N (138 ppm), N uptake and N use efficiency improved due to coating with POR. Coating urea with increasing amounts of nano rock phosphate decreased N uptake indicating that nano rock phosphate (RP) coating reduced the availability of N from urea in both the soils (Tables 2.1.6 and 2.1.7). Also, P uptake by maize increased with the increase in loading of nano-rock phosphate in both the soils. The results indicate that P supplied through nano-rock phosphate could be effectively utilized by plant. Hence, coating urea with nano rock phosphate may be a most economic option for choosing a slow release urea fertilizer.

Table 2.1.6 Biomass yield of maize as affected by application of nano-rock phosphate coated urea in Red Soil

Treatment	Yield (g/pot)	%N in grain	%P in grain	Grain N uptake (mg/pot)	Grain P uptake (mg/pot)	NUE (%)	PUE (%)
Control	27.87	0.651	0.214	181.43	59.64	-	-
U+P	48.11	1.226	0.248	589.82	119.31	29.59	38.87
CU+P	52.29	1.243	0.251	649.96	131.24	33.95	46.64
CU+15%RP	39.58	1.217	0.196	481.68	77.57	21.75	27.26
CU+20%RP	42.38	1.106	0.220	468.72	93.23	20.82	38.30
CU+25%RP	42.88	1.152	0.224	493.97	96.05	22.64	33.25
CU+30%RP	44.15	1.205	0.229	532.00	101.10	25.40	31.53
CU+35%RP	46.38	1.192	0.241	552.84	111.77	26.91	33.96
LSD ($p = 0.05$)	3.27	0.048	0.023	47.40	11.12	2.53	3.28

U: Normal urea, CU: POR coated urea, P: SSP@ 153.51 mg P/pot, N dose: 1380 mg/pot, NUE: Nitrogen use efficiency, PUE: Phosphorus use efficiency

Table 2.1.7 Biomass yield of maize as affected by application of nano-rock phosphate coated urea in Black soil

Treatment	Yield (g/pot)	%N in grain	% P in grain	Grain N uptake (mg/pot)	Grain P uptake (mg/pot)	NUE (%)	PUE (%)
Control	32.28	0.682	0.196	220.15	63.26	-	-
U+P	54.30	1.248	0.236	677.66	128.15	33.15	42.27
CU+P	56.15	1.251	0.241	702.45	135.32	34.95	46.94
CU+15%RP	43.53	1.213	0.203	528.01	88.36	22.31	38.16
CU+20%RP	45.12	1.218	0.214	549.56	96.55	23.87	37.95
CU+25%RP	46.75	1.220	0.208	570.35	97.24	25.37	31.03
CU+30%RP	50.18	1.206	0.217	605.17	108.89	27.90	34.70
CU+35%RP	51.97	1.216	0.223	631.95	115.89	29.84	34.28
LSD ($p = 0.05$)	3.92	0.034	0.029	24.84	9.69	2.68	3.62

2.1.9 Effect of pine oleoresin coating on urea hydrolysis kinetics

Urea can be coated with pine oleoresin (POR), a novel coating material, for making slow release urea with minimal cost. In search for a cheap solvent to solubilize POR, we tested a number of solvents and found that commercial petrol is a very effective and cheaper solvent to solubilize POR. Using petrol as a solvent, we prepared four types of slow release urea coated with POR @ 1.25%, 2.50%, 3.75% and 5.0% and the N content of the resultant final products (coated urea) was 45.43%, 44.87%, 44.33% and 43.80%, respectively. The POR coated urea releases N slowly by the action of a physical barrier and increases N availability by inhibiting urease activity through antibacterial properties and reduces volatilization loss by acidifying alkaline micro-sites in the soil. At the end of the incubation period (96h), a considerable amount of urea remained unhydrolysed in the soil due to pretreatment with POR (Table 2.1.8). The urea hydrolysis was found to follow the first-order reaction and based on the value of first-order rate constant ($k=0.026$, $R^2=0.963$), the time required for 90% hydrolysis of applied urea (2000 mg g⁻¹ soil) was 88.56 h which was markedly increased to 328.94 h in the presence of POR (250 ppm). The average urease activity (mg kg⁻¹ h⁻¹) also decreased considerably from 151.5 to 62.4 in Vertisol, 163.2 to 60.8 in Inceptisol, 143.5 to 50.4 in Aridisol and 121.2 to 44.6 in Alfisol when 250 ppm POR was applied to the soil. This indicates that POR is a potential urease inhibitor. The urease inhibitory effect of POR is due to its acidity and antimicrobial properties controlling the population of urease-producing microorganism in the soil. Moreover, POR may contain phenolic compounds and aromatic ketones which could bind the urease enzymes, thereby, reducing the enzyme-substrate reaction rate.

Table 2.1.8 Effect of soil application of pine oleoresin (POR) on urease activity and kinetics of urea hydrolysis in Vertisols

Treatments	Urease activity (mg kg ⁻¹ h ⁻¹)				Kinetics of urea hydrolysis in Vertisols	
	Vertisol (Bhopal)	Inceptisol (Ludhiana)	Aridisol (Jodhpur)	Alfisol (Betul)	First-order rate constant k (h ⁻¹)	Time required for 90% hydrolysis of urea (h)
Control	151.8	163.2	143.5	121.2	0.026 ($R^2=0.963$)	88.56
100 ppm POR	107.4	129.6	97.4	91.8	0.014 ($R^2=0.975$)	164.47
150 ppm POR	96.6	83.4	77.6	60.2	0.010 ($R^2=0.959$)	230.25
200 ppm POR	78.8	70.2	63.2	56.9	0.009 ($R^2=0.959$)	255.84
250 ppm POR	62.4	60.8	50.4	44.6	0.007 ($R^2=0.975$)	328.94
LSD ($p = 0.05$)	14.3	15.3	11.9	13.4		

2.1.10 Reduction in nitrous oxide (N₂O) emission from urea application using pine oleoresin, Nano-ZnO and nano rock phosphate

Application of N fertilizers to the soil is the major source of N₂O emission contributing 70% of total emissions from all sources. Because of the strong inter-relationship between N use and climate change, there is an urgent need to search possibilities to reduce N₂O emission from applied fertilizer N. An investigation under controlled condition in the laboratory was attempted to reduce N₂O emission through use of POR, nano-ZnO (<100 nm) and nano rock phosphate (<48.6 nm) as a coating material (Table 2.1.9 and Plate 2.1.5). In comparison with normal prilled urea, application of POR (5%) coated urea reduced the N₂O emission in soil to the extent of 20.26%. Further fortification of 2% nano-ZnO or 35% nano rock phosphate particles with urea through POR coating decreased the N₂O emission to 44.95% and 40.15%, respectively. Nano-ZnO coated urea showed the least N₂O emission (0.28 µg N₂O mg⁻¹ N) followed by 35% nano-RP coated urea (0.30 µg N₂O mg⁻¹ N).

Table 2.1.9 Emission of N₂O from different coated urea fertilizers after 33 days of incubation

Coated urea fertilizer	Concentration of N ₂ O in the head space (µl L ⁻¹)	Total N ₂ O in the head space (µl)	Total mass of N ₂ O in the head space (µg)	Total mass of N ₂ O-N in the head space (µg)	N ₂ O-N emission per unit applied N (µg mg ⁻¹ N ⁻¹)	Reduction in N ₂ O emission (%)
Urea	22.27	2.67	4.69	2.98	0.32	-
Urea coated with 5% POR	17.76	2.13	3.74	2.38	0.26	20.26
Urea coated with 5% POR and 2% nano-ZnO	12.26	1.47	2.58	1.64	0.18	44.95
Urea coated with 5% POR and 15% nano-RP	17.81	2.14	3.75	2.39	0.26	20.01
Urea coated with 5% POR and 20% nano-RP	17.60	2.11	3.71	2.36	0.26	20.97
Urea coated with 5% POR and 25% nano-RP	15.95	1.91	3.36	2.14	0.23	28.41
Urea coated with 5% POR and 30% nano-RP	15.12	1.82	3.18	2.03	0.22	32.10
Urea coated with 5% POR and 35% nano-RP	13.32	1.60	2.81	1.78	0.19	40.15
LSD (<i>p</i> = 0.05)	1.42	0.19	0.333	0.21	-	-

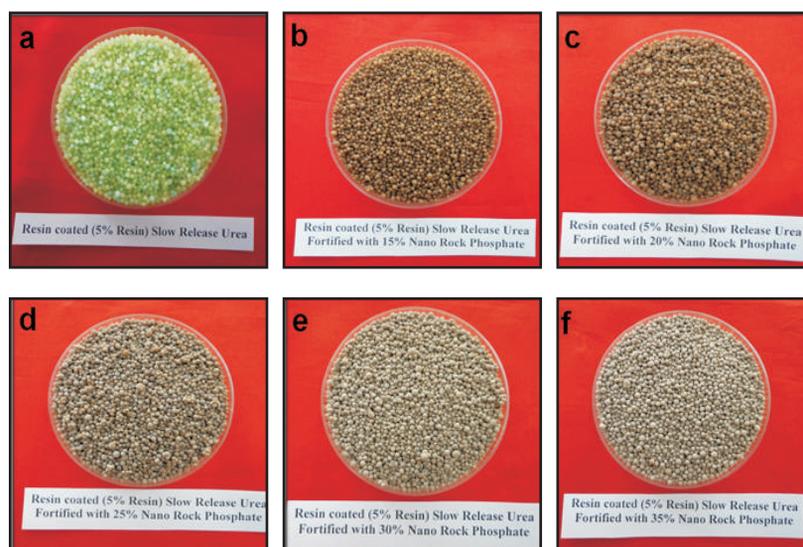


Plate 2.1.5 Coated urea fertilizers: a) POR coated urea; b) 15% nano-RP fortified POR coated urea; c) 20% nano-RP fortified POR coated urea; d) 25% nano-RP fortified POR coated urea; e) 30% nano-RP fortified POR coated urea; f) 35% nano-RP fortified POR coated urea

2.1.11 Integrated assessment of some IISS technologies for enhancing agro-ecosystem productivity and livelihood sustainability

The farmers' field demonstration of four technologies, developed by Indian Institute of Soil Science viz., Integrated Plant Nutrient Supply System (IPNS), Biofertilizers, Phospho-Sulpho-Nitro Compost, and Soil Test based Fertilizer Recommendation (STCR), in nine farmers' fields at Megra Kalan village of Bhopal district for the soybean-wheat system showed a good performance in the second crop season as compared to the conventional farmers' fields. Biofertilizers (powder and liquid) were used in the IPNS treatment (IPNS-1) and phospho-sulpho-nitro compost (IPNS-2) for both soybean and wheat crops. Crop varieties used in the second year were JS-9560 for soybean and C-306 and GW-322 for wheat. Before the *kharif* and *rabi* crop season, soil samples were collected from each treatment plots of the nine farmers' fields and analyzed for available forms of N, P, K and fertilizer calculations for STCR treatments for the soybean and wheat crop were done based on these



Plate 2.1.6 Monitoring of soybean crop



Plate 2.1.7 Wheat harvest

soil test values. For the soybean crop, the yield increase for the three treatments compared to the farmers' practice were 17.0% with IPNS-1, 22.9% with IPNS-2, and 18.5% with STCR based fertilizer recommendations (Plate 2.1.6 and Plate 2.1.7) The corresponding increases for wheat crop were 9.5%, 22.0%, and 14.8%, respectively.

2.1.12 Soil Quality assessment for enhancing crop productivity in some tribal districts of Madhya Pradesh

For conducting demonstration trials, 10 farmers' fields were selected from tribal dominated Alirajpur and Jhabua district of Madhya Pradesh. Initial soil fertility and quality status of these demonstration fields were analyzed. All the soil samples had neutral pH (6.3 to 7.8), the dichromate oxidizable carbon ranged from 0.33% to 0.85%, available N, P, K and S are 147-305 kg ha⁻¹, 4.1-19.2 kg ha⁻¹, 222-830 kg ha⁻¹ and 3.71-10.4 mg kg⁻¹, respectively. All the samples showed sufficient range in DTPA extractable micronutrients and hot water soluble B. Based on the relative soil quality index (RSQI), the number of farmers' fields that fall under poor (<60%), moderately poor (60%-70%) and medium (70%-80%) categories were 3, 6 and 1, respectively.

During *kharif*, 2014 six trials on soybean and four trials on maize were conducted in farmers' fields of tribal district of Alirajpur and Jhabua. Due to unfavorable monsoon, there was a reduction in yield to the extent of 25-35% compared to normal yield levels of the area. But, when compared to farmers' practices, there was an increase in soybean yield by 4.30% (range 3.64-5.48%), 5.94% (range 4.85-6.46%) and 7.35% (range 6.80-7.89%) in RDF, IPNS (75% chemical fertilizers + 25% organic) and soil test based nutrient recommendation (STNR), respectively. Similarly maize yield also increased by 6.58% (range 5.06-8.65%), 6.82% (range 4.73-9.89%) and 10.59% (range 7.34-12.92%), respectively (Fig 2.1.4).

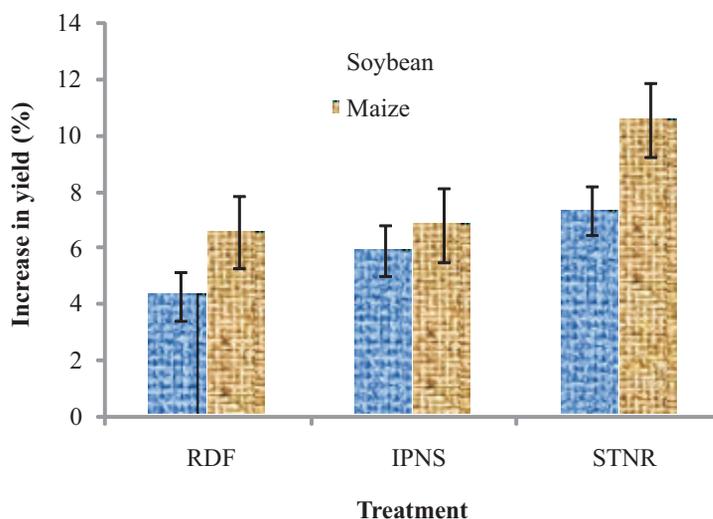


Fig.2.1.4 Percent increase in yield over farmers' practice

2.2 Monitoring Long-Term Productivity

2.2.1 Long-term evaluation of integrated plant nutrient supply modules for sustainable productivity in a Vertisol

A field experiment was initiated in 2012 to evaluate different integrated plant nutrient supply modules (Table 2.2.1) in maize- chickpea cropping sequence in Vertisols. Total dry matter yield of maize in *kharif* 2014 varied significantly with the application of various integrated plant nutrient supply modules (Table 2.2.2). Grain yield of maize was highest in T5 (75% NPK of T3 +5 t FYM) followed by T3 (soil-test crop response (STCR) equation based recommended dose of fertilizers). The same trend was observed in total nutrient uptake. The mean increase in grain yield were 1.03 and 0.91 t/ha under T5 and T3 over T2 (GRD), respectively. Soil test based recommended dose of fertilizer and FYM based INM module performed better than other modules in terms of maize productivity probably because of higher nutrient addition. Only organics modules (T9 and T10) were significantly lower than T2 (GRD). The highest agronomic efficiency, partial factor productivity and recovery efficiency were observed in FYM based INM module (Fig.2.2.1). The highest chickpea grain yield (Table 2.2.3) was recorded in the treatment T5 which was on par with the treatments T2, T3, T9, T11, and T12. The application of 5 tonnes farmyard manure every year in chickpea also improved the grain and straw yield of chickpea as compared to maize residue incorporation with P input (T10). Increase in grain and straw yield of chickpea might be due to residual fertility effect of organic manures in maize. Soil enzyme activity was influenced due to application of various integrated plant nutrient supply modules (Table 2.2.4). Highest FDA ($39.5 \mu\text{g g}^{-1} \text{ soil h}^{-1}$) and dehydrogenase activities ($105.8 \mu\text{g TPF g}^{-1} \text{ soil h}^{-1}$) were recorded in the treatment

Table 2.2.1 Treatment details

Designation	Maize	Chickpea
T1 Control	No Fertilizer/ Manure	No Fertilizer/ Manure
T2 GRD	120- 60- 30	20-60-20
T3 RD (STCR)	135-55-50 (Target- 5 t maize)	0-0-0 (1.5 t chickpea)
T4	75% NPK of T3	100% P only
T5	75% NPK of T3 +5 t FYM	100% P only
T6	75% NPK of T3+ 1 t PM	100% P only
T7	75% NPK of T3 + 5 t UC	100% P only
T8	75% NPK of T3 +MR	100% P only+ MR as Mulch
T9	MR +1 t PM+Gly 2 t ha ⁻¹	100% P only+ MR as Mulch
T10	MR + 5t FYM+Gly 2 t ha ⁻¹	100% P only+ MR as Mulch
T11	20 t FYM (every year)	5 t FYM (Every year)
T12	75% NPK of T3 +20 t FYM (once in 4 years)	100% P only

Note: Nutrient application is based on soil test crop response equation, MR-Maize residue, UC- Urban compost, PM- Poultry manure, FYM- Farmyard manure, and Gly-*Glyricidia* lopping

where 20 tonnes of FYM was applied every year in maize. Phosphatase enzyme plays an important role in the P cycle because it provides P for plant uptake by solubilizing apatite. Highest alkaline phosphatase activity ($140 \mu\text{g PNP g}^{-1} \text{ soil h}^{-1}$) was recorded in GRD (120-60-60) treatment. The lowest enzyme activities (FDA, dehydrogenase and alkaline phosphatase) were recorded in the control (no fertilizer/ manure).

Table 2.2.2 Yields and nutrient uptake of maize as influenced by different integrated plant nutrient supply modules

Treatment	Yield (t ha^{-1})		Total Nutrient uptake (kg ha^{-1})		
	Grain	Harvest index	N	P ₂ O ₅	K ₂ O
T1	2.02	0.40	36.3	12.4	23.5
T2	5.01	0.42	104.0	36.4	77.0
T3	5.92	0.43	108.0	43.8	89.2
T4	4.91	0.42	98.2	38.8	72.7
T5	6.04	0.42	133.1	46.7	99.7
T6	4.65	0.37	90.4	37.2	78.6
T7	4.44	0.39	90.6	34.2	66.9
T8	4.86	0.42	85.6	31.3	55.1
T9	2.98	0.39	60.8	26.9	46.3
T10	3.05	0.42	63.4	25.5	52.3
T11	4.71	0.43	92.8	38.4	82.3
T12	5.28	0.40	105.8	32.9	82.2
LSD ($p = 0.05$)	0.77	NS	13.86	5.28	9.86
SEm(\pm)	0.26	NS	4.69	2.05	3.34

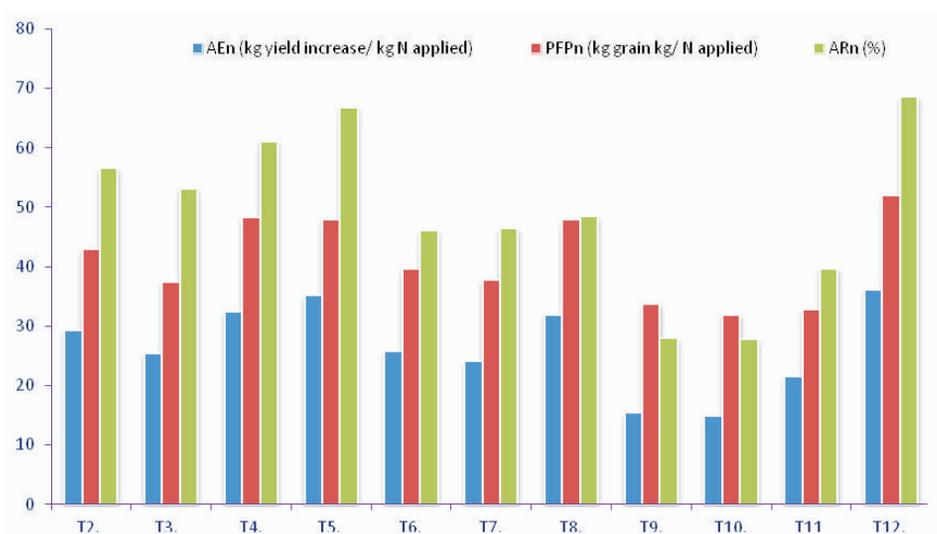


Fig.2.2.1 Nitrogen use efficiency in maize as influenced by integrated plant nutrient supply modules

Table 2.2.3 Effects of integrated plant nutrient supply modules on yield of chickpea under Vertisol

Treatment	Grain yield (q ha ⁻¹)	Harvest Index
T1	11.6	0.34
T2	18.9	0.32
T3	19.1	0.34
T4	14.2	0.32
T5	19.3	0.31
T6	16.3	0.31
T7	16.9	0.30
T8	16.3	0.33
T9	18.4	0.32
T10	16.9	0.34
T11	18.0	0.29
T12	18.4	0.30
LSD ($p = 0.05$)	2.2	NS
SEm(\pm)	0.8	NS

Table 2.2.4 Effects of integrated plant nutrient supply modules on soil microbial properties after maize harvest

Treatment	FDA ($\mu\text{g fluorescein g}^{-1}\text{ soil h}^{-1}$)	DHA ($\mu\text{g TPF g}^{-1}\text{ soil day}^{-1}$)	Alk. Phosp. ($\mu\text{g PNP g}^{-1}\text{ soil h}^{-1}$)
T1	20.3	32.1	96.5
T2	24.2	60.7	140.0
T3	23.1	56.4	122.2
T4	22.2	50.3	110.3
T5	29.9	71.2	112.3
T6	28.8	67.3	121.1
T7	28.0	66.6	130.5
T8	26.4	66.3	118.2
T9	31.9	95.1	109.1
T10	33.3	95.9	108.3
T11	39.5	105.8	124.1
T12	34.4	97.8	123.3
LSD ($p = 0.05$)	2.0	6.4	9.0
SEm(\pm)	0.7	2.1	3.1

TPF- Triphenyl formazan, PNP- p-nitrophenyl phosphate, FDA-Fluorescein diacetate, DHA-Dehydrogenase activity

2.2.2 Evaluation of organic, inorganic and integrated nutrient management practices on soybean yield and soil properties

The yield of soybean crop in all the cropping systems was higher in organic nutrient management system than integrated and inorganic nutrient management systems. Among cropping systems, the yield of soybean was found to be higher in soybean-mustard cropping system compared to other cropping systems (Table 2.2.5). There was insignificant difference in yield between 100% organic and 75% organic with innovative practice. There was no significant difference in soil pH owing to the nutrient management options. The soil electrical conductivity also remained unaffected due to different nutrient management options and varied from 0.17 to 0.18 dS m⁻¹. Mean soil organic carbon content under soybean wheat system varied from 0.52 to 0.81% and was lowest under inorganic nutrient management options under all the four cropping systems (Table 2.2.6). Among the cropping systems, soybean-wheat recorded higher SOC followed by soybean-linseed, soybean-mustard and soybean-chickpea. Mean soil available P under different nutrient management options varied from 15.2 to 37.9 kg ha⁻¹ and minimum being under State blanket recommendation. The organic matter addition has shown higher phosphorus levels as compared to inorganic nutrient management. The magnitude of variation in soil available P was low under state fertilizer recommendation across the cropping systems. Mean soil available K varied from 441 to 560 kg ha⁻¹ among the cropping systems and there was insignificant variation in its content. Among the treatments, the content of soil available K was not significantly different as the soil contains high amounts of available potassium.

Table 2.2.5 Yield of soybean (kg ha⁻¹) under different nutrient management practices and cropping systems

Cropping system (CS)	Organic Management (As per NPOP standard)		Inorganic Management		Integrated Management	
	Practice 1	Practice 2	Practice 3	Practice 4	Practice 5	Practice 6
<i>Kharif</i>						
CS1	639	594	528	537	564	591
CS2	666	608	452	489	499	601
CS3	570	611	487	515	532	613
CS4	638	574	479	504	488	576
LSD	Manure		29.9			
(<i>p</i> = 0.05)	Cropping System		9.9			
	Manure X Cropping System		24.4			

Cropping Systems: (CS1) Soybean-Wheat, (CS2) Soybean-Mustard, (CS3) Soybean- Chickpea and (CS4) Soybean-Linseed

* The overall yield was poor due to inclement weather and incessant rainfall

Practice 1: 100% Organic (Organic manure equivalent to 100 % N requirement of the system), Practice 2: 75 % organic (Organic manure equivalent to 75 % N requirement of the system) + innovative practices (spray of cow urine and vermin-wash 10% each two times), Practice 3: 100% inorganic package, Practice 4: State blanket fertilizer recommendation, Practice 5: 50 % Organic + 50 % inorganic package, Practice 6: 75% Organic + 25 % inorganic

In respect of soil microbial parameters, highest count of bacteria, fungi and actinomycetes was found in the organic system as compared to INM and inorganic systems. Among the different cropping systems, the total count of soil microbes was highest in chickpea than wheat. Dehydrogenase activity was found to be highest in organic treatment followed by integrated management and least in inorganic management (Fig.2.2.2). Integrated management performed either better or equal to in organic treatment.

Table 2.2.6 Influence of organic, inorganic and integrated nutrient management practices on soil properties

Nutrient management practice	Soil pH	Soil EC (dS m ⁻¹)	Organic C (%)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
Practice 1	7.76	0.17	0.81	37.9	536
Practice 2	7.80	0.18	0.75	30.9	492
Practice 3	7.79	0.17	0.64	27.6	496
Practice 4	7.82	0.17	0.66	28.1	531
Practice 5	7.82	0.18	0.52	20.0	501
Practice 6	7.83	0.18	0.55	15.2	490
LSD (<i>p</i> = 0.05)	NS	NS	0.06	4.7	47
Cropping system					
CS ₁	7.86	0.17	0.72	26.3	553
CS ₂	7.91	0.17	0.62	27.9	507
CS ₃	7.84	0.17	0.61	21.7	453
CS ₄	7.72	0.19	0.68	30.7	517
LSD (<i>p</i> = 0.05)	NS	NS	NS	2.8	31.9

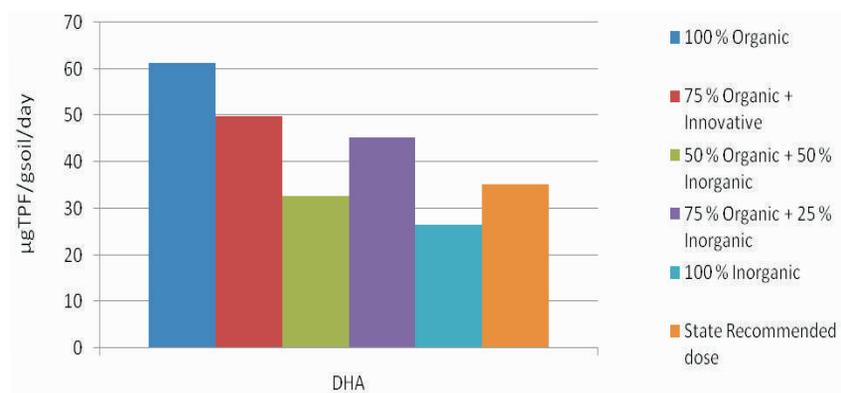


Fig.2.2.2 Dehydrogenase enzyme activity influenced by different nutrient management practices in soybean

Performance of different varieties of soybean and maize were evaluated for their yield response to screen out most promising variety for organic management practices for central India (Plate 2.2.1 and 2.2.2). Out of twelve soybean varieties, the yield of RVS-2002-4 (1236 kg ha⁻¹) was found to be higher followed by JS-97-52 (1193 kg ha⁻¹) and JS-20-41 (1129 kg ha⁻¹). Among the JS varieties, JS-97-52 recorded higher yield. Among the RVS varieties, RVS-2002-4 was found to give higher yield. Maize cv. Kanchan recorded a maximum seed yield of 2764 kg ha⁻¹ while Sweet corn cv. produced poor yield (837 kg ha⁻¹) under organic farming practices (Table 2.2.7). Protein and oil content in soybean seed were influenced significantly among varieties of soybean. The higher value of protein was recorded in JS-93-05 variety followed by JS-335, NRC-7 and JS-20-41 and other varieties showed at par value. However, higher value of oil content was recorded in RVS-2002-7 variety. Total minerals content in maize grains did not vary significantly among various varieties but the protein and tryptophan content varied significantly among various varieties of maize grown under organic package of practices.

Table 2.2.7 Performance evaluation of different varieties of major crops under organic farming practices

Soybean variety	Seed yield (kg ha ⁻¹)	Protein (%)	Oil (%)	Maize variety	Seed yield (kg ha ⁻¹)	Protein (%)	Total minerals (%)	Tryptophan (g ⁻¹ 16 g N)
JS-335	820	36.17	19.63	Kanchan	2764	9.71	1.41	0.81
JS-93-05	784	36.48	19.43	Pratap- 5	1928	9.53	1.39	0.78
JS-95-60	788	36.14	18.76	Arawali	1773	8.75	1.38	0.72
JS-20-41	1129	36.12	18.81	Sona -222	1727	9.7	1.44	0.82
NRC-7	1007	35.17	18.72	Pratap- 6	1997	9.4	1.43	0.74
NRC-37	846	36.00	18.66	JM -216	1593	9.5	1.39	0.71
JS-20-29	709	-	-	Popcorn- 1	911	8.9	1.43	0.65
RVS-2002-4	1236	35.03	19.69	JM- 8	2193	9.4	1.45	0.84
RVS-2002-6	768	35.2	20.03	JM -12	1856	9.2	1.42	0.81
RVS-2002-7	977	35.72	20.8	Proagro-4412	2537	10.0	1.33	0.87
JS-97-52	1193	35.74	18.9	Sweet Corn	837	8.9	1.37	0.68
JS-20-34	631	-	-	CPBG 4202	1365	9.7	1.35	0.79
LSD (<i>p</i> = 0.05)	83	0.2	0.4		712	0.1	NS	0.05



Plate 2.2.1 A view of maize in experiment (kharif 2014)



Plate 2.2.2 Performance of different Varieties of soybean crop (kharif 2014)

2.3 Soil quality and resilience

2.3.1 Biochar effect on soil properties

The study was conducted with the hypothesis that leguminous biochar with high alkalinity could be the substitute for lime in correction of soil acidity. The amendment effect of biochar produced from *Leucaena* biomass was investigated in short-term incubation study in acidic soil (Alfisol; pH (H₂O) = 4.5) of north-west India. The biochar (BC) was mixed at 2, 4 and 6 (%w/w) with soil and change in soil pH, EC, NH₄ and NO₃-N, exchangeable bases (Ca+Mg, K, Na), exchangeable Al and Bray's P were measured periodically up to 90 days. The mean increase in soil pH compared with control was 0.65, 1.35 and 2.0 unit at 2, 4 and 6% (w/w) of biochar incorporation, respectively (Fig.2.3.1). Application of biochar significantly (P<0.01) reduced NH₄-N content of soil whereas nitrate-N concentration increased by 3 and 5 folds by application of 2 and 4% (w/w) of biochar, respectively (Fig.2.3.2). Addition of biochar at 2, 4 and 6% (w/w) increased mean soil exchangeable Ca+Mg concentration by 50, 92 and 138%, respectively (Fig.2.3.3). Exchangeable K of soil increased to 5.8, 9.2 and 13.8 times with addition of 2, 4 and 6% of biochar, respectively. Application of biochar above 2% (w/w) reduced exchangeable Al concentration to non detectable limit. The study provides the utility of *Leucaena* biochar as an alternative liming material for reclamation of highly acidic soils.

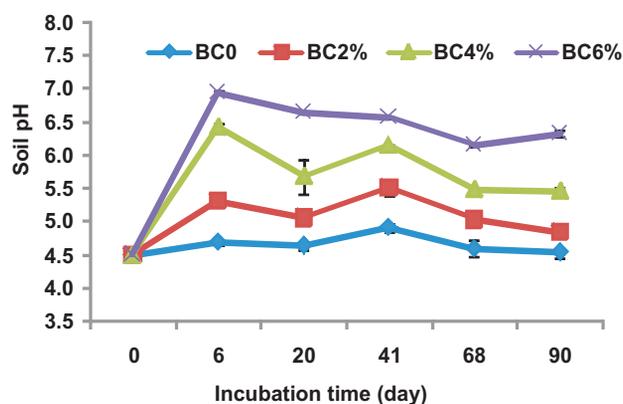


Fig.2.3.1 Effect of *Leucaena* biochar on soil pH

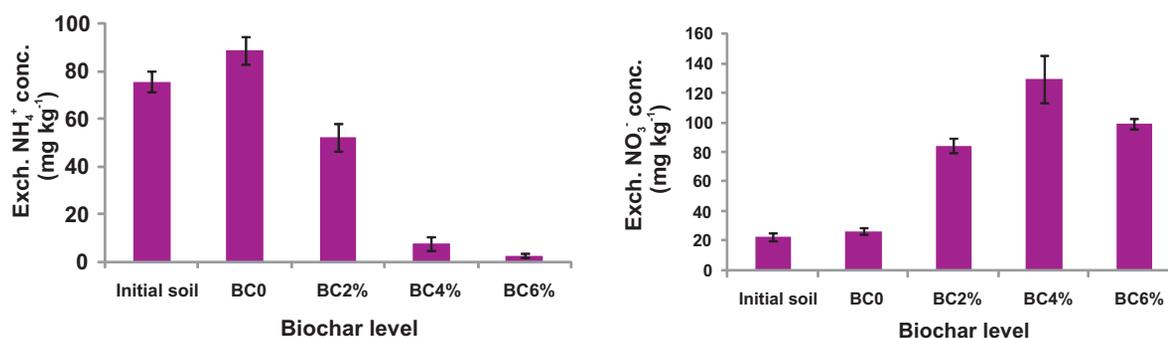


Fig.2.3.2 Effect of *Leucaena* biochar on mineral-N content of soil

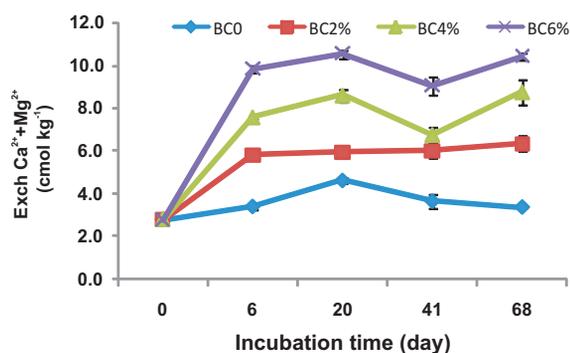
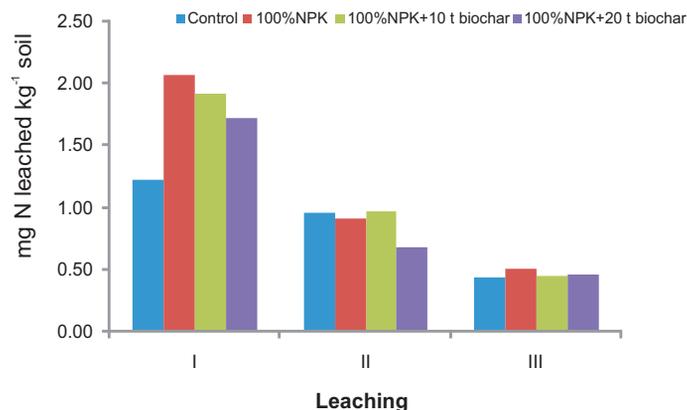


Fig.2.3.3 Effect of *Leucaena* biochar on soil exchangeable Ca²⁺+Mg²⁺ concentration

2.3.2 Biochar for reducing leaching loss of nutrients

A leaching study with biochar and fertilizers was conducted simulating the field conditions in red and black soils. The study revealed that the N loss from the red and black soils is high when fertilizers are added to soil (Fig.2.3.4). The N leached through the 30 cm soil column increased with fertilizer addition, but, there was a significant decrease in the N loss when biochar was added along-with fertilizer at the rate of 10 and 20 t ha⁻¹ that was 4 and 18% less than normal fertilizer application for red soil and 25 and 37% less for black soil, respectively. Similarly, a reduction in losses was observed with biochar addition with respect to P and K (25 and 76% in red soils and 18 and 23% in black soils, with the addition of biochar @ 10 and 20 t ha⁻¹, respectively).



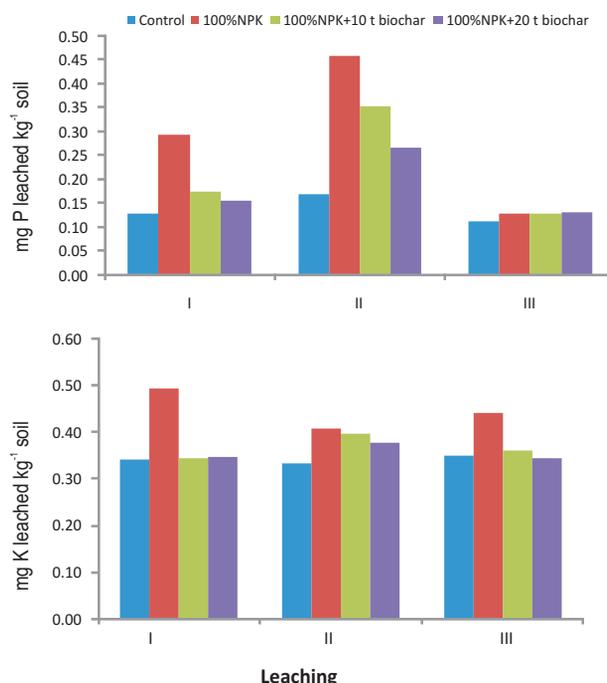


Fig.2.3.4 Nutrient leaching losses from a red soil

2.3.3 Urease inhibitor product (LIMUS) for nutrient use efficiency in maize

To study the effect of different N sources on maize, a study was initiated in *kharif* season at the Research Farm of Indian Institute of Soil Science during July 2014 with ten treatments as detailed in Table 2.3.1. The grain yield of maize ranged from 2527 to 5365 kg ha⁻¹. Significant increase in grain yield was observed in all the treatments over control. Significant increase in yield was observed when 80 kg N was supplied in two splits at V4 and V8 stages only. The first season findings indicate

Table 2.3.1 Effect of different N sources on grain and biomass yield of maize

N source	N rate kg ha ⁻¹	Basal	Top dressing stage			Grain yield (kg ha ⁻¹)	100 grain weight (g)	Agronomic Efficiency (kg grain/kg N applied)
			V4*	V8*	VT*			
No Urea	0	0	0	0	0	2527 ^d	17.65 ^c	-
Normal Urea	150	37.5	0	75	37.5	4733 ^b	20.82 ^{ab}	14.7
Normal Urea	120	30	0	60	30	4565 ^{bc}	21.03 ^{ab}	17.0
Normal Urea	80	16	20	24	20	4070 ^c	20.40 ^{ab}	19.3
LIMUS Urea	80	16	20	24	20	4621 ^{bc}	21.74 ^a	26.2
Normal Urea	80	0	40	40	0	4795 ^b	20.40 ^{ab}	28.4
LIMUS Urea	80	0	40	40	0	5365 ^a	21.78 ^a	35.5
Normal Urea	64	0	33	33	0	4458 ^{bc}	20.23 ^{ab}	30.2
LIMUS Urea	64	0	33	33	0	4632 ^{bc}	19.98 ^b	32.9
Neem Coated Urea	80	16	20	24	20	4892 ^{ab}	20.44 ^{ab}	29.6

* V4 - fourth leaf visible; V8 - collar of eighth leaf visible; VT - last branch of the tassel completely visible but silk not yet emerged

** Figures with common letters are not significantly different

that the LIMUS urea has shown an edge over normal urea and there is more advantages in yield with adjustment towards time of fertilizer application. At the same time, neem coated urea has resulted in the statistically higher grain yield of maize compared to prilled urea application and statistically at par yield compared to LIMUS urea application with the similar method of application (Table 2.3.1 and Fig. 2.3.5).

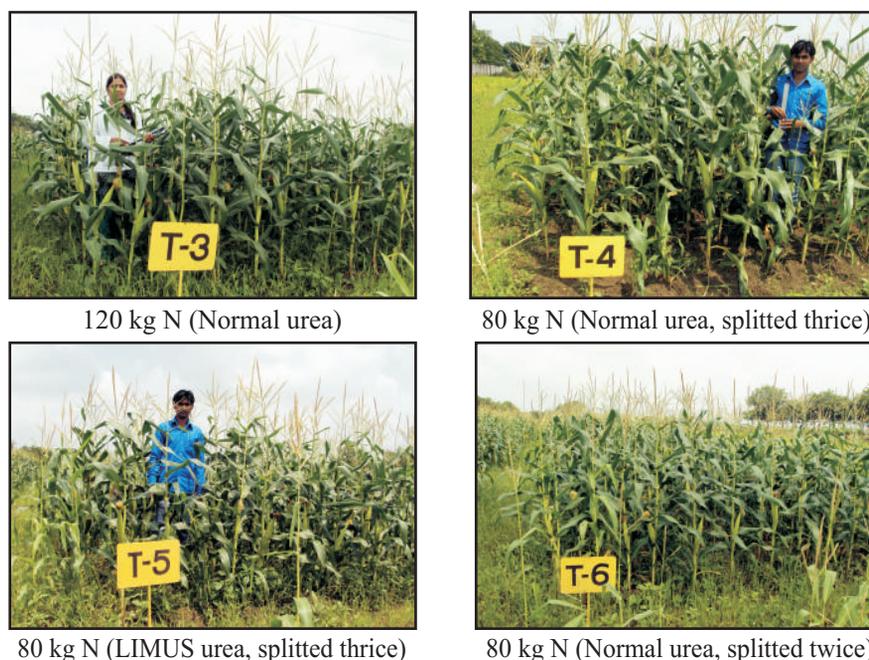


Fig.2.3.5 Performance of maize under different split application and N sources

Theme II: Conservation Agriculture and Carbon Sequestration vis-à-vis Climate Change

2.4 Conservation Agriculture and Climate Change

2.4.1 Elevated temperature and carbon dioxide concentration effects on wheat productivity in Madhya Pradesh

The Agricultural Production System Simulator (APSIM) Wheat model was used to test the sensitivity of wheat cropping system for the Bhopal region in Madhya Pradesh for the following scenarios: Baseline- this scenario looked at simulations derived from the unmodified current climate data of 30 years (1980-2010); Increased temperature- this scenario examined the impact of increasing the mean temperature by 1, 2, 3, 4, 4.5 and 5°C, keeping all other parameters constant; carbon dioxide fertilization- this scenario examined the impact of increasing the CO₂ level to 850 ppm from 350 ppm keeping all other parameters constant; and Carbon dioxide and temperature changes interactive effect.

The wheat cultivar Sujata was used for this simulation study. It was found that there was a negative relationship between grain yield and temperature while there were positive correlations of grain yield with increased atmospheric CO₂ concentration for the region under study (Plate 2.4.1) On an average, there was 8% decrease in wheat grain and biomass yield per 1°C increase in temperature.

On the contrary, wheat grain yield increased by 33% and biomass yield by 35% with the elevation in CO₂ concentration from 350 to 850 ppm. However a combination of increasing the temperature by 1°C and CO₂ concentration to 500 ppm from 350 ppm reduces the yield decline in wheat as compared to the individual effect of increased temperature alone (Fig.2.4.1).

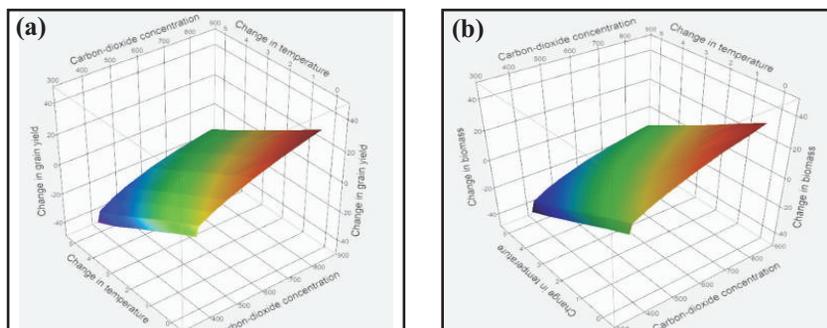


Plate 2.4.1 Combined effects of change in temperature and CO₂ concentration on recent change in (a) wheat grain and (b) biomass yield

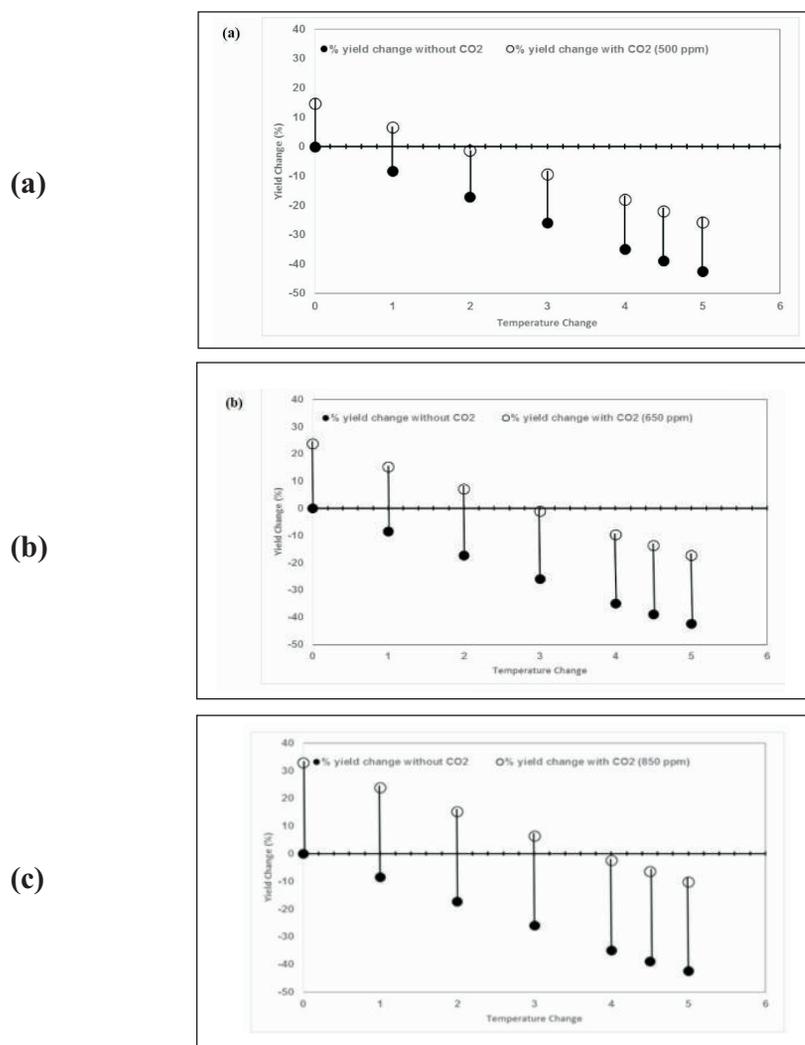


Fig.2.4.1 APSIM model estimates of wheat yield changes for different levels of temperature

2.4.2 Development of root mass distribution model under different tillage systems in Vertisol

Root mass is one of the most commonly used parameter for studies of root growth in response to environment. Despite their importance for nutrient cycling, resource capture, and global biogeochemistry, root biomass are neither modeled nor included in global models. In this study, a statistical model was identified to describe root mass distribution along soil depth under different tillage practices. To achieve these objective, root samples of two chickpea cultivars viz JG-130 and JG-11 were collected at various growth stages under No tillage (NT) and conventional tillage (CT). Higher root mass density was observed in JG-130 as compared to JG-11, indicating JG-130 is more suitable to drought condition than JG-11 (Fig. 2.4.2). To model root mass density, different statistical models were tested and Cubic statistical model was identified as best model to explain distribution of root biomass along depth (Table 2.4.1). Further, the identified cubic model was validated with different set of root biomass data and 1:1 graph indicated the higher predictability of the developed model (Fig.2.4.3).

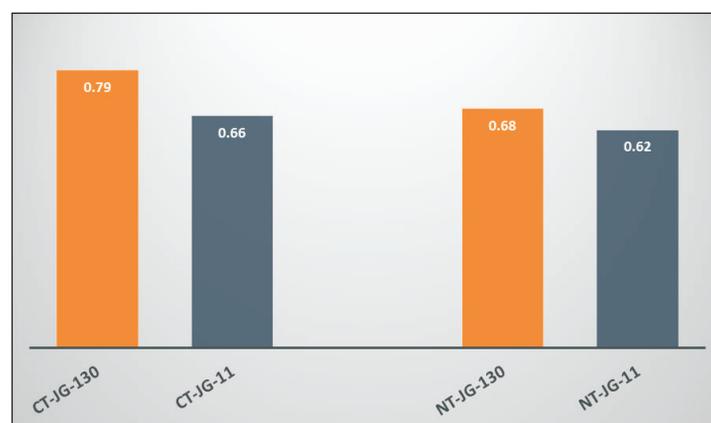


Fig.2.4.2 Root mass density (mg cc⁻¹) at flowering under different management practices

Table 2.4.1 Details of various statistical models

Statistical Model	General Expression	Model Summary		
		R ²	Adjusted R ²	Standard error of estimate
Linear	Y=ax+b	0.77	0.6	0.079
Logarithmic	Y=a+blnx	0.75	0.74	0.062
Inverse	Y = a+(b/t)	0.82	0.81	0.053
Quadratic	Y=ax ² +bx+c	0.78	0.77	0.059
Cubic	Y=ax ³ +bx ² +cx+d	0.83	0.82	0.051
Power	Y=ax ^b	0.6	0.59	0.685
Growth	Y = e ^{(a + (b*t))}	0.55	0.54	0.722
Exponential	Y=ae ^{kx}	0.55	0.54	0.722

Y = Root biomass distribution, x = Soil depth

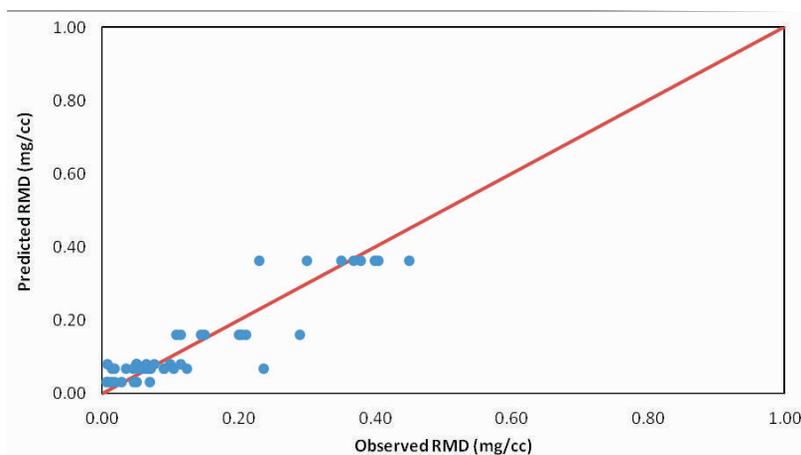


Fig.2.4.3 Relationship between observed and predicted Root Mass Density (RMD) as predicted by Cubic model

2.4.3 Weed management for major cropping systems under conservation agriculture in Vertisols

Weed management has always been a challenge in conservation agriculture. For effective weed management under conservation agriculture in vertisols, herbicidal weed management options were being evaluated against control and hand weeding for four dominant cropping systems viz. soybean-chickpea, soybean- wheat, maize-chickpea and maize-mustard in zero till condition. Crops were sown with zero till seed cum fertilizer drill and the standard CA practices along with weed control treatments were followed. The major weed flora in maize and soybean comprised of *Echinochloa crusgalii*, *Panicum javanicum* and *Brecharia recemosa* among grassy weeds whereas *Digera*

Table 2.4.2 Effect of weed control treatment on yield of soybean

Treatment	Grain Yield (q ha ⁻¹)	Weed Index (%)
Absolute control	6.27	-74.02
Two hand weedings at 20 & 40 DAS (Conventional weed management)	22.62	0.00
Pre em. Pendimethalin @1000 g ai ha ⁻¹	16.50	-27.70
PoE Propaquizafop 100g ai+ Chlorimuron ethyl 9 g ai ha ⁻¹ at 20 DAS	15.14	-32.87
PoE Imazethapyr 100 g ai ha ⁻¹ at 20 DAS	22.14	-1.84
Pre em. Pendimethalin @ 1000g ai ha ⁻¹ Fb PoE Imazethapyr @70g ai ha ⁻¹ at 30 DAS	24.95	10.34
PoE Propaquizafop 100 g ai+ Chlorimuron ethyl 9 g ai ha ⁻¹ Fb removal of escaped weeds at 40 DAS	24.01	5.63
PoE Imazethapyr 70 g ai ha ⁻¹ Fb removal of escaped weeds at 40 DAS	22.66	-1.55
Pre em. Pendimethalin 1000 g ai ha ⁻¹ Fb removal of escaped weeds at 30 DAS	22.91	2.07
LSD ($p=0.05$)	4.84	

arvensis, *Alternanthera sessalis*, *Celosia argentea*, and *Euphorbia geniculata* among dominant broad leaved weeds in the experimental field. In case of soybean based cropping systems pre emergence application of Pendimethalin @1.0 kg a.i. ha⁻¹ followed by post emergence application of Imazethaypar gave grain yield at par with grain yield obtained under two hand weeding treatments (Table 2.4.2 and Plate 2.4.2). Similarly, under maize based cropping system pre emergence



Plate 2.4.2 View of experimental field displaying weed flora under control plot and soybean crop under herbicide treated plot

Table 2.4.3 Effect of weed control treatment on yield of maize

Treatment	Biological yield (q ha ⁻¹)	Grain yield (q ha ⁻¹)	Weed Index (%)
Absolute control	68.25	27.30	-55.36
Two hand weeding at 20 and 40 DAS	146.96	61.16	0.00
Pre em. Atrazine 1000 g ai ha ⁻¹	78.64	32.62	-46.66
Pre em. Pendimethalin 1000 g ai ha ⁻¹	102.86	42.86	-29.92
PoE Atrazine 1000 g ai ha ⁻¹ at 20 DAS	106.17	44.24	-27.67
Pre em. Pendimethalin 1000 g ai ha ⁻¹ fb PoE Atrazine 750 g ai ha ⁻¹ at 30 DAS	150.66	62.67	2.47
Pre em. Pendimethalin 1000 g ai ha ⁻¹ Fb removal of escaped weeds at 30 DAS	140.96	58.43	-4.46
Pre em. Atrazine 1000g ai ha ⁻¹ Fb removal of escaped weeds at 30 DAS	123.43	50.87	-16.82
Pre em. Pendimethalin @500 g ai ha ⁻¹ fb PoE Atrazine 750 g ai ha ⁻¹ at 30 DAS	112.03	46.78	-23.51
LSD ($p = 0.05$)	15.01	6.42	

Pre em = Pre emergence, PoE = Post emergence, DAS = Days after sowing, a.i. = Active ingredient, Fb= followed by Weed index- % reduction in grain yield as compared to hand weeding



Plate 2.4.3 View of experimental field displaying weed flora under control plot and maize crop under herbicide treated plot

application of Pendimethalin @1.0 kg a.i. ha⁻¹ followed by post emergence application of Atrazin gave grain yield at par with grain yield obtained under two hand weeding treatments (Table 2.4.3 and Plate 2.4.3). The *rabi* crops have also been sown under zero till condition after harvest of *kharif* crops.

2.4.4 Interactive effect of tillage and manure on least limiting water range (LLWR) after six years of experiment in Vertisols

The least limiting water range (LLWR) is the range in soil water content within which limitations to plant growth associated with water potential, aeration and mechanical resistance to root penetration

Table 2.4.4 Effect of tillage and manure on soil penetration resistance (SPR) after sowing and before harvest of wheat crop in selected treatments

After sowing : Date of observation 29/11/2013						
Soil depth (cm)	SPR (MPa)					
	RT-T1	NT-T1	RT-T4	NT-T4	RT-T7	NT-T7
0-15	1.15	1.20	0.90	0.95	1.10	0.95
15-30	1.30	1.45	1.05	1.30	1.10	1.20
30+	1.40	1.45	1.05	1.20	1.05	1.15
Before harvest : Date of observation 20/03/2014						
0-5	1.10	1.50	0.80	1.00	1.00	1.40
5-15	1.50	2.60	1.50	2.40	1.70	2.50

Note: RT: Reduced tillage, NT: No tillage, T1: NPK alone, T4: NPK + FYM-C (2 Mg ha⁻¹ yr⁻¹), T7: NPK + FYM-C (10 Mg ha⁻¹ once in 5 five years)

are minimal. The LLWR, which integrates several soil physical parameters, has been proposed as an index of soil structural quality. The interactive effect of tillage and manure was used to assess response to LLWR and soil physical properties after six years of soybean-wheat cropping cycle.

The results showed that the values of the LLWR under different tillage and manure practices ranged from 0.16 to 0.24, 0.10 to 0.17 and 0.09 to 0.14 cm³ water / cm³ soil. LLWR in the 0-5, 5-10 and 10-15 cm soil layer were significantly lower under NT than RT ($p < 0.05$), whereas the difference in the 15-30 cm layer was not significant ($p > 0.05$). This is supported by increase in soil penetration resistance in no tillage plots (Table 2.4.4) during wheat growth season at 0-15 and 15-30 cm soil depth. Similarly higher bulk density (B.D.) was observed in no tillage plots compared to reduced tillage at 0-15 and 15-30 cm soil depth. Bulk density under different tillage and manure practices ranged from 1.08 to 1.29, 1.23 to 1.39 and 1.37 to 1.48 Mg m⁻³ at 0-5, 0-15 and 15-30 cm soil depth, respectively. Application of farmyard manure was found to have positive effect on water availability, improving soil physical properties in reduced tillage compared to no tillage in Vertisols.

2.4.5 Global warming potential of long-term nutrient management practices in soybean-wheat system in Vertisols of Central India

A study was conducted to compare the greenhouse gases (GHGs) emission from three nutrient management systems viz., 100% organic (OM), 100% inorganic (NPK) and integrated nutrient management (INM) continued for nine years in soybean-wheat cropping system in the Vertisols of central India. The gas samples for three key GHGs (CO₂, CH₄ and N₂O) were collected by static chamber method at about one month interval using chambers of 71 X 46 X 15 cm (length X width X height) placed between crop rows throughout the crop growing season. There was significant difference between the treatments with regard to their global warming potential (GWP). In terms of net GWP considering the soil carbon accretion, the treatments were in the order of NPK > INM > OM. This means mitigation potential of the 100% organic treatment was highest followed by INM and NPK treatments.

Theme III: Microbial Diversity and Genomics

2.5 Microbial Diversity and Soil Genomics

2.5.1 Metagenomic characterization and spatio-temporal changes in the rhizoplane of bioenergy crop *Jatropha curcas*

Bioenergy crop *Jatropha curcas* are known for their adaptation potential under stress (low nutrient and water scarcity). Experiments were carried out to understand (1) nutrient cycling microbial population and (2) stress mitigating microbes in the rhizosphere and phyllosphere of this plant. Microbes representing different functional groups were isolated and characterized by 16S rRNA gene sequence. DNA sequences revealed that *Bacillus safensis*, *Bacillus subtilis*, *Bacillus flexus*, *Methylothermobacter multivorans*, *Brevibacillus sp.*, *Staphylococcus succinis*, *Acinetobacter sp.*, *Terribacillus sp.* and *Rhizobium tropici* were predominantly found in the ecto and endorhizosphere of *J. curcas*. The isolates were further characterized for their C source utilization pattern, acetylene reduction assay (ARA) and PGPR activities. 16S rRNA gene sequence of phyllosphere microbes revealed prevalence of *Bacillus flexus*, *B. pumillus*, *Rhizobium leguminosarum* and *Acinetobacter baumannii*, etc. These bacteria are mostly N₂ fixing, methane oxidizing groups. We hypothesize that these groups aid in plant's stress response.

2.6 Recycling and Rationale Usage of Different Wastes in Agricultural Soils

2.6.1 Developing technique for acceleration of decomposition process using thermophilic organisms

A Rapid Composting bioreactor was designed and fabricated with a capacity of 100 kg (Plate 2.6.1) to perform aerobic method of composting. It is a rotating drum type reactor of size 1.25 m diameter and 1.5 m length. It is made of double wall with outer wall insulated with 50mm glasswool. The heating arrangement is provided through four strip heating elements of 1 kW each. The water was filled in between the double wall to provide uniform heating. A temperature indicator cum controller was provided to control the temperature of substrate inside the reactor. The bioreactor is mounted on three wheeled structure for easy transport. The bioreactor can be rotated manually to achieve mixing and better aeration.

Microscopic study of lignocellulolytic thermophilic fungi was done (Plate 2.6.2). Segregation was the first step performed followed by mixing the segregated waste (150 kg) with fresh cowdung (50 kg) and consortium of microbes (10⁵ viable cell). 60% of moisture content was maintained throughout the composting period. Periodic turning was done to provide aeration. The samples were collected at 15 and 30 days of decomposition.

The samples were analyzed for physical, chemical and biological properties. At 30 days of decomposition the colour of the compost was dark brown and with no foul odour. C:N ratio falls from 62:1 to 14:1 (Fig.2.6.1), CEC reached to 94 cmol (p+) kg⁻¹, lignin/cellulose ratio increases from 0.5 to 2.4%, CEC/TOC ratio increased from 0.27 (initial) to 4.56 at 30 days of decomposition,

water soluble carbon reached to 0.5% whereas the content of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ varied from 1.3-0.28 and 0.14-0.84 g kg^{-1} , respectively. Dehydrogenase activity, FDA and alkaline phosphatase activity increase from 111 to 413 $\mu\text{g TPF g}^{-1}$ compost day^{-1} , 98-260 $\mu\text{g fluorescein g}^{-1}$ compost h^{-1} and 94-171 $\mu\text{g PNP g}^{-1}$ compost h^{-1} , respectively.

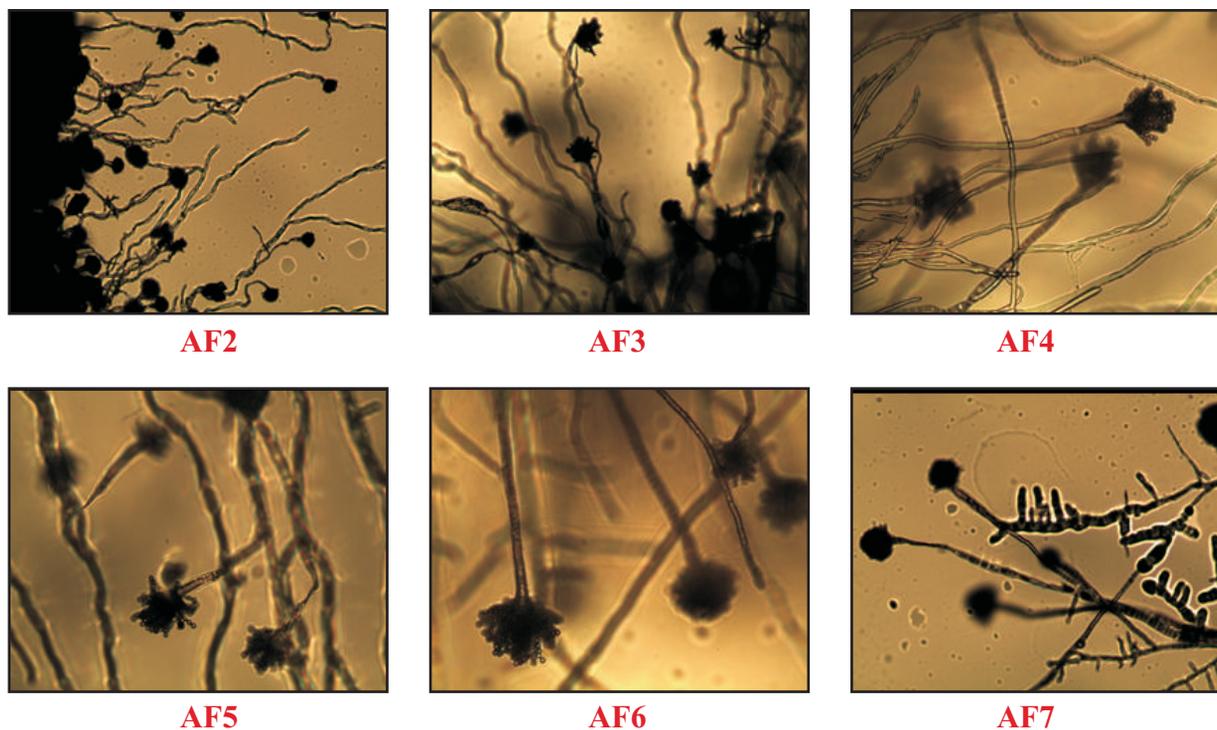


Plate 2.6.2 Microscopic view of lignocellulolytic thermophilic fungi



Plate 2.6.1 View of rapid composting bioreactor

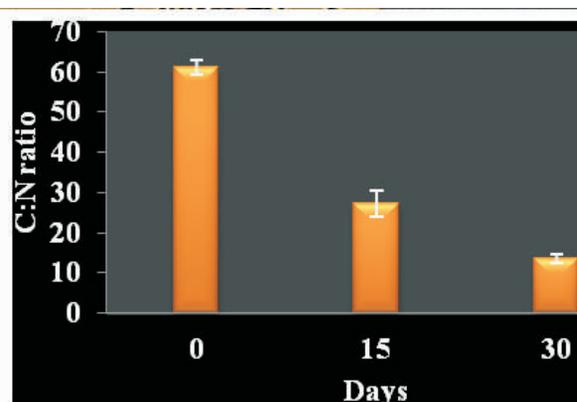


Fig. 2.6.1 C:N ratio of the materials at 0, 15 and 30 days of decomposition

2.6.2 Chemical and microbiological evaluation of biodynamic and organic preparations

To evaluate effect of different organic and biodynamic preparations, a pot experiment was conducted with wheat as test crop. Agronomic parameters like root length, shoot length, root dry weight, shoot dry weight at 55 days of sowing was recorded. Grain weight and straw weight was taken after crop harvest. Highest root length was observed in T7 (combination of all nutrient) followed by integrated (T3). Shoot length was recorded highest in Panchagavya treatment which was statistically at par with control, inorganic and organic treatment, however, the plant appeared slender in case of control and panchagavya. The plant biomass (shoot dry weight and straw yield) was also recorded low in the control and panchagavya (Table 2.6.1). Grain yield was noticed highest in T7 (combination of all nutrients) followed by inorganic nutrient sources (T2). Organic and integrated nutrient management performed at par to each other and no significant difference was observed between organic and biodynamic treatment.

Table 2.6.1 Plant growth parameters and yield under different nutrient management practices

Treatment	Root length (cm)*	Shoot length (cm)*	Root dry wt./plant (g)*	Shoot dry wt./plant (g)*	Grain yield (g)*	Straw yield (g)*
T1	14.40	38.40	1.63	3.57	6.52	13.19
T2	17.60	38.40	4.66	7.22	13.8	21.23
T3	20.00	32.80	3.33	6.32	12.50	24.76
T4	19.20	39.30	2.77	6.60	12.00	21.85
T5	16.00	33.20	2.55	4.78	11.50	17.01
T6	19.80	40.30	1.91	4.05	8.88	12.67
T7	23.00	31.60	3.88	7.15	14.94	21.99
LSD ($p = 0.05$)	3.28	5.84	0.48	0.61	0.98	3.32

*Average of 5 randomly selected plants

T1: Control (No fertilizer or manure), T2: Chemical fertilizer, T3: Integrated nutrient management, T4: Organic nutrient management, T5: Biodynamic treatment, T6: Panchagavya, T7: T3+T5+T6

Theme IV: Soil Pollution, Remediation and Environmental Security

2.7 Amelioration of Contaminated Soils

2.7.1 Status of heavy metals content in and around Singrauli (M.P.) and Sonebhadra (U.P.) Industrial area

As per direction of Hon'ble National Green Tribunal (NGT), surface (upper 15 cm) geo-referenced soil samples from both agriculture and forest land from the nearby industrial and mining area (termed as impact zone) as well as from areas far away (termed as reference samples) were collected from Singrauli and Sonebhadra. The samples have been analyzed for heavy metals contents of

cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) by the wet digestion method.

Results showed that average contents of heavy metals in the reference soil samples were 0.39 (range 0.1 to 1.1) mg kg⁻¹ Cd, 30.0 (range 4.5 to 68.7) mg kg⁻¹ Cr, 20.2 (range 1.6 to 52.7) mg kg⁻¹ Cu, 21.5 (range 2.5 to 42.1) mg kg⁻¹ Ni, 19.1 (range 4.6 to 40.6) mg kg⁻¹ Pb and 67.7 (range 30.3 to 115.2) mg kg⁻¹ Zn. The average content of heavy metals in the soils from impact zone were 0.42 (range 0.03 to 2.6) mg kg⁻¹ Cd, 33.1 (range 8.3 to 38.3) mg kg⁻¹ Cr, 18.0 (range 3.7 to 43.6) mg kg⁻¹ Cu, 22.8 (range 3.7 to 52.3) mg kg⁻¹ Ni, 15.3 (range 7.6 to 42.9) mg kg⁻¹ Pb, and 61.5 (24.0 to 132.6) mg kg⁻¹ Zn. The above results indicate that there is no significant change in the heavy metal contents in the soils nearby industrial and mining area when compared to the soils of agricultural and forest land far away from the impact zone. It can be concluded that the contents of total heavy metals Cd, Cr, Cu, Ni and Pb in the soils of agricultural and forest land in the impact zone are within the range normally observed in case of soils of unpolluted area.

Only one soil sample collected from the forest area of *Murdhwa nalla* in Sonebhadra (U.P.) contained significantly high Cd (2.57 mg kg⁻¹ Cd) and this location is about one kilometer away from a caustic soda plant. Two ash samples collected from ash dyke pond of thermal power plants have also been analyzed for heavy metal contents and results show that their contents are quite low as compared to the contents found in several soils in the study area. Analysis of red mud sample (a waste product of the Hindalco aluminium industry of Renukoot, Sonebhadra) indicated that it contains high level of Cr (647.33 mg kg⁻¹) and therefore, may contaminate soil if gets discharged into the agricultural land.

2.7.2 Impact of sewage water irrigation on soil properties

The Geo-referenced surface soil samples were collected from different locations in the long-term sewage irrigated area of both sides of *Patra Nala* of Bhopal region (Plate 2.7.1). Sewage water samples at an interval of 1-2 km upto Halali dam and soil samples from different sewage irrigated farmers' fields were collected from the surface layer (0-15 cm). The pH of the soil samples was in the range of 7.1-8.6 and EC in the range of 0.12-0.37 dS m⁻¹. The contents of P, K and S in sewage water were 4.2-12.6, 8.8-13.9 and 11-13 ppm, respectively. Long-term use of sewage water for irrigation resulted in significant increase in soil organic carbon (SOC) which ranged from 0.54% to 1.92% with an average value of 1.07%. The population of bacteria, fungi and actinomycetes in sewage irrigated soils were significantly higher (1.3, 13.5 and 5.6 times, respectively) as compared to the ground water irrigated area. Activities of different soil enzymes alkaline phosphates, dehydrogenase and FDA-induced enzymes were also much higher in sewage irrigated soils. The contents of Cu, Cd, Pb, Cr, Ni and Zn were also higher in the soils under sewage irrigation compared to the soils with ground water irrigation. The concentration (mg kg⁻¹) of different heavy metals were Cu 40.9-100.4 (mean 61.5); Cd 1.6-19.6 (mean 3.9); Pb 9.8-31.2 (mean 15.8); Cr 25.0-65.6 (mean 41.9); Ni 31.7-69.6 (mean 47.1); and Zn 37.1-162.0, (mean 64.7). The sewage water for irrigation has built up total Cu, Cd, Pb, Cr, Ni & Zn by 2.1, 3.2, 1.4, 1.8, 2.0 & 1.6 times more than groundwater irrigated field.



Plate 2.7.1 Collection of soil and sewage water samples

Geo-referenced profile samples (Plate 2.7.2) were also collected from different soil depth (0-15, 15-30, 30-45 and 45-60 cm) at 58 places (in 54 different locations along the drainage channel and up to 2 km away from the channel at a distance interval of 0.5, 1.0, 1.5 and 2.0 km where sewage water is used for irrigation and 4 ground water (GW) irrigated areas) to find out the soil organic carbon build up. The SOC build up at 15, 30, 45 and 60 cm depth was 1.6, 1.8, 2.1 and 2.5 times more, respectively at sewage irrigated fields compared to ground water irrigated field.



Plate 2.7.2 Soil profile sample collection

2.7.3 Interactive effect of heavy metals in tannery effluent on chromium concentration in spinach biomass

The tannery industry effluent contains different cations, anions and other heavy metals besides Cr in large concentrations. These major ions and metals are likely to influence the uptake of heavy metals due to interaction on the root surface. A pot culture experiment was conducted to study the interaction of Cr with Cd and Zn on their uptake by spinach crop. Results showed that increasing the Cr, Cd and Zn application enhanced the concentration of the respective metal ions in root and shoot when applied alone. Cadmium application @ 2 mg kg⁻¹ decreased Cr concentration in root & shoot in Cr contaminated (100 mg kg⁻¹) soil (Fig.2.7.1). Zinc application had no significant effect on Cr

concentration in root and shoot, and its uptake. Thus, this study revealed that the presence of Cd in tannery effluent may decrease the Cr concentration in spinach crop.

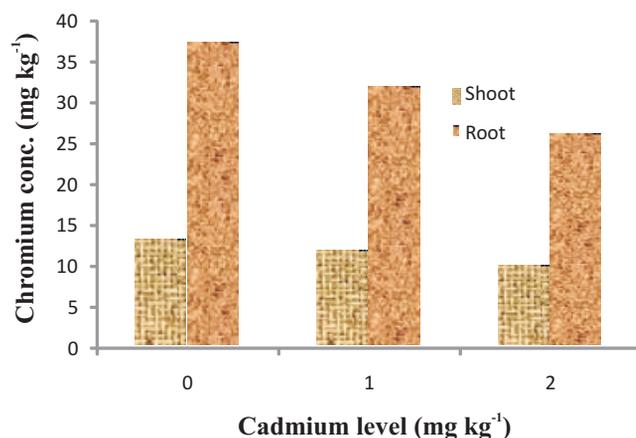


Fig. 2.7.1 Effect of Cd on Cr root and shoot concentration

2.7.4 Chromium toxicity on soil enzymatic activities

Tannery effluent contains a larger amount of chromium (Cr), which reaches agricultural field by the irrigation during crop production. Accumulated Cr concentration in soil significantly affected soil enzyme activities i.e. dehydrogenase activity, alkaline phosphate and fluorescein diacetate. A laboratory study conducted with graded doses of Cr (0, 5, 10, 15, 20, 40, 80 and 100 mg kg⁻¹) revealed that increasing the concentration of Cr (0 to 100 mg kg⁻¹) reduced the enzyme activities and the maximum reduction was observed in the early stages of incubation. Among the enzyme activities, dehydrogenase activity was more sensitive to Cr toxicity. Dehydrogenase activity was decreased by 71.3% in 100 mg kg⁻¹ Cr treated soil over control. Thus, it is concluded that Cr contamination of soil through anthropogenic activities like tannery effluent irrigation in soil, has a significant adverse effect on soil microbial and enzymatic activities.

2.7.5 Preparation of standard reference soil material for heavy metals analysis

In the process of preparation of standard reference soil material for heavy metals analysis, soil sample of about 250 kg was collected from the farm of the Indian Institute Soil Science, Bhopal (Location: N 23°18' 33.6" E77° 24' 27.2"; area 1m² and 0-20 cm depth). The collected soil samples were air dried, processed and passed through a 2 mm sieve. Thus obtained sample of about 160 kg was mixed by hand and split by coning and quartering, bulking opposite quarters to form the half samples, and setting one half samples aside, it was done till about 40 kg of soil obtained. Then it was ground manually using wooden pestle and mortar and manually homogenized for 72 hours using plastic rolling drum. After homogenization bottling was done as 10 samples were taken from the centre of the drum immediately upon stopping the rotation of the mixing drum to prevent segregation of fine particles, and were placed into 10 pre-cleaned brown glass bottles, so each contained a minimum of 100 g of soil. The drum was again rotated for a further ten minutes and a

further 10 samples were sub-sampled in the same way into bottles. The sub-sampling and bottling operation was continued until 250 bottles of the soil were obtained. About 20 bottles were randomly selected over the whole bottling procedure for homogeneity and stability testing. The moisture content of the final soil sample was 1.07% (w/w), had a clayey texture with 42.37% clay content, 0.46% SOC, pH 7.98 and CaCO₃ 5.76%. The average total content (mg kg⁻¹) of Cu, Cd, Pb, Cr, Ni and Zn in the soil was 53.46, 0.12, 20.68, 74.91, 60.89 and 61.02, respectively. From the homogeneity test it was found that heavy metals like Cu, Pb, Cr, Ni, Zn had less than 10% coefficient of variation (CV) and Cd had 27.45% CV. The higher CV for Cd was probably due to very low analytic concentration in the sample extracts.

2.7.6 Bio-filtration of heavy metals using selected mesophilic fungi

Metabolism independent binding or adsorption of heavy metal to living or dead cells, extra cellular polysaccharides, capsules and slime layers are referred to as bioadsorption. This technique was used to remove heavy metal pollution from municipal compost. The single solution adsorption isotherm model of Freundlich was developed for heterogenous surfaces. The Freundlich isotherm was computed as follows: $Q=KCe^{1/n}$ Where, Q= Metal uptake capacity of biomass, or amount of metal ion biosorbed per unit biomass, K= Biosorption equilibrium constant indicative of biosortive uptake capacity, n= Biosorption equilibrium constant, Ce= Equilibrium metal ion concentration in solution after biosorption.

The basic data of Pb, Cd, Cu, Ni, Zn and Cr biosorption on different fungi mass (0.250 g) were fitted into Freundlich isotherm equation (X/m vs. Ce) to explain the adsorption behavior of heavy metals (Table 2.7.1). X/m is the capacity of adsorption ($\mu\text{g g}^{-1}$) of biomass and Ce is the equilibrium concentration (mg L^{-1}). The variation in equilibrium of Pb, Cd, Cu, Zn, Ni and Cr concentration in different dead fungi were 0.04 to 28.25, 0.056 to 12.3, 0.43 to 34.04, 1.65 to 18.23, 0.87 to 26.8, and 0.07 to 34.65 mg L^{-1} , respectively. The correlation coefficient, Freundlich isotherm constant (k) and 1/n values have been presented in Table 2.7.1.

The adsorption parameters 1/n and K for Pb, varied from 3.69 to 16.2 and 195.1 to 372.7, respectively and for Cd from 3.4 to 16.0 and 96.2 to 183, respectively. In case of Cu, 1/n and K value varied from 10.9 to 15.8 and 88.13 to 173.4, respectively and for Zn, 1/n and K values varied from 2.8 to 9.0 and 1.57 to 23.03, respectively. Similarly for Ni, 1/n and K value varied from 7.7 to 27.8 and 28.28 to 150.4, respectively and for Cr, they varied from 9.9 to 18.8 and 100.3 to 280, respectively. Higher values of K indicate higher biosortive uptake capacity of metal ions. It was also observed that higher the “1/n” value, higher the metal adsorption binding affinities towards fungi cell. In the present study K values were higher for all the fungi for Pb.

Table 2.7.1 Biosorption capacity of non living fungi for removal of heavy metals

Metals	Freundlich isotherm parameters	Fungi					
		F1	F2	F3	F4	F5	F6
Pb	Regression Coefficient R ²	0.82	0.87	0.89	0.68	0.79	0.71
	K value	218	290.3	267.1	195.1	196.3	372.7
	1/n value	7.9	3.8	4.6	16.2	14.0	3.69
Cd	Regression Coefficient R ²	0.72	0.52	0.69	0.41	0.86	0.38
	K value	108.4	185.1	183.0	177.6	96.2	140.3
	1/n value	5.4	8.6	9.0	16.0	3.4	6.7
Cu	Regression Coefficient R ²	0.90	0.92	0.87	0.79	0.81	0.89
	K value	172.6	118.6	173.4	139.9	151.1	88.13
	1/n value	14.9	12.3	15.8	15.3	14.7	10.9
Zn	Regression Coefficient R ²	0.87	0.89	0.64	0.63	0.79	0.81
	K value	1.57	9.65	23.03	9.81	15.36	12.78
	1/n value	2.8	6.1	9.0	4.9	6.7	3.7
Ni	Regression Coefficient R ²	0.58	0.55	0.79	0.76	0.76	0.89
	K value	28.28	89.9	74	150.4	38.25	47.47
	1/n value	7.7	27.7	20.8	27.8	10.0	9.7
Cr	Regression Coefficient R ²	0.77	0.46	0.51	0.83	0.50	0.58
	K value	131.7	220.6	280	115.6	210.4	100.3
	1/n value	12.0	16.3	17.2	13.3	18.8	9.9

F1 = *Trichoderma viride*, F2 = *Aspergillus heteromorphus*, F3 = *Rhizomucor pusillus*, F4 = *Aspergillus flavus*; F5 = *Aspergillus terreus*, F6 = *Aspergillus awamori*

Further, a protocol has been developed for biofilter. According to this, a series of perforated biofilter (containing living fungi) blocks are inserted in the municipal solid waste compost. After 30 days, it was observed that the removal of Pb was maximum followed by Ni and Zn (Table 2.7.2). Further it was observed that among six fungi *Trichoderma viride* performed better for removal of Pb, Ni, Zn and Cd followed by *Aspergillus flavus*. It was also observed that the removal of heavy metals decreased with distance.

Table 2.7.2 Per cent removal of heavy metals using biofilter

Metal	Initial concentration (mg kg ⁻¹)	Concentration of heavy metals after inoculation with fungi (mg kg ⁻¹)					
		F1	F2	F3	F4	F5	F6
Zn	297.7	210 (29.5)*	201 (32.5)	200 (32.8)	212 (28.8)	284 (4.6)	278 (6.6)
Cu	193.2	180.6 (6.5)	150.1 (22.3)	167 (13.6)	173.9 (10)	178 (7.9)	169 (12.5)
Cr	63.6	53.6 (15.7)	51 (19.8)	53.4 (16.0)	56.9 (10.5)	60.9 (4.2)	61.3 (3.6)
Cd	1.4	1.1 (21.4)	1.2 (14.3)	1.1 (21.4)	1.1 (21.4)	1.3 (7.1)	1.2 (14.3)
Ni	38	24.6 (35.3)	25.6 (32.6)	26 (31.6)	24 (36.8)	30 (21.1)	32.1 (15.5)
Pb	206	100 (51.5)	140 (32)	150 (27.2)	120 (41.7)	169 (18)	166 (19.4)

F1= *Trichoderma viride*, F2= *Aspergillus heteromorphus*, F3= *Rhizomucor pusillus*, F4= *Aspergillus flavus*, F5= *Aspergillus terreus*, F6= *Aspergillus awamori*

* Values in bracket show the percent removal of heavy metals

2.7.7 Greenhouse gases (GHGs) emissions from 'static' pit of farmyard manure versus 'mixed' farmyard manure

'Static' pit of farmyard manure (FYM) involves no mechanical intervention while 'mixed' method involves mixing which ensures proper aeration during composting. Greenhouse gases (CH₄ and N₂O) emission from 'static' and 'mixed' pits of FYM was measured using the static box method. Sampling was carried out at *Ikhedi* village of Bhopal district. CH₄ emission was high in 'static' compared to the 'mixed' type composting system (Fig.2.7.2). N₂O emission from the pile was also

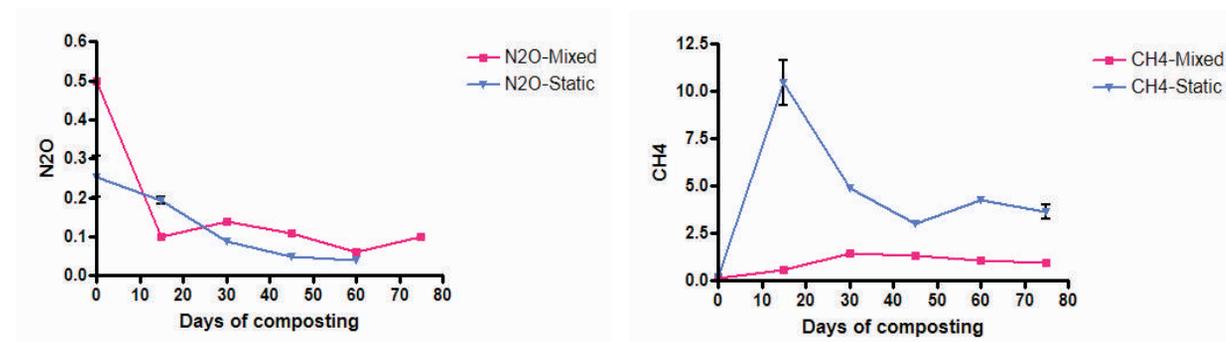


Fig.2.7.2 N₂O and CH₄ emission (mg m⁻³ d⁻¹) from static pit vs mixed farmyard manure

monitored over the composting period. Microbial diversity estimate elucidated that heterotrophic bacteria, and nitrifiers varied in response to GHGs flux values ($p = 0.05$). In order to mitigate GHGs emission from composting system, methanotrophs isolated from compost are being evaluated.

2.7.8 Biodegradation of imidacloprid (pesticide) under the influence of climatic factors

Pesticide (imidacloprid) biodegradation was studied under the influence of climate factors. The climate factors were CO₂ (ambient and 800 ppm), soil moisture (60% and 100% of moisture holding capacity (MHC), and temperature (15°C, 35°C and 45°C). Soil moisture and temperature stimulated pesticide degradation, while elevated CO₂ inhibited degradation rate at 35°C and 45°C. Degradation rate ($\mu\text{g g}^{-1} \text{ soil d}^{-1}$) of imidacloprid varied from 0.07 to 0.29 (Fig.2.7.3). Pure cultures of pesticide degrading bacteria were isolated for further use (Plate 2.7.3).

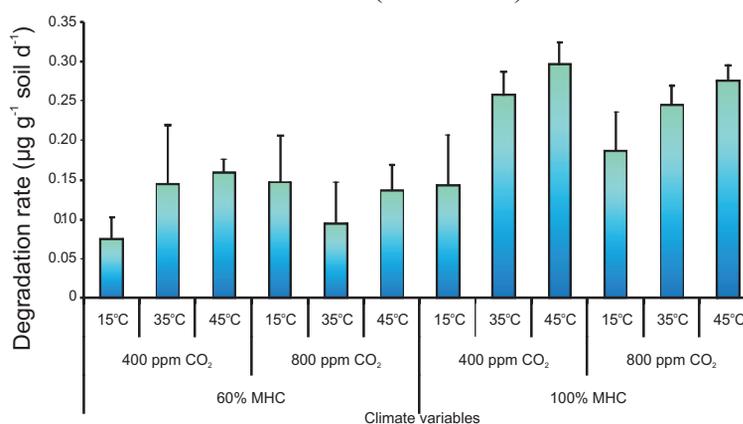


Fig.2.7.3 Biodegradation rate of Imidacloprid in soil under the influence of elevated CO₂, temperature and moisture regime

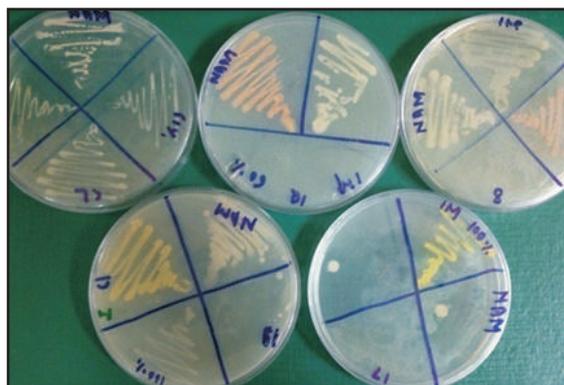


Plate 2.7.3 Pesticide (Imidacloprid, Chloropyrifos) degrading bacteria isolated from soil under elevated CO₂, temperature and moisture regime

2.7.8 Linking agricultural practices with degradation kinetics and microbial response to predict pesticide biodegradation under future climate change scenarios

An experiment was carried out to study the influence of complex interaction of climate drivers like elevated CO₂, temperature, soil moisture, and chloropyrifos on (1) N₂O production, (2) soil enzymatic activities, and (3) microbial abundance. The environmental factors were CO₂ (ambient and

800 ppm), temperature (25°C, 35°C, and 45°C), soil moisture holding capacity (60% and 100%) and chloropyrifos (0 and 10 ppm). Production of N₂O (ng g⁻¹soil) was high (18.06) under normal environmental condition, while the rise in CO₂, temperature and chloropyrifos reduced N₂O production to 2.94. One way analysis of variance (ANOVA) revealed significant influence of the factors on the soil variables (p<0.01). Soil enzymatic activities including fluorescein diacetate hydrolysis and dehydrogenase activities were significantly affected by these climate drivers (p <0.01). Principal component analysis explained 68.2% and 19.1% variation by first two components. Result highlighted that intensive use of chloropyrifos in future may increase the severity of negative impact of climate change on the soil biogeochemical processes

3. RESEARCH ACHIEVEMENTS – AICRPs/AINP

Theme I: Soil Health and Input Use Efficiency

3.1 Soil Fertility Evaluation

AICRP on STCR

3.1.1 GPS and GIS based soil fertility mapping in nineteen states of India

GPS and GIS based soil fertility maps (macro and micro-nutrients, organic C, pH, and EC) were developed for Pune and Jalgaon districts of Maharashtra (Fig.3.1.1, Fig.3.1.2) and Dindigal district of Tamil Nadu (Fig.3.1.3).

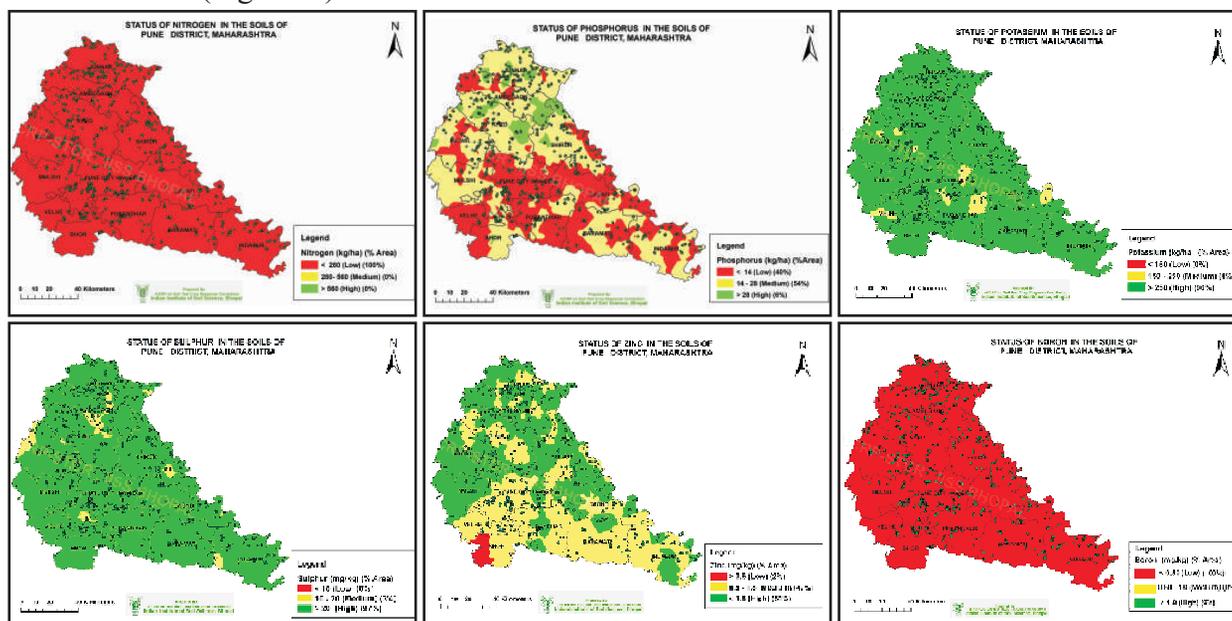


Fig 3.1.1 GIS based soil fertility maps of Pune district of Maharashtra

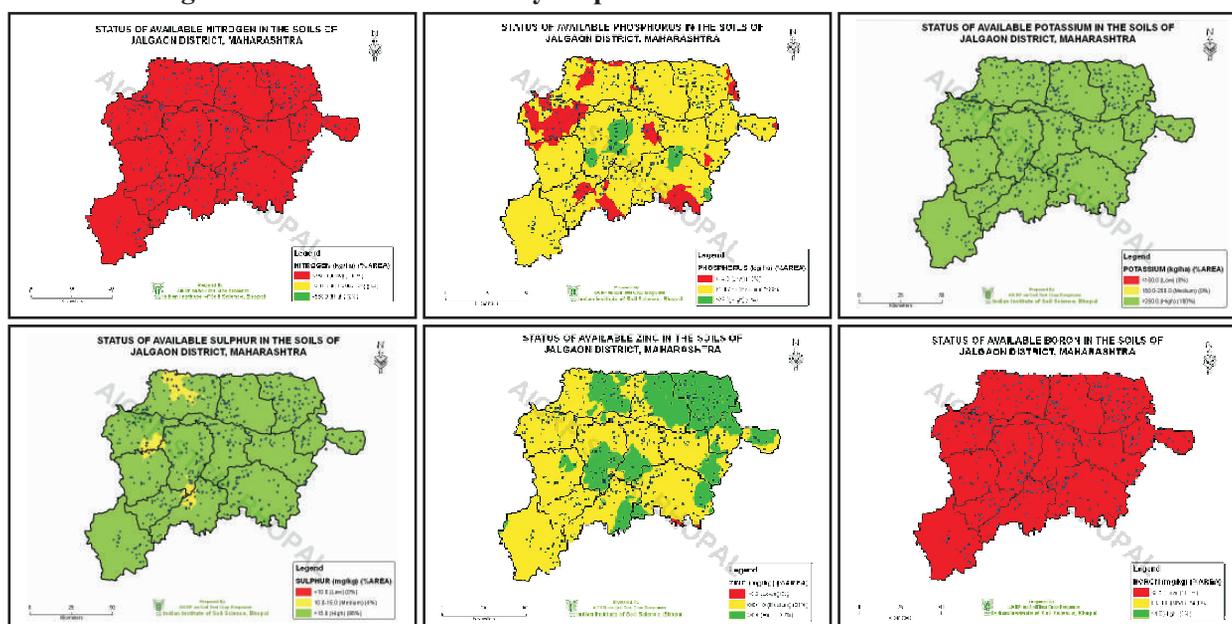


Fig.3.1.2 GIS based soil fertility maps of Jalgaon district of Maharashtra

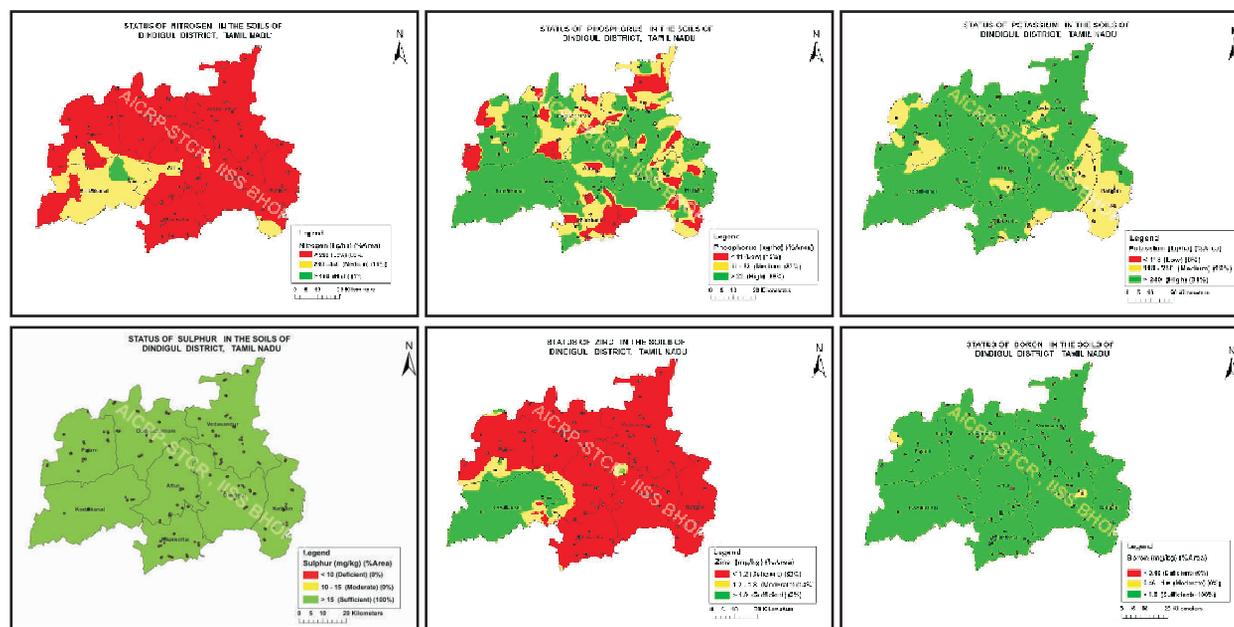


Fig.3.1.3 GIS based soil fertility maps of Dindigul district of Tamil Nadu

AICRP on MSN

3.1.2 Delineation of micro nutrients status

Multi-micronutrients deficiency

In recent years, fertilizers containing multi-micronutrients are available in plenty in market and these fertilizers are being used by farmers without systematic recommendation. Deficiency of multiple micronutrients in crops in Indian soils has occurred due to depletion in soil fertility and the deficiency of a single micronutrient prevails compared to two, three and four micronutrients deficiencies. The two micronutrients deficiency in certain states of the country are emerging at increasing rate and need to be addressed. Within a time frame of last two decades multiple nutrient deficiencies were reported in crops for Zn+Fe, Zn+Cu, Zn+Mn and Zn+B which vary from 3.04 to 8.63% (Table 3.1.1). The Zn + B deficiency was found more prevalent in acid leached and Lateritic soils of India.

The deficiencies of two elements together seldom exceed 10% while it is less than 2% for three or four nutrients (Zn+Fe+Mn, Zn+Cu+Mn and Zn+Fe+B). Thus, application of single micronutrient fertilizer is useful instead of multi-micronutrients mixtures with higher cost of production. Among the two micronutrients deficiency, the combined deficiency of Zn+B is prevalent in states like Maharashtra (30.5%), Bihar (16.5%), Tamil Nadu (13.5%), Odisha (12.2%) and Jharkhand (11.7%). A combination of Zn+Fe deficiency was reported in Maharashtra, Telangana, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Haryana and Gujarat. Although the deficiency combination seldom exceeds 10% except in Maharashtra. Though individually Zn or Mn deficiency is increasing in Punjab, their combined (Zn+Mn) deficiency is also coming up in rice-wheat growing areas of the state.

Table 3.1.1 Deficiency status of multi-micronutrients in soils of different states of India

State	Two micronutrients (% of total samples analyzed)				Three micronutrients (% of total samples analyzed)		
	Zn+Fe	Zn+Cu	Zn+Mn	Zn+B	Zn+Fe+Mn	Zn+Cu+Mn	Zn+Fe+B
Andhra Pradesh	6.40	0.40	0.61	0.81	0.16	0.03	0.16
Assam	0.00	1.50	0.00	4.47	0.00	0.00	0.00
Bihar	4.01	0.89	2.67	16.49	1.11	0.11	1.25
Gujarat	6.00	0.24	2.30	4.83	0.86	0.00	1.30
Haryana	6.38	2.22	1.80	0.74	0.85	0.37	0.46
Himachal Pradesh	0.00	0.00	0.31	0.00	0.00	0.00	0.00
Jharkhand	0.00	0.00	0.00	11.74	0.00	0.00	0.00
Madhya Pradesh	7.56	0.12	1.35	1.50	0.59	0.01	0.24
Maharashtra	12.32	0.11	2.74	30.47	1.82	0.06	0.20
Odisha	0.34	0.17	0.26	12.22	0.04	0.00	0.17
Punjab	1.79	1.93	4.68	1.85	0.46	0.28	0.18
Tamil Nadu	8.45	10.69	6.00	13.50	1.71	2.12	1.38
Telangana	6.21	0.58	0.92	2.05	0.33	0.13	0.47
Uttar Pradesh	2.99	2.46	2.34	6.80	0.77	0.48	0.67
Uttarakhand	0.27	0.62	0.93	0.78	0.12	0.31	0.00
West Bengal	0.00	0.55	0.47	3.73	0.00	0.04	0.00
India	6.29	3.97	3.04	8.63	1.01	0.76	0.86

In most of the states the deficiencies of three micronutrients combination is not alarming as it seldom exceed 2%. In most of the states, such deficiencies are negligible, however, localized deficiency may occur in pockets or fields.

Micronutrients mapping

Based on the available database micronutrients (Zn, Fe, Cu, Mn and B) deficiency status maps have been prepared for farmers, planners, policy makers and other stake holders, especially fertilizer manufacturers/suppliers so that proper use of micronutrient could be ensured for maximum economic gain and quality produce.

a) Mapping Zn deficiency status

Zn deficiency status in soils examined from 379 districts of the country revealed that 84 districts, particularly in acid soils of states like Himachal Pradesh, West Bengal, Odisha, Kerala, Uttarakhand and Karnataka fall in the category where Zn deficiency is reported to be less than 10% (Fig.3.1.4). Some districts of Haryana and Punjab also fall in this range due to regular use of Zn fertilizer in these states. Fifty three districts fall in the range where Zn deficiency status varied from 10-20%, 44 districts in 20-30%, 38 districts in 30-40% and 40 districts in the category of 40-50%. Even after regular use of Zn fertilizer in many parts of the country Zn deficiency in 120 districts is more than 50%, representing about one third soils of the country. Most of the districts fall in states like Tamil

Nadu, Madhya Pradesh, Maharashtra, Bihar, some part in Uttar Pradesh, Gujarat and Rajasthan. Surprisingly, six districts in Punjab (Ferozpur, Kapurthala, Mansa, Muktsar, Roopnagar and Sangrur) are shown with more than 50% deficiency, however, the average Zn deficiency of the states has declined from 49 to 17%. Although Zn deficiency is reported less in acid soils but three districts (Angul, Bhadrak and Boudh) of Odisha also fall in this category. Data depicted in map of Zn deficient soil areas in India indicated that about one-third of the country's vast area had acute Zn deficiency.

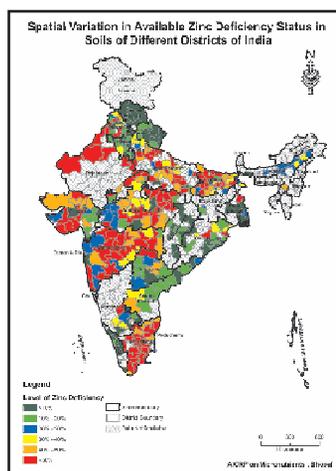


Fig.3.1.4 Spatial variation in available Zn deficiency status in soils of different districts of India

b) Mapping Fe deficiency status

Results of the soil samples analysed from 371 districts of the country indicated that more than half of the districts are having Fe deficiency less than 5% (Fig.3.1.5). Only 12-15% districts come under high Fe deficiency status in states like, Maharashtra, Gujarat, Rajasthan, Haryana, Punjab, Madhya Pradesh and Tamil Nadu. Some pockets of Uttar Pradesh (Bareilly, Hamirpur, Banda, and Shahjahanpur), Bihar (Begusarai, Samastipur and Vaishali) and Andhra Pradesh (Anantapur, Kurnool and Prakasham) also have as high as 20-30% Fe deficiency. Fe availability is poor in soils of arid and semiarid regions, consequently its content is also low in forage and grains grown in these areas as compared to those grown in soils of humid and sub humid regions.

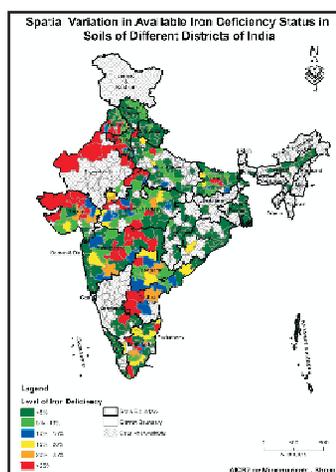


Fig.3.1.5 Spatial variation in available Fe deficiency status in soils of different districts of India

c) Mapping Mn deficiency status

Of the total soil samples analysed from 373 districts more than 75% are shown with less than 5% Mn deficiency. Some districts in Punjab, Haryana, Tamil Nadu, Rajasthan and Uttar Pradesh are shown with Mn deficiency more than 25% (Fig.3.1.6). In Punjab, rice-wheat cropping system has exhausted most of the micronutrient reserves. Mn deficiency in soils ranges from negligible to as high as 67% in Bhatinda, Punjab. Prevalence of Mn deficiency in wheat grown in sandy soils of Punjab, Haryana and Uttar Pradesh is increasing due to leaching of soluble Mn to lower layers during submergence of rice in rice-wheat system. This is the primary factor of upcoming Mn deficiency in wheat. The average Mn deficiency in this region has been reported to be 22%. Wheat grown in more than 3 lakh ha of coarse textured soils of Punjab showed high responses to Mn fertilization ranging 200-2960 kg ha⁻¹. Jaisalmer and Churu in Rajasthan, Villupuram, Dindigul in Tamil Nadu, Ranga Reddy in Telangana, Badaun, Bijnor and Shahjahanpur in Uttar Pradesh, Rudra Prayag in Uttarakhand and Jagatsinghpur in Odisha are major Mn deficient districts where Mn deficiency varied from 25 to 67%.

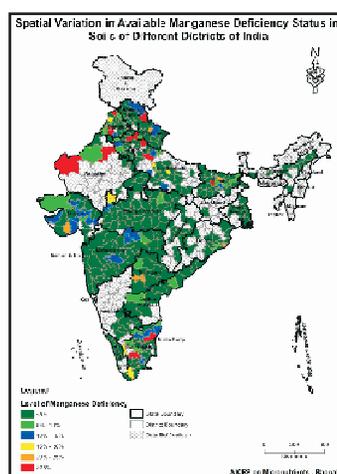


Fig.3.1.6 Spatial variation in available Mn deficiency status in soils of different districts of India

d) Mapping Cu deficiency status

Out of 379 districts, 246 districts have Cu deficiency less than 1%. In some districts of Haryana (Karnal-10.80%, Mohindergarh-13.0%), Tamil Nadu (Kanyakumari-13.3%, Pudukkottai-11.7%, Ramanathapuram-11.6%, Sivagangai-13.7%, Theni-14.9%, Dindigul-12.2% and Tuticorin-14.10%), Uttar Pradesh (Kannauj-10.5%, Banda-11.0% and Mathura-13.0%) and one district of Punjab (Sangrur-12%) Cu deficiency is increasing and it ranged from 10-15% (Fig.3.1.7). The Cu deficiency was recorded highest in Tamil Nadu due to adoption of higher critical limit (0.60-1.20). Though the Cu content is usually higher in acid and laterite soils, however, one district each in Bihar (West Champaran-11.50%), Odisha (Kendrapara-12%) and two districts in Assam (Jorhat-18.5% and Sibsagar- 23.2%) were reported to have Cu deficiency of about 10-20%. Some districts like Arwal, Aurangabad and Khagaria in Bihar, Bikaner, Churu, Jaisalmer and Sri Ganganagar in

Rajasthan; Coimbatore, Madurai, Thirunelveli, Villupuram in Tamil Nadu and Farrukhabad, Lakhimpur, Badaun, Shahjahanpur and Bareilly in Uttar Pradesh showed Cu deficiency more than 25%.

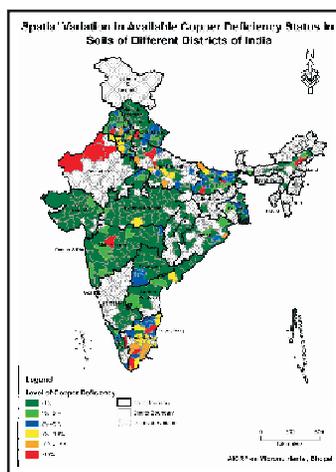


Fig.3.1.7 Spatial variation in available Cu deficiency status in soils of different districts of India

e) Mapping B deficiency status

Out of about 74,000 soil samples analysed from 193 districts, 84 districts have B deficiency less than 10%. About 35 districts fall in B deficiency range of 10-20% and 15 to 16 districts each come in 20-30, 30-40 and 40-50% deficiency range (Fig.3.1.8). Soils of Jharkhand, Odisha, West Bengal, Karnataka and part of Bihar, Tamil Nadu and four districts in Gujarat are highly deficient (more than 50%) in Boron. Boron deficiency has been commonly reported in soils which are highly leached and/or developed from calcareous, alluvial and loess deposits. However, calcareous part of the country does not exhibit boron deficiency in crops due to sufficient B in irrigated water. Underground water used for irrigation purpose has been reported to contain toxic amounts of B in many parts (Uttar Pradesh, Rajasthan, Haryana, Punjab, and Gujarat) of India.

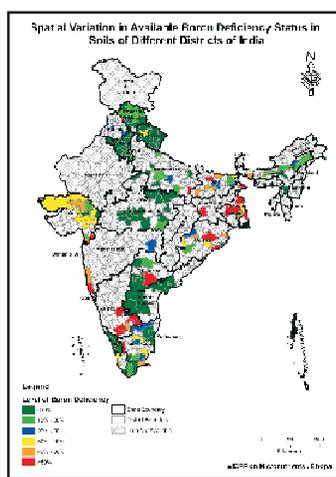


Fig.3.1.8 Spatial variation in available B deficiency status in soils of different districts of India

3.2 Monitoring long-term productivity

AICRP on LTFE

3.2.1 Evaluation of basic slag in Alfisols

Basic slag is a byproduct of steel industry and has liming property. To evaluate and demonstrate the effect of basic slag on productivity of wheat, field demonstrations were conducted in farmers' fields in Ranchi and Singhbhum districts of Jharkhand. The results revealed that the use of basic slag as soil amendment resulted a increase in productivity of wheat by 10 to 12% over farmers' practice. However, increase in productivity on application of basic slag or lime was much higher when their applications were coupled with recommended dose of nutrients (Plate 3.2.1 and Table 3.2.1) instead of farmers' practice. Perusal of data further indicated that both basic slag and lime were equally effective in terms of yield. The Increase in productivity on amending soil with lime or basic slag was due to increase in availability of nutrients as a result of increase in soil pH. Lower yields in farmers' practice were due to supply of nutrients in less quantity and in imbalanced way.



Plate 3.2.1 Demonstration of basic slag at farmer's field at Chandlasa village of Lohardoga block of Ranchi district

Table 3.2.1 Evaluation of basic slag as liming material in farmers' fields of Angora block of Ranchi district of Jharkhand

Treatment	Wheat yield (q ha ⁻¹)				Average (q ha ⁻¹)	% increase over control
	Site-I	Site-II	Site-III	Site-IV		
Farmer's practice (control)	24.2	22.2	24.7	25.2	24.07	-
Farmer's practice + basic slag	26.7	30.3	30.4	19.2	26.65	10.2
Farmer's practice + lime	27.3	26.0	27.7	28.3	7.32	12.8
100% NPK (control)	37.4	36.1	42.1	34.0	37.40	-
100% NPK+ basic slag (3 q ha ⁻¹)	41.2	38.3	45.6	39.7	41.20	10.2
100% NPK lime (3 q ha ⁻¹)	40.8	41.1	43.4	37.0	40.57	8.5
LSD (<i>p</i> = 0.05)	3.8	3.7	4.2	3.2	3.30	-

- Please note that percentage increase in row No. 2 & 3 is calculated over the data given in row No. 1 and in rows 5 & 6, it is calculated against the data given in row No. 4
- Farmers' practice: 80 kg N, 20 kg P₂O₅ ha⁻¹
- Recommended fertilizer dose (100 % NPK): 120 kg N, 60 kg P₂O₅, and :40 kg K₂O per ha.

3.2.2 Balanced use of nutrient and rice yield

Balanced use of nutrients is essential to sustain productivity. Keeping this in view, field demonstrations were conducted on farmers' fields in Rayagada block (Rayagada dist.) and Bassim, Muniguda and Bolagarh blocks (Cuttack dist) of Odisha. The results revealed (Plate 3.2.2, Table 3.2.2) that imbalanced use of nutrients and unadequate quantities resulted in poor yield of rice as compared to integrated nutrient management (INM) and nutrient application through soil test crop response (STCR) and recommended dose of fertilizers (RDF). Increase in productivity under RDF and STCR is due to balanced use of nutrient. It was found that farmers were using nutrients in less quantity and that too in imbalanced way. Data further revealed that incorporation of FYM over and above NPK further improved the productivity due to additional supply of nutrients through FYM and improvement in physical condition of soil.



Plate 3.2.2 Rice in farmer's field in Rayagada block (Dist Rayagada) in Odisha

Table 3.2.2 Impact of balanced application of nutrients on yield of rice (q ha⁻¹) in Alfisols

Treatment	Block / district				Average yield	Per cent increase over farmer's practice
	Rayagada/ Rayagada	Bassim/ Cuttack	Muniguda/ Cuttack	Bolagrah/ Cuttack		
Farmers' practice	31.5	29.1	28.0	25.0	28.4	-
RDF	39.4	38.1	38.1	31.8	36.8	29.5
STCR	41.7	37.9	40.6	32.8	38.2	34.5
RDF+FYM	58.8	41.6	47.2	44.3	47.9	68.6
LSD ($p=0.05$)	4.5	5.2	4.7	5.8	-	-

RDF N:P₂O₅:K₂O = 80:40:40, FYM 5 t ha⁻¹

*Average of 5 to 10 farmers

Theme III: Microbial Diversity and Genomics

3.3 Microbial Diversity and Biofertilizers

AINP on BF

3.3.1 Rhizobia diversity and formulation

Arid zone

The genomic DNA of chickpea (48) and methi (33) isolates was tested for *nod D* and *nif H* gene amplification for authentication of rhizobia. Amplification of 16S rRNA gene with 27F and 1378R primers and ADARA was performed using the digestion of 16S rRNA amplicons with *Alu I*, *Taq I*, *Hinf I* and *Hae III*. Chickpea strains showed significant molecular diversity and the dendrogram differentiated 48 strains into 2 major and 6 minor clusters, respectively with a coefficient ranging from 0.15 to 0.95. Dendrogram obtained from *methi* strains differentiated the 33 strains into 6 major clusters with a coefficient ranging from 0.31 to 0.85. Most of the strains were able to grow at 40°C and 20% PEG. Characterization of 52 rhizobial cultures from root nodules of cluster bean, green gram, soybean, cowpea, black gram and groundnut for PGPR activities revealed that 14 are ammonia producers, 15 are phosphate solubilizers, 21 are moderate to high IAA producers and 18 are siderophore producing rhizobial strains. Eighty eight rhizobial strains from root nodules of Sunhemp and Groundnut from Udaipur, Jaipur, Ajmer, Dausa, Nagaur and Bhilwara regions were characterized. Twenty two rhizobial strains from sunhemp and 29 strains from groundnut were positive for ammonia production (MPUAT, Udaipur).

Rhizobia were isolated from sandy soils from hyper-arid zone of Rajasthan pH (7.0- 9.3), Organic carbon (0.15-0.45%) and EC (0.02- 0.45 mS cm⁻¹). The MPN counts of rhizobia varied from 170-1000 rhizobia/g soil. Two hundred two out of 313 rhizobial isolates of different *kharif* legumes retrieved from arid and hyper-arid zones of Rajasthan were characterized for stress tolerance. On the basis of temperature (40 & 45°C) and drought (30 & 40% PEG) tolerance, 58 rhizobial isolates were selected, out of which 29 isolates belonged to Moongbean, 22 to clusterbean and 7 to mothbean. The isolates obtained from Bikaner and Jaisalmer districts were more stress tolerant as compared to isolates obtained from Churu and Barmer districts. Most of these isolates were P-solubilizers and their solubilization index (P-SI) varied from 1.1 to 5.3. Some of these isolates were good ammonia excretors (36%), however, only 3% of the isolates were able to produce high amount of IAA (> 20 µg/ml). The bacteriocin production was also limited to only 28% of the isolates (HAU, Hisar).

Sixteen out of 130 mungbean rhizobial isolates, obtained from South-West Haryana and Rajasthan state were found to have multi-trait characters like P-solubilization, IAA production, acetylene reduction assay (ARA), ammonia excretion, ACC utilization, siderophore and bacteriocin production. Five promising rhizobial isolates namely MR 63, MR 54, MH 8b2, MH 6c1 and MB 17a with multi-trait characters were further assessed in green house experiment. Two mungbean rhizobial isolates, MR54 and 8b2, isolated from Rewari and Hisar districts, respectively were selected as more efficient isolates than commercial strain, 703 on the basis of nodulation efficiency

and plant growth parameters, when inoculated either singly or when co-inoculated with PSB (HAU, Hisar).

Rhizobia in tal lands

Rhizobial isolates obtained from lentil (18), chickpea (10), pea (10), lathyrus (4) and bakla were characterized. Five isolates of lentil, four isolates of chickpea, two isolates of pea, two isolates of *Lathyrus* and three isolates of Bakla were identified as fast growers. A media based on household waste was designed for mass culturing of *Rhizobium* species which showed good results (RAU, Pusa).

Antifungal and plant growth promoting attributes of rhizobia

Chickpea-*Rhizobium* strains showing antagonistic behaviour against *Fusarium oxysporum* f. sp. *ciceri*, *Ascochyta rabiei*, *Botrytis cinerea* and *Macrophomina phaseolina* were screened for production of ammonia, HCN, siderophore and antibiotics. Only two isolates specific to chickpea A3 and A16 were found positive for ammonia production. Among all the isolates only CR18 was found positive for HCN production whereas none of the isolates showed production of siderophore. Isolates A-13, A-15, CR-14 and CR-18 were able to solubilise phosphorus (IARI, Delhi).

Proteomics of rhizobia in acid soils

Role of genes crucial in imparting tolerance to rhizobia in acid soils was elucidated through proteomics. Several important and unique protein differences amongst the various *Rhizobium* isolates were documented. Analysis of the MALDI-TOF-TOF data showed expression of about 14 genes that play a crucial role in providing adaptability to soil-acidity. These encode a wide range of functions, which are implicated in modulation of the chemo-taxis system, required for virulence, enzymes that catalyze redox transformations, biosynthesis/intermediary metabolism/detoxification, export/import of a wide variety of substrates, receptors for osmotic solutes produced, movement of diverse solutes, catalysis of the transfer of a methyl group, transport large folded proteins/Na⁺ dependent unidirectional secondary transporters and cellular metabolism respectively (BAU, Ranchi).

3.3.2 Archaea and actinobacteria in vertisols of central India – assessment of diversity, biogeochemical processes and bioinoculant potential

Much uncertainty lies in our understanding of the role of archaea in agricultural soil ecosystems. Actinobacteria are a ubiquitous group of micro-organisms involved in decomposition of organic matter and suppression of soil borne plant pathogens. Exploration of actinobacteria in enhancing crop production is limited. We hypothesize that these microbial groups are sources of useful genes that can be deployed in agriculture. The focus of the work is to explore the culturable and unculturable diversity of archaea and actinobacteria, their role in biogeochemical cycle and soil functions with the ultimate goal of enhancing nutrient transformation and agricultural productivity through developing of suitable microbial technology.

Soil samplings were done in *kharif* in the rhizosphere of soybean (Bhopal, IISS farm; Geelakhedi, farmer field), rice (Jabalpur, JNKVV farm) and maize (Chhindwara, Farmer field) in Madhya

Pradesh. In *rabi* samplings were done in the rhizosphere of chickpea at IISS, Bhopal and JNKVV, Jabalpur and in wheat at Chhindwara and Geelakhedi (Farmers fields). Sampling was done at peak crop growth and soils were stored at -20°C for analysis. The soils had high abundance of Actinomycetes (10^6 g^{-1} soil, Table 3.3.1) and *Arthrobacter* (10^4 g^{-1} soil). Nitrogen fixers were in the range of 10^5 and fungi 10^3 g^{-1} soil. Cultural diversity of *Arthrobacter* was as follows: Maize (Chhindwara) > Soybean (Geelakhedi) = Soybean (Bhopal) > Rice (Jabalpur) (30, 20, 20, 5 morphotypes). A total of 10 morpho-variants (Plate 3.3.1) were selected for further experiments which are under progress.

Table 3.3.1 Microbial counts (cfu g^{-1}) in the rhizosphere of different sampling sites

Site	Bacteria		Fungi		N ₂ Fixers		Actinomycetes		Arthro bacter	
	CFU	10 ⁶	CFU	10 ³	CFU	10 ⁵	CFU	10 ⁶	CFU	10 ⁴
Geelakhedi	28.2	6.7	13.3	3.3	101.5	8.8	18.4	1.5	9.2	0.9
Jabalpur	20.2	4.9	26.6	12.0	66.8	14.8	11.0	0.9	5.8	1.3
Chhindwara	24.8	4.5	10.0	0.0	82.8	19.0	15.2	1.5	16.0	4.5
Bhopal	31.7	7.9	26.6	1.6	132.3	2.0	26.1	1.6	13.0	1.7

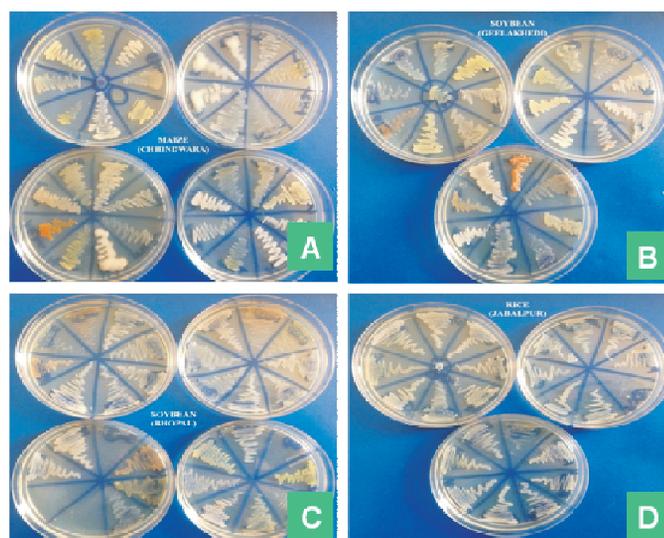


Plate 3.3.1 Cultural diversity of *Arthrobacter* spp. in different crops. A- Maize (Chhindwara), B- Soybean (Geelakhedi), C- Soybean (Bhopal), D- Rice (Jabalpur)

Experiments were carried out to reveal differential response of archaeal and bacterial contribution towards N₂O production. Archaea contribute significantly to N₂O production. N₂O production rate (ng g^{-1} soil d^{-1}) was evaluated as slope of log transformed values. The rate of N₂O production by both bacteria and archaea varied in the range of 0.34 to 0.89 ng g^{-1} soil. When the soil samples were amended with the sulfadiazine (SDZ) N₂O production was in the range of 0.20 to 0.50 ng g^{-1} soil. Cumulative N₂O production was high in no sulfadiazine and low in soil + sulfadiazine. (Fig.3.3.1). Archaeal nitrification rate was almost equivalent to that of ammonium oxidizing bacteria. This highlighted their significant role in agricultural soils which can be explored further.

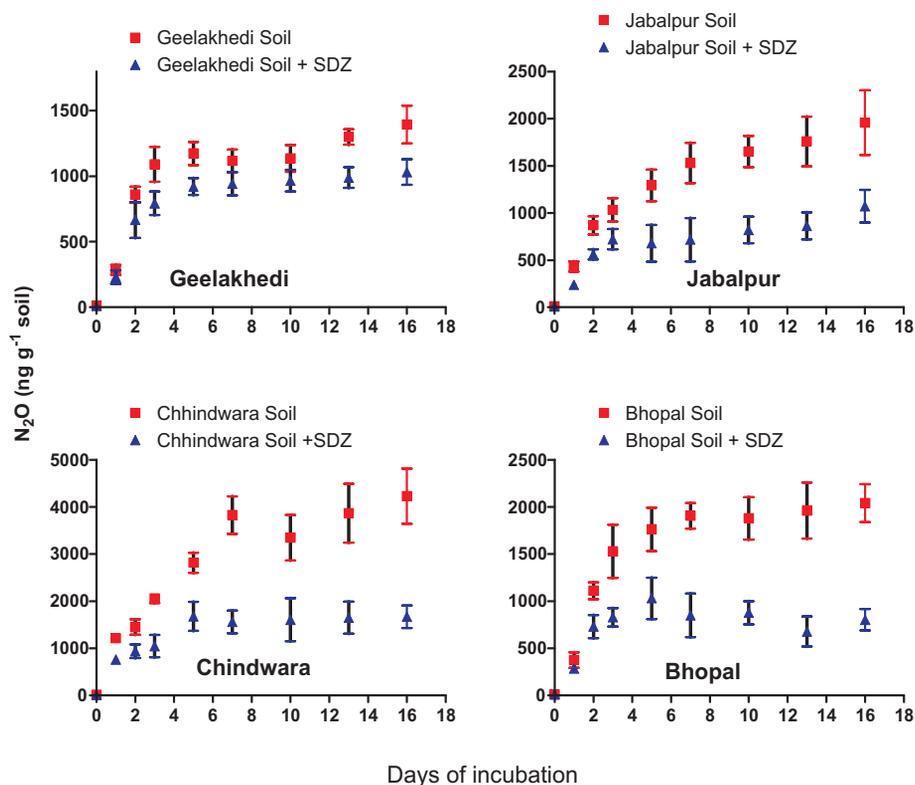


Fig.3.3.1 Nitrous oxide production in rhizosphere soils of different crops

PGPR for wheat in Himalayan soils

In the rhizosphere of wheat grown in low to high hills and cold deserts, a total of 125 isolates were screened for PGP traits, 79 isolates were P-solubilizers, 108 were siderophore producers and only 20 were positive for HCN production and about 30 isolates showed antagonism against soil borne pathogen *Fusarium graminearum*, *Alternaria triticina* and *Claviceps purpurea* causing head blight, leaf blight and ergot diseases, respectively (YSPUHF, Solan).

Seabuckthorn PGPR from cold desert

Bacterial isolates (206 no.) associated with sea-buckthorn from cold desert of Himachal Pradesh, were screened for various PGP traits, 52% were P-solubilizers, 76% were Indole Acetic Acid producers, 44 % were siderophore and 20% were hydrogen cyanide producers. Growth inhibition against *Fusarium oxysporum* and *Alternaria* sp. was detected in 26% and 47% isolates, respectively (YSPUHF, Solan).

PGPR for apricot

Bacterial isolates (188 no.) from apricot growing in mid and high hills, were screened for PGP traits. About 39% were P-solubilizers, 60% were Indole Acetic Acid producer, 49 % were siderophore, 6% were hydrogen cyanide producers and 54% exhibited chitinase and 42% exhibited protease activity and 66% isolates showed per cent growth inhibition against *Dematophora necatrix* (YSPUHF, Solan).

Characterization of *Parapedobacter*

A eubacterial isolate from an HCH (hexa-chloro cyclohexane) dump site was characterised taxonomically by using polyphasic approach and was found to be a novel species of the genus *Parapedobacter* and the name *Parapedobacter indicus* sp. nov. was proposed. It has a G+C content of 37-44.5 mol %. It was gram-negative, non-spore forming, rod shaped, non-motile, obligately aerobic, and oxidase and catalase positive. Analysis for chemotaxonomic attributes revealed: Homospermidine as the only polyamine detected; menaquinone MK-7- a major respiratory quinone and sphingolipid (SL) and phosphatidylethanolamine (PE) as major polar lipids (DU, Delhi).

***Frankia* from actinorhizal trees**

Frankia were isolated from temperate region alders (*Alnus* spp.) and *Casuarina* spp. (subtropical species) on various defined media viz., DPM-Defined Propionate Minimal Medium, Qmod agar medium, BAP medium and solid P medium. The colony of *Frankia* appear submerged in agar, very small (0.5-3.0 mm dia) and grow without producing any turbidity in liquid broth after 5 weeks of incubation. The DPM medium was found best for its growth. Out of 10 isolates, 6 isolates exhibited multiple PGP traits (YSPUHF, Solan).

3.3.3 Arbuscular mycorrhizal fungi (AMF) colonization and bioinformatic analysis

Promising AMF strain

Twelve different arbuscular mycorrhizal strains were isolated from various soils of Andhra Pradesh. The AM fungal isolate Myc 7 showed highest root colonization and plant growth promotion (ANGRAU, Amaravathi).

Bioinformatic analysis of AMF growth trigger

In further attempt to identify more compounds triggering growth of AM-fungi in absence of living host root, using bioinformatic tools, triglycerides were found to be stimulating AMF growth. Triglycerides effectively docked with protein receptor MtPT6, a Pi transporter protein (Accession ID N_C AQ42956; NCBI database) with higher antagonistic effects (CRURRS, Hazaribagh).

3.3.4 Other microbial organisms

Soil mesofauna

Twenty one soil samples from agricultural and forest ecosystems and fallow land were examined for the presence of collembolans. The highest numbers were extracted from the forest ecosystems (4784/g soil followed by fallow land (3194) and rice agro-ecosystem (2419). An effort was made to multiply collembolans in the laboratory by using different base materials of which activated charcoal with water (5:2) exhibited promising results (AAU, Jorhat).

3.3.5 Biofertilizer applications

Fluorescent pseudomonads for groundnut

Application of multiple plant growth promoting and DAPG-producing fluorescent pseudomonads besides capability of suppressing soil-borne fungal pathogens like *A. niger*, *A. flavus* and *S. rolfisii*

improved plant growth and biomass significantly in most cases over uninoculated control at harvest during summer 2014. Application of *P. putida* DAPG6 and *P. fluorescens* FP98 enhanced the pod yield (15.6% by DAPG6, 2213 kg ha⁻¹; and 14.8% by FP98, 2198 kg ha⁻¹) and haulm yield, shelling out turn, nodule number, root and shoot length, plant biomass at 45 and 90 DAS significantly over uninoculated control (pod yield of 1915 kg ha⁻¹) at harvest with cultivar TG37A. However, in kharif 2014 application of *P. putida* DAPG1, *P. putida* DAPG4, and *P. fluorescens* FP98 resulted in significant enhancement in pod yield (9.5 – 11%) of groundnut cultivar TG37A, the maximum pod yield was obtained in the treatment with FP98 (3283 kg ha⁻¹) as compared to uninoculated control (2957 kg ha⁻¹) (DGR, Junagadh).

Suppressive soils

To make soils naturally suppressive to soil-borne fungal pathogens like *Sclerotium rolfsii* causing stem rot in groundnut, DAPG-producing fluorescent pseudomonads, highly antagonistic to *S. rolfsii*, were applied and evaluated with the susceptible cultivar GG20. Seedling mortality of groundnut, cultivar GG20 reduced from 82% in pathogen control to 23-31% in treatments inoculated with different DAPG-producing fluorescent pseudomonads. Moreover, application of *Pseudomonas* sp. FP46, *P. putida* FP86, *P. fluorescens* FP93, *P. putida* FP121, *P. monteilli* FP133 and *P. fluorescens* FP98 significantly improved the pod yield of groundnut, cultivar GG20 during kharif 2014 from 10-16%, the maximum was due to inoculation of FP133 (2909 kg ha⁻¹ as compared to uninoculated control, 2512 kg ha⁻¹). These DAPG-producing fluorescent pseudomonads have also been evaluated during kharif 2014 at different AICRP (G) centres throughout the country (DGR, Junagadh).

Zinc solubilising bacteria

Growth attributes of Bt cotton and nutrient availability in soil was significantly influenced by microbial inoculants. Zn solubilization in soil was nearly 37% higher with *Trichoderma viridae* inoculation (0.78 mg kg⁻¹) over uninoculated control (0.57 mg kg⁻¹). It was at par with *Pseudomonas striata* followed by *Bacillus megaterium* - all were superior over control. However, maximum available P was noticed with *Bacillus megaterium* (MAU, Parbhani).

In two year field trials, there was significant increase in seed cotton yield up to 27.4% in Bt cotton with microbial inoculation of *Trichoderma viridae* as a zinc solubilizers (21.4 q ha⁻¹) as compared to control (only RDF) (16.8 q ha⁻¹) followed by *Pseudomonas striata* (20.4 q ha⁻¹) and *Bacillus megaterium* (19.0 q ha⁻¹). Nutrient availability in soil was also influenced by these microbial inoculants. Available N (218 kg ha⁻¹), K₂O (646 kg ha⁻¹), Zn (0.73 mg kg⁻¹) and Fe (6.46 mg kg⁻¹) were found to be significantly increased up to 35%, 14%, 22% and 13%, respectively with *Trichoderma viridae* as compared to control plots. Maximum P₂O₅ availability (25.8 kg ha⁻¹) was recorded with *Bacillus megaterium* and the increase was up to 23.3% as compared to control (20.9 kg ha⁻¹) (MAU Parbhani).

Inoculation of a Zn solubilizing isolate (ZSBS₁) from rice rhizosphere improved the Zn nutrition in rice crop and produced significantly higher concentration of Zn (43.1 mg kg⁻¹) in rice grain compared to application of ZnSO₄ @25kg/ha (39.2 mg/kg) (AAU, Jorhat).

Actinomycetes inoculants

Field trial with liquid inoculants of 17 actinomycetes isolates were conducted on soybean (JS-9752) along with FUI (Fertilizers 20:80:20 and uninoculated) and UFUI (unfertilized, uninoculated) controls. Isolate A10 gave the highest yield of 2528 kg ha⁻¹ (78 % higher over FUI yield of 1417 kg ha⁻¹). Ten more isolates (A2, A4, A1, A6, A14, A15, A12, A8, A9 and A16) were at par to it with average yield of 2144 kg ha⁻¹ (51 % higher to FUI). These actinomycetes liquid formulations were also evaluated on wheat (JW-366) along with FUI (Fertilizers 120:60:40 and uninoculated) and UFUI (unfertilized, uninoculated) controls. Liquid formulations of two effective actinomycetes isolates (A₁₀, A₁₇) individually inoculated or in a mixed consortium (CRP) of *Rhizobium* (R₄₀, R₅₆) and PGPR (P₃, P₁₀, P₂₅) were evaluated on chickpea (JG-16) along with FUI (Fertilizers 20:80:20 and uninoculated) and UFUI (unfertilized, uninoculated) controls (JNKVV, Jabalpur and IISS, Bhopal).

Bionutrient package for direct seeded rice

Direct seeded rice was given seed treatment with *Azospirillum*, soil surface cyanobacterial application after 1st rainfall after seeding and foliar spray of *Bacillus* on 30th days either alone or along with chemical fertilizers. Application of such biofertilizer combination in the presence or absence of chemical fertilizers (50% RDF & 100% RDF) resulted in significant increase in yield attributing characters, grain and straw yield of rice. Minimum rice yield (19.4 q ha⁻¹) was recorded in control while maximum yield (42.1q ha⁻¹) was recorded at 100% RDF + microbial combination (RAU, Pusa).

Long term biofertilization for rice

In long term INM for nine years, the treatment of 25% RDN (10 kg ha⁻¹) and P (5 kg ha⁻¹) with 100% K (20 kg ha⁻¹) along with enriched compost @ 2 t ha⁻¹ could sustain the rice production at 4.1 t ha⁻¹ which was comparable with inorganic fertilizer dose (100%NPK) (3.9 t ha⁻¹) (AAU, Jorhat).

Organic package for rice

Application of *Azolla* @ 0.5t/ha with biofertilizer (four years average data) gave highest grain yield (3.62 t ha⁻¹) which was at par with application of either enriched compost @ 5 t ha⁻¹ with biofertilizer (3.53 t ha⁻¹) or green manure @ 2.5 t ha⁻¹ with biofertilizer (3.50 t ha⁻¹) (AAU, Jorhat).

Tropical vegetables

Response to use of biofertilizers (*Azotobacter* + *Azospirillum*+ PSB) use for *kharif*-maize and *rabi* cabbage crops grown in sequence was evaluated in long term experiment at same site (5 years). Responses ranged from increase in yield of maize and cabbage heads from 12 and 134%, respectively with organics (FYM or vermicompost); 16 and 158% with organics+ BF; 33 and 173% with organics + Lime + BF (OUAT, Bhubaneswar).

INM for capsicum

The conjoint use of consortium of PGPR (*Bacillus subtilis* + *Bacillus* spp.) by seed treatment + seedling dip at 80% recommended doses of NP fertilizers produced fruit yield equivalent to 100 %

recommended doses of fertilizers saving 20% chemical fertilizers besides showing biocontrol against *Ralstonia solanacearum*, causing bacterial wilt (YSPUHF, Solan).

Biofertilizers for jute

The application of biofertilizers as component of INM in Jute (*var*: Tarun) and Mesta (*var*: AMC108) for second year resulted the higher yield of fibres. At Shillongoni, even a reduction of 50% NP and 100%K along with application of biofertilizers (*Azospirillum*, *Azotobacter* and PSB) as seed treatment produced significantly higher (2.74 t ha⁻¹) fibre yield compared to 100% chemical fertilizers (2.31 t ha⁻¹). In case of Mesta at Gossaingaon, the INM treatment produced the fibre yield of 1.48 t ha⁻¹ compared to 100% chemical fertilizers (1.63 t ha⁻¹) (AAU, Jorhat).

The response of jute crop to BFs application varied with the dose of inorganic nutrients: 11, 19 and 15% with 0, 75 and 100 % NPK doses respectively. Integrating BFs application with soil deficient micronutrients like Zn, B increased the responses to the levels of 15, 31 and 22% respectively at the three NPK levels. The rice crop grown on residual fertility enriched with leaf litter of jute and application of *Azolla* recorded on an average 11, 11 and 8% increase in grain yield of rice with 0, 75 and 100 % NPK doses of inorganic nutrients. Integrating micronutrients (Zn, B) application with BF use resulted in 18, 16 and 13% yield increase when combined with 0, 75 and 100 % inorganic doses of nutrients. The results showed the importance of correcting micronutrients deficiency in order to obtain best efficiency of biofertilizers (OUAT, Bhubaneswar).

3.3.6 Biofertilizer Technology

Seed coat formulation of bioinoculants

Liquid formulation of *Rhizobium* (COS1) and *Azospirillum lipoferum* (AZ 204) with initial cell load of 10¹⁰ cfu ml⁻¹ were blended with semi-synthetic binding polymer, hydroxy-propyl methyl cellulose (0.1%) to improve the stickiness of inoculants on the seed. The initial population of 10⁴ per seed was obtained. Further study is in progress to assess the survival of the organism and seed vigour (TNAU, Coimbatore).

Post-planting biofertilizer application

In collaboration with DAATT centres of ANGRAU, Andhra Pradesh a method for application of liquid biofertilizers was standardized for situations when the farmers miss the application at the time of sowing or planting. In this method 500 ml of liquid biofertilizer containing 5.0 x 10⁸ CFU ml⁻¹ of *Azospirillum*/PSB or both are mixed in 70 liters of water and sprayed on the surface of the soil with a Taiwan sprayer (ANGRAU, Amaravathi).

Liquid inoculants on soybean-wheat

Three years field study showed that in soybean-wheat sequence seed treatment of N-fixer + PSB through good quality carrier based biofertilizers (CFU 10⁷ g⁻¹) was equally good with similar liquid bioinoculants (CFU 10⁸ ml⁻¹) in increasing yield, nutrient uptake, quality of produce and soil health (MAU, Parbhani).

3.4 Soil Genomics

3.4.1 Metagenomics of organic soils

Bacterial richness diversity and their distribution pattern in different components of organic farming (farmyard manure, sheep manure, poultry manure, vermicompost, recommended dose of fertilizer and no nutrient) at various growth stages of maize was analysed by metagenomics approach. V3 region of 16S rRNA was amplified and separated by denaturing gradient gel electrophoresis (DGGE). The components of organic farming improved the species richness which was highest in vermicompost applied soils. Except the “no-nutrient” control, all samples showed medium Shannon diversity index with highest in sample applied with FYM. Few species are dominant in all the samples indicating medium functionality. The relative proportion of copiotrophic bacteria like, Alphaproteobacteria, Betaproteobacteria, Deltaproteobacteria and Actinobacteria is high in organic soil. Similarly, the relative proportion of oligotrophic bacteria like Gammaproteobacteria is more in inorganic soil. The key species like *Arthrobacter*, *Rhizobium*, *Pseudomonas* and *Bacillus*, known for beneficial role in soil are statistically more in organic farm soil. Genes involved in respiration and cell division are significantly high in organic farm soil indicating the microbes are actively growing and reproducing. The transcripts are significantly more in organic farm soil indicating microbes in organic farming are actively multiplying and expressing their genes. Large proportion of genes involved in osmoprotection was observed in inorganic farm soil (UAS, Dharwad).

3.4.2 Nutrient management, carbon sequestration and sustainability

In a study on impact of long-term nutrient management modules in old permanent trial, inorganic (IC), Organic management (OM) and Integrated Nutrient Management (INM) for 20 years compared to unfertilized control, OM and INM favored the build up of soil organic carbon (SOC), microbial carbon (MBC), water soluble carbon (WSC) and humic acid (HA). Fulvic acid and alcohol soluble carbon (ASC) did not show any significant change due to long-term nutrient managements. The characterization of purified humic acid for active functional groups through FTIR spectroscopy and quantification of carbon fixing genes using Realtime quantitative PCR are in progress (TNAU, Coimbatore).

3.4.3 Rice rhizosphere microbiome

In studies on Rice- *Rhizobium* association in 'chaur' land, metagenomic analysis of 'Desariya' rice growing with and without association with the stem nodulating legume *Aeschynomene* was done. The PCR amplified partial 16S rDNA sequences showed the occurrence of *Bradyrhizobium* in the rhizospheric and nodular roots of *Aeschynomene* and the 'Desariya' rice. Further metagenomic analysis is in progress to ascertain if *Bradyrhizobium* found in rice has been acquired from the *Aeschynomene* (RAU, Pusa).

4. TRANSFER OF TECHNOLOGY

4.1 Frontline Demonstrations

A. Main Institute

Farmers' field demonstration in Berasia, Bhopal district

Four technologies developed by IISS viz., Integrated Plant nutrient supply system, Phospho-sulpho-nitro compost, biofertilizers (powder and liquid formulations) and Soil test based fertilizer recommendation for targeted crop yield were demonstrated in the farmers' fields to show the superiority of these technologies over farmers' practice in giving a good yield and better income to farmers with the optimum use of resources available at the farm. These technologies were demonstrated in nine farmers' fields of Berasia Tahsil of Bhopal district (Plate 4.1.1). The technologies performed differently in different field conditions but gave superior results compared to farmers' practice in terms of resource use and net profit to the farm family.



Plate 4.1.1(a) Performance of wheat crop (b) Seed treatment with biofertilizers

Farmers' field demonstration in the tribal dominated Alirajpur and Jhabua district

Demonstration trials on integrated plant nutrient supply (IPNS) and soil test based nutrient recommendation (STNR) were conducted in ten farmers' fields (soybean-6 fields and maize-4 fields) in the Alirajpur and Jhabua district of Madhya Pradesh during *kharif* season (Plate 4.1.2).



Plate 4.1.2 Soybean demonstration in Bawdikurd village, Alirajpur district

B. All India Coordinated Research/Network Projects

AICRP on STCR

Rice in Assam

Frontline demonstration trials on rice cv. Ranjit were conducted in 12 farmers' fields in five villages of Dergaon area, Golaghat district, Assam. The range and mean values of available soil nutrients is given in Table 4.1.1 and the results are given in Table 4.1.2. The targeted yield of 50 and 60 q ha⁻¹ under T3 and T4 where chemical fertilizers were applied alone has very little negative deviations (-0.4% and -3.7%, respectively). On the other hand, targeted yield of 50 and 60 q ha⁻¹ could easily be attainable when integrated application of chemical fertilizers are applied with a B:C ratio of 2.2.

Table 4.1.1 Range, mean and standard deviation of soil properties of FLDs

Properties	Minimum	Maximum	Mean	Stdv
Available N (kg ha ⁻¹)	178.8	314.8	245.9	46.6
Available P (kg ha ⁻¹)	4.1	7.3	6.1	1.1
Available K (kg ha ⁻¹)	108.0	278.6	194.8	62.3
OC (%)	0.6	1.1	0.8	0.2

Table 4.1.2 Results of verification trials/FLDs of *sal* rice (mean of 12 trials, and 2 years)

Treatments	Grain yield (q ha ⁻¹) Year 1	Grain yield (q ha ⁻¹) Year 2	Deviations from the targeted yield (%)	Average grain yield (q ha ⁻¹)	B : C
T1- Control	23.2	27.2	-	25.2	1.3
T2- State recommendation	33.5	38.4	-	36.0	1.5
T3- Yield target 50 q ha ⁻¹	50.4	48.8	-0.4	49.6	2.0
T4- Yield target 60 q ha ⁻¹	57.3	57.8	-3.7	57.6	1.9
T5- FYM 5 t ha ⁻¹ Yield target 50 q ha ⁻¹	53.1	50.9	+4.2	52.0	2.2
T6- FYM 5 t ha ⁻¹ Yield target 60 q ha ⁻¹	58.6	61.6	+0.2	60.1	2.2

Summer green gram in Assam

Frontline demonstration trials on summer green gram cv. Pratap were conducted in 8 farmers' fields in four villages of Dergaon area, Golaghat district, Assam (Plate 4.1.3). The range and mean values of available soil nutrients is given in Table 4.1.3 and the results on productivity are given in Table 4.1.4. The results revealed that the yield target of 12 q ha⁻¹ with inorganic treatments could not be obtained showing 1.7 % negative deviations while that could be attained with IPNS treatment with 2% positive deviations. On the other hand, 14 q ha⁻¹ target could not be attained with either of the treatments mainly due to moisture shortage during crop growth. However, the B:C ratio was

comparatively higher in treatments T4 and T6 with IPNS components. Noteworthy increase in yield was observed in targeted yield treatments over the farmers' practice.

Table 4.1.3 Range, mean and standard deviation of soil properties of FLDs

Properties	Min	Max	Mean	Stdv	CV(%)
Available N (kg ha ⁻¹)	197.7	304.8	274.4	23.0	8.4
Available P (kg ha ⁻¹)	6.9	10.6	8.9	1.5	16.8
Available K (kg ha ⁻¹)	114.7	249.5	191.5	36.0	18.8
OC (%)	0.8	1.3	1.0	0.1	10.3

Table 4.1.4 Results of verification trials/FLDs of summer green gram (mean of 8 trials)

Treatment	Seed yield (q ha ⁻¹)	% Increase/decrease over target	B : C
T1- Control (farmers' practice)	9.3	-	2.9
T2- State recommendation	11.1	-	3.0
T3- Yield target 12 q ha ⁻¹ (Inorganic)	11.8	-1.7	3.1
T4- Yield target 14 q ha ⁻¹ (Inorganic)	12.8	- 8.6	3.4
T5- FYM 5 t ha ⁻¹ yield target 12 q ha ⁻¹ (IPNS)	12.2	2.0	3.1
T6- FYM 5 t ha ⁻¹ yield target 14 q ha ⁻¹ (IPNS)	13.3	-5.0	3.3



Plate 4.1.3 Summer Moong - Golaghat district, Assam

Tomato in Odisha

FLDs were conducted on tomato cv. BT-10 in Balibandh village of Jhumpura block of Keonjhar district during rabi 2013-14. The soil fertility status and fertilizer nutrient rates are given in Table 4.1.5. Maximum yield of tomato was achieved where fertilizers were applied as per the fertilizer adjustment equations (Table 4.1.6). Although 12.68% more yield of tomato was achieved in case of Soil Test Based (STB) fertilizer recommendation (L-M-H basis) and 27.71% more yield was achieved in case of STCR plots compared to the farmers' practice. Besides, 13.36% more yield in

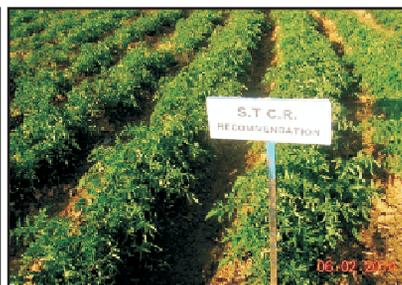
STCR over STB treated plot indicate the superiority of Fertilizer Prescription equation in site specific nutrient management (Plate 4.1.4). These demonstrations have motivated the tribal farmers to convert hitherto fallow lands into cultivated land. Similarly, frontline demonstrations on tomato cv. BT-10 were also conducted in Sadhupalli billage, Reamal block, of Deogarh district which indicated the similar trend in the yields of tomato.

Table 4.1.5 Front line demonstration on tomato at Balibandh village, Keonjhar district

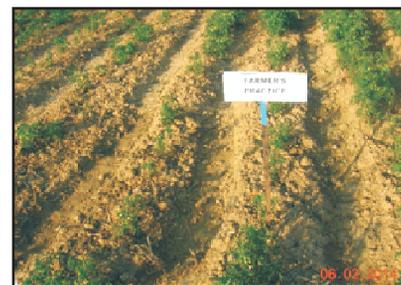
Sl. No.	Name of Farmers	pH (1:2)	E.C. (dSm ⁻¹)	OC (%)	Av. N (kg ha ⁻¹)	Av. P (kg ha ⁻¹)	Av. K (kg ha ⁻¹)
1.	Arjun Munda	6.60	0.18	0.61	73.8	4.8	140.0
2.	Pradip Munda	6.24	0.28	0.02	65.0	6.4	110.9
3.	Sankar Munda	6.22	0.69	0.54	102.5	5.6	131.1
4.	Trilochan Munda	5.75	0.67	0.57	137.5	4.8	96.3
5.	Akshay Munda	5.64	0.26	0.54	108.8	6.4	245.3
6.	Rabi Munda	5.66	0.69	0.46	225.0	5.0	84.0



Field Visit of Project Coordinator



STCR based fertilizer recommendation



Negligible amount of fertilizer applied in farmers' practice



Pesticide solution is being prepared for tomato seedling treatment at Sadhupalli village of Deogarh district



Tomato seedlings being transplanted in the experimental field

Plate 4.1.4 Tomato - Keonjhar, Odisha

Table 4.1.6: Yield of tomato

Sl. No.	Name of Farmer	Fruit yield (q ha ⁻¹)		Fruit yield (q ha ⁻¹) STCR recommendation (Target - 225 q ha ⁻¹)	% increase or decrease over targeted yield
		Farmer's practice	Soil Test Based		
1.	Arjun Munda	167.7	187.5	201.7	(-)10.4
2.	Pradip Munda	172.3	192.9	237.1	(+) 5.4
3.	Sankar Munda	176.4	196.6	236.1	(+) 4.9
4.	Trilochan	165.7	188.9	203.3	(-) 9.6
5.	Akshay Munda	159.8	183.7	205.4	(-) 8.7
6.	Rabi Munda	171.3	191.8	211.3	(-) 6.1

Mustard in Odisha

FLDs were conducted on Mustard (cv. Sushree) in Bangalimunda village of Teleibani block of Deogarh district during rabi 2013-14. The soil fertility status with respect to available N was low, available P low-medium and available K medium to high. The fertilizer nutrient rates are given in Table 4.1.7. Maximum yield of mustard was achieved where fertilizers were applied as per the fertilizer adjustment equation. Although 30.18% more yield of Mustard was achieved in case of soil test Based fertilizer recommendation (L-M-H basis) and 47.92% more yield was achieved in case of STCR plots compared to the farmers' practice plots. Beside this, 13.63% more yield in STCR over STB treated plot indicate the superiority of fertilizer prescription equation in site specific nutrient management.

Table 4.1.7 Soil Test (STB) and STCR targeted yield based fertilizer doses

Sl. No	Name of Farmer	Soil Test Based			STCR		
		N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
		(kg ha ⁻¹)			(kg ha ⁻¹)		
1.	Poulus Ekka	75	37.5	10	61	31	10
2.	Peter Minj	75	37.5	10	54	31	10
3.	Tito Kindo	75	37.5	10	62	32	10
4.	Joseph Toppo	75	37.5	10	57	32	10
5.	Vincent Minj	75	37.5	10	55	35	10
6.	Rosalia Lakra	75	37.5	10	60	33	10
7.	Anil Tirkey	75	37.5	10	69	33	10
8.	Sushama Tirkey	75	37.5	10	62	34	10
9.	Augustin Tirkey	75	37.5	10	64	35	10
10.	Lily Tirkey	75	37.5	10	70	33	10
11.	Nicholas Kullu	75	37.5	10	68	33	10

Raya in Punjab

Five frontline demonstrations on raya crop were conducted in different agro-ecological regions of Punjab. Results indicate that except in one case, applying fertilizers on the basis of target yield approach proved superior to the general recommended Dose (GRD) and the farmers' practice (Table 4.1.8).

Table 4.1.8 Results of FLDs on raya in various districts of Punjab during Rabi

Treatment	Fertilizer nutrient applied(kg ha ⁻¹)			Grain yield (q ha ⁻¹) (Value cost ratio)
	N	P ₂ O ₅	K ₂ O	
1. Name and address: Sital Singh, V. Jaffarpur, Distt. Gurdaspur				
Soil test values: OC (%) = 0.45, SN=116.5 kg ha ⁻¹ , SP=22.5 kg ha ⁻¹ , and SK=67.2 kg ha ⁻¹				
GRD	100	30	15	16.5 (8.79)
Target 20q ha ⁻¹	118	0	74	13.3 (3.97)
Target 22q ha ⁻¹	135	0	83	14.5 (4.45)
Farmers' practice	140	55	30	11.3 (1.74)
Control	0	0	0	8.8
2. Ramesh Lal , V. Pachowal, Distt. Gurdaspur				
Soil test values: OC (%) = 0.75, SN=161 kg ha ⁻¹ , SP=19.5 kg ha ⁻¹ , and SK=376 kg ha ⁻¹				
GRD	100	30	15	16.9 (10.1)
Target 20 q ha ⁻¹	97	0	0	15.6 (17.0)
Target 22 q ha ⁻¹	114	0	0	16.8 (16.6)
Farmers' practice	150	50	30	11.3 (2.32)
Control	0	0	0	8.0
3. Rakesh Kumar, V. Rasoolpur, Distt. Gurdaspur				
Soil test values: OC (%) = 0.79, SN=170 kg ha ⁻¹ , SP=30.8 kg ha ⁻¹ , and SK=141.1 kg ha ⁻¹				
GRD	100	30	15	15.0 (8.17)
Target 20 q ha ⁻¹	93	0	49	16.8 (9.75)
Target 22 q ha ⁻¹	110	0	58	17.3 (11.1)
Farmers' practice	120	55	30	10.5 (2.03)
Control	0	0	0	7.8
4. Amarjeet Singh, V. Sham Chak, Distt. Gurdaspur				
Soil test values: OC (%) = 0.90, SN=206 kg ha ⁻¹ , SP=30.8 kg ha ⁻¹ , and SK=141 kg ha ⁻¹				
GRD	100	30	15	14.8 (8.05)
Target 20 q ha ⁻¹	76	0	48	15.2 (10.1)
Target 22 q ha ⁻¹	93	0	58	17.0 (10.4)
Farmers' practice	120	55	30	10.3 (1.88)
Control	0	0	0	7.7
5. Ranjodh Singh V. Chugga, Distt. Moga				
Soil test values: OC (%) = 0.48, SN=180 kg ha ⁻¹ , SP=27.2 kg ha ⁻¹ , and SK=234 kg ha ⁻¹				
GRD	100	30	15	16.3 (7.83)
Target 20 q ha ⁻¹	88	0	17	14.4 (18.6)
Target 22 q ha ⁻¹	106	0	27	19.5 (17.1)
Farmers' practice	100	55	0	21.4 (4.94)
Control	0	0	0	9.4

Soybean and toria in Himachal Pradesh

In order to popularize the prescription based fertilizer application, fourteen frontline demonstrations, seven each on soybean (*khariif*) and toria (*zaid*) were conducted. All of the FLDs on toria were conducted in district Una in low hills sub-montane zone of Himachal Pradesh, whereas four FLDs on soybean were laid out in Kangra and three were carried out in Hamirpur district of the state. Five treatments were tested in both the crops. In soybean, the treatments were control, farmers' practice, general recommended dose, two pre- fixed yield targets of 20 and 25 q ha⁻¹. In case of toria, the treatments consisted of control, farmers' practice, GRD and two pre-fixed yield targets of 10 and 15 q ha⁻¹. The average data with respect to fertilizer nutrients applied, seed yields recorded, per cent deviations and economic aspects for soybean and toria are given in Tables 4.1.9 and 4.1.10. In case of soybean, as anticipated, the lowest yield was obtained under farmers' practice (9.1 q ha⁻¹) followed by farmers' practice (10.7 q ha⁻¹). By applying the same dose of N and less doses of P₂O₅ and K₂O higher yield was recorded under pre- fixed target of 20 q ha⁻¹ in comparison to GRD. The close agreement between targeted and observed yields was achieved in case of both the pre- fixed targets of 20 and 25 q ha⁻¹, as the percent deviations in both the cases were within the permissible limit ($\pm 10\%$) i.e. -6.0 and -8.5 per cent, respectively. The net returns in targeted treatments over farmers' practice and GRD were higher justifying the usefulness of targeted yield concept based fertilizer application. The benefit cost ratio was highest (3.55) in the treatment comprising of target 25 q ha⁻¹ followed by target 20 q ha⁻¹ (3.27) as against the farmers' practice where it was comparatively low (1.78). So, the cultivation of soybean based on targeted concept may be recommended to harvest better yields thereby getting more returns in low hills sub-montane zone of Himachal Pradesh in Hamirpur and Kangra districts. Similar to soybean, in case of toria, application of fertilizers as per target yield approach, in general, resulted in higher yield of toria in comparison to farmers' practice and general recommended dose. Similarly, few more demonstrations were conducted in Bilaspur, hamirpur, and Una district with soybean (cv. PK 472) and toria (cv. Bhawani). In case of soybean, as anticipated, the lowest yield was obtained under control (8.7 q ha⁻¹)

Table 4.1.9: Fertilizer demonstrations on soybean in Kangra and Hamirpur districts of H.P.

Treatments	Nutrient doses applied (kg ha ⁻¹)			Yield (q ha ⁻¹)	Deviat ion (%)	Cost of yield (Rs. ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Net returns (Rs.ha ⁻¹)	B:C ratio
	N	P ₂ O ₅	K ₂ O						
Control	0	0	0	9.1		23543	12200	11343	1.93
FP	20	0	0	10.7		27553	15436	12117	1.78
GRD	20	60	40	17.2		44400	16377	28024	2.71
Target 20 q ha ⁻¹	20	38	28	18.8	-6.0	48410	14786	33624	3.27
Target 25 q ha ⁻¹	20	67	49	22.9	-8.5	58894	16578	42316	3.55

In FP, FYM was applied @ 3t ha⁻¹ on fresh weight basis;

Fertilizer rate: N=11.8 Rs. kg⁻¹, P₂O₅= 48.1 Rs. kg⁻¹, K₂O=18.8 Rs. kg⁻¹, price of soybean grains: Rs. 2500 q⁻¹

followed by farmers' practice (10.4 q ha⁻¹). The treatments based on STCR concept out yielded all other treatments (control, farmers' practice as well as GRD). In case of toria, application of fertilizers as per target yield approach, in general, resulted in higher yield of toria in comparison to farmers' practice and general recommended dose.

Table 4.1.10: Fertilizer demonstrations on toria in low hills sub-montane zone of H.P

Treatment	Nutrient doses applied (kg ha ⁻¹)			Yield (q ha ⁻¹)	Deviat ion	Price of yield (Rs. ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	B:C ratio
	N	P ₂ O ₅	K ₂ O						
Control	0	0	0	4.2	-	10607	7500	3107	1.41
FP	20	0	0	7.0	-	17607	9836	7771	1.79
GRD	60	40	40	11.0	-	27393	10885	16508	2.52
Target 10	47	28	41	10.8	7.57	26893	10185	16708	2.64
Target 15	73	47	70	16.0	6.95	40107	11912	28195	3.37

In FP, FYM was applied @ 3t ha⁻¹ on fresh weight basis, sale price of toria seed = Rs.25.00 kg⁻¹, Cost of fertilizers (Rs. kg⁻¹): N=11.8, P₂O₅= 48.1, K₂O=18.8

Tribal sub plan programme in Chhattisgarh

A number of field demonstrations on various crops were conducted in tribal districts of Chhattisgarh (Table 4.1.11, Plate 4.1.5). Twenty six tribal farmers from 7 hadi's (hamlet's) at Kakanakote forest area of H.D. Kote taluk were identified based on the land available with them. The soil samples were

Table 4.1.11 Field demonstrations in the tribal districts of Chhattisgarh

Name of tribal district	Village	Crop/No of FLD's	No of beneficiaries	% Yield increased over FP
Kanker	Dhaneli	chick pea = 4	20	1.85-2.72
	Kanhar, Siltara,	wheat = 7		0.4-2.72
	Babudabena	maize = 9		0.6-1.0
Dantewada	Binjam, Nagul,	chick pea = 12	20	7-24
	Ronge	wheat = 8		26-52
Kondagaon	Bhagdewa, Bolbola	wheat = 10	20	32-42
		maize = 10		24-37
Jagdapur	Tekameta, Tandpal	wheat = 20	20	24-54
Surajpur	Sambalpur	wheat = 20	20	28-47
Balrampur	Chirkoma	wheat = 20	20	40-50
Korba	Dongri	chick pea = 20	20	9-31
Koreya	Bakira	wheat = 20	20	18-38
Narayanpur	Karalakha, Palaki,	chick pea = 10	20	8-37
	Devgaon	wheat = 10		24-33
Ambikapur	Beldagi, Kunwarpur	wheat = 20	20	26-44

FP - Farmers' practice

collected with geographical positioning system (GPS) depicting latitude and longitude of each soil sample. These samples were analyzed for available N, P and K. Based on the soil test values and yield target fixed, fertilizers were distributed to these farmers for chickpea crop by using the chickpea targeted yield equation developed at Acharya N.G. Ranga Agricultural University (ANGRAU), Andhra Pradesh.



Bumper crop of toria in Bilaspur



Field Day at Una

Plate 4.1.5 Field demonstrations in Chhattisgarh

Maize (Hybrid Hema)

A follow up trial on hybrid maize at ZARS, GKVK under dry land condition was undertaken to evaluate the targeted yield equation developed at the STCR centre. Under dryland condition, significantly higher grain yield of 47.35 q ha^{-1} in STCR (173-94-98) 90 q ha^{-1} target was obtained, as compared to package of practice (150-75-40) treatment (39.6 q ha^{-1}). However, all these values were far below the target fixed because the crop was not irrigated and the rainfall received during crop growth were very less.

Equations used:

$$\begin{aligned} \text{FN} &= 3.84 \text{ T} - 0.42 \text{ SN} (\text{KMnO}_4\text{-N}) \\ \text{FP}_2\text{O}_5 &= 1.57 \text{ T} - 1.18 \text{ SP}_2\text{O}_5 (\text{Bray's-P}) \\ \text{FK}_2\text{O} &= 1.15 \text{ T} - 0.11 \text{ SK}_2\text{O} (\text{Am. Ac.-K}) \end{aligned}$$

Ragi (GPU-28)

A follow up trial on *ragi* was conducted at ZARS, Hiriyur to evaluate the targeted equation developed at ZARS, Mandya. Highest grain yield of 37.0 q ha^{-1} was recorded in STCR (60 q ha^{-1}) targeted treatment with the fertilizer nutrient dose of 163-100-0 followed by an yield of 36.2 q ha^{-1} in STCR target of 50 q ha^{-1} with fertilizer nutrients 135-83.2-0 (N- P_2O_5 - K_2O). However, all these yields were far below the target fixed. Highest VCR of 8.68 was recorded in STCR target of 60 q ha^{-1} with integrated approach (81.7-50-0 (N- P_2O_5 - K_2O) + FYM). Lowest VCR of 3.66 was recorded in package of practice (100-50-45) treatment.

Equations used:

$$FN = 3.29T - 71.17SN (\%OC) - 0.00281 OM$$

$$FP_2O_5 = 1.789T - 0.189 SP_2O_5 (\text{Olsen's-P}) - 0.00173 OM$$

$$FK_2O = 1.775T - 0.15 SK_2O (\text{Am. Ac.-K}) - 0.0015 OM$$

Ragi (GPU-28)

A follow-up trial on ragi was taken to verify the targeted yield equation of dryland ragi at ZARS, GKVK. Significantly highest grain yield of 41.4 q ha⁻¹ was recorded in STCR (30q ha⁻¹) integrated treatment which was on par with package of practice (40.4 q ha⁻¹). These yields were far above the target fixed due to sufficient rains during the crop growth period even though it is grown under dryland condition. The yield response worked out was higher (12.30q ha⁻¹) in STCR (30 q ha⁻¹) integrated treatment followed by package of practice and VCR was highest (29.71) in STCR (20 q ha⁻¹) with only inorganics followed by STCR (30 q ha⁻¹) with only inorganics (8.68) as compared to package of practice (POP) and STL approaches. Even though STCR integrated approaches have given higher yields, yet lower VCR were recorded mainly due to very high cost of FYM added.

Potato (Kufri Jyoti 2)

In order to verify the newly developed IPNS equation for potato, five multi-location follow up experiments were conducted during *rabi* on natural soil fertility conditions at farmers' fields. All the experimental sites fall under wet temperate zone of Himachal Pradesh. The treatments comprised control, farmers' practice, general recommended dose and two pre-fixed yield targets with and without the use of FYM in case of potato.

The targets evaluated were 150 and 200 q ha⁻¹ of potato tubers. In farmers' practice, FYM was applied @ 25 t ha⁻¹. Initial soil test values with respect to available N varied from 209 to 285 kg ha⁻¹ with a mean value of 247 kg ha⁻¹, that of available P from 23 to 44 kg ha⁻¹ with a mean value of 33 kg ha⁻¹, and available K varied between 179 and 194 kg ha⁻¹ with an average of 184 kg ha⁻¹. The target yield equations used for applying fertilizers in potato were as given below (Table 4.1.12).

Table 4.1.12 Fertilizer adjustment equations used for potato crop

Crop	Equations		
	FN	FP ₂ O ₅	FK ₂ O
Potato	3.37T-0.90SN-0.22ON	0.71T-0.95SP-0.18OP	1.47T-0.62SK-0.10OK

SN, SP, SK, T etc. above have their usual meanings. ON, OP, OK stand for amounts of N, P & K in kg added from organic manure as per dosage involved.

The lowest yield (84 q ha⁻¹) of potato (Table 4.1.13) was recorded in control followed by farmers' practice (120 q ha⁻¹). As far as the pre-fixed yield targets vis-à-vis yields obtained are concerned, deviation was within 10 per cent between the actual yield obtained and the pre-fixed targets under

both the situations *i.e.* with and without the use of FYM. The net returns were highest (Rs. 132457 ha⁻¹) in 200 q ha⁻¹ target without FYM followed by the same target with FYM (Rs. 122951 ha⁻¹) and lowest was in control (Rs. 29167 ha⁻¹). The benefit cost ratio was highest (2.92) in 200 q ha⁻¹ target without FYM followed by the same target with FYM (2.47). The benefit cost ratio for the yield target of 150 q ha⁻¹ with and without FYM were 2.07 and 2.45, respectively.

Table 4.1.13: Target yield experiment (involving IPNS based equations) on potato

Treatment	N (kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)	FYM (t ha ⁻¹)	Tuber yield (q ha ⁻¹)	Deviati on (%)	Gross returns (Rs. ha ⁻¹)	Cost of inputs (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	B:C ratio
Control	0	0	0	-	84	-	84167	55000	29167	1.53
FP	30	0	0	25	120	-	120000	80354	39646	1.49
GRD	120	80	60	-	141	-	141333	61394	79940	2.30
Nutrients as per Targets (q ha ⁻¹)										
150	279	77	105	-	157	4.4	156667	63963	92704	2.45
200	448	112	179	-	202	0.8	201500	69043	132457	2.92
150 (IPNS)	269	68	99	15	162	7.9	161833	78302	83531	2.07
200 (IPNS)	437	103	172	15	206	3.2	206333	83382	122951	2.47

Besides 30 kg N, farmers apply FYM @ 25 t ha⁻¹, FYM was applied @ 15 t ha⁻¹ in 150 and 200 q ha⁻¹ target with IPNS, Sale price of potato = Rs. 10 kg⁻¹. Fertilizer: N=11.8 Rs.kg⁻¹, P₂O₅= 48.1 Rs. kg⁻¹, K₂O=18.8 Rs. kg⁻¹

Maize (PG 2474)

A long term yield target experiment was started from *kharif* five years ago with maize and wheat as test crops with the objectives to verify fertilizer adjustment equations for maize and wheat grown in a sequence and simultaneously to study the impact on soil quality over the years. The IPNS based fertilizer adjustment equations were used to calculate nutrient doses for various targets which were kept as treatments for maize and wheat (Table 4.1.14, Plate 4.1.6).

Table 4.1.14 Fertilizer adjustment equations (IPNS based) used in long term target yield experiment in maize-wheat sequence

Maize	Wheat
FN = 5.88 T- 0.23 SN - 0.93 ON	FN = 5.27 T- 0.25 SN - 1.06 ON
FP ₂ O ₅ = 4.87 T- 1.22 SP -0.81 OP	FP ₂ O ₅ = 4.13 T- 0.38 SP - 0.98 OP
FK ₂ O = 3.66 T- 0.49 SK -0.51 OK	FK ₂ O = 2.87 T- 0.15 SK - 0.55 OK

The lowest grain yield of 19.3 q ha⁻¹ in maize was recorded under control (No fertilizers) whereas, farmers' practice (40-0-0) and application of fertilizers based on soil test (STB) (150-45-40) and general recommended dose (GRD) (120-60-40) recorded yield levels of 23.3, 26.2 and 25.7 q ha⁻¹, respectively. A close agreement between the yield targeted and the actual yield obtained was observed in the four pre-fixed targets of 30 and 40 q ha⁻¹ with and without FYM. FYM involving two yield targets recorded higher yields than their non-FYM counterparts. However, the net returns and benefit cost ratio were higher in case of non FYM treatments because of additional cost of FYM. The highest net returns were obtained in treatment corresponding to yield target of 40 q ha⁻¹ without FYM. The benefit cost ratio was also highest (2.57) in targeted yield level of 40 q ha⁻¹ without FYM followed by targeted yield level of 30 q ha⁻¹ without FYM (2.38) and least was in farmers' practice (1.07).

Almost, similar yield trends were also observed in case of wheat. The lowest grain yield of 13.2 q ha⁻¹ was recorded in control followed by farmers' practice (16.3 q ha⁻¹). Application of fertilizers based on soil test (STB) and general recommended dose resulted in 18.6 and 18.0 q ha⁻¹ grain yield of wheat, respectively. The pre- fixed targets (25 and 35 q ha⁻¹), where FYM was applied consumed less nutrients but produced more grain yield.



Plate 4.1.6 Long term experiment on wheat

Target yield concept based fertilizer application excelled all other approaches in terms of yield and net returns.

AICRP on MSN

Micro and secondary nutrients

Technologies generated in AICRP- Micronutrients for micronutrient management were demonstrated in more than 500 farmers' fields through cooperating centres (Plate 4.1.7). Micronutrient kits and soil health card were distributed to more than 500 tribal farmers (Table 4.1.15, Plate 4.1.8). Number of Farmers day / Field day / On spot advice / *Krishi melas* conducted in tribal areas to increase the awareness regarding the use of micro and secondary nutrients for enhancing crop productivity and animal/human health



Plate 4.1.7 Front line demonstrations in different crops

Table 4.1.15 Distribution of soil health card, micronutrient kit and extension materials in tribal areas

State/Centre	No. of beneficiaries		
	Soil health card	Micronutrients kit	Extension materials
Maharashtra (Akola)	61	61	320
Tamil Nadu (Coimbatore)	50	50	450
Gujarat (Anand)	164	45	1250
Jharkhand (Ranchi)	80	80	-
Andhra Pradesh (Hyderabad)	20	20	240
Madhya Pradesh (Jabalpur)	76	18	300
Assam (Jorhat)	50	50	250
West Bengal (Kalyani)	20	20	150
Odisha (Bhubaneswar)	500	125	500
Uttarakhand (Pantnagar)	50	50	-
Himachal Pradesh	130	130	-
Bihar	16	100	100



Plate 4.1.8 Distribution of micronutrient kit and extension materials

AINP on BF

PGPR for apple, cauliflower, pea

The demonstrations of PGPR on apple (5 nos.), cauliflower (3 nos.) and pea (3 nos.) resulted in about 38 %, 22% and 26 % increase in yield over recommended package of practices in mid and high hills of Himachal Pradesh (YSPUHF, Solan).

Biofertilizers and upland rice in eastern India

Demonstrations (wet season 2014) on biofertilizer application in direct seeded upland rice variety

'CR Dhan 40' showed that application of AMF inoculum (soil application) and *Azotobacter* (seed application) resulted in 29 % and 13 % increase in grain yield, respectively in Jharkhand. Similar trends of results obtained during last three seasons (wet seasons of 2011-12, 2012-13 and 2013-14 confirmed better performance of AMF inoculum over *Azotobacter* in acidic upland soils of Jharkhand (CRURRS, Hazaribagh).

Biofertilizer technology intervention in tribal/ non-tribal farmers in eastern India

Biofertilizer technology intervention was introduced in rice and pulse (lentil and urdbean) crop of tribal & non-tribal farmers of West Champaran East Champaran, Samastipur, Muzaffarpur, Vaishali, Katihar and Bhagalpur district in Bihar. Intervention in rice crop at ten farmer's site resulted 7-16 % increase in grain yield. Increase in lentil (13 -24%) and urdbean (4-8%) yield was recorded due to *Rhizobium* inoculation. There was poor response to inoculation in *Diara* land of Katihar and Bhagalpur district on urdbean owing to good soil fertility and adequate rhizobial populations or both (RAU, Pusa).

Tribal demonstrations

In three villages of Kalahandi district, 64 on-farm (tribal area) trials were conducted with nine crops: namely tomato (15 nos.), cauliflower (13 nos.), cabbage (3 nos.), brinjal (4 nos.), cowpea (3 nos.), french bean (1 nos.), maize-cowpea (8 nos.), sole maize (8 nos.) and cotton (9 nos.). For vegetable crops on an average 400 m² area per farmer, for maize/ maize-cowpea 1000 m² per farmer and for cotton 2000 m²/ farmer were allowed to grow their desired crops and were supplied with critical inputs like seed, fertilizers, BFs and pesticides. The BFs used were *Azotobacter*, *Azospirillum*, PSM and *Rhizobium*. The response to BFs inoculation ranged from 10.6- 22.0 %, lowest with maize and highest with cowpea. On an average bioinoculation of crop increased the economic yields by 17.6 % (OUAT, Bhubaneswar).

Fourteen demonstrations were carried out in tribal villages of Mandla and Chhindwara districts with farmer practice (imbalanced fertilization without biofertilizer) and recommended doses of fertilizers with biofertilizers on soybean (var. JS-9752). An increase of 21.5% was demonstrated with RDF+BF (average 1730 kg ha⁻¹) over F.P. (average 1424 kg ha⁻¹). Six demonstrations were carried out on maize (var. JM-216) in tribal villages of Chhindwara district with farmers practice and RDF+BF. An increase of 75% was demonstrated with RDF+BF (average 768 kg ha⁻¹) over F.P. (average 1343 kg ha⁻¹) (JNKVV, Jabalpur).

Production and supply of biofertilizers

Biofertilizer packets- 60323, 24842, 16481, 1504, 40096 and 3187 pkts of PSB, *Trichoderma*, *Azotobacter*, *Azospirillum*, *Rhizobium*, and soil based BGA respectively were produced and supplied to farmers amounting to sale of Rs. 35.50 lakhs (JNKVV, Jabalpur). Biofertilizer sale during 2014-15 was of Rs. 6.50 lakhs, which was lesser compared to 2013-14 (Rs. 7.95 lakhs) owing to drought situation in Maharashtra (MAU, Parbhani). Using the strains of AINP on Soil Biodiversity and Biofertilizers, 170 MTs of solid carrier based biofertilizers and 20 MTs of liquid

biofertilizers worth Rs. 121.20 lakhs were produced during 2014-15 (ANGRAU, Amaravathi). More than 3000 packets (200g each) of *Azotobacter*, *Rhizobium*, *Azospirillum* and PSB were prepared and supplied to farmers. In addition 1000 packets of BGA inoculant and 300 packets (1 and 5 kg) of AM inoculant were prepared and supplied (IARI, New Delhi). Training was given to different farming groups on the usage of liquid biofertilizers as well as solid biofertilizers (IISS, Bhopal and all centers).

4.2 On-Farm Demonstrations

On-farm demonstration of resource conservation technology

To popularize the resource conservation technology among farmers of Central India, Division of Soil Physics, IISS, Bhopal has been demonstrating following packages of treatments to the farmers since last five years in the institutes research farm (Plate 4.2.1). Details of treatments and yield (Table 4.2.1) are given below:

- Two tillage practices viz. (a) No-Till and (b) Reduced Tillage were demonstrated. In both tillage practices Broad Bed and Furrow system is being followed. In No-tillage, sowing was done by slit-drill whereas; in reduced tillage sowing was done with tropi-culter after one ploughing by duck foot cultivator.
- Three cropping systems selected for this purpose were: (a) maize - chick-pea, (b) soybean – wheat, and (c) soybean + pigeon pea (inter-cropping ratio is 3:2). In all the treatments recommended fertilizer doses with 8 t FYM ha⁻¹ yr⁻¹ were applied and standard pest management and weed management (manual + chemical) practices were followed.

Table: 4.2.1 Crop yield observed during Rabi season of 2014-2015

	Wheat (q ha ⁻¹)	Chickpea (q ha ⁻¹)
BBF+No Tillage	43	20
BBF+Reduced Tillage	42	22



Plate 4.2.1 Demostration of resource conservation technologies

Demonstration of STCR based nutrient recommendations

Institute is maintaining eight demonstration plots on nutrient recommendations for the soybean-wheat cropping system since 2003. Different treatments in the demonstration trial are given in Table 4.2.2. The soil analysis of the samples taken in 2013-14 revealed that available K was 287 kg ha⁻¹ in STCR (-K) treatment as compared to 414 in STCR (full) treatment. The values for organic C were

0.58% and 0.72% in -N and STCR (full) treatment, respectively. The most prominent reduction was observed in available P status which was only 2.2 kg ha⁻¹ in STCR (-P) treatment as compared to 18.7 kg ha⁻¹ in STCR (full) treatment.

Table 4.2.2 Treatments in the trial

S. No.	Treatment	S. No.	Treatment
1	STCR based (-N)	5	STCR based (Full)
2	STCR based (-P)	6	IPNS
3	STCR based (-K)	7	STCR based (Limited irrigation)
4	State recommended dose (NPK)	8	IPNS (Limited irrigation)

In STCR based (-N) treatment, P and K rates were applied as per STCR equations, N was not applied

Demonstration of enriched composting

Institute is doing on-farm demonstrations on preparation of different enriched composts (Plate 4.2.2). Different compost preparations are vermicompost, phosphocompost, microbial enriched compost, poultry compost and parthenium compost.



DDG (NRM) Dr. A.K. Sikka's visit to composting unit



Farmers' visit to the composting unit

Plate 4.2.2. Composting unit of IISS

4.3 Method Demonstrations

In connection with demonstration of IISS technologies in Mengra Kalan village of Bhopal step-by-step procedure of biofertilizer treatment of soybean and wheat seeds, and preparation of phospho-sulpho-nitro compost in portable plastic pits were shown to a group of 30 farmers under the supervision of the scientists of the Institute, during soybean-wheat, 2014-15 (Plate 4.3.1).

Demonstration of soil nutrients analysis using *Mridaparikshak* was done on the following occasion

- 86th AGM meeting, NASC, New Delhi, February 02, 2015
- Pusa Krsihi Vigyan Mela, IARI, New Delhi, March 09-12, 2015
- Demostration at *Krishi Bhawan*, New Delhi, March 25, 2015



Plate 4.3.1 : Method demonstration on use of bio-fertilizers and compost preparation

4.4 Technology/Product Developed

A Main Institute

Mridaparikshak

A new mini lab named *Mridaparikshak*, a mini soil lab has been developed at ICAR-IISS, Bhopal. This can estimate 10 parameters viz., pH, EC, Organic carbon, available N, P, K, S, Fe, Zn, and B. Fertilizer recommendations for specified targets for selected crop and soil can be generated which can be transmitted to farmers mobile. This is compatible with soil health card. This technology was demonstrated during annual general body meeting of ICAR (Plate 4.4.1).



Mridaparikshak development team



Demonstration before Hon'ble Union Minister of Agriculture Shri Radha Mohan Singh

Plate 4.4.1 Demonstration of *Mridaparikshak*

Rapo-compost technique

A survey of farmers' fields has revealed that 'Rapid Composting' technique which can reduce the time required for obtaining good quality compost, is the need of the hour. Therefore, a new technology, 'Rapo-compost Technique' using consortium of Ligno-cellulolytic thermophilic organisms, has been developed by ICAR-IISS that has considerably reduced the time required for composting to 1-1.5 months. This technology is especially suitable for recycling of kitchen wastes

and vegetable wastes. The institute has developed this technique in collaboration with ICAR-CIAE, Bhopal and ICAR-NBAIM, Mau. As a part of this technology, lignocellulolytic thermophilic organisms, important for accelerating the decomposition, were isolated, screened and identified by ICAR-IISS. The technology has been demonstrated to farmers and trainees of winter school (Plate 4.4.2).). It has received accolades from Natural Resource Management (NRM) division of ICAR and has been identified as a key component for the recycling of biodegradable wastes and could be very useful in pursuing the “Swachh Bharat Abhiyan” of the Government.



Rapo-compost device

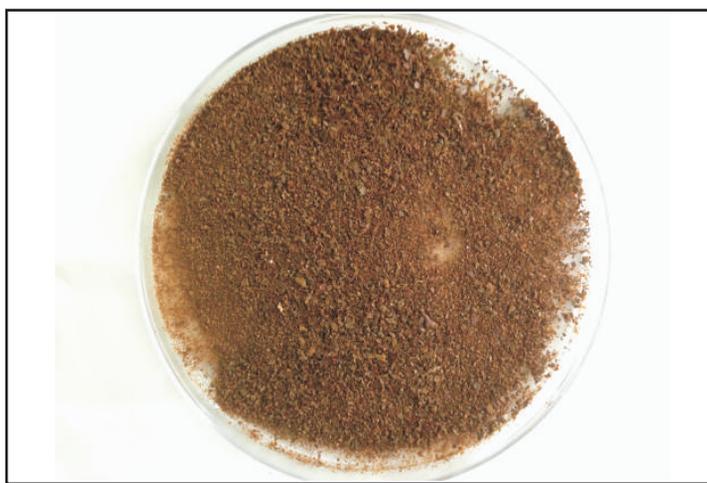


Demonstration of 'Rapo-compost technique' to trainees of winter school

Plate 4.4.2 Demonstration of rapid composting technology

*Bioactive products from *Jatropha curcas**

Experiments were carried out to determine how best the biomass of *J. curcas* can be used to improve agriculture. Leaf biomass was extracted by a specific aqueous extraction method (Plate 4.4.3). Leaf extract at different concentration (0 - 1.0% v/v). was added to soil Preliminary study highlighted this product has the capacity to enhance soil methane (CH₄) uptake by about 20-40%. It can also decrease N₂O production. Product also increased microbial abundance including heterotrophs, N fixers and P solubilizers. Further tests are being undertaken to study the effect of the extract on plant growth attributes.

Plate 4.4.3 Leaf extract concentrate of bioenergy crop *J. curcas*

Biofilter technology

The main problem in using municipal and solid wastes (MSW) for compost making is the presence of high content of heavy metals. These heavy metals may harm the plants and in turn the animal and humans who consume these contaminated plants. The Institute has developed a bio-filter (plate 4.4.4) containing fungi which can reduce the quantity of the heavy metals in MSW compost. These MSW compost after decontamination can be safely used in agricultural fields as an amendment.



Plate 4.4.4 View of inserted bio-filter block

4.5 Participatory Technology Developed

IPNS with Phospho - Sulpho - Nitro - (PSN) compost

Considering the lack of availability of farmyard manure (5 t ha^{-1}) for adopting the IPNS recommendation of IISS, the nutrient package was modified by integrating another IISS technology viz., phospho-sulpho-nitro compost (2 t ha^{-1}). The technology was evaluated in the farmers' field for a period of two years for the soybean-wheat cropping system (Plate 4.5.1). For the soybean crop, average grain yield in the first year for IPNS with PSN compost was 12.3 q ha^{-1} and that of IPNS with FYM was 11.2 q ha^{-1} . In the second year the corresponding yields were 12.3 and 11.5 q ha^{-1} respectively. For the wheat crop, average grain yield in the first year for IPNS with PSN compost was 42.7 q ha^{-1} and that of IPNS with FYM was 40.7 q ha^{-1} . In the second year the corresponding yields were 45 and 41 q ha^{-1} .



Plate 4.5.1 Preparation of PSN compost under farmers' field conditions

4.6 Farmers'/Field Days Organized

- Drs. M.C. Manna, A.B. Singh and A.K. Tripathi had organized Field Day on 19th January, 2015 at *Parwalia Sadak*, Bhopal (Plate 4.6.1).
- Several Field Days were organized in Alangandi district of Tamil Nadu and Dhaneli Kanhar, Siltara, Babudabena districts of Chhattisgarh under the tribal sub plan (TSP) of AICRP on STCR.



Plate 4.6.1 Farmers' field day at Parwalia village

4.7 Technology Demonstration in Farmers' Fairs/ Exhibitions

- Drs. A.B. Singh, Sanjay Srivastava, R.H. Wanjari, A.K. Vishwakarma, Shinogi K.C., Vinod Babu Pal and Vinod Chaudhary attended IISS Stall in '*Haldhar Krishi Yantra Kisan Mela*' organized under *Krishi Mohotsav 2014* at Lal parade ground Bhopal during 26-28 Sept., 2014.
- Drs. R.H. Wanjari, Anand Vishwakarma and Vinod Chaudhary put the IISS Stall in the ICAR Regional Committee Meeting (RC VII) held at IGKV, Raipur on 17th October 2014.
- Drs. Sanjay Srivastava, A.K. Vishwakarma, I.Rashmi, and Shinogi K.C. put the IISS stall in *Pusa Krishi Vigyan Mela* held at IARI New Delhi during 10-12 March, 2015.



Plate 4.7.1 Scientists demonstrating IISS technologies in farmers' fair

4.8 Procurement and Distribution of Inputs

- Under the project on farmers' field demonstration of IISS technologies, soybean and wheat seeds, fertilizers, herbicides, pesticides, portable compost pits, pyrite and rock phosphate were procured and distributed to 9 farmers of Mengra Kalan village of Berasia Tehsil, Bhopal.

4.9 Farm/Field Surveys Conducted

A Georeferenced organic cluster survey was carried out in *Parwalia Sadak* and *Raati Bar* villages of Bhopal during January 2015 (Plate 4.8.1). A total of 20 organic farmer fields were surveyed with the questionnaire prepared by ICAR-IIFSR, Modipuram, Meerut and firsthand information on their farming practices, input use and problems faced were obtained. The suggestions for further improvement of the organic farming technologies were given. Further, a GPS recording of the organic farms was also made to ascertain the authenticity of the organic farms for future studies. These organic clusters will be provided with 'technical know-how and do-how' on the latest advancements in organic crop management practices both on-farm and off-farm for further strengthening the farmer-institute linkage in the sector.

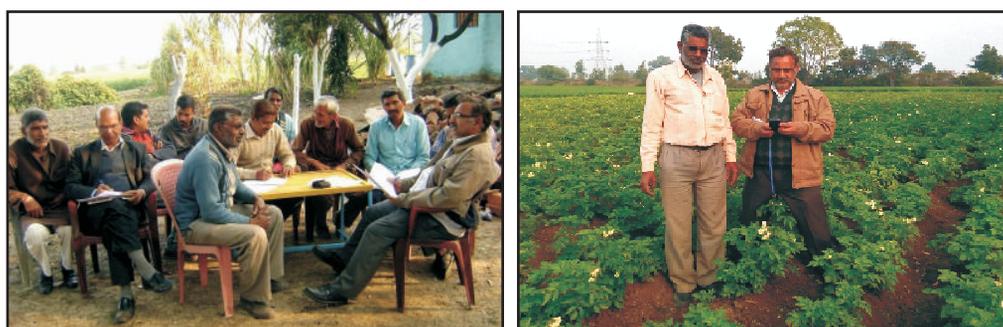


Plate 4.8.1 Farmers' field survey in *Parwalia Sadak* and *Raati Bar* villages of Bhopal

4.10 Farmers'/Agricultural Officers'/Students' Visits

Several visits of the farmers/scientists/agriculture officers/extension workers/ students in the institute were organized during which they were explained about the technologies generated by the institute particularly on organic farming, vermi-compost, phospho-sulph-nitro-composting and other technologies for enriched compost production. (Table 4.10.1).

Table: 4.10.1 Visit of Farmers, Extension workers, and Students in the Institute

S. No.	Department	No. of participants	Period
1.	RKDF University, Bhopal, M. P.	88 B Sc.(Ag) Students	26-27/11/ 2014
2.	Dept. Agri., M.P. (ATMA project)	100 Progressive farmers	-
3.	Department of Agriculture, Ujjain, M.P.	20 Village Development Officers	03/07/2014
4.	M.P. Jan Abhiyan Parishad Bhopal	50 Progressive farmers	31/12/2014
5.	Agricultural College, Hassan Karnataka	44 B Sc. (Ag) Students	06/12/2014

4.11 Other Extension Activities

- Dr. A.K. Tripathi participated in *The Krishi Mahotsav-2014* organized by Agriculture Development and Farmers Welfare Department (Govt. of Madhya Pradesh) during September 25, 2014 to October 20, 2014.

- Dr. Sangeeta Lenka imparted training to state agriculture department staff, state extension officers and KVK staff in state level workshop on “Climate change and their effect on agriculture” organized by SIAET, Bhopal on 4th August, 2014.
- Dr B.P. Meena attended a farmers' fair under the Krishi Mahotsav organized by Government of Madhya Pradesh at Khargone during October 17-20, 2014.
- Dr A. B. Singh
 - ✱ Brief presentation on organic farming in an interactive meeting for extension officers for *kharif* crop production technology on June 04 at CIAE, Bhopal.
 - ✱ Training given on “Natural resource management and organic farming & its future to the extension officers/extension workers on June 16, 2014, arranged by State Institute of Agriculture Extension & Training (SIAET), Bhopal.
 - ✱ Training given on “Organic farming & Soil Health” in the State Level *Krishi Mela*, arranged by Agriculture and Horticulture Department at Rajgarh (Vyawara), Madhya Pradesh during June 25-26, 2014.
 - ✱ Training given on Vermicompost production and its uses in organic farming, organized by BAMETI, Bihar during June 27-29, 2014 at Patna.
 - ✱ Training given on “Organic farming” to the farmers on June 06, 2014, arranged by Project Director, ATMA at Villages, Ratua and Sonkacch, Berasia Block, Bhopal.
 - ✱ Training given on “*Jaivik kheti*” under ATMA Farmer- Scientist Interaction programme on August 22, 2014, arranged by Project Director, ATMA at ICAR-CIAE, Bhopal.
 - ✱ Training given on “Vermicompost and organic manure production” to the producers engaged in the utilization of waste materials produced from the factory from 31/08/2014 to 01/09/2014, arranged by *Mahakaushal* Sugar & Power Industry Limited Bachai, Narsinghpur, Madhya Pradesh.
 - ✱ Training given on “Future need for promoting IPM for sustainable pest management” to the extension officer/ agriculture officers on September 09, 2014, arranged by SIAET, Bhopal.
 - ✱ Training given on “*Jaivik Khad va Kenchwa Khad Banane ki Bidhi*” to the farmers on October 15, 2014, arranged by ICAR-IISS, Bhopal.
 - ✱ TV programme on “organic farming and vermicomposting” on November 05, 2014, made by *Doordarshan* Kendra, Bhopal.
 - ✱ Training given on “Organic farming and composting technique” in the RAEO foundation course on November 21, 2014, arranged by SIAET, Bhopal.
 - ✱ Training given on “*Jaivik Khad ka utpadhan evam krishi utpadhan mein yogdan*” to the farmers of ATMA, Katihar Bihar on December 12, 2014, arranged by ICAR- CIAE, Bhopal.
 - ✱ Training given on “Organic farming and soil health,” in Organic Farming Workshop on February 06, 2015, arranged by DDA, Bhopal at ICAR-CIAE, Bhopal.
 - ✱ Training given on “Organic farming and soil health, crop diversification & new varieties” to the extension officers/extension workers on March 17, 2015, arranged by SIAET, Bhopal.

5. TRAINING AND CAPACITY BUILDING

5.1. Training attended in India

Training Programme on Infrared Spectroscopy use in Soil Health Assessment

Under the ICAR-ICRAF collaboration on soil research, a training programme on 'Infrared Spectroscopy use in Soil Health Assessment' was organized at the Indian Institute of Soil Science, Bhopal during March 9-13, 2015. Dr. Evis Weullow and Dr. Andrew Sila, were resource personnel from World Agroforestry Centre, Nairobi. A total of seventeen scientists from Indian Institute of Soil Science (IISS), Bhopal, Central Agroforestry Research Institute (CAFRI), Jhansi and Borlough Institute for South Asia (BISA), Ludhiana participated in the training programme.

Scientists Attending Different Training Programmes

Participant	Title	Organization	Duration
Dr. Rajendiran S.	Training on Advance in Nutrient Dynamics in Soil-plant-Atmosphere System for Improving Nutrient Use Efficiency	IISS, Bhopal	September 02-11, 2014.
Drs. B.P. Meena and Pankaj K. Tiwari	Recent Advance in Micro irrigation System and Fertigation under Covered and Open Cultivation for Sustainable and Enhanced Crop Production and Productivity in Vertisols	CIAE, Bhopal	September 09-29, 2014.
Dr. Nishant K. Sinha	Conservation Agriculture: Developing Resilient Systems	CSSRI, Karnal	September 27 to October 04, 2014.
Drs. Asha Sahu, J.K. Thakur and M.L. Dotaniya	Winter school on "Waste Recycling and Resource Management through Rapid Composting Techniques	IISS, Bhopal	December 03-23, 2014.
Dr. Sangeeta Lenka	DST training on Role of Scientists in Natural Resources and Environment Management	IIFM, Bhopal	February 16-20, 2015.

5.2 Short Term Training Organized for Students/Scientists

Name of Student	Name of College/ Institute/ University	Duration in Months	Name of the Scientist	Training Programme
Ms. Harsha Prajapati and Ms. Sandhya Tripathi	School of Biochemistry, Devi Ahilya University, Indore	1	Dr. Asha Sahu	Evaluation of maturity and stability indices of enriched compost

5.3 Research Guidance for Degree Programmes

Name of Student	Name of College/ Institute/ University	Degree	Name of Co-guide
Mr. Awanish Kumar	Indira Gandhi Krishi Vishwa Vidyalaya (IGKV), Raipur	Ph.D.	Dr. A.K. Biswas
Ms. Babeeta Porwal	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior	M.Sc.	Dr. S. Srivastava
Ms. Chandraprabha Miri	Indira Gandhi Krishi Vishwa Vidyalaya (IGKV), Raipur	M.Sc.	Dr. S. Srivastava
Mr. Satish Aher	Ramkishan Mission Vivekanand University, Belur Math, Howrah	Ph. D.	Dr. Brij Lal Lakaria
Mr. Prakash Patidar	RMVRS College of Agriculture, Sehore	M.Sc.	Dr. Brij Lal Lakaria
Ms. Poonam Mandale	RMVRS College of Agriculture, Sehore	M.Sc.	Dr. Brij Lal Lakaria
Mr. Dameshwar Kumar	Indira Gandhi Krishi Vishwa Vidyalaya (IGKV), Raipur	M. Sc.	Dr. R. Elanchezhian
Ms. Anusuiya Panda	Indira Gandhi Krishi Vishwa Vidyalaya (IGKV), Raipur	M.Sc.	Dr. Pramod Jha
Mr. Anil Kanthale	Indira Gandhi Krishi Vishwa Vidyalaya (IGKV), Raipur	M.Sc.	Dr. N. K. Lenka
Ms Sneh Tiwari	Bundelkhand University, Jhansi	M.Phil.	Dr. S. R. Mohanty
Ms. Mamata Ahirwar	Shrimant Madhavrao Scindia Government Model Science College, Gwalior	M.Sc.	Dr. K.Bharati
Mr. Sandeep Karode	RMVRS College of Agriculture, Sehore	M.Sc.	Dr. Asit Mandal
Ms. Megha	RMVRS College of Agriculture, Sehore	M.Sc.	Dr. M. Vassanda Coumar

5.4 Foreign Training/Visit

- Dr. A.K. Patra, Director, visited World Agroforestry Centre (ICRAF, Nairobi, Kenya) Soil Spectral Lab for soil health assessment, during November 16-19, 2014.
- Dr. Sanjay Srivastava as member of official delegation visited Kenya, Rwanda and Tanzania in Africa during November 12-18, 2014 in connection to setting up of different projects under Indo African Forum Summit (IAFS-II). Also presented the project on 'Establishing soil water tissue testing laboratory' in Kenya and Tanzania (Plate 5.4.1).



Plate 5.4.1 Discussion with Rwandan officials for establishment of seed production cum demonstration centre

6. AWARDS, HONOURS AND RECOGNITIONS

Awards

- Dr. AK Patra won Bioved Agri-innovation Award 2015 for outstanding contribution in the area of sustainable crop production
- Dr. MC Manna selected as Fellow of National Academy of Agricultural Sciences during the year 2015
- Dr. Pradip Dey selected as Fellow of Indian Society of Soil Salinity and Water Quality, Karnal, Haryana
- Dr. AK Shukla bagged International Zinc Association and – Fertilizer Association of India (IZA-FAI) Award (2014) on “Promoting the Use of Zinc in Indian Agriculture”. He also got Shri Ram Award (2014) by the Fertiliser Association of India, New Delhi
- Dr. Tapan Adhikari bagged JC Bose Gold Medal Award - 2014 of Indian Society for Plant Physiology, New Delhi. He also received Twelfth International Congress Commemoration Award - 2014 of the Indian Society of Soil Science, New Delhi
- Dr. NK Lenka was selected as Associate of the National Academy of Agricultural Sciences (NAAS), New Delhi
- Dr. SR Mohanty got Eminent Scientist Award 2014–National Environmental Science Academy, New Delhi. He also got Young investigator award 2015 – India Bioscience, during young investigator meet (YIM 2015) at National Centre for Biological Science (NCBS)
- Dr. K Bharati received Scientist of the Year Award, 2014 from National Environmental Science Academy
- Dr. AK Vishwakarma won ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences (Natural Resource Management & Agricultural Engineering) for 2011-12 by ICAR on the occasion of 86th Foundation Day at New Delhi on 29th July, 2014
- Dr. Sangeeta Lenka received Young Scientist Award from Education Expo-2014
- Dr. I Rashmi bagged ISSS Best Doctoral Research Presentation Award during 79th Annual Convention of the Indian Society of Soil Science (ISSS) held at Acharya N.G. Ranga Agricultural University, Hyderabad during November 24-27, 2014

Best Paper/Poster/Oral Presentation Award

- Drs. Muneshwar Singh and RH Wanjari were awarded Third Prize as "Dhiru Morarji Memorial Award" for "Best Article in Agricultural Sciences 2013-14" for the article entitled “Balanced Nutrient Management: A Key to Sustain Productivity and Soil Health on Long Term Basis” published in December, 2013 issue of Indian Journal of Fertilizers by Fertiliser Association of India, New Delhi
- Dr. AK Tripathi won Shri Ram Khad Patrika Award, Second Prize for the best article published in *Khad Patrika*, December, 2013 issue entitled “*Sukshma Poshak Tatwo Ki Kami Ke Lakshan va Prabandh*” by AK Tripathi, AK Shukla, MC Manna and A Subba Rao

- Dr. Pradip Dey got Best Poster Award (Second) at National Conference on Soil Health on "Soil Health: A Key to Unlock and Sustain Production Potential" organized by Jabalpur Chapter of Indian Society of Soil Science at JNKVV, Jabalpur on 4-5 September, 2014
- Dr. KM Hati and Team bagged Best Oral Presentation Award for "Long-term effect of conservation tillage on soil physical properties, organic carbon content and its distribution in aggregate size fractions" in the International Symposium on New-Dimensions in Agro meteorology for Sustainable Agriculture at GBPUAT, Pantnagar during October 16-18, 2014
- Drs. K Ramesh, AK Biswas and AK Patra got Best Poster Presentation Award in National conference on Indigenous innovation and foreign technology transfer in fertilizer industry: needs, constraints and desired simplification held at ICAR-CRIJAF, Barrackpore on January 17, 2015
- Dr. AK Viswakarma and team got Best Research Paper Award of the year 2014 for the paper entitled "Decision support system for contour trenching" by Indian Association of Soil and Water Conservationists. He also got best Oral Presentation Award for "Effect of different herbicides on weed growth and yield of soybean under conservation agriculture" in the National Conference on Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management held at DRR, Hyderabad during December 13-14, 2014
- Drs. A Mandal, JK Thakur, Asha Sahu, MC Manna, AK Patra got best Oral Presentation Award in the Second International Conference on Bio-resource and Stress Management, Hyderabad, Telangana State, India during January 7-10, 2015
- Drs. Shinogi KC, Jayasree Krishnankutty, Sanjay Srivastava, I Rashmi, Renu Balakrishnan and Reshma Gills got Best Paper Award for the paper entitled "Market-led Extension and Empowerment of Rural Farmers: The Case of Self Help Groups in Kerala" in ISEE National Seminar on Extension Innovations and Methodologies for Market-led Agricultural Growth and Development organized by Indian Society of Extension Education during 26-28th February, 2015 at Rajmata Vijayaraje Scindia Krishi Viswa Vidhyalaya, Gwalior, Madhya Pradesh

Recognitions

- Dr. DLN Rao was Invited speaker at the 55th Annual Meeting of the Association of Microbiologists of India, TNAU, Coimbatore, November 12-13, 2014, and in the 102nd meeting of Indian Science Congress Association at Mumbai in the Agriculture & Forestry section on January 5, 2015. He also acted as DPC member (Microbiology) at CRIJAF, Barrackpore and NBAIL, Bangalore
- Dr. AK Biswas Chaired a session in Annual Workshop of AICRP on LTFE at CSK HPKV, Palampur, during June 2-3, 2014. He also acted as member of the Judging Committee for ISSS Best Doctoral Research Presentation Award and ISSS Zonal Award 2014 for the West Zone, at Udaipur during September 25-27, 2014
- Dr. Pradip Dey received following recognitions
 - * Chaired Technical Session on "Natural Resource Management for Enhancing and Sustaining

- Agricultural Productivity” of Section of Agriculture & Forestry, 102nd Indian Science Congress organized at University of Mumbai on January 6, 2015
- * Chaired Technical Session on “Soil testing and Bio-fertilizers-Focus on Gujarat” in AINP Workshop on Soil Biodiversity–Biofertilizers at the Directorate of Groundnut Research, Junagadh, Gujarat on December 6, 2014
 - * Co-chaired two Technical Sessions (VI and VII) in AICRP-LTFE Workshop at HPKV, Palampur on June 2-3, 2014
 - * Chaired Technical Session III on Specific Intervention for Mountain Agriculture Workgroup on Nutri-dense farming and area specific nutria-crops of Mountain Agricultural Assistance Service (MAAS) at India Habitat Centre, New Delhi on August 7, 2014
 - * As Member Secretary, RAC, ICAR-IISS, Bhopal conducted RAC meeting on January 30-31, 2015 and submitted proceedings to Headquarters
 - * Member Secretary, National level Committee under Mission Soil Health Card Scheme constituted by Honourable Secretary, DARE & DG, ICAR
 - * Editor, Research Journal of Environmental and Earth Sciences
 - * Consulting Editor (National), Journal of Soil Salinity and Water Quality
 - * Vice President, Indian Society of Agrophysics, New Delhi
- Dr. AK Tripathi acted as Member, Institute Management Committee, IGFRI, Jhansi
 - Dr. Sanjay Srivastava was appointed Nodal Officer from India for setting up Soil Water Tissue laboratory in African Countries. He was also Invited Speaker and Chaired a session in Third International Conference on Recycling and Reuse of Materials and their Products, at MG University, Kerala during April 11-13, 2014
 - Dr. R Elanchezhaian received following recognitions
 - * Co-Chairman of Poster Evaluation Committee of the National Conference of Plant Physiology held at OUAT, Bhubaneswar during November 23-25, 2014
 - * External subject expert as Vice Chancellor's Nominee in the selection panel of scientists in Lucknow University, Lucknow on December 23, 2014
 - * Chancellor's Nominee in the Selection Committee for recruitment to the post of Professors, Associate Professors and Assistant Professors in UBKV, West Bengal
 - * Examiner for Evaluation of Ph.D. Thesis in Biotechnology from Jawaharlal Nehru Technological University, Hyderabad
 - Dr. K Ramesh was Invited speaker at State Level Krishi Mela, Bhopal (October 26-28, 2014), workshop on Climate change and Agriculture, Hoshangabad (March 23, 2015) and Powerkheda (March 26, 2015). He also acted as External Examiner for the evaluation of M.Sc. Thesis in Agronomy from Tamil Nadu Agricultural University, Coimbatore
 - Dr. AK Viswakarma acted as Co-chairman in the Technical Session on Information Technology in Agriculture in the National Conference on "Emerging Challenges and Opportunities in Biotic

- and Abiotic Stress Management" held at DRR, Hyderabad, during December 13-14, 2014
- Drs. RS Chaudhary and AK Vishwakarma were Expert Members from IISS nominated by Director, IISS Bhopal for participation in the State Level Krishi Mela "Haldhar Agri Expo-2014" from September 26-28, 2014 organized by Farmer Welfare and Agriculture Department, Government of Madhya Pradesh
 - Dr. Sangeeta Lenka had following recognitions
 - * Member of Scientific Advisory Committee, Krishi Vigyan Kendra, CIAE, Bhopal
 - * Resource person in "State Level Workshop on Climate change and their effect on agriculture" organized by SIAET, Bhopal on August 4th, 2014
 - * Resource person in Model training course on "Climate Change and Conservation Agriculture" at IISS Bhopal from January 28th to February 4th, 2015
 - Dr. BP Meena Delivered a lecture on "Best Agronomic Practices on Wheat and Chickpea" in Farmer's Fair under the Krishi Mohatsav organized by Government of Madhya Pradesh at Kharkone during October 17-20, 2014
 - Dr. M Vassanda Coumar acted as Rapporteur in the session "Soil degradation control, remediation and reclamation" in 79th Annual Convention of Indian Society of Soil Science held at Prof. Jayshankar Telengana State Agricultural University, Hyderabad during November 24-27th, 2014
 - Dr. ML Dotaniya had following recognitions
 - * Krishak Sangosthi Expert in the "Haldhar-Agri-Expo-14" State Level Krishi Mela, Lal Parade ground, Bhopal during September 26-28th, 2014
 - * Rapporteur in the session "Soil and the Environment; Soils and Land Use Change" in 79th Annual Convention of Indian Society of Soil Science held at Prof. Jayshankar Telengana State Agricultural University, Hyderabad during 24-27th November, 2014
 - * Editorial Board Member- African Journal of Agricultural Research
 - Dr. Shinogi KC delivered Invited Lecture in Third International Conference on Recycling and Reuse of Materials and their Products (ICRM-2014) held at MG University, Kottayam, Kerala during April 11-13, 2014
 - Dr. SR Mohanty had following recognitions
 - * External Examiner of M. Tech III Semester (MBT 305- Project Synopsis) Biotechnology Examination on December 29, 2014
 - * External Examiner for M.Sc. IV Semester of M.Sc. Microbiology at Bundelkhand University, Jhansi on July 9, 2014
 - Dr. Rajendiran S selected for Young Scientist Training Fellowship-2015 by MPCOST, Bhopal
 - Drs. Tapan Adhikari, J Somasundaram and Sangeeta Lenka were selected for Endeavour Research Fellowship-2015

7. LINKAGES AND COLLABORATIONS

ICAR-ICRAF Collaboration on Soil Research

Under the ICAR-ICRAF collaboration on soil research, a training programme on 'Infrared Spectroscopy use in Soil Health Assessment' was organized at the Indian Institute of Soil Science, Bhopal during March 9-13, 2015. Dr. Evis Weullow and Dr. Andrew Sila, were resource personnel from World Agroforestry Centre, Nairobi. A total of seventeen scientists from Indian Institute of Soil Science (IISS), Bhopal, Central Agroforestry Research Institute (CAFRI), Jhansi and Borlough Institute for South Asia (BISA), Ludhiana participated in the training programme. The programme was inaugurated by Dr. A.K. Patra, Director, IISS, Bhopal. The training course covered the basic aspects of infrared spectroscopy, details of the instrument alpha MIR spectroscope, its installation and operation, laboratory database system, management of MIR spectral data, pre-processing of spectral data, mining of information using statistical software, chemometric methods for spectral exploration, calibration and prediction methods. Trainees have actively participated in the theory as well as 'hands on' practical both on software and hardware training programme. During the course of the training diffused reflectance MIR spectral data of more than forty different soil samples were generated and they were used for development of prediction models for different soil properties like pH, EC, soil organic C, total C, total nitrogen using the laboratory analysed wet chemistry data of the soil samples, and the models were then validated using cross validation technique. The training was concluded with a review of the training programme and concluding remarks. It is expected that this collaboration will help in development of diffused reflectance mid-infrared based spectral library of the different soil types in different agro-climatic zones of the country and also in development of effective models for estimation of soil properties from non-destructive and fast scanning soil spectral data. The outcome will be useful for soil health assessment and development of fertilizer prescription equations for major cropping systems for maintaining higher productivity and reducing environmental degradation



Plate 7.1 Resource personnel from WAC, Nairobi giving training to IISS scientists

Dr Sanjay Srivastava, as a member of official delegation, visited Kenya, Rwanda and Tanzania in Africa during November 12-18, 2014 in connection to setting up of different projects under Indo African Forum Summit (IAFS-II). Also presented the project on "Establishing soil water tissue testing laboratory (SWTL)' in Kenya and Tanzania. The visit is expected to establish linkages with these countries for the evaluation of soil fertility. It is proposed that ICAR-IISS will contribute scientifically and technically in the establishment and functioning of SWTL in these countries.

8. ONGOING RESEARCH PROJECTS

Programme I: Soil Health and Input Use Efficiency

A. Institute Projects

1. Long-term evaluation of integrated plant nutrient supply modules for sustainable productivity in Vertisol.
Muneshwar Singh, A. K. Biswas, A. B. Singh, R. S. Chaudhary and B. P. Meena
2. Study on nanoporous zeolites for soil and crop management.
K. Ramesh and I. Rashmi
3. Studies on soil resilience in relation to soil organic matter in selected soils.
N. K. Lenka, Sangeeta Lenka, Brij Lal Lakaria and Asit Mandal
4. Biofortification of grain sorghum and finger millet varieties with zinc through agronomic measures.
Ajay, A. K. Shukla and J. K. Saha
5. Biochar on soil properties and crop performance
Brij Lal Lakaria, Pramod Jha, A. K. Biswas, K. M. Hati, J. K. Thakur, M. Vassanda Coumar, A. K. Dubey (CIAE) and S. Gangil (CIAE)
6. Impact of crop covers on soil and nutrient losses through runoff in Vertisol.
R. K. Singh, J. Somasundaram and I. Rashmi
7. Characterizing rooting behaviours, soil water patterns and nutrient uptake of soybean-chickpea under different tillage and water regimes in Vertisols.
N. K. Sinha, M. Mohanty, Ritesh Saha and I. Rashmi
8. Integrated assessment of some IISS Technologies in enhancing Agro-Ecosystems productivity and livelihood sustainability.
Shinogi K. C., Sanjay Srivastava, D. L. N. Rao, Radha T. K, B. P. Meena, N. K. Sinha, Hiranmoy Das and A. B. Singh
9. Nano particle delivery and internalization in plant systems for improving nutrient use efficiency
R. Elanchezian, A. K. Biswas, Tapan Adhikari, K. Ramesh, S. Kundu, A. K. Shukla and A. Subba Rao
10. Soil quality assessment for enhancing crop productivity in some tribal districts of Madhya Pradesh (TSP)
Rajendiran S., M. L. Dotaniya, M. Vassanda Coumar, N. K. Sinha, Sanjay Srivastava, A. K. Tripathi and S. Kundu
11. Evaluating rock phosphates for their suitability for direct application
Sanjay Srivastava, K. Ramesh, A. K. Tripathi, I. Rashmi and P. Dey

12. Evaluation of modified urea materials and agronomic interventions for enhancing nitrogen use efficiency and sustaining crop productivity

B. P. Meena, K. Ramesh, Neenu, S. and R. Elanchezhian

13. Standardization of foliar feeding of zinc for correcting its deficiency and grain enrichment in wheat

Pankaj K. Tiwari, A. K. Shukla, R. Elanchezhian and B. P. Meena

B. Externally Funded Projects

14. Network Project on organic farming

A. B. Singh, K. Ramesh, Brij Lal Lakaria, S. Ramana and J.K. Thakur

Programme II: Conservation Agriculture, Carbon Sequestration and Climate Change

A. Institute Projects

15. Evaluating conservation tillage on various sequences/rotations for stabilizing crops productivity under erratic climatic conditions in black soils of Central India

J. Somasundaram, R. S. Chaudhary, Neenu S. and Ajay

16. Assessing impacts of climate change on different cropping systems in Central India and evaluating adaptation studies through crop simulation models

M. Mohanty, K. M. Hati, N. K. Sinha, Sangeeta Lenka, Pramod Jha, Neenu S., R. S. Choudhary, R. Elanchezhian and A. Subba Rao

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

Sangeeta Lenka, M. C. Manna, Brij Lal Lakaria, R. K. Singh and R. C. Singh (CIAE)

18. Evaluating conservation agriculture for stabilizing crop productivity and carbon sequestration by resilient cropping systems/sequences under aberrant climatic conditions in black soils of central India.

J. Somasundaram, R. S. Chaudhary, M. Vassanda Coumar, K. M. Hati, A. Subba Rao, Pramod Jha, K. Ramesh and Ajay

19. Weed management for major cropping systems under conservation agriculture in Vertisols

A. K. Vishwakarma, R. S. Choudhary, N. K. Sinha, B. P. Meena, K. Bharati and Sobha Sondhia (DWSR)

B. Externally Funded Projects

20. Quantifying Greenhouse gases (GHGs) emissions in soybean-wheat system of Madhya Pradesh (MPCOST)

Sangeeta Lenka, N. K. Lenka, S. Kundu and A. Subba Rao

Programme III – Soil Microbial Diversity and Biotechnology**A. Institute Projects**

21. Consequences of transgenic cotton on soil microbial diversity
Asit Mandal, J. K. Thakur, Asha Sahu and M. C. Manna
22. Developing technique for acceleration of decomposition process using thermophilic organisms
Asha Sahu, U. B. Singh (NBAIM), J. K. Thakur, V. K. Bhargav (CIAE), H. L. Kushwaha (CIAE), Asit Mandal, M. C. Manna and A. Subba Rao
23. Chemical and microbiological evaluation of biodynamic and organic preparations
J. K. Thakur, Asha Sahu, Asit Mandal and A. B. Singh
24. Greenhouse gas (GHG) emission from composting systems and characterization of GHG regulating microbes
K. Bharati, J. K. Saha, S. R. Mohanty and Shinogi K. C.

B. Externally Funded Projects

25. Metagenomic characterization and spatio-temporal changes in the prevalence of microbes involved in nutrient cycling in the rhizosphere of bio-energy crops (DST)
S. R. Mohanty, Asit Mandal and K. Bharati
26. Biodegradation of pesticides under changing climate and metagenomic profiling of functional microbes (DBT)
K. Bharati, Radha T. K and S. R. Mohanty
27. Novel bio-filtration method using selected mesophilic fungi for removal of heavy metals from municipal solid waste in Madhya Pradesh (MPCOST)
M. C. Manna, Asit Mandal, Asha Sahu, J. K. Thakur, S. Ramana and A. Subba Rao

Programme IV: Soil Pollution and Remediation**A. Institute Projects**

28. Interaction among tannery effluents constituents on heavy metals uptake by spinach
M. L. Dotaniya, J. K. Saha, Rajendiran S., M. Vassanda Coumar and S. Kundu
29. Impact of long term use of sewage water irrigation on soil and crop quality in Bhopal region of Madhya Pradesh
Vasudev Meena, M. L. Dotaniya, M. Vassanda Coumar, Rajendiran S., Asha Sahu and S. Kundu
30. Determination of baseline concentration for delineating contaminated areas in black soils of Central India
Rajendiran S., J. K. Saha, S. Kundu, Hironmoy Das and M. L. Dotaniya

9. CONSULTANCIES/CONTRACTUAL SERVICES/PATENTS

S. No.	Title	Project Team	Sponsorer
1.	Evaluation of plant nutrition product (NP - 1) for nutrient use efficiency in cereal crops	R. Elanchezhian, A.K. Biswas, K Ramesh, N.K. Lenka, A. Subba Rao	Nagarjuna Fertilizers and Chemicals Pvt Ltd., Hyderabad
2.	Effect of urea pestilic productivity and nutrient use efficiency in some soils of India	Pramod Jha, B.L. Lakaria , A.K. Biswas, Pradip Day, A. Subba Rao B. Kumar-Ranchi S.R. Singh-Barrackpur	Sandvik India Pvt. Ltd.
3.	Investigations on the safe use of sludge in agriculture land generated from effluent from plant of a soft drink.	J.K. Saha, A. Subba Rao S. Kundu, Vassanda Coumar	Coca Cola India Pvt. Ltd., Gurgaon
4.	Testing a new slow release 14-7-14 NPK fertilizer for its efficiency under field conditions	Dr. Sanjay Srivastava, K. Ramesh, P. Dey, A.K. Biswas, A. Subba Rao	PRII, Gurgaon
5.	Evaluation of urease inhibitor product (limus) for nutrient use efficiency in cereal crops	Brij Lal Lakaria, Pramod Jha, B.P. Meena, A.K. Biswas	BASF Pvt. Ltd., Mumbai
6.	Evaluation of nano-nutrients product (NUALGI) for improving nutrient use efficiency of crops	R. Elanchezhian, A.K. Biswas, K. Ramesh, A.K. Shukla, J.K. Thakur, A.K. Patra	NUALGI Biotech, Bangalore
7.	A Rapid Soil Test Kit for making soil test based fertilizer recommendations and preparing soil health card with respect to soil fertility parameters	Sanjay Srivastava, Pramod Jha, Neenu S, I Rashmi, Tapan Adhikari, A.K. Biswas, P. Dey, A. K. Patra	IISS cum NFCL
8.	Evaluation of efficacy of polysulphate on oil seed crops (Soybean-Mustard)	K. Ramesh, Sanjay Srivastava, A.K. Biswas	PRII, Gurgaon

10. PUBLICATIONS

A. Papers in Research Journals (National/International)

International (NAAS Rating more than 6)

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- Aparna K, Rao DLN and Manna MC (2014). Microbial inoculation of chickpea (*Cicer arietinum* L.) enhances rhizosphere effects on soil biological quality. *Agrochimica* 58: 114-125.
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- Lenka NK, Lenka S and Biswas AK (2015). Scientific endeavors' for natural resource management in India. *Current Science* 108 (1): 39-44.
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11. INSTITUTE COMMITTEES/CELLS/SECTIONS/UNITS

INSTITUTE COMMITTEES

Research Advisory Committee (RAC)

Dr C.L. Acharya	Chairman
Dr. T.K. Adhya	Member
Dr. A.N. Ganeshmurthi	Member
Dr N.S. Raghuwanshi	Member
Dr. (Mrs.) A. Juwarkar	Member
Dr S.K. Chaudhari, ADG (S&WM), ICAR	Member
Dr Ashok K. Patra, Director, ICAR-IISS	Member
Sh. Vilasrao Viswanath Shringarpawar	Member
Sh. Tanaji Katkar	Member
Dr Pradip Dey, PC (STCR)	Member-Secretary

Institute Management Committee (IMC)

Dr. Ashok K Patra, Director	Chairman
Dr. A.K. Shukla, Project Coordinator (Micronutrient)	Member
Dr. D.K. Painuli, Pr. Scientist, Central Arid Zone Research Institute, Jodhpur	Member
Dr. Obi Reddy, Sr. Scientist (GIS), National Bureau of Soil Survey & Land Use Planning Nagpur	Member
Sh. A. Maheshwari, Finance & Accounts Officer, DSR, Indore	Member
Dr. H.S. Yadav, Director Research Service, Gwalior	Member
Mr. Surendra Amrute, Nominee of Director of Agriculture, Govt. of Madhya Pradesh, Bhopal	Member
Sh. Tanaji Katkar	Member
Sh. Rajesh Dubey, AF & AO, IISS	Special Invitee
Sh. V.K. Derashri, Administrative Officer, IISS	Member-Secretary

Institute Purchase Committee (IPC)

Dr. J.K. Saha, Pr. Scientist & HOD (Environmental Soil science)	Chairman
Dr. K.M. Hati, Pr. Scientist	Member
Dr. N.K. Lenka, Pr. Scientist	Member
Dr. J.K. Thakur, Scientist	Member
FAO/AF&AO	Member
AO/AAO	Member-Secretary
Indenter	Member

Institute Technology Management Committee (ITMC)

Dr. Ashok. K. Patra, Director	Chairman
Dr. J.K.Saha, HOD (Environmental Soil science)	Member
Dr. A.K. Biswas, I/c HOD (Soil Chemistry & Fertility)	Member
Dr. Pradip Dey, PC (Soil Test Crop Response)	Technical Expert
Dr. M.C. Manna, I/c HOD (Soil Biology)	Technical Expert
Dr. P.C. Bargale, HOD, TTD, CIAE	Outside Expert
Dr. Niranjan Mishra, Pr. Scientist, NIHSAD	Outside Expert
Dr. Sanjay Srivastava, Pr. Scientist	Member-Secretary

Institute Building Committee

Dr. Ashok. K. Patra, Director	Chairman
Dr. Muneshwar Singh, PC (Long Term Fertilizer Experiments)	Member
Dr. J.K. Saha, HOD (Environmental Soil Science)	Member
Dr. M.C. Manna, HOD (Soil Biology)	Member
Dr. A.K. Biswas, HOD (Soil Chemistry & Fertility)	Member
Dr. A.K. Shukla, PC (Micro & Secondary Nutrients)	Member
Dr. R.S. Chaudhary, HOD (Soil Physics)	Member
Dr. Pradip Dey, PC (Soil Test Crop Response)	Member
AO or AAO	Member
FAO or AF&AO	Member

PME Committee (PMC)

Dr. Ashok K. Patra, Director	Chairman
Dr. R.S. Chaudhary, HOD (Soil Physics)	Member
Dr. A.K. Biswas, HOD (Soil Chemistry & Fertility)	Member
Dr. M.C. Manna, HOD (Soil Biology)	Member
Dr. J.K. Saha, HOD (Environmental Soil Science)	Member
Dr. Brij Lal Lakaria, Pr. Scientist	Member-Secretary

Library Committee

Dr. M.C. Manna, HOD (Soil Biology)	Chairman
Dr. S. Ramana, Pr. Scientist	Member

Dr. Pramod Jha, Sr. Scientist	Member
Dr. J. Somasundaram, Sr. Scientist	Member
Dr. S.R. Mohanty, Sr. Scientist	Member
Dr. (Mrs.) Asha Sahu, Scientist	Member
AO or AAO	Member
FAO or AF&AO	Member
Mrs. Nirmala Mahajan, Senior Technical Officer	Member-Secretary

Institute Joint Staff Council

Dr. Ashok K. Patra, Director	Chairman, Office side
Dr. M.C. Manna, Pr. Scientist & HOD	Member, Office side
Sh. V.K. Derashri, Administrative Officer	Member, Office side
Sh. Rajesh Dubey, AF&AO	Member, Office side
Sh. Sunil Kumar, AAO	Member-Sec., Office side
Sh. Hira Lal Gupta, UDC, CJSC Secretary	Member, Staff side
Sh. Anurag, Security Supervisor, IJSC Secretary	Member, Staff side
Sh. Hukum Singh Pal, Technical Assistant	Technical, Staff side
Sh. Khilan Singh Raghuvanshi, Sr. Technical Assistant	Technical, Staff side
Sh. Harish Kumar Barmaiya, SSS	Supporting, Staff side
Sh. Jagannath Gaur, SSS	Supporting, Staff side

Seminar Committee

Dr. Ajay, Pr. Scientist	Chairman
Dr. (Mrs.) Sangeeta Lenka, Scientist	Member
Dr. B.P. Meena, Scientist	Member

Farm Advisory Committee

Dr. A.K. Shukla, PC (Micronutrient)	Chairman
Dr. R.S. Chaudhary, HOD (Soil Physics)	Member
Dr. A.K. Tripathi, Pr. Scientist	Member
AO	Member
F&AO	Member
Dr. K. Ramesh, Sr. Scientist & I/c Farm	Member-Secretary

Farm Management Committee

Dr. K. Ramesh, Sr. Scientist	Chairman
Dr. R.H. Wanjari, Sr. Scientist	Member
Dr. Pramod Jha, Sr. Scientist	Member
Dr. M. Mohanty, Scientist	Member
Dr. B.P. Meena, Scientist	Member
Sh. Vasudev Meena, Scientist	Member
Sh. D.R. Darwai, Sr. Technical Officer	Member-Secretary

Horticulture Maintenance Committee

Dr. M. Vassanda Coumar, Scientist	Chairman
Ms. T.K. Radha, Scientist	Member
Dr. Nishant K. Sinha, Scientist	Member
Sh. R.K. Mandoli, Assistant Chief Technical Officer	Member
Sh. D.R. Darwai, Technical Officer	Member
Sh. Vinod Chaudhary, Technical Assistant	Member

Maintenance of Civil and Electrical Works Committee

Dr. N.K. Lenka, Pr. Scientist	Chairman
Dr. R.H. Wanjari, Sr. Scientist	Member
Dr. (Mrs.) Neenu S, Scientist	Member
Dr. N.K. Sinha, Scientist	Member
Sh. P.S. Sunil Kumar, AAO	Member
Sh. Shahab Siddiqui, Senior Technical Officer	Member
Sh. C.T. Wankhede, Electrician	Member

Standing Sports Promotion Committee

Dr. Brij Lal Lakaria, Pr. Scientist	Chairman
Dr. (Mrs.) Neenu S. , Scientist	Member
Sh. Thomas Joseph, Pvt. Secretary	Member
Sh. Anurag, Security Supervisor	Member
Sh. C.T. Wankhede, Electrician	Member
Sh. Sanjay Katenga, LDC	Member

Contractual Research Project Monitoring Committee

Director	Chairman
Project Leader of the Contractual Research Project	Member
AO or AAO	Member
FAO or AF&AO	Member
Representative of the contracting party	Member

Committee for Prevention of Sexual Harassment of Women Employees

Dr. (Mrs.) K. Bharati, Sr. Scientist	Chairman
Ms. Chhaya Khale, Sr. Programme Officer, BAIF (Member representing NGO)	Member
Ms. Babita Tiwari, Assistant	Member
Ms. Geeta Yadav, Pvt. Secretary	Member
AO or AAO	Member-Secretary

Vehicle Operation Committee

Dr. J.K. Thakur, Scientist	Incharge
Sh. Vinod Babu Pal, T-6	Alternative I/c

Screen House Management

Dr. R. Elanchezhian, Pr. Scientist	Incharge
Dr. (Mrs.) Asha Sahu, Scientist	Alternative I/c

Staff Recreation Club (SRC)

Dr. Ashok K. Patra, Director	Patron
Dr. Ajay, Pr. Scientist	President
Dr. R. Elanchezhian, Pr. Scientist	Vice-President
Dr. M. Mohanty, Scientist	Secretary
Sh. Anurag, Security Supervisor	Sports Secretary
Sh. R.K. Mandloi, ACTO	Treasurer

Water Management Committee

Dr. R.S. Chaudhary, HOD (Soil Physics)	Chairman
Dr. A.K. Tripathi, Pr. Scientist	Member
Dr. K. Ramesh, Sr. Scientist	Member
Dr. A.K. Vishwakarma, Sr. Scientist	Member
Sh. C.T. Wankhede, Electrician	Member

CELLS/SECTIONS/UNITS

Consultancy Processing Cell

Dr. Pradip Dey, PC (STCR)	Chairman
Dr. R. Elanchezhian, Pr. Scientist	Member
Dr. Tapan Adhikari, Pr. Scientist	Member
Dr. A.K. Vishwakarma, Sr. Scientist	Member
Dr. (Mrs.) K. Bharati, Sr. Scientist	Member
AO	Member
FAO	Member

PME Cell (PME)

Dr. Brij Lal Lakaria, Pr. Scientist	Incharge
Dr. K.M. Hati, Pr. Scientist	Member
Dr. R. Elanchezhian, Pr. Scientist	Member
Dr. M. Vassanda Coumar, Scientist	Member
Sh. Sanjay Kumar Kori	Steno Grade III

Results-Framework Documentation (RFD) Cell

Dr. Brij Lal Lakaria, Pr. Scientist	Nodal Officer
Dr. J. Somasundaram, Sr. Scientist	Member
Sh. P.S. Sunil Kumar, AAO	Member

Institute Technology Management Unit (ITMU)

Dr. Sanjay Srivastava, Pr. Scientist	Incharge
Dr. (Ms.) Shinogi, K.C., Scientist	Member
Mr. Hiranmoy Das, Scientist (On study leave)	Member

Academic Cell

Dr. S. Kundu, Pr. Scientist	Chairman
Dr. K.M. Hati, Pr. Scientist	Member
Dr. Pramod Jha, Sr. Scientist	Member
Dr. (Mrs.) K. Bharati, Sr. Scientist	Member

Technology Assessment & Transfer Unit (TA&TU)

Dr. A.B. Singh, Pr. Scientist	Incharge
Dr. A.K. Tripathi, Pr. Scientist	Member
Dr. Sanjay Srivastava, Pr. Scientist	Member

Dr. Ritesh Saha, Sr. Scientist	Member
Dr. M. Vassanda Coumar, Scientist	Member
Dr. (Ms.) Shinogi, K.C., Scientist	Member

Women Cell

Dr. (Mrs.) Sangeeta Lenka, Scientist	Chairperson
Ms. T.K. Radha, Scientist	Member
Dr. (Mrs.) I. Rashmi, Scientist	Member
Dr. (Mrs.) Asha Sahu, Scientist	Member
Ms. Nirmala Mahajan, T-6	Member
Ms. Kirti Singh Bais, Personal Assistant	Member
Ms. Babita Tiwari, Assistant	Member
Ms. Kavita Bai, SS Gr. III	Member

Statistics & Computer Application Section

Dr. (Mrs.) K. Bharti, Sr. Scientist	Incharge
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Central Lab

Dr. S.R. Mohanty, Sr. Scientist	Incharge
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Library

Dr. S. Ramana Pr. Scientist	Incharge
Dr. (Ms.) Shinogi K.C., Scientist	Alternative Incharge
Ms. Nirmala Mahajan, T-6	Librarian

Training Hostel

Dr. M. Mohanty, Scientist	Controlling Officer
Mr. Hiranmoy Das, Scientist	Incharge
Dr. B.P. Meena, Scientist	Alternative I/c
Sh. Saurabh Kumar	Assistant
Sh. Vinod Choudhary, Technical assistant	Care Taker

Nodal Officers

Dr. K.M. Hati, Pr. Scientist	HRD
Dr. A.K. Vishwakarma, Sr. Scientist	Weed Management

12. IMPORTANT MEETINGS/ACTIVITIES

Institute Research Council Meeting

The Institute Research Council (IRC) meeting of the institute was held during 19 – 20 March 2015. The Member-Secretary (IRC), Dr. A. K. Biswas welcomed the participants and guest member Dr. A. Subba Rao, Former Director, IISS. The Member Secretary, IRC requested the scientists to take the IRC as a platform for discussion on scientific matter and to see light in the dark. Dr. Subba Rao, the special invitee, appreciated the achievements of institute scientists. However, he stressed that there is a need to highlight our findings many a time people outside the organization are highlighting our work better than us. The IRC Chairman Dr. Ashok K. Patra thanked Dr. A. Subba Rao for accepting the invitation and sought further guidance and suggestions for future research issues. He provoked the scientists to propose research projects having usefulness and outcome. He stated that research should be development focused. He pointed out that outcome of the research projects should have strength. He also advised to follow instructions of ICAR as communicated by PME Cell. All the projects were presented and reviewed with respect to progress made in the last year.

In the concluding remarks the IRC Chairman complimented all the speakers for their presentations and healthy discussion on achievements. He also stressed that the project load of the institute is high and can be minimized after scrutinizing some of the projects. He also stressed that each scientist must present his achievements for the year in the IRC meeting.

Institute Management Committee Meeting

The 38th meeting of IMC was held on 19th July, 2014 under the chairmanship of Dr. Ashok K. Patra, Director, IISS, Bhopal. During this meeting IMC recommended to purchase some of the proposed items. The constitution of the committee is mentioned below:

1.	Dr. Ashok K. Patra, Director, IISS, Bhopal	Chairman
2.	Dr. A. K. Shukla, Project Coordinator (Micronutrient), IISS, Bhopal	Member
3.	Dr. D. K. Painuli, Pr. Scientist, Central Arid Zone Research Institute, Jodhpur	Member
4.	Dr. Obi Reddy, Sr. Scientist (GIS), National Bureau of Soil Survey & Land Use Planning, Nagpur	Member
5.	Shri A. Maheshwari, Finance & Accounts Officer, DSR, Indore	Member
6.	Dr. H. S. Yadav, Director Research Service, Gwalior	Member
7.	Mr. Surendra Amrute, Nominee of Director of Agriculture, Govt. of Madhya Pradesh, Bhopal	Member
8.	Sh. Rajesh Dubey, AF & AO, IISS, Bhopal	Special Invitee
9.	Sh. V. K. Derashri, Administrative Officer, IISS, Bhopal	Member-Secretary

At the outset the Chairman welcomed all the members of the committee. The Member Secretary informed that the Council, vide letter No. NRM/12/10/2013-IA.II dated 25.07.2013, has conveyed the approval to the proceedings of the XXXVIIth IMC meeting held on 11.06.2013. The Member Secretary also informed the action taken on the approved proceedings of last meeting of IMC held on 11/06/2013.

Research Advisory Committee Meeting

The XXI meeting of the Research Advisory Committee (RAC) of the Institute (First meeting of the current RAC) constituted vide the council letter no. NRM/12-16/2014-IA-II dated November 7, 2014 was held on January 30-31, 2015 at the Committee Room of ICAR-IISS, Bhopal. At the outset, Dr. Pradip Dey, Member Secretary welcomed the Chairman and all other Members including Special Invitees of the RAC along with other scientists and informed that as a follow up of the Proceedings of the XX RAC meeting (14th December, 2013) a critical review of the research projects was done in the IRCs. He also mentioned that ICAR-IISS is eagerly looking forward for objective reinforcement of research work of the institute from the RAC. The Member Secretary presented the Action Taken Report on the issues raised in the XX meeting of the RAC. Dr Ashok K. Patra, Director formally welcomed the Chairman and Members of RAC and apprised them about the new initiatives taken and highlighted important issues related to soil health, nutrient use efficiency and soil health card for farmers. This was followed by remarks by members RAC and finally Dr. C.L. Acharya, Chairman, RAC in his remarks mentioned that the Institute has done commendable work on different aspects of soil research. In the current scenario with emerging new issues, he urged the scientists to focus on research of national importance for improving livelihood of resource poor farmers.

After thorough discussion, the following recommendations were finalized:

A. Research

1. In the context of changing climate and input use scenario, effect on crop productivity and soil health through initiating satellite experiments [Action: PC (LTFE)], as well as studies on water and nutrient interaction, water balance, soil physical health and water management under conservation agriculture [Action: HoD (SP) and HoD (SCF)] should be taken up.
2. Measurement of root architecture in non-symbiotic fungal endophytes under upland situation, standardization of medium and comparative efficacy of the strains on *Frankia* [Action: PC (SBB)] as well as nutrient cycling microbes particularly for C, N, P, K, S and Zn for enhancing nutrient use efficiency and feasibility of organic farming in different areas of India [Action: HoD (SB)] should be attempted.
3. Defining applicability, history of management and efficiency under different conditions for fertilizer prescription equations [Action: PC (STCR)] and critical limits of micronutrients [Action: PC (MSN)] should be tested.
4. Work on alternatives to liming material and amelioration of sub-surface acidity, corrective

measures by reframing Walkley-Black C rating and developing ready-reckoner of available N [Action: HoD (SCF)] and mechanism of micronutrients enrichment [Action: PC (MSN)] for different soil types need be taken up.

5. Studies on determination of maximum safe concentration limits of heavy metals for major soil types of the country, bio-safety mechanism for working with nano particles and on-site reclamation of agricultural land in the identified industrially polluted area need to be taken up [Action: HoD (ESS)].

B. Research management/development (Collective responsibility)

1. Data sharing at institute level and data harmonization at national level with proper IP protection should be ensured.
2. Water harvesting in ponds with silpaulin lining should be taken up to conserve water for raising good crops under different experiments.
3. In all experiments on conservation tillage (zero, minimum, zero tillage with surface retained residues) sowing and fertilizer application operations should be done with an appropriate implements/ machinery like Happy seeder.

Institute Technology Management Committee (ITMC) Meeting

The Institute Technology Management Committee (ITMC) meeting was held at IISS-Bhopal on March 30, 2015. The agenda of the meeting was to examine the cost and pricing of Mridaparikshak, a soil test mini lab developed at ICAR-IISS, Bhopal. At the outset the Chairman welcomed the members and apprised them about the genesis of the technology. The committee also discussed the IPR issues and decided that the patent application has to be filed by ICAR-IISS before handing the license of manufacture and sale to the producer. The ICAR-IISS may contact ZTMC for patent filing. The meeting ended with the vote of thanks by the Member-Secretary, ITMC.

IISS Foundation Day

A 27th Foundation Day was organized on 16th April, 2014. Dr Navin Chandra, I/c Director, AMPRI, Bhopal presided over the function. Honourable dignitaries release the landmark publication on this occasion. Farmers from different villages along with all the staff of the Institute participated in the function. Farmers were given the certificate and memento for their contribution for the welfare of the agriculture



World Soil Day

Indian Institute of Soil Science, Bhopal in association with Bhopal chapter of Indian Society of Soil Science celebrated the World Soil Day on December 05, 2014. Several dignitaries, paragons of soil science, and school students along-with their teachers participated in the programme. On the occasion, Dr. G. A. Kinhal, Director, Indian Institute of Forest Management and Chief Guest of the function emphasized the importance of soils for sustaining forest ecosystem. He urged the people to protect the soils with a slogan “Plant a tree whenever you are free”. Dr. S. S. Khanna, Former member, Planning Commission and a stalwart of Soil Science highlighted the functions and roles of soils. Dr. P. J Sudhakar, Additional Director General, PIB, Ministry of Information and Broadcasting informed the participants about soil as the 'soul of infinite life'. He told that every human being is born out of soil and hence it is the duty of all to protect our soils. Earlier, Dr. Ashok K. Patra, Director of the institute welcomed the children and dignitaries. A presentation was also arranged to educate the children on the different functions of soils. A drawing competition was also held on the theme 'S (Soul) O (Of) I (Infinite) L (Life)'. Children from Saint George School, St. Paul School, Sardar Patel Govt. Higher Secondary School, New Niketan School, and Brigadier Trivedi Memorial School participated in the competition. The children were also taken to Soil Museum and shown the different types of soils present in India. Children and other participants were also shown a video film highlighting the importance of soil in agriculture and civilization. World Soil Day is celebrated on December 05 to highlight the importance of soil as a critical component of the natural system and as a vital contributor to the human common wealth through its contribution to food, water and energy security and as a mitigator of biodiversity loss and climate change. The programme ended with prize distribution to children.



Independence Day Celebration

The 68th 'Independence Day' was celebrated on 15th August, 2014 in the Institute premises. Different sports and cultural events were organized for the family members of the staff on the day. The programme was concluded with the distribution of prizes to the winners by Mrs. Rina Patra and Dr A. K. Patra, Director, IISS, Bhopal.

Hindi Pakhwada

Government of India encourages its organizations and the employees to participate in Hindi Pakhwada celebrations to promote and spread the use of Hindi as a common medium of language throughout the country. Accordingly, Hindi *Pakhwada* was celebrated in the Institute during 14-28 September, 2014. Several competitions such as debate, quiz and Hindi vocabulary (*sabda gyan*), typing were conducted during the fortnight in which majority of staff members participated. On the concluding day, Dr. K. K. Singh, Director, CIAE, Bhopal, the Chief Guest, distributed prizes to the winners of different competitions.

Swachh Bharat Mission

The Institute staff members fully contributed in the nation-wide program of “Swachh Bharat Mission” launched by the Government of India, as per the call of the Hon'ble Prime Minister. The Swachhta Shapath was administered to all the staff members by the Director of the Institute on 2nd October, 2014. This was followed by the voluntary cleaning of the Institute premises by the staff members. Afterwards, an intensive campaign was started with finalization of the weekly plan and timely execution for keeping the inside and outside of the Institute premises clean.



Vigilance Awareness Week

As per the directive of the Central Vigilance Commission, vigilance awareness week was observed in the Institute during 27 October to 01 November, 2014 with the theme on “Combating corruption – technology as an enabler”. A speech competition was organized among the staff members on this theme on 29 October, 2014. The concluding function was held on 01 November, 2014 with Mr. Arun Pratap Singh, Inspector General of Police in the Government of Madhya Pradesh as the Chief Guest.



New Year Day

The Staff Recreation Club (SRC) organized a 'New Year Day' celebration on 1st January, 2015. The staff members wished each other for the 'Happy and Prosperous New Year 2015'. The honorable patron SRC, Dr A.K. Patra, Director of the Institute wished everybody and requested for setting the higher scientific targets and output to get name and fame to the Institution.

Republic Day

The Institute celebrated 66th 'Republic Day' with enthusiasm. All the staff members of IISS participated in various events with thrill and great enthusiasm. Activities include racing and drawing for children, musical chair for men and women. The programme was concluded with the distribution of prizes to the winners.



Women's Day

International women's day was celebrated at IISS with great fervor and gaiety. Different competitions were organized for women staff and spouses of IISS staff. There was active participation of women in all competition such as *Rangoli*, spot the city and *Maan Ki Baat*. Dr. S. Lenka, chairman women cell highlighted the importance of celebrating women's day function on 8th March every year. The chief guest of function was Dr. Mridulla Billore, the first women Dean of College of Agriculture Khandwa. Her elaborate speech left the audience mesmerized on women rights, status and related issues. She also highlighted that, the status and position of women have improved over years. Guest of honor, Shrimati Reena Patra, highlighted the importance of women health and education. At the end prizes were distributed to winners of different competitions.



- a) Chief guests with organizers b) Rangoli competition which bagged first prize
c) Prize distribution to winners of International women's day competition

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

Name	Programme	Venue	Period
Dr. A.K. Biswas	Attended meeting of the Editorial Board of ISSS	New Delhi	April 5, 2014
Dr. D.L.N. Rao	Indo-German Workshop on Microbial Ecology and Application of Inoculants in Biocontrol	IARI, New Delhi	April 9, 2014
Drs. Sanjay Srivastava and Shinogi K.C.	Third International Conference on Recycling and Reuse of Materials and their Products (ICRM-2014)	MG University, Kottayam, Kerala	April 11-13, 2014
All Scientists	Silver Jubilee Seminar	IISS, Bhopal	April 15-16, 2014
Dr. D.L.N. Rao	Meeting of PC's of NRM division Interactive meeting of Vice-chancellors and Directors	New Delhi New Delhi	April 27, 2014 April 28, 2014
Dr. Pramod Jha	Workshop on Development of Greenhouse Gas Emission Inventory and Carbon Budget for Indian Agriculture	CESCRA, IARI New Delhi	May 7-8, 2014
Dr. D.L.N. Rao	Meeting of NRM Divn, DOAC and other officials from IARI, TERI on Coating of Seeds with Biologicals	National Seeds Corporation, Delhi	May 15, 2014
Dr A.B. Singh	9 th Annual Group Meeting of Net Work Project on Organic Farming	Hill Agricultural Research & Extension Centre, Kullu	May 19 -20, 2014
Dr. B.L. Lakaria	Sensitization workshop of PME cell In charges	NASC, New Delhi	May 27, 2014
Dr. Sanjay Srivastava	Technical committee meeting to examine the method of sampling of imported fertilizer and method of analysis	DAC, ICAR, Krishi Bhavan	May 29, 2014
Dr. Sanjay Srivastava	Zonal Institute Technology Management Committee (ZITMC) meeting	CIRCOT, Mumbai	June 02, 2014

Name	Programme	Venue	Period
Drs. Muneshwar Singh, A.K. Biswas R.H. Wanjari and Pramod Jha	Annual Workshop of AICRP (LTFE)	CSKHPKV, Palampur	June 2-3, 2014
Dr. D.L.N. Rao	Meeting of Directors and PC's of NRM Divn, ICAR	NASC Complex, New Delhi	June 4-5, 2014
Dr. S. Lenka	Workshop on Impact of Capacity Building Programs under NAIP	NASC Complex, New Delhi	June 6-7, 2014
Dr. R.S. Chaudhary	State level review and sanctioning committee meeting for "On-Farm water management" component under NMSA	Vindhyanchal Bhavan, Bhopal	June 10, 2014
Dr. Asit Mandal	20 th World Congress of Soil Science (20WCSS)	ICC Jeju, Korea	June 8-13, 2014
All Scientists	Workshop on Contingency Planning for <i>Kharif</i> Crops under Delayed Monsoons in Malwa Plateau Region of MP	IISS, Bhopal	July 3, 2014
Drs. J. Somasundaram and Manoranjan Mohanty	3 rd Annual workshop of NICRA	NASC Complex, New Delhi	July 3-4, 2014
Drs. A.B. Singh, R.S. Chaudhary, A.K. Tripathi and A.K. Vishwakarma	National workshop on Technologies for Sustainable Rural Development– having Potential of Socio-Economic Upliftment	CSIR AMPRI and MPCOST, Bhopal	July 4-5 2014
Dr. D.L.N. Rao	RAC meeting of NBAIM, Mau	NBAIM, Mau	July 10, 2014
Ashok K. Patra Drs. D.L.N. Rao Muneshwar Singh A.K. Shukla Pradip Day A.K. Biswas	Meeting of Directors and PC's of IISS, Bhopal in NRM Division, ICAR for finalization of EFC presentation	New Delhi	July 15-16, 2014
Drs. A.B. Singh and K. Ramesh	Rashtriya Sanghosti on the role of Machinery in the Changing Agriculture Scenario	CIAE, Bhopal	July 28, 2014

Name	Programme	Venue	Period
Dr. R. Elanchezhian	MDP on Consultancy Project Management	NAARM, Hyderabad	August 22-27, 2014
Dr A. B. Singh	Group Meeting /Workshop of Press Information Bureau, Central Region	Vaishali Nagar, Kotra Sultanabad, Bhopal	August 27, & November 28, 2014
Dr. S. Ramana	International Conference of Natural Fibres	Kolkata	August 1-3, 2014
Drs. I. Rashmi and Shinogi K.C.	International conference on Agriculture, Forestry, Horticulture, Aquaculture, Animal Science, Food Technology, Biodiversity & Climate Change Sustainable approaches	Krishi Sanskriti, JNU, New Delhi	August 30-31, 2014
Dr. R.S. Chaudhary	State level Workshop on Future Strategies for Agriculture and Irrigation Sector in MP	NABARD, Bhopal	September 4, 2014
Dr. N.K. Lenka	Workshop on Developing Winning Research Proposal	NAARM, Hyderabad	September 9-11, 2014
Dr. K. Ramesh	National conference on Sustainability, Organic Villages and Markets	Bangalore	September 19, 2014
Dr. B.P. Meena	Recent advance in Micro irrigation System and Fertigation under Covered and Open Cultivation for Sustainable and Enhanced Crop Production and Productivity in Vertisols	CIAE, Bhopal	September 9-29, 2014
Dr. R. Elanchezhian	Interactive meeting with Dr Sunil Nanda, President (North), Nualgi Nanobiotech	New Delhi	September 22-23, 2014
Dr. R. Elanchezhian	Interactive meeting on Plant Growth Regulators with Dr Sudhir Bhargava, Member ICAR	NRM Division of ICAR, New Delhi	October 15, 2014
Drs. D.L.N. Rao and Muneshwar Singh	Meeting of the ICAR Regional Committee	IGKV, Raipur	October 17-18, 2014

Name	Programme	Venue	Period
Dr. A.K. Biswas	Standing Committees and Council of the Indian Society of Soil Science	New Delhi	October 17-18, 2014
Dr. K. Ramesh	National Food Security Mission Meeting	SIAET, Bhopal	October 21, 2014
Dr. S. Srivastava	A meeting under the Chairmanship of DDG (NRM), ICAR to discuss the issue related to inclusion of new fertilizer in FCO, 1985	Krishi Bhavan, New Delhi	October 21, 2014
Drs. S. Srivastava & J. Somasundaram	ICAR-FAO workshop on Open Access to Agriculture Knowledge for Inclusive Growth and Development	NAARM, Hyderabad	October 29-30, 2014
Dr. D.L.N. Rao	55 th AMI Conference	Coimbatore	November 12-14, 2014
Dr. A.B. Singh	International Conference on Emerging Trends in Agriculture and Environmental Engineering	Bhopal	November 15-17, 2014
Drs. R.H. Wanjari, K. Ramesh and B.P. Meena	National symposium on Agricultural Diversification for Sustainable Livelihood and Environmental Security	PAU, Ludhiana	November 18 -20, 2014
Dr. J. K. Saha	Meeting of Subcommittee-3, constituted by Honorable National Green Tribunal, New Delhi	MP Pollution Control Board, Bhopal	November 22, 2014
Drs. Ajay, Tapan Adhikari and R. Elanchezhian	National conference of Plant Physiology-2014	Orissa University of Agriculture & Technology, Bhubaneswar	November 23-25, 2014.
Drs. M.C. Manna, A.K. Shukla, Tapan Adhikari, B.L. Lakaria, R.K. Singh, M. Vassanda Coumar I. Rashmi, M.L. Dotaniya and Pankaj K. Tiwari	79 th Annual Convention of Indian Society of Soil Science on Developments in Soil Science	Prof. Jayashankar Telangana State Agrl. University, Hyderabad	November 24-27, 2014

Name	Programme	Venue	Period
Dr. J. K. Saha	National Conference on Harmony with Nature In Context of Environmental Issues & Challenges of the 21 st Century	Mohanlal Sukhadia University, Udaipur	November 28-30 , 2014
Dr. Tapan Adhikari	International Conference on Emerging Electronics (ICEE-2014)	Indian Institute of Science, Bangalore	December 3-6, 2014
Drs. S. Srivastava and A.K. Tripathi	Brainstorming meeting on Waste Management	IISS, Bhopal	December 04, 2014
Dr. S.R. Mohanty	Group Meeting of AINP on Soil Biodiversity-Biofertilizers	Junagarh	December 08, 2014
Dr. Muneshwar Singh	FAI Annual Meet	PRII	December 9-11, 2014
Dr. A.K. Tripathi	FAI annual seminar on Unshackling the Fertilizer Sector		December 10-12, 2014
Dr. A.K. Vishwakarma	National conference on Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management, (ECOBASM-2014)	DRR, Hyderabad	December 13-14, 2014
Dr. R.S. Chaudhary	National seminar on Climate change and Water Resources	AISECT Univ. Bhopal	December 19, 2014
Dr. A.B. Singh	Workshop on Training Need Assessment	State Institute of Agriculture Extension & Training Berkhedi Kalon, Bhopal	December 22-23, 2014
Dr. J.K. Saha	NAAS Silver Jubilee Symposium on Managing Natural Resources for Posterity: 25 Years of Achievements and Way Forward	BCKV, Kalyani	December 30, 2014
Dr. Tapan Adhikari	102 nd Indian Science Congress	University of Mumbai, Mumbai	January 3-7, 2015
Dr. Asit Mandal	Second International Conference on Bio-resource and Stress Management	Hyderabad	January 7-10, 2015

Name	Programme	Venue	Period
Dr. K. Ramesh	National conference on Indigenous Innovation and Foreign Technology Transfer in Fertilizer Industry: Needs, Constraints and Desired Simplification	CRIJAF, Barrackpore	January 17, 2015
Dr. S. Srivastava	Meetings on various aspects of soil health card under the Chairmanship of Additional Secretary, DAC	Krishi Bhavan, New Delhi	January 18, 21, 2015, & March 24, 2015.
Dr. K. Bharati	Innovative/ Best Practices in NeGP-Agriculture for all States and Union Territories	Bhopal	January 19-21, 2015
Dr. S.R. Mohanty	Annual Review Meeting of AMAAS (Application of Microorganisms in Agriculture and Allied Sector)	NASC complex, New Delhi	January 22-23, 2015
Dr. D.L.N. Rao	Brainstorming session for developing ICAR Vision 2050 document	IFPRI, New Delhi	January 29, 2015
Dr. A.K. Tripathi	Official language conference for Central and Western Regions, Government of India	BHEL, Bhopal	January 30, 2015
Drs. S. Kundu, M.C. Manna	XII Agricultural Science Congress	NDRI, Karnal	February 3-6, 2015
Dr. A.K. Tripathi	Institute Management Committee of ICAR-Indian Grassland and Fodder Research Institute, Jhansi	IGFRI, Jhansi	February 07, 2015
Drs. M.C. Manna, S. Srivastava, R.H. Wanjari, J. Somasundaram and M. Vassanda Coumar	International Conference on Natural Resource Management for Food Security and Rural Livelihoods	Soil Conservation Society of India, New Delhi	February 10-13, 2015
Dr. A.K. Biswas	Reactive N Assessment Workshop	NASC, New Delhi	February 13-14, 2015
Drs. A.K. Biswas, S. Srivastava, Pramod Jha and I. Rashmi	Annual General Meeting (AGM)	ICAR, New Delhi	February 18, 2015

Name	Programme	Venue	Period
Drs. S.R. Mohanty and K. Bharati	National Seminar on Science led Development for Environmental Sustainability	Indian National Science Academy, New Delhi	February 20-22, 2015
Drs. S. Srivastava and Shinogi K.C.	17 th Indian Agricultural Scientists and Farmer's Congress	BRIAT, Allahabad	February 21-22, 2015
Dr. B.L. Lakaria	PME Indicators & Implementation Strategy	NASC, New Delhi	February 23, 2015
Dr. Shinogi K.C.	Extension Innovations and Methodologies for Market-Led Agriculture Growth & Development	RVSKVV, Gwalior	February 26-28, 2015
Dr. Rajendiran S.	30 th M. P. Young Scientist Congress	MPCST, Bhopal	February 28 - March 01, 2015
Dr. A.K. Tripathi	National Conference on Sustainable Agriculture Development through Biotechnological Techniques and its Impact on Food Security, Human Welfare and Climate	Monad University, Hapur,	February 28 - March 01, 2015
Dr. S. Lenka	Workshop on Climate Change and its Impact on Agriculture	KVK, Burhanpur	March 1-2, 2015
Dr. A. B. Singh	State level Organic Conference and Agri- Fair Jaivik Haat-2015	Swaraj Udyan Ravindra Bhawan, Bhopal	March 2-4, 2015
Drs. K.M. Hati, R.S. Chaudhary, M. Mohanty and Nishant K. Sinha	Infrared Spectroscopy in Soil Health Assessment under ICAR-ICRAF Collaboration on Soil Research	ICAR-IISS, Bhopal	March 9-13, 2015
Drs. Muneshwar Singh, A.K. Biswas and R.H. Wanjari	IFI-FAI National Seminar	New Delhi	March 16-17, 2015
Dr. S. Lenka	Workshop on Climate Change and its Impact on Agriculture	KVK, Raisen	March 18, 2015

Name	Programme	Venue	Period
Drs. A.K. Biswas, B.L. Lakaria, K.M. Hati, J. Somasundaram, A.K. Vishwakarma and M. Mohanty	Organized and attended a core- group meeting of CRP on CA	KAB -II, ICAR, New Delhi	March 22, 2015
Dr. S.R. Mohanty	Young investigator meeting 2015	Srinagar	March 27– April 01, 2015
Drs. I. Rashmi and Asha Sahu	National Seminar on Recent Trends in Science and Technology under the auspices of The Indian Science Congress Association, Kolkata	MPCST, Bhopal	March 30 - 31,2014

14. WORKSHOPS, SEMINARS, TRAININGS ORGANIZED

Training/Short Courses Conducted

Programme	Course Director/ Coordinator(s)	Duration	Sponsor
Short course on advances in nutrient dynamics in soil-plant-atmospheric systems for improving nutrient use efficiency.	Drs. R. Elanchezhian, K. Ramesh & A.K. Biswas	September 2-11, 2014	ICAR
Model training course on best nutrient management practices for major crops and cropping systems of India	Drs. K. Ramesh, B.L. Lakaria & S. Neenu	October 7-14, 2014	Ministry of Agriculture, GoI
Winter school training on waste recycling and resource management through rapid composting techniques	Drs. M.C. Manna, A.B. Singh & A.K. Tripathi	December, 3-23, 2014	ICAR
Model training course (MTC) on climate change and conservation agriculture	Drs. M. Mohanty, J. Somasundaram & R.S. Chaudhary	January 28 to February 4, 2015	Ministry of Agriculture, GoI

Workshops/Farmers' Training Conducted

Programme	Course Director/ Coordinator(s)	Duration
Training-cum-workshop on soil health and fertility management for the scientists of KVK of Region VII	Drs. Sanjay Srivastava & A.K. Biswas	May 7-9, 2014
Interactive workshop on contingency planning for <i>kharif</i> crops under delayed monsoon in Malawa plateau region of Madhya Pradesh	Dr. Sanjay Srivastava	July 03, 2014
Training programme on farmers' friendly technologies for improved crop production for the farmers of Mengra Kalan village (Bhopal district) of Madhya Pradesh	Drs. Shinogi K.C. & Sanjay Srivastava	July 9-11, 2014
Training programme on soil health and balanced fertilization for the farmers of Sehore district of Madhya Pradesh	Drs. A.K. Tripathi & A.B. Singh	July 14-18, 2014

Programme	Course Director/ Coordinator(s)	Duration
Training programme on soil health and balanced fertilization for the farmers of Shivapuri district of Madhya pradesh	Drs. A.K. Tripathi & Shinogi K.C.	October 14-18, 2014
Training programme on soil health and balanced fertilization for the farmers of Guna district of Madhya pradesh	Dr. A.K. Tripathi	November 24-28, 2014
Training programme on soil health and balanced fertilization for the farmers of East Champaran district of Bihar	Drs. A.K. Tripathi & Sanjay Srivastava	December 08-12, 2014
ICAR – ICRAF training on MIR spectroscopy	Dr. K.M. Hati	March 9-13, 2015
Training programme on soil health management for sustainable production to KVK persons under RVSKVV, Gwalior	Dr. A.K. Biswas	March 24-25, 2015

Training Conducted under AICRPs/AINP

AICRP on Micro and Secondary Nutrient Elements: Number of training were organized in tribal areas on micronutrient management in vegetable crops; Importance of Zn and Fe in soils, plants and human nutrition; Role of B in crop nutrition for higher production; Methods and application of different micronutrient fertilizers; Role of S and B in oil seed crops for higher oilseed production and quality, livelihood promotion of tribal farmers through value base agricultural technique etc.

State (Centre)	No. of trainings conducted	No. of Trainees/ Beneficiaries
Maharashtra (Akola)	02	85
Madhya Pradesh (Jabalpur)	01	30
West Bengal (Kalyani)	02	40
Tamil Nadu (Coimbatore)	02	75
Bihar	06	200
Total	13	430

AICRP on STCR organized a one day training programme in collaboration with State Department, Govt. of Himanchal Pradesh at SAMETI, Moshobra, Shimla on 6th September, 2014, and another one day training programme on Use of GPS based soil fertility maps for District Officers, Soil Testing Staffs and progressive farmers of Tamil Nadu States was organized by AICRP (STCR) in collaboration with Tamil Nadu State Government at TNAU, Coimbatore on 09 September, 2014.

15. DISTINGUISHED VISITORS

- Dr. Navin Chandra, Acting Director, Advanced Materials and Processes Research Institute, Council of Scientific & Industrial Research (CSIR) visited the institute on 16 April, 2014 as Chief Guest of the 27th Foundation Day.
- Prof. Rajarajan (Retired) from Tamil Nadu Agricultural University (TNAU), Coimbatore delivered the Dr. S.P. Raychaudhari Memorial Lecture on 9th September, 2014.
- Dr. Junpei Takano, Laboratory Molecular Biology, Research Faculty of Agriculture, Hokkaido University, Japan and Prof. Lingaraj Sahoo, Dept. of Biotechnology, IIT Guwahati visited the institute on 3rd November, 2014.
- Dr. J.S. Chauhan, ADG (Seeds) visited on 25th September, 2014.
- Mr. Arun Pratap Singh, Inspector General of Police in the Government of Madhya Pradesh visited ICAR-IISS, on November 01, 2014 as the Chief Guest in the concluding function of vigilance awareness week.
- Following dignitaries visited the institute on the occasion of the World Soil Day on 5 December, 2014.

Dr. G.A. Kinhal, Director, IIFM Bhopal

Dr. S.S. Khanna, Former Planning Commission Member and VC, NDUAT, Faizabad

Dr. P.J. Sudhakar, Additional Director General, Press Information Bureau, Ministry of Information and Broadcasting, GOI

- Dr. Alok K. Sikka, Hon' ble DDG (NRM) & ADG (SWM), ICAR visited the institute on 19th January, 2015 (Plate 15.1).
- Dr. C.L. Acharya Chairman, and Drs. T.K. Adhya, N.S. Raghuwanshi, S.K. Chaudhary, Members, RAC visited the institute during 30-31 January, 2015.
- Drs. Evis Weullow and Andrew Sila from ICAR-ICRAF, Nairobi, Kenya visited the institute during 9-13th March, 2015 as resource personnel from World Agroforestry Centre, Nairobi.
- Dr. Panjab Singh, Ex. Sec., DARE & DG, ICAR and Ex. VC, BHU, Varanasi and Dr. B.N. Singh, Registrar, RKDF University, Bhopal visited the institute on 24 March, 2015.



Plate 15.1 Dr. Alok K. Sikka, DDG (NRM) visiting ESS Lab



Plate 15.2 Dr. Panjab Singh and Dr. B.N. Singh, in a meeting with director, PCs & HODs

16. INFRASTRUCTURE DEVELOPMENT

16.1 Instrument/ Equipments Purchased

During the year different scientific instruments were purchased including water purification systems, gas cylinders for smooth functioning of miscellaneous equipments, spares for instruments like TOC analyzer and Lyophilizer, BOD incubator, BBF maker etc. In addition to above infrastructural facilities were also developed.

16.2 Library Developments

The library is well maintained with facilities lending, reference service, reprographic services etc. The Library also exchanges the institute publication with the other ICAR Institutes, SAUs and renowned Scientists in the field of Soil Science. The institute library has been further strengthened with following new additions.

Document	Additions during 2014-15	Total
Books	14	2591
Annual Reports	135	2152
Foreign Journals Subscribed	3	3
Indian Journals Subscribed	19	19

16.3 Miscellaneous Works Completed

In the financial year 2014-15, the renovation of reception area work done by CPWD by putting sensor door in front and glass doors at the backside, amounting Rs 4.45 lakhs. Another work of renovation of library was also done at the total cost of Rs. 8.74 lakhs.

16.4 Farm Activities

1. Successfully red gram (6.11 ha) crop was raised in the farm inspite of incessant rains during the kharif season 2014. Thus red gram cv. Asha emerged as a profitable crop for the shifting weather pattern at Bhopal.
2. Maize was raised in an area of 4.55 ha with a production of 91.27 q which realized an income of Rs. 1.04 lakhs.
3. Soybean was cultivated in an area of 2.83 ha with an income generation of Rs. 0.74 lakhs.
4. During rabi season, inspite of scanty rains, successfully raised Gram in an area of 9.21 ha due to quick sowing after rabi showers.
5. Laser leveling of fields was done with CIAE laser leveler at an estimated cost of 0.84 lakhs

17. SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE PERSONNEL

Name	Designation	Discipline	Date of Joining ICAR	Date of Joining IISS
DIRECTOR'S CELL				
Dr. Ashok K. Patra	Director	Soil Chemistry/Fertility/ Microbiology	05.10.1989	01.05.2014
Sh. Thomas Joseph	PS	Office Staff	18.09.1989	18.09.1989
Smt. Yojana Meshram	PA	Office Staff	12.05.1997	12.05.1997
Sh. Bhoilal Uaikey	Lab Attendant	Skilled Supporting Staff	13.11.1995	13.11.1995
DIVISION OF SOIL PHYSICS				
Dr. R.S. Chaudhary	Head & Pr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1993	09.12.1999
Dr. K.M. Hati	Pr. Scientist	Soil Physics/Soil & Water Conservation	27.12.1996	27.12.1996
Dr. J. Somasundaram	Sr. Scientist	Soil Physics/Soil & Water Conservation	12.11.2001	22.12.2008
Dr. Anand Kumar Vishvakarma	Sr. Scientist	Agronomy	16.04.2003	01.08.2013
Sh. M. Mohanty	Scientist	Soil Physics/Soil & Water Conservation	10.11.1999	10.11.1999
Dr. R.K. Singh	Sr. Scientist	Soil Physics/Soil & Water Conservation	25.01.1993	16.10.2002
Dr. N.K. Sinha	Scientist	Agriculture Physics	20.04.2010	27.08.2010
Sh. R.K. Mandloi	T-7-8	Asstt. Chief Technical Officer	19.06.1989	19.06.1989
Sh. Hukum Singh	T-3	Technical Assistant	30.12.1988	30.12.1988
Sh. Darashram	Lab attendant	Skilled Supporting Staff	15.03.1990	15.03.1990
DIVISION OF SOIL CHEMISTRY AND FERTILITY				
Dr. A.K. Biswas	Head & Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	21.01.1992	11.01.1993
Dr. Sanjay Shrivastava	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	22.03.1996	02.09.1996
Dr. Brij Lal Lakaria	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	01.10.1997	15.01.2007
Dr. R. Elanchezhian	Pr. Scientist	Plant Physiology	09.11.1998	17.02.2012
Dr. N. K. Lenka	Pr. Scientist	Soil Physics/Soil & Water Conservation	30.11.2000	09.10.2009

Name	Designation	Discipline	Date of Joining ICAR	Date of Joining IISS
Dr. Pramod Jha	Sr. Scientist	Soil Chemistry/Fertility/ Microbiology	16.04.2003	17.07.2009
Dr. K. Ramesh	Sr. Scientist	Agronomy	04.09.2008	04.09.2008
Dr. (Mrs.) I. Rashmi	Scientist	Soil Chemistry/Fertility	21.04.2009	27.08.2009
Dr. (Mrs.) Neenu S.	Scientist	Soil Chemistry/ Fertility	21.04.2009	27.08.2009
Mrs. J.S. Virgine Tenshia	Scientist	Soil Chemistry/Fertility	28.05.2010	28.05.2010
Dr. B.P. Meena	Scientist	Agronomy	15.09.2011	22.12.2011
Sh. Deepak Kaul	T-7-8	Asstt. Chief Technical Officer	29.12.1988	29.12.1988
Sh. Khilan Singh Raghuvanshi	T-5	Technical Officer	29.12.1988	29.12.1988
Sh. Bhanwar Singh Yadav	Messenger	Skilled Supporting Staff	01.09.1993	23.01.1999

DIVISION OF SOIL BIOLOGY

Dr. M.C. Manna	Head & Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	21.01.1992	11.01.1993
Dr. A.B. Singh	Pr. Scientist	Biochemistry	22.03.1999	22.03.1999
Dr. A.K. Tripathi	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	05.08.1991	25.07.1992
Dr. S. Ramana	Pr. Scientist	Plant Physiology	06.02.1997	06.02.1997
Dr. S.R. Mohanty	Sr. Scientist	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
Dr. (Mrs.) K. Bharati	Sr. Scientist	Microbiology - Plant Science	29.10.2009	05.04.2011
Dr. Asit Mandal	Scientist	Soil Chemistry/Fertility	23.06.2009	30.10.2009
Dr. J. K. Thakur	Scientist	Agricultural Microbiology	20.04.2010	27.08.2010
Dr. (Mrs.) Asha Sahu	Scientist	Soil Chemistry/Fertility	03.05.2010	03.05.2010
Sh. Vinod Babu Pal	T-6	Sr. Technical officer	15.02.1993	15.02.1993
Sh. Vinod Choudhary	T-3	Tech. Assistant	14.06.1989	14.06.1989
Mrs. K.S. Baise	PA	Officer Staff	05.05.1997	18.02.2002
Sh. Ram Bharose	Lab attendant	Skilled Supporting Staff	20.03.1990	20.03.1990

DIVISION OF ENVIRONMENTAL SOIL SCIENCE

Dr. J.K. Saha	Head & Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	21.01.1992	02.01.1993
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Name	Designation	Discipline	Date of Joining ICAR	Date of Joining IISS
Dr. S. Kundu	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	22.07.1986	03.07.2007
Dr. Ajay	Pr. Scientist	Plant Physiology	12.04.1993	31.08.1999
Dr. Tapan Adhikari	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	22.03.1996	07.11.1996
Dr.(Mrs) Sangeeta Lenka	Scientist	Soil Physics/Soil & Water Conservation	08.01.2007	18.05.2007
Dr. M.Vassanda Coumar	Scientist	Soil Chemistry/Fertility/ Microbiology	04.11.2009	15.03.2010
Dr. M. L. Dotaniya	Scientist	-do-	20.04.2010	28.08.2010
Dr. Rajendiran S.	Scientist	-do-	02.09.2010	10.01.2011
Shri. Vasudev Meena**	Scientist	Agronomy	15.09.2011	23.12.2011
Smt. Seema Sahu	T-7-8	Asstt. Chief Technical Officer	14.04.1987	24.01.1989
Sh. Sant Kumar Rai	T-3	Technical Asstt.	15.06.1989	15.06.1989
Sh. Kalicharan	Lab attendant	Skilled Supporting Staff	01.09.1993	10.06.1999
AICRP-LTFE				
Dr. Muneswar Singh	Project Co-ordinator	Soil Chemistry/Fertility/ Microbiology	11.07.1989	11.07.1989
Dr. R.H. Wanjari	Sr. Scientist	Agronomy	07.01.1999	07.01.1999
Sh. Sunny Kumar	Steno. GR.III	Office Staff	21.12.2011	21.12.2011
Sh. A. K. Mishra	Lab attendant	Skilled Supporting Staff	01.09.1993	10.06.1999
AICRP-MSN				
Dr. A.K. Shukla	Project Co-ordinator	Soil Chemistry/Fertility/ Microbiology	05.07.1996	31.03.2011
Sh. P.K. Tiwari	Scientist	Soil Chemistry/Fertility/ Microbiology	01.01.2013	11.04.2013
Sh. Sahab Siddiqui	T-6	Sr. Technical Officer	05.10.1992	05.10.1992
Sh. Jai Singh	T-5	Technical Officer	22.05.1999	22.05.1990
Sh. Venny joy	PA	Office Staff	14.02.1991	23.03.1998
Sh. Harish Kumar	Lab attendant	Skilled Supporting Staff	14.03.1990	14.03.1990
AICRP-STCR				
Dr. Pradip dey	Project Co-ordinator	Soil Chemistry/Fertility/ Microbiology	03.06.1993	01.02.2012
Dr. N.S. Bhogal	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	14.05.1999	26.05.2014

Name	Designation	Discipline	Date of Joining ICAR	Date of Joining IISS
Sh. Abhishek Rathore*	Scientist	Agricultural Statistics	16.12.2002	16.12.2002
Shri Hironmoy Das**	Scientist	Agriculture Statistics	15.09.2011	23.12.2011
Mrs. Geeta Yadav	Private Secretary	Office Staff	26.12.1995	26.12.1995
Sh. Janak Singh Mehra	Khalasi	Skilled Supporting Staff	08.09.1997	08.09.1997
Sh. Sanjay N. Gharde	Lab attendant	Skilled Supporting Staff	15.06.1999	15.06.1999
AINP-BIOFERTILIZERS				
Dr. D.L.N. Rao	Network Coordinator (Biofertilizer)	Soil Chemistry/Fertility/ Microbiology	29.07.1978	25.06.1998
Mrs. Radha T.K.	Scientist	Agricultural Microbiology	10.02.2009	20.06.2009
Sh. A.B. Mate	Lab attendant	Skilled Supporting Staff	15.06.1999	15.06.1999
PME CELL				
Dr. Brij Lal Lakaria	Pr. Scientist	Officer In-Charge	01.10.1997	15.01.2007
Sh. Sanjay Kumar Kori	Steno. GR. III Secretary	Office Staff	03.01.2012	03.01.2012
ITMU				
Dr. S. Srivastava	Pr. Scientist	Officer In-Charge	22.03.1996	02.09.1996
Dr. Shinogi K.C.	Scientist	Agricultural Extension	27.04.2011	05.09.2011
AKMU				
Dr. J. Somasundaram	Sr. Scientist	Officer In-Charge	12.11.2001	22.12.2008
STATISTICS AND COMPUTER APPLICATION SECTION				
Dr. Kollah Bharati	Sr. Scientist	In-Charge	29.10.2009	05.04.2011
Smt. Kavita Bai	Safaiwala	Skilled Supporting Staff	20.12.1988	20.12.1988
LIBRARY SECTION				
Smt. Nirmala Mahajan	T-6	Sr. Technical Officer	15.03.1993	15.03.1993
Sh. P.K. Raut	Beldar	Skilled Supporting Staff	21.07.1992	21.07.1992
Smt. Geesi Devi	Trainee	Supporting Staff	31.05.2014	31.05.2014
CENTRAL LAB				
Dr. S.R. Mohanty	Sr. Scientist	Officer In-Charge	18.06.2009	18.06.2009
Sh. Vinod Babu Pal	T-6	Sr. Technical officer	15.02.1993	15.02.1993
Sh. Jagannath Gaur	Lab attendant	Skilled Supporting Staff	20.07.1992	20.07.1992

Name	Designation	Discipline	Date of Joining ICAR	Date of Joining IISS
REFERRAL LAB				
Dr. Pradip Dey	Project Co-ordinator	Officer In-Charge	03.06.1993	01.02.2012
FARM SECTION				
Dr. K. Ramesh	Sr. Scientist	Officer In-Charge	04.09.2008	04.09.2008
Sh. O.P. Shukla	T-4	Tractor Mechanic	22.04.1989	22.04.1989
Sh. C.T. Wankhede	T-5	Technical Officer (Tractor Mechanic)	03.08.1992	03.08.1992
Sh. D.R. Darwai	T-5	Technical Officer (Field Assistant)	23.01.1993	23.01.1993
Sh. P.K. Chauhan	T-5	Technical Officer	15.02.1993	15.02.1993
Sh. Bhagwat Prasad	Beldar	Skilled Supporting Staff	24.01.1992	24.01.1992
Sh. Lalaram Sahu	Beldar	Skilled Supporting Staff	24.07.1992	24.07.1992
Sh. R.K. Sen	Beldar	Skilled Supporting Staff	08.09.1997	08.09.1997
VEHICLE SECTION				
Dr. J.K. Thakur	Scientist	Officer In-Charge	20.04.2010	27.08.2010
Sh. Sukh Ram Sen	T-3	Tech. Asstt (Driver)	25.01.1991	
Sh. N.S. Yadav	T-4	Asstt. Tech. Officer (Driver)	23.09.1987	03.05.1999
ADMINISTRATION SECTION				
Shri V. K. Derashri	AO	Administration	19.05.1976	16.06.2012
Mr. Neeraj Tahiliani	FAO	Audit & account	12.06.2012	22.07.2014
Sh. Rajesh Dubey	AF&AO	Audit & account	21.12.1988	26.11.1998
Sh. P. S. Sunil Kumar	AAO	Administration	30.01.1989	30.01.1989
Sh. A.S. Rajput	Assistant	Establishment section	14.03.1990	14.03.1990
Smt. Babita Tiwari	Assistant	Central store	30.05.1996	30.05.1996
Sh. Bansilal Sarsodia	Assistant	Purchase section	10.09.1997	10.09.1997
Sh. Hiralal Gupta	UDC	Bill section	23.12.1988	23.12.1988
Sh. O.P. Yadav	UDC	Audit & account	19.12.1988	19.12.1988
Sh. Jineshwar Prasad	UDC	Administration	13.12.1988	13.12.1988
Sh. S. Mukharjee	LDC	Bill section	30.09.1999	30.09.1999
Sh. Sanjay Katinga	LDC	Cash section	20.06.1989	20.06.1989
Smt. Raksha Parsai	LDC	Administration	24.05.2013	24.05.2013
Sh. Anurag	Security Supervisor	Security section	29.09.1997	29.09.1997

Name	Designation	Discipline	Date of Joining ICAR	Date of Joining IISS
Sh. L.N. Chouksey	Messenger	Skilled Supporting Staff	17.12.1988	17.12.1988
Sh. S.K. Batham	Messenger	Skilled Supporting Staff	19.12.1988	19.12.1988
Sh. D.R. Singh	Messenger	Skilled Supporting Staff	10.09.1993	14.06.1999

*on deputation; ** on study leave

Joining

- Dr. A.K. Patra joined as Director IISS, Bhopal on May 01, 2014.
- Dr. N. S. Bhogal, Senior Scientist (Soil Chemistry/ Fertility/Microbiology) joined to the institute on May 25, 2014.
- Mr. Neeraj Tahiliani, Joined as FAO on July 22, 2014.

Promotion

- Ms. Seema Sahu was promoted from Sr. Technical Officer to Asst. Chief Technical Officer on April 01, 2014.
- Mr. Sant Kumar Rai was promoted from Senior Technician to Technical Assistant, *w.e.f.* 22 May 2014.

Transferred/Resigned

- Mr. Saurav Kumar, Assistant, resigned on June 13, 2014.
- Dr. Ritesh Saha, Sr. Scientist transferred (in the same scale) to NBSSLUP, Regional Centre, Kolkatta on November 05, 2014.
- Sh. M.S. Hedau, Assistant transferred on promotion to Directorate of Weed Research, Jabalpur on October 10, 2014.
- Dr. Neenu S. transferred to CPCRI Kasargod on January 08, 2015.

Superannuation

- Dr. A. Subba Rao, Director IISS, Bhopal retired from ICAR service on April 30, 2014.
- Mr. T. Ayodhya Ramaiah, P.A. retired from ICAR service on April 30, 2014.

**RESULTS-FRAMEWORK DOCUMENT FOR INDIAN INSTITUTE OF
SOIL SCIENCE (2013-2014)**



RFD
Results-Framework Document
For
Indian Institute of Soil Science
(2013-14)

SECTION 1
Vision, Mission, Objectives and Functions

Vision

Basic and strategic research on physical, chemical and biological processes in soils for improving soil health and crop productivity

Mission

To provide scientific basis for enhancing and sustaining productivity of soil resource with minimal environmental degradation

Objectives

1. Appraisal and management of soil health
2. Improving nutrient use efficiency
3. HRD & capacity building

Functions

1. To plan, coordinate, implement and monitor research and development programmes for improvement of soil health and serve as a knowledge repository in the field of soil science.

SECTION 2

Inter se Priorities among Key Objectives, Success Indicators and Targets

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria				
							Excellent	Very good	Good	Fair	Poor
						100%	90%	80%	70%	60%	
1	Appraisal and management of soil health	45	Assessment of soil health Management of soil health	Soil health assessment under different crops and cropping systems INM packages developed for different agro-eco regions of the country	No.	15	6	5	4	3	2
				Developed conservation agricultural practices for crops / cropping systems	No.	10	3	2	1	-	-
				Developed management practices for remediation of polluted soils	No.	5	3	2	1	-	-
2	Improving nutrient use efficiency	20	Balanced and judicious use of fertilizers	Soil test based balanced fertilizer prescription equations developed for improving nutrient use efficiencies	No.	10	4	3	2	-	-
				Efficient bio-fertilizers strains/ formulations developed	No.	5	3	2	1	-	-
3	HRD & capacity building	24	Transfer of technology and creation of awareness/ knowledge	Frontline demonstrations conducted Farmers' trainings organized Workshop/ seminar/ summer/ winter school organized	No.	15	28	24	22	20	18
					No.	5	5	4	3	2	1
					No.	4	10	8	6	4	2

SECTION 3

Trend values of the Success Indicators

S.No.	Objectives	Actions	Success Indicators	Unit	Actual value for 2011 -12	Actual value for 2012 -13	Target value for 2013-14	Projected value for 2014 -15	Projected value for 2015 -16
1	Appraisal and management of soil health	Assessment of soil health	Soil health assessment under different crops and cropping systems	Number	-	-	5	6	6
		Management of soil health	INM packages developed for different agro-eco regions of the Country	Number	5	8	8	8	9
			Developed conservation agricultural practices for crops / cropping systems	Number	-	-	2	3	3
			Developed management practices for remediation of polluted soils	Number	-	-	2	2	2
2	Improving nutrient use efficiency	Balanced and judicious use of fertilizers	Soil test based balanced fertilizer prescription equations developed for Technologies developed for improving nutrient use efficiencies	Number	3	4	3	4	4
			Efficient bio-fertilizers strains/ formulations developed	Number	1	2	2	2	3
			Frontline demonstrations conducted	Number	2	2	5	5	6
3	HRD & capacity building	Transfer of technology and creation of awareness/ knowledge	Farmers' trainings organised Workshop/ seminar/ summer/ winter school organized	Number	13	15	24	28	32
				Number	5	10	4	5	6
				Number	5	4	8	8	9

Objectives	Actions	Success Indicators	Unit	Actual value for 2011-12	Actual value for 2012-13	Target value for 2013-14	Projected value for 2014-15	Projected value for 2015-16
Efficient Functioning of the RFD System	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	-	-	May 16, 2013	-	-
	Timely submission of Results for RFD (2012-13)	On-time submission	Date	-	-	May 2, 2013	-	-
Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	-	-	95	-	-
	Prepare an action plan for Innovation	On-time submission	Date	-	-	Aug. 10, 2013	-	-
Improving internal efficiency /responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	-	-	95	-	-
		Independent Audit of implementation of public grievance redressal system	%	-	-	95	-	-

SECTION 4

Description and definition of success Indicators and Proposed Measurement Methodology

S.No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Soil health assessment under different crops and cropping systems	Soil health monitoring with the use of imbalanced and inadequate fertilizer application is essential to monitor the changes in different agro-eco regions. Assessment of soil health through delineating nutrient deficiency areas is essential for location specific fertilizer recommendation. Agricultural inputs like nutrient and water are not only costly but also scarce. Therefore, development of INM nutrient prescriptions for various crops and cropping systems is essential for attaining higher productivity levels.	Long-term fertilizer experiments are assets to address the issue of soil health under continuous use of imbalanced and inadequate fertilizer application and also balanced and integrated nutrient use.	Soil health assessment/ improvement through different interventions.	
2	INM packages developed for different agro-eco regions of the country		Integrated plant nutrient supply systems (INM/ IPNS) encompassing conjunctive use of both chemical and organic nutrient sources will be developed to provide optimum nutrition to crops for sustaining better crop productivity for different crops and cropping systems.	No. of IPNS systems developed for crops and cropping systems	
3	Developed conservation agricultural practices for crops / cropping systems	Conservation agriculture is an important aspect in improving soil health through optimization of tillage and residue retention for better soil health.	Various crops and cropping systems would be evaluated and best practices would be identified for improved soil health.	Conservation agriculture technologies for sustainable crop production	
4	Developed management practices for remediation of polluted soils	Judicious use of polluted water/sewage is important to meet the nutrient and water demand of crops especially near to urban areas	Assessment of soils polluted with sewage water and its remediation through plant at different sites	Technologies for use of polluted water	
5	Soil test based balanced fertilizer prescription	Soil test based fertilizer prescription is the demand of the hour due to large scale field	Soil test based prescription equations would be developed for	No. of prescriptions developed	

S. No.	Success Indicator	Description	Definition	Measurement	General Comments
	equations developed	variability on the farm level. Also the resource availability with the client need to be included sometimes to provide nutrients to crops through various resources than alone from the fertilizers.	different crops in different agro-eco-regions.		
6	Technologies developed for improving nutrient use efficiencies	Enhancing nutrient use efficiency is of utmost importance keeping in view the high cost of fertilizers and less availability due to limited production.	Different techniques will be employed to enhance the nutrient use efficiency.	No. of technologies developed	
7	Efficient bio-fertilizers strains/formulations developed	Soil is full of microbial life and very limited organisms have to be exploited for increasing nutrient use efficiency.	A continuous effort is required to research upon the beneficial microbial strains and their formulations to enhance nutrient use efficiency.	No. of formulations/strains identified	
8	Frontline demonstrations conducted	Frontline demonstrations (on-farm and off-farm) at different agro eco-regions is required to convince the stakeholders that the technology works at their location too.	Frontline demonstrations would be conducted at different locations in the country	No. of demonstrations conducted	
9	Farmers' trainings organised	Human resource development is a dynamic process. Farmers need to be educated through the experts directly. At this level they feel the pulse of high end research and many a time come to know the things they never heard at their farms.	Farmers' training will be conducted for farmers from different regions for faster technology transfer	No. of trainings organized	
10	Workshop/seminar/summer/ winter school organized	Human resource development is a dynamic process. Scientists working in a narrow research areas many a time need to be updated on recent techniques/advances in research.	Scientists interaction would be facilitated through these activities	No. of workshops/summer/winter schools organized	

SECTION 5

Specific Performance Requirement from other departments that are Critical for Delivering agreed result

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirement is not met
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

SECTION 6

Outcome/ Impact of Activities of Organization

S. No.	Outcome/ Impact of organisation	Jointly responsible for influencing this outcome/ impact with the following organisation(s)/ departments/ ministry(ies)	Success Indicator (s)	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
1.	Ensuring good soil health through balanced fertilization	State Agricultural Universities/ KV/Ks/ State Agricultural Departments	Increase in micronutrient fertilizer use Increase in bio fertilizer use over previous year Increase in organic manure use	%	2	2	5	5	5

Performance Evaluation Report

S.No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value				Performance			
							Excellent 100%	Very Good 90%	Good 80%	Average	Poor 60%	Achievements	Raw score	Weighted score
1	Appraisal and management of soil health	45	Assessment of soil health Management of soil health	Soil health assessment under different crops and cropping systems INM packages developed for different agro-eco regions of the Country Developed conservation agricultural practices for crops / cropping systems Developed management practices for remediation of polluted soils	No.	15	6	5	4	15	2	8	100	15
2	Improving nutrient use efficiency	20	Balanced and judicious use of fertilizers	Soil test based balanced fertilizer prescription equations developed Technologies developed for improving nutrient use efficiencies Efficient bio-fertilizers strains/ formulations developed. Frontline demonstrations conducted	No.	10	3	2	1	5	-	3	100	5
3	HRD & capacity building	24	Transfer of technology and creation of awareness/ knowledge	Farmers' trainings organized Workshop/ seminar/ summer/ winter school organized	No.	15	28	24	22	15	11	28	100	15
					No.	5	5	4	3	5	1	5	100	5
					No.	4	10	8	6	4	2	12	100	4

S.No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value				Performance			
							Excellent 100%	Very Good 90%	Good 80%	Average	Poor 60%	Achievements	Raw score	Weighted score
4*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	May 15, 2013	May 16, 2013	May 17, 2013	May 20, 2013	May 21, 2013	29 April, 2013	100	2
			Timely submission of Results for RFD (2013-14)	On-time submission	Date	1	May 1 2013	May 5 2013	May 6, 2013	May 7, 2013		29 April, 2013	100	1
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80	16 March, 2013	100	2
	Improving internal efficiency /responsiveness / service delivery of Ministry / Department	4	Prepare an action plan for Innovation	On-time submission	Date	2	Jul 30, 2013	Aug. 10, 2013	Aug. 20, 2013	Aug. 30, 2013	Sept. 10, 2013	21 Nov, 2013	0	0
			Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80		100	2
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	-	100	2

* Mandatory Objectives

Total composite score = 98.0

Acronyms

HRD : Human Resource Development
 INM : Integrated Nutrient Management
 IPNS : Integrated Plant Nutrient Supply System
 KVK : *Krishi Vigyan Kendra*

मृदा परीक्षक

2

स्थांतरण और रिएजेंट को मिलाना

1

वजन करना



3

शोक करना



4

फिल्टर करना

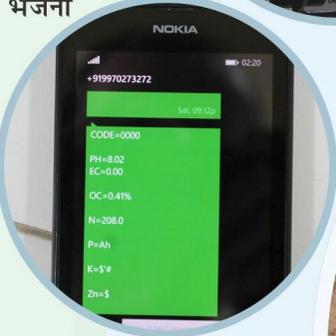


स्थान्तरित करना

5



किसी भी के
मोबाइल पर
भेजना



9

परिणाम को देखना



8

स्मार्ट सॉइल
प्रो में रखना



7

क्युवेट में लेना



6

रिएजेंट मिलाना और
रंग विकसित करना

स्वस्थ मृदा
स्वस्थ फसल
स्वस्थ जीवन

I I S S

