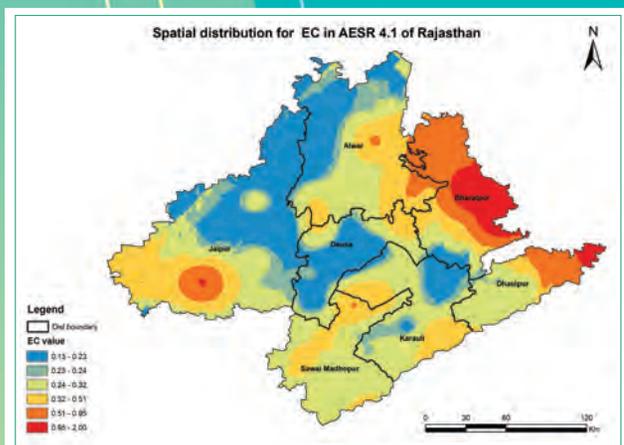




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ICAR-INDIAN INSTITUTE OF SOIL SCIENCE

(ISO 9001 : 2015 Certified)

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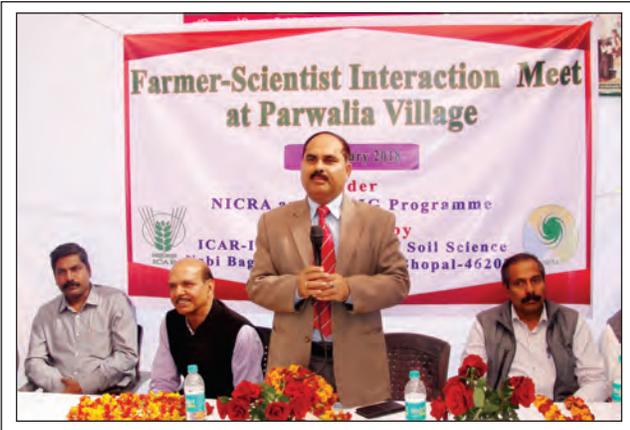
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Top left: Thematic map showing soil quality index, Top right: Technology demonstration, Bottom left: Endophytic fungi, Bottom right: Zero Till Seed Drill in Conservation Agriculture.

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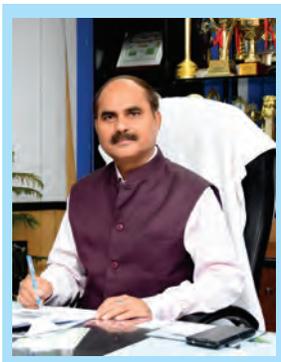
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Preface



Soil is a scarce natural resource. It sustains the vast diversity of terrestrial ecosystem. Therefore, it requires rigorous research on soil management as well as creation of awareness among people about best soil management practices. In India, the food production and the associated agricultural enterprises have to be carried out in 140 million hectares of agricultural land which is diminishing owing to increasing land degradation and various anthropogenic pressures. The degradation of soil is dwindling the crop yields and contributing to the animal/human malnourishment in many places across India. Hence, the improvement and maintenance of soil health is indispensable for sustaining agricultural productivity.

ICAR-Indian Institute of Soil Science, Bhopal is engaged in research on all aspects of soil science with the mission “to provide scientific basis for enhancing and sustaining productivity of soil resources with minimal environmental degradation”. Over the years, the institute has developed several viable technologies with field level validation for improvement of soil health. This annual report vividly illustrates the multi-scale approach in the area of soil health and input use efficiency, conservation agriculture, carbon sequestration, soil microbial diversity and genomics, soil pollution, remediation and environmental security. The report also describes the work done on integrated nutrient management, balanced fertilization, delineation of micronutrient deficiencies, validation of fertilizer prescription equations, *in-situ* decomposition of crop residues, farmers’ participatory research and demonstration of the technologies at farmers’ fields across the length and breadth of the country through various AICRPs/AINP centres. It is thus, a great pleasure for me to bring out the Annual Report 2017-18 of the institute.

During the year reported, some new technologies and methodologies were developed and refined viz. specific methodology for assessment of soil quality; development of prediction models for SOC using MIR & NIR spectroscopy; consortia of ligno-cellulolytic microbes for in-situ decomposition of crop residues; family net compost vessels for domestic waste recycling; and development of regional management zones for precise micronutrient prescription. On the basic research front, impact of nanoparticles on plant growth and metabolism was assessed; soil quality index and soil organic carbon stock was measured; genome of *Pseudomonas fluorescens* was sequenced and critical limits of Cd for major soil orders of India was determined. Further, this report presents a glimpse of all the important activities undertaken by the institute during the period reported upon.

I take this opportunity to express my sincere appreciation to all the Project Coordinators and Head of the Divisions for compiling the information at AICRP/AINP/Division level. I also extend my thanks to all the scientists and staff members of the institute for their painstaking efforts in carrying out the research and other developmental activities of the institute.

I place on record, my sincere appreciation to editorial committee comprised of Dr. R. Elanchezian, Dr. B.L. Lakaria, Dr. R.H. Wanjari, Dr. S.K. Behera, Dr. M. Mohanty, Dr. M.V. Coumar and Dr. Asha Sahu for their dedicated efforts in compiling and editing the report. The service rendered by Mr. S.K. Kori in collecting information and type setting the manuscript is appreciated.

With deep sense of gratitude and respect, I acknowledge Dr. Trilochan Mohapatra, Hon’ble Secretary, DARE and Director General, ICAR for his guidance, motivation and encouragement and for providing necessary financial support for overall growth and development of the institute. I am highly thankful to Dr. K. Alagusundaram, DDG (Agri. Engg.) and I/c DDG (NRM), ICAR and Dr. S.K. Chaudhari, ADG (S&WM) for their active involvement and constructive suggestions in carrying out various research and development activities for overall progress of the institute.

Bhopal
30 June 2018

(Ashok K. Patra)

Director

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कार्यकारी सारांश

विषयवस्तु I : मृदा स्वास्थ्य एवं आदान उपयोग की दक्षता

संतुलित व एकीकृत पोषण प्रबंधन:

- मक्का—अरहर फसल प्रणाली में आई एन एम मॉड्यूल में रासायनिक, जैविक व भौतिक गुणों सहित मृदा स्वास्थ्य के सभी मापदण्डों में उल्लेखनीय सुधार देखा गया। NPK उर्वरक के साथ गोबर खाद व कुक्कुट खाद के संतुलित प्रयोग से मृदा के स्वास्थ्य संबंधी विभिन्न मापदण्डों में उच्चतम मान देखे गए।
- मक्का की फसल में नत्रजन की भिन्न-भिन्न मात्राओं में से यह देखा गया कि बुवाई के 20 तथा 40 दिनों के अंतराल पर नाइट्रोजन (N) की कुल मात्रा (120 किलो ग्राम प्रति हेक्टेयर) दो एक समान भागों में प्रयोग किए जाने पर (60 किग्रा N प्रति हेक्टेयर) फसल उपज तथा नत्रजन उपयोग दक्षता में अर्थपूर्ण वृद्धि हुई।
- बायोचार के साथ 120 किग्रा प्रति हेक्टेयर नत्रजन के प्रयोग किए जाने पर उपज में वृद्धि हुई किन्तु उल्लेखनीय वृद्धि तभी देखी गई जब 120 किग्रा नत्रजन प्रति हेक्टेयर के साथ 5 तथा 10 टन प्रति हेक्टेयर बायोचार का प्रयोग किया गया।
- यह देखा गया कि मध्य भारत में सोयाबीन प्रणाली के स्थायित्व के लिए दलहन आधारित विविध फसल प्रणाली उपयुक्त है इसमें लघु अवधि के लिए अरहर तथा उड़द अंतर फसलों के रूप में बोई जा सकती है।
- शत प्रतिशत जैविक उपचार से सोयाबीन बीज की सर्वाधिक मात्रा प्राप्त की गई। तत्पश्चात 75 प्रतिशत जैविक, 25 प्रतिशत अजैविक तथा 75 प्रतिशत नवोन्मेषी उपचार (गोमूत्र का छिड़काव एवं वर्मीवॉश प्रत्येक का दो बार 10 प्रतिशत छिड़काव) करके प्रयोग किया गया। सोयाबीन प्रजाति (किस्म) RVS-2002, 4 तथा मक्का कल्टीवार कंचन में बीज की उपज बेहतर हुई।
- भारत के चयनित AESR में मृदा के नमूने एकत्रित करने एवं मिट्टी की गुणवत्ता का मूल्यांकन करने हेतु एक विशिष्ट कार्यविधि विकसित की गई। इस कार्यविधि का प्रयोग कर AESR 4.1 से मिट्टी के नमूने एकत्रित किए गए तथा राजस्थान के नौ जिलों हेतु चयनित मृदा गुणवत्ता मापदण्डों के लिए विषयगत GIS (जी. आई.एस.) मानचित्र विकसित किए गए।
- सोयाबीन—गेहूँ फसल प्रणाली के अंतर्गत वर्टीसोल (काली मिट्टी) में दीर्घ अवधि तक संतुलित मात्रा में उर्वरक के प्रयोग से उच्चतम मृदा गुणवत्ता सूचक (SQI) प्राप्त की गई। उर्वरक तथा खाद के संतुलित प्रयोग से मृदा की गुणवत्ता में सकारात्मक परिवर्तन देखा गया एवं उत्पादकता के स्थायित्व को बनाए रखने में भी सहायता मिली। गेहूँ की पैदावार हेतु एपसिम (APSIM) पूर्वानुमान तथा विकसित मृदा गुणवत्ता सूचक ($R^2=0.99$) के बीच परस्पर संबंध सकारात्मक पाया गया।
- मध्य प्रदेश की वर्टीसोल्स (काली मिट्टी) तथा संबंधित अन्य प्रकार की मिट्टी की किस्मों की 30 सेमी की ऊपरी परत में मृदा जैविक कार्बन स्टाक (मात्रा) का मूल्यांकन किया गया तथा यह

4.1 से 56 Mg ha^{-1} (मेगाग्राम प्रति हेक्टेयर) की श्रेणी में पाया गया। अध्ययन से ज्ञात हुआ कि प्रदेश के पूर्वी तथा मध्य भाग की मिट्टी में मृदा जैविक स्टाक की मात्रा प्रदेश के पश्चिमी व उत्तरी भाग की तुलना में अपेक्षाकृत अधिक थी। इसका कारण प्रदेश के पूर्वी तथा मध्य भाग में अधिक वर्षा प्राप्त होना हो सकता है।

- MIR (एम.आई.आर.) स्पेक्ट्रोस्कोपी का प्रयोग कर एल्फिसॉल्स में रेत का अंश, मृदा जैविक कार्बन तथा N, P तथा K की उपलब्ध मात्रा का विश्लेषण किया गया। यह देखा गया कि प्रयोगशाला में किए गए मृदा के गुणों के विश्लेषण तथा एम आई आर स्पेक्ट्रोस्कोपी द्वारा किए इन गुणों के आंकलन में परस्पर संबंध उपयुक्त था।
- मध्य भारत के वर्टीसोल्स की मृदा गुणवत्ता का आंकलन तथा मिट्टी के गुणों का अध्ययन VIS NIR स्पेक्ट्रोस्कोपी का प्रयोग करते हुए त्वरित मात्रात्मक विधि से किया गया। प्राप्त परिणामों से ज्ञात हुआ कि प्रयोगशाला से प्राप्त मृदा गुणवत्ता सूचक (SQI) एवं स्पेक्ट्रा से प्राप्त मृदा गुणवत्ता सूचक (SQI) में महत्वपूर्ण तथा सकारात्मक संबंध था।

कृषि निवेशों के उपयोग की दक्षता सुधारने के लिए नैनो प्रौद्योगिकी:

- सोयाबीन, गेहूँ तथा मक्का में पौधों के विकास एवं उपापचय प्रक्रिया पर नैनो पार्टिकल्स (सूक्ष्म कणों) के होने वाले प्रभाव का अध्ययन करने पर ज्ञात हुआ कि नैनोपार्टिकल्स का प्रभाव विशिष्ट फसल एवं उर्वरक की मात्रा के अनुरूप होता है। सब-ऑप्टिमल (उप-इष्टतम) मात्रा दिए जाने पर नैनो पार्टिकल्स पौधों के विकास एवं उपापचय में उत्प्रेरक का कार्य करते हैं तथा ये फसल की उच्च पैदावार प्राप्त करने में उपयोगी हो सकते हैं।

मृदा उर्वरता मूल्यांकन:

- सम्पूर्ण देश में उर्वरकों के दीर्घावधि प्रयोगों से यह स्पष्ट हुआ कि बाहर से पोषण का प्रदाय किए बिना उत्पादकता को स्थायी रखना सम्भव नहीं है।
- पालमपुर, रांची तथा बेंगलुरु के एल्फिसोल्स में चूने की तुलना में FYM (गोबर खाद) मृदा की उत्पादकता बढ़ाने के लिए बेहतर थी। जैविक खाद का प्रयोग किए जाने पर मृदा स्वास्थ्य में सुधार होने के साथ ही पौधों को पोषण प्राप्त होता है, जबकि चूना पत्थर से मिट्टी के pH स्तर सहित उसके अन्य संबंधित गुणों में सुधार लाया जा सकता है।
- अकोला के वर्टीसोल्स (काली मिट्टी) के अध्ययनों से ज्ञात हुआ कि जैविक खाद के माध्यम से पोषण दिए जाने के 26 वर्षों बाद भी फसल की उपज शत प्रतिशत NPK के प्रयोग के समान नहीं हो पाई। अतः अजैविक पोषण प्रदाय से प्राप्त उपज को ध्यान में रखते हुए अधिक उपज प्राप्त करने हेतु जैविक खाद की मात्रा को और बढ़ाए जाने की आवश्यकता है।
- परिणामों से ज्ञात हुआ कि पालमपुर एवं अन्य स्थानों पर मक्का तथा गेहूँ की फसलों में केवल यूरिया (अर्थात केवल छ) का

प्रयोग किए जाने पर मिट्टी की pH में एक इकाई की कमी देखी गई तथा पौधों के विकास के लिए P तथा K की उपलब्धता में कमी आई। इससे उक्त फसलों की उत्पादकता पर विपरीत प्रभाव हुआ।

- किसी भी किस्म की मिट्टी या फसलों में गोबर की खाद (FYM) अथवा हरी खाद को मिलाए जाने पर न केवल फसल की उत्पादकता में बढ़ोत्तरी देखी गई बल्कि जीवाणु संख्या तथा उनकी एन्जाइम संबंधी गतिविधियों में भी वृद्धि हुई। पन्तनगर में S (सल्फर) तथा Zn (जिंक) एक साथ प्रयोग किए जाने पर धान की पैदावार में वृद्धि देखी गई।
- बाजारा-गेहूँ वाली फसलीय प्रणाली के अंतर्गत एक दीर्घावधि प्रयोग के दौरान मृदा की उर्वरता एवं पैदावार में स्थायित्व बनाए रखने के उर्वरक समायोजन सूत्र समानुपात की उपयुक्ता का परीक्षण किया गया। विभिन्न उपचारों के दौरान उपलब्ध N तथा P से ज्ञात हुआ कि गोबर की खाद (FYM) तथा उर्वरकों का प्रयोग मिट्टी में पोषक तत्वों को बनाए रखने या उनमें वृद्धि करने में सहायक होता है।
- भारत के दक्कन पठार क्षेत्र में क्षेत्रीय प्रबंधन अंचलों (RZs) का विकास किया गया ताकि उपलब्ध सूक्ष्म पोषक तत्वों एवं मिट्टी के कुछ गुणों की स्थानिक परिवर्तनीयता (spatial variability) को ध्यान में रखकर सूक्ष्म पोषक तत्वों की सटीक मात्रा निर्धारित की जा सके। क्षेत्रीय प्रबंधन अंचलों (RZs) में उपलब्ध सूक्ष्म पोषक तत्वों एवं मिट्टी के गुणों का मापन करने पर इनमें काफी भिन्नता देखी गई। इससे (RZs) तकनीक से सूक्ष्म पोषक तत्वों के सटीक प्रबंधन की उपयोगिता सिद्ध हुई।
- देश में विभिन्न फसल प्रणालियों जैसी धान-सरसों, मक्का-गेहूँ, धान-चना, सरसों-मूँगफली, सोयाबीन-गेहूँ, आलू-गन्ना तथा कपास-प्याज आदि में संतुलित पोषक द्वारा अधिकतम पैदावार प्राप्त करने में सल्फर व जिंक युक्त जैविक उर्वरकों की प्रभावशीलता का मूल्यांकन किया गया। तीनों प्रमुख फसलों धान, गेहूँ तथा मक्का में $ZnSO_4$, Zn मेटेलोसेट तथा ZnEDTA के माध्यम से जिंक की प्रतिपूर्ति किए जाने के सकारात्मक परिणाम प्राप्त हुए।
- अनाज, सब्जी तथा फलों की फसलों में बोरॉन (B) पोषक हेतु पर्ण छिड़काव के रूप में B मेटेलोसेट की प्रभावशीलता का मूल्यांकन किया गया। सभी अनाज की फसलों में B प्रयोग का महत्वपूर्ण प्रभाव देखा गया। बोरॉन मेटेलोसेट के माध्यम से मानक संकेन्द्रित/सधन बोरॉन के फोलियर प्रयोग से अधिकतम प्रभाव प्राप्त हुआ।
- मध्य प्रदेश के मण्डला व बैतुल जिलों की जनजातीय आबादी में मिट्टी तथा पशु/मनुष्य स्वास्थ्य के बीच संबंध में जिंक (Zn) तथा लोहे (Fe) के महत्व का मूल्यांकन किया गया। इस आबादी में जिंक तथा लोहे के अपर्याप्त उपयोग से इनमें Zn/Fe की कमी होने का खतरा देखा गया। मिट्टी, अनाज, पशुचारा, पशुओं तथा मनुष्यों के रक्त में जिंक मात्रा में विश्लेषण किए जाने पर मिट्टी-पौधे-पशु-मनुष्यों की परस्पर निर्धरता व अंतः संबंधों की जानकारी प्राप्त हुई।

विषयवस्तु-II संरक्षण खेती, कार्बन स्थिरीकरण एवं जलवायु परिवर्तन

- एल्यूवियल मिट्टी में धान गेहूँ फसलीय प्रणाली के अंतर्गत गेहूँ के अपशिष्ट के बिना धान की सीधी रोपाई (DSR) तथा उसके पश्चात् धान के संपूर्ण अपशिष्ट के साथ शून्य जुताई के माध्यम से गेहूँ की बुवाई करने से 0-5 तथा 5-15 सेमी मिट्टी की गहराई पर SOC (7.6 ग्रा.प्रति किलो) की उच्च सघनता प्राप्त की गई जिन जिन उपचारों में धान अथवा गेहूँ के अपशिष्ट मिलाए गए थे वहाँ मिट्टी के रासायनिक व जैविक गुणों में सुधार देखा गया।
- N% अरैखिक एस.डब्ल्यू.आर.सी. मॉडल का वैब गैनुशन वॉटर रिटेंशन मॉडल, ब्रुकस कोरे वॉटर रिटेंशन मॉडल, फ्रेडलेन्ड जिंगा वॉटर रिटेंशन, कोसगी मॉडल, डर्नर वॉटर रिटेंशन मॉडल तथा सेकी वॉटर रिटेंशन मॉडल को पांच विभिन्न उपचारों अर्थात् चौड़ी क्यारी तथा फरो बिना जुताई, चौड़ी क्यारी तथा फरो-कम जुताई, बिना जुताई, कम जुताई तथा पारम्परिक जुताई में मूल्यांकन किया गया। उच्च मान R^2 तथा न्यूनतम मान (एकक सूचना) के आधार पर सीकी (2007) द्वारा विकसित मॉडल मध्य भारत के वर्टीसोल्स के जल ग्रहण गुणों के मूल्यांकन हेतु सर्वाधिक उपयुक्त था।
- मध्य प्रदेश के बहुस्थलीय आँकड़ों का प्रयोग करते हुए JG-11 कल्टीवार हेतु एपसिम (APSIM)-चना के केलीब्रेटेड मॉड्यूल की जांच की गई। प्रेक्षण किए गए तथा अनुमानित आँकड़ों के बीच R^2 (0.85) के उच्च मान से मॉडल की संतोषजनक जांच की गई। विभिन्न फसलीय अवस्था में जी आई एस से जोड़कर विभिन्न स्थानिक अध्ययनों के लिए एपसिम (APSIM) मॉडल का उपयोग किया जा सकता है।
- मध्य प्रदेश के विभिन्न जलवायु क्षेत्रों के अन्तर्गत जलवायु एवं मिट्टी के गुणों में सतही एवं उपसतही मिट्टी में मृदा जैव कार्बन (SOC) एवं नत्रजन की जांच मृदा परिछेदिकाओं से प्राप्त मिट्टी के 80 नमूनों में की गई। सभी स्थानों पर वन क्षेत्रों की तुलना में फसलीय भूमि में सतही व उपसतही परत में C तथा N कम पाए गए।
- गेहूँ की फसल में अनाज की उपज तथा WUE कम करने में "ओपन टॉप चेम्बर" अध्ययन से तापमान में बढ़ोत्तरी के बारे में जानकारी मिली। बढ़ी हुई CO_2 के उपचार के उच्चतम WUE तथा पैदावार देखी गई। बढ़े हुए तापमान वाली अवस्था में WUE तथा पैदावार में एम्बियट की तुलना में कमी देखी गई।

विषयवस्तु-III जैविक विविधता तथा जैव प्रौद्योगिकी

- मध्य प्रदेश (धान-गेहूँ), हरियाणा (धान-गेहूँ) तथा महाराष्ट्र (गन्ना) के किसानों के खेतों के फसल अपशिष्ट के विघटन में लिग्नो सेल्युलाइटिक सूक्ष्म जीवाणु (4 फंगी, 4 बैक्टीरिया, 4 एक्टिनोमाइसाइट्स) का सफलतम प्रयोग किया गया।
- पौधों में भारी धातुओं की (कैडमियम तथा लेड) सहनशीलता (पेनिसिलियम) एवं पोषण प्रयोग दक्षता (MER4) सुधारने में एन्डोफाइटिक फंगी सहायक पाई गई।
- फाइटोपैथोजेन्स के जैव नियंत्रण तथा पौधों के विकास को सुधारने हेतु स्यूडोमोनास फ्लोरेसेंस स्ट्रेन Pt 14 तथा PsChi के

जीनोम सीक्वेंसेस से जीन्स की उपस्थिति का पता चला।

- मूँगफली की पैदावार विकास तथा पोषकता हेतु डी.ए.पी.जी. उत्पादन का स्यूडोमोनस प्यूटिडा (डी.ए.पी.जी.4) तथा पी प्यूटिडा (FP86) का विकास व अनुसंशा की गई। मूँगफली में कॉलर तथा स्टेम रॉट रोग की रोकथाम में लाभदायक थे।
- ज्वार के डंठल के 45 दिनों के अंदर विघटन के लिए डिकम्पो A व B तथा जैविक कन्सॉर्शिया का विकास किया गया।
- वर्षा सिंचित अवस्था में ज्वार में तीन बायोफर्टिलाइजर (NPK) 75 प्रतिशत RDF के प्रयोग से 25 प्रतिशत RDF की बचत के साथ ही अनाज की फसल में 18 प्रतिशत की बढ़ोतरी हुई।
- केरल के वायनाड जिले की अम्लीय मिट्टी से राइजोबिया स्ट्रेन अलग किया गया जिसके काली मिर्च के पौधे में इनओकुलेट किए जाने पर उच्च पैदावार एवं विकास देखा गया। काली मिर्च की फसल को अम्लीय मिट्टी में उगाने के लिए जैव उर्वरक विकसित किया गया।
- फसलीय प्रणाली में सोयाबीन—गेहूँ में उच्च FDA देखा गया जिसके पश्चात् सोयाबीन सरसों तथा सोयाबीन अरहर प्रणाली विकसित की गई। इसी प्रकार अजैविक व समेकित प्रबंधन की तुलना में जैविक प्रबंधन में डिहाइड्रोजिनेज गतिविधि एल्केलाइन फास्फेट तथा ग्लूकोसाइडोज एन्जाइम गतिविधि उच्चतम थी।

विषयवस्तु—IV मिट्टी में प्रदूषण तथा उपचार

- कपास में Cd तथा Pb तत्वों की सहनशीलता का निर्धारण किया गया। अध्ययन में देखा गया कि कपास के पौधे 200 mg kg⁻¹ Cd मिट्टी तथा 1000 mg kg⁻¹ Pb की मात्रा सहन कर पाए।
- भारत में प्रमुख मिट्टियों में Cd की अधिकतम सीमा का निर्धारण किया गया तथा देखा गया कि Cd का मान लेटरिटिक में 4.87 एल्यूवियल में 3.22 तथा काली मिट्टी में 2.32 ppm था। सभी प्रकार की मिट्टी में महत्वपूर्ण रैखिक संबंध देखे गए।
- इन्दौर जिले की कृषि मिट्टी में भारी धातुओं (HM) के स्थानिक वितरण एवं आधारभूत सघनता के आंकलन लिए एक प्राथमिक सर्वेक्षण किया गया। स्थानिक वितरण से ज्ञात हुआ कि Cd, Ni तथा Zn सुरक्षित मात्रा में थे किन्तु Cu, Cr तथा Pb की सघनता कुछ अधिक थी।
- नगर निगम टोस अपशिष्ट पदार्थ डालने के स्थान पर पौधारोपण के लिए विभिन्न पौधों जैसे बेसरम (इपोमिया कारनिया) वेटिवर (वेटिवरिया जिजान्योडेस) सुबबूल (ल्यूसिनिया ल्यूकोसेफेला), एरण्ड (रिसिनस काम्यूनिस) आदि को रोपा गया।
- मलाजखंड क्षेत्र में कॉपर खदानों द्वारा कुप्रभावित मिट्टियों को हरा भरा बनाने के लिए बहुस्तरीय फसलें (घास—झाड़ियां छोटे पेड़—बड़े पेड़) लगाए गए। शुरु में वेटिवर घास प्रभावित मिट्टियों में लगाया गया जिसका सरवाइवल लगभग 90 प्रतिशत रहा।
- भोपाल के भानपुर नाले के पास की मिट्टी तथा पानी में भारी धातुओं की मात्रा का मूल्यांकन किया गया तथा नाले से 1 व 2 किमी दूर तक मिट्टी के नमूने लेकर विश्लेषण किया गया। भारी धातुओं की मात्रा की सघनता स्वीकार्य सीमा में पाई गई।

Executive Summary

Theme I: Soil Health and Input Use Efficiency

Balanced and Integrated Nutrient Management

- There were significant improvements in various soil health parameters including physical, chemical and biological properties in all INM modules in maize–chickpea cropping system. Balanced use of NPK along with FYM or poultry manure recorded the highest values for different soil health parameters.
- Agronomic interventions in maize revealed that crop yield and nitrogen use efficiency were significantly higher when basal dose of N was skipped and total amount of N was applied in two equal splits (60 kg N ha^{-1}) at 20 and 40 DAS.
- Biochar application along with N @ 120 kg ha^{-1} resulted in increased yield but significant increase could be recorded with 5 and 10 t biochar ha^{-1} over application of 120 kg N ha^{-1} alone.
- Pulse based cropping systems revealed ample possibility for sustainability of soybean system in Central India through crop diversification by inter-cropping with short duration pulses like pigeon pea and urd bean.
- The seed yield of soybean was recorded highest in 100% organic treatment followed by 75% organic + 25% inorganic and 75 % organic + innovative treatment (spray of cow urine and vermi-wash 10% each twice). The soybean cultivar RVS 2002-4 and maize cultivar Kanchan performed better in terms of seed yield.
- A specific methodology was developed for soil sampling and assessment of soil quality in selected AESRs of India. Using this methodology, soil samples were collected from AESR 4.1 and thematic GIS maps for selected soil quality parameters for 9 districts of Rajasthan were developed.
- The highest SQI was obtained in long-term application of balanced fertilization in Vertisols under soybean-wheat cropping system. Balanced fertilization along with manures showed positive changes in soil quality and maintained sustainability of productivity. There was a good correlation between APSIM predicted wheat grain yield and developed soil quality index ($R^2 = 0.99^{**}$).
- The soil organic carbon stock in the surface (0-30 cm) soil layer in the Vertisols and associated soils of Madhya Pradesh was assessed and found to be in the range of 4.1 to 56 Mg ha^{-1} . The study revealed that soils from eastern and central part of the state were relatively higher in SOC

stock than the western and northern part of the state which may be due to greater amount of rainfall received in eastern and central part of the state.

- The soil organic carbon, available N, P and K, EC, pH, and sand content of the Alfisols were analysed using MIR spectroscopy and it was observed that there was a good correlation between laboratory analysed soil properties and the properties estimated by MIR spectroscopy.
- A rapid quantitative method using visible (VIS)-near infrared (NIR) spectroscopy was used for characterisation of soil properties and assessment of soil quality of Vertisols of central India. The results indicated a significant and positive correlation between laboratory derived SQI and spectral derived SQI.

Nano Technology for Improving Input Use Efficiency

- The impact of nanoparticles on plant growth and metabolism of soybean, wheat and maize revealed that crop and dose specific the behavior of nanoparticles . At sub-optimal dose, nanoparticles acted as catalyst for plant growth and metabolism which may be useful for achieving higher crop yield.

Soil Fertility Evaluation

- The long-term fertilizer experiments conducted across the country clearly indicated that it is not possible to sustain productivity without external supply of nutrients.
- In Alfisols of Palampur, Ranchi and Bengaluru, FYM as soil amendment was found superior to lime as far as soil productivity is concerned. Application of organic manure moderates soil condition and also supplies plant nutrients, whereas lime improves soil pH and associated soil properties. Application of urea alone had deleterious effect on maize and wheat productivity at Palampur and other places due to decline in soil pH by one unit which reduces the availability of P and K for plant growth.
- In Vertisols of Akola, application of nutrient through organic manures could not maintain crop yield as yield obtained under 100% NPK even after 26 years. Therefore, there is need to further increase the dose of organic manure to achieve more yield compared to that obtained with inorganic nutrient supply.
- Irrespective of soil and crop, incorporation of farmyard manure or green manure not only resulted in increased in crop productivity but also increased microbial count and

enzymatic activities. At Pantnagar, application of S and Zn together showed additive effect on rice yield.

- The validity of fertilizer adjustment equations was tested in terms of yield sustainability and maintenance of soil fertility in a long-term experiment under pearl millet-wheat cropping sequence. The available N and P in different treatments revealed that the application of FYM and / or fertilizers resulted in maintenance or improvement of these nutrients in soil.
- Using GPS & GIS tools, regional management zones (RZs) in a Deccan Plateau Region of India were developed for precise micronutrient prescription by considering spatial variability of some soil properties and available micronutrients. The measured soil properties and available micronutrients in the RZs varied significantly highlighting the usefulness of RZ delineation technique for precise micronutrients management.
- The efficacy of newly developed sulphur and zinc containing complex fertilizers was evaluated for maximizing yield through balanced nutrition of different cropping sequences namely rice–mustard, maize–wheat, rice–black gram, mustard–groundnut, soybean–wheat, potato–sugarcane and cotton–onion across the country. The performance of new complex fertilizers was at par with the performance of straight fertilizers.
- The efficacy of liquid formulations i.e. Zn metalosate and B metalosate was evaluated in cereal, vegetable and fruit crops. The performance of Zn and B containing liquid formation was at par/or superior to the performance recorded under Zn and B application from the standard sources.
- In order to assess the link between soil health and animal/human health, soil, food, feed, plant and animal/human blood samples were collected from Mandla & Betul districts of M.P. Analysis of Zn/Fe content in soil, grain, straw feed, animal and human blood serum established a strong correlation and interdependence among different components of soil-plant-animal human continuum.

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

- Direct seeded rice (DSR) without wheat residue in reduce tillage (RT) maintained higher concentration of SOC in both 0-5 and 5-15 cm of soil depths followed by zero tilled wheat with entire rice residue retention in rice-wheat cropping system in alluvial soils. The treatments where

rice or wheat residues were added improved the soil chemical and biological properties.

- Six non-linear SWRC models viz. van Genuchten water retention mode, Brooks-Corey water retention model, Fredlund-Zing water retention model, Kosugi model, Durner water retention model and Seki water retention model were evaluated from five different treatments namely broad bed and furrow – no tillage, broad bed and furrow – reduce tillage, no tillage, reduce tillage and conventional tillage. Based on higher value of R^2 and lower value of Akaike information criterion, Seki water retention was the best suited for evaluation of water retention characteristics of Vertisols of central India.
- A well calibrated APSIM-chickpea module was validated for JG-11 cultivar using the multi-locational data from Madhya Pradesh. The observed and predicted data indicated the satisfactory validation of the model ($R^2=0.85$). The APSIM model could be used for spatial studies by linking with the GIS for exploring agronomic adaptations.
- Using data from 80 soil profiles, soil organic carbon content at surface and subsurface soil was investigated in relation to climate and soil properties under various climate regimes of Madhya Pradesh. Across all sites, cropped land had significantly lower C and N stocks in the surface and subsurface soil layers than native forest sites.
- The Open Top Chamber study revealed that rise in temperature reduced water use efficiency (WUE) and grain yield in wheat crop. On the other hand, elevated CO_2 alone and in combination with elevated temperature increased the WUE and yield. The highest WUE and yield was observed under elevated CO_2 treatment. As compared to ambient, there was a significant reduction in the WUE and yield under elevated temperature condition.

Theme III: Microbial Diversity and Genomics

- A consortia of ligno-cellulolytic microorganisms (4 fungi, 4 bacteria, 4 actinomycetes species) were used for in-situ decomposition of crop residues in farmer fields of Madhya Pradesh (rice-wheat), Haryana (rice-wheat) and Maharashtra (sugarcane).
- Endophytic fungi (*Penicillium sp.*) proved to be efficient for improving nutrient use efficiency (MER4) and heavy metal (cadmium and lead) tolerance of host plants.
- Genome sequences of *Pseudomonas fluorescens* strains Pt 14 and PsChi revealed the presence of genes for improving plant growth and biocontrol of phytopathogens.

- Formulations of DAPG-producing *Pseudomonas putida* (DAPG4) and *P. putida* (FP86) were developed and recommended for enhancing growth, yield and nutrient uptake in groundnut. The inoculants were also useful to manage stem and collar rot diseases of groundnut.
- Microbial consortia of Decompo A and Decompo B were developed and found to decompose sorghum straw within a period of 45 days.
- Rhizobia strains isolated from acidic soils of Wayanad district of Kerala upon inoculation to pepper plants exhibited significantly higher growth and yield compared to non-inoculated control. Biofertilizers for pepper crop grown in acidic soil was developed.
- Among the cropping systems, soybean-wheat recorded higher FDA followed by soybean-mustard and soybean-chickpea system. Similarly, dehydrogenase activity, alkaline phosphatase and β -Glucosidase enzymes activities were highest in organic management compared to in inorganic and integrated management.

Theme IV: Soil Pollution, Remediation and Environmental Security

- Tolerance limit of cotton to Cd and Pb was determined. The study indicated that cotton plant could tolerate up to 200 mg Cd kg soil⁻¹ and 1000 mg Pb kg soil⁻¹ without any mortality.
- Critical limits of Cd in major soil orders of India were determined. Transfer coefficient value for Cd was significantly higher in lateritic (4.87) followed by alluvial (3.22) and black soil (2.32). Significant linear relationship was observed between the extractable Cd by 1 M CaCl₂ extractant and total Cd content with R² value of 0.98, 0.98 and 0.96 in lateritic, alluvial and black soil, respectively.
- A primary survey was conducted to estimate the baseline concentrations and spatial distribution of heavy metals in agricultural soils of Indore district. The spatial distribution showed that concentrations of Cd, Ni and Zn were within the safe range but the concentrations of Cu, Cr and Pb were higher.
- Plantation of various crops like Beshram (*Ipomoea carnea*), Vetivar (*Vetiveria zizanioides*), Subabul (*Leucaena leucocephala*), Castor (*Ricinus communis*) etc have been done for the establishment of green cover at the municipal solid waste dumping site at Bhanpur, Bhopal.
- Establishment of green cover by multitier plantation crops (Grass–Shrubs–Small trees–Tall trees) and rejuvenation of the soil system was carried out at copper mining affected land in Malanjhand area of Madhya Pradesh. Initially, Vetiver grass (*Vetiveria zizanioides*) was planted in the experimental site and its survival percentage was found to be 90%.
- The heavy metal load in water and nearby soil of Bhanpur Nala, Bhopal was assessed. The analysis of soil samples collected from near Nala, 1 km and 2 km away from Nala showed that heavy metal concentration was within the permissible limits.



1. Introduction

Food and nutritional security are the two major global challenges of the 21st century which depends primarily upon the soil resources for successful eradication of hunger and malnutrition. Intensive agriculture has resulted in unprecedented exploitation of scarce soil resources worldwide. Though, India has achieved self-sufficiency in food grain production, yet there is a need to produce more food from limited resources for burgeoning population. However, during last 4-5 decades, soil health is declining at faster rate with higher rates of erosion, declining factor productivity and reduced nutrient use efficiency, loss of soil biota and degradation of land due to environmental pollution. Under such scenario, increasing food-grain production from shrinking land resources requires reorientation of research pursuits, addressing the emerging issues like enhancing nutrient and water use efficiency; sustaining soil and produce quality; exploitation of soil biodiversity and genomics, conservation agriculture to adapt to climate change and carbon sequestration; minimizing soil pollution etc. ICAR-IISS was established on 16 April, 1988 with the mission of "Providing scientific basis for enhancing and sustaining productivity of soil resources with minimal environmental degradation". Since its inception, the institute has made earnest 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 three All India Coordinated Research Projects and one All India Network Project. These four institute based projects act as a part of the "Network-Support Programmes" of the Institute with their centers located in various State Agricultural Universities and ICAR institutes, providing access to the diverse soils, agro-ecosystems across the agro-ecological zones of the country for effective implementation of the various programs of the Institute at national level. During the year under report, the institute has made significant scientific contributions in the frontier areas of soil science such as input use efficiency including nanotechnology, carbon sequestration and climate change, integrated nutrient supply system (IPNS), biofortification, nutrient transformation and dynamics in soil-plant systems, organic matter recycling and management, soil biodiversity and genomics, environmental impact on agricultural production, utilization of solid wastes and waste water, bio and phyto-remediation. The salient research findings, infrastructural development, technology transfer, human resource development, awards and recognitions and linkages and collaborations etc. are briefly highlighted in this annual report.

1.1 Mission and Mandate

The Institute has the mission of "Providing scientific basis for enhancing and sustaining productivity of soil resources with minimal environmental degradation" with following mandates:

- Basic and strategic research on physical, chemical and biological processes in soils related to management of nutrients, water and energy
- Advanced technologies for sustainable soil health and quality
- Coordinate the network research with State Agricultural Universities, National, International and other Research Organizations

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
- Nutrient 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
- Quality compost production and quality standards

Programme 4: Soil Pollution, Remediation and Environmental Security

- Bio-remediation/ phytoremediation of contaminated soils
- Waste waters – quality assessment and recycling

1.3 Organizational Setup

Divisions

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

Sections

- (i) Farm Section
- (ii) Administration Section
- (iii) Remote Sensing & GIS

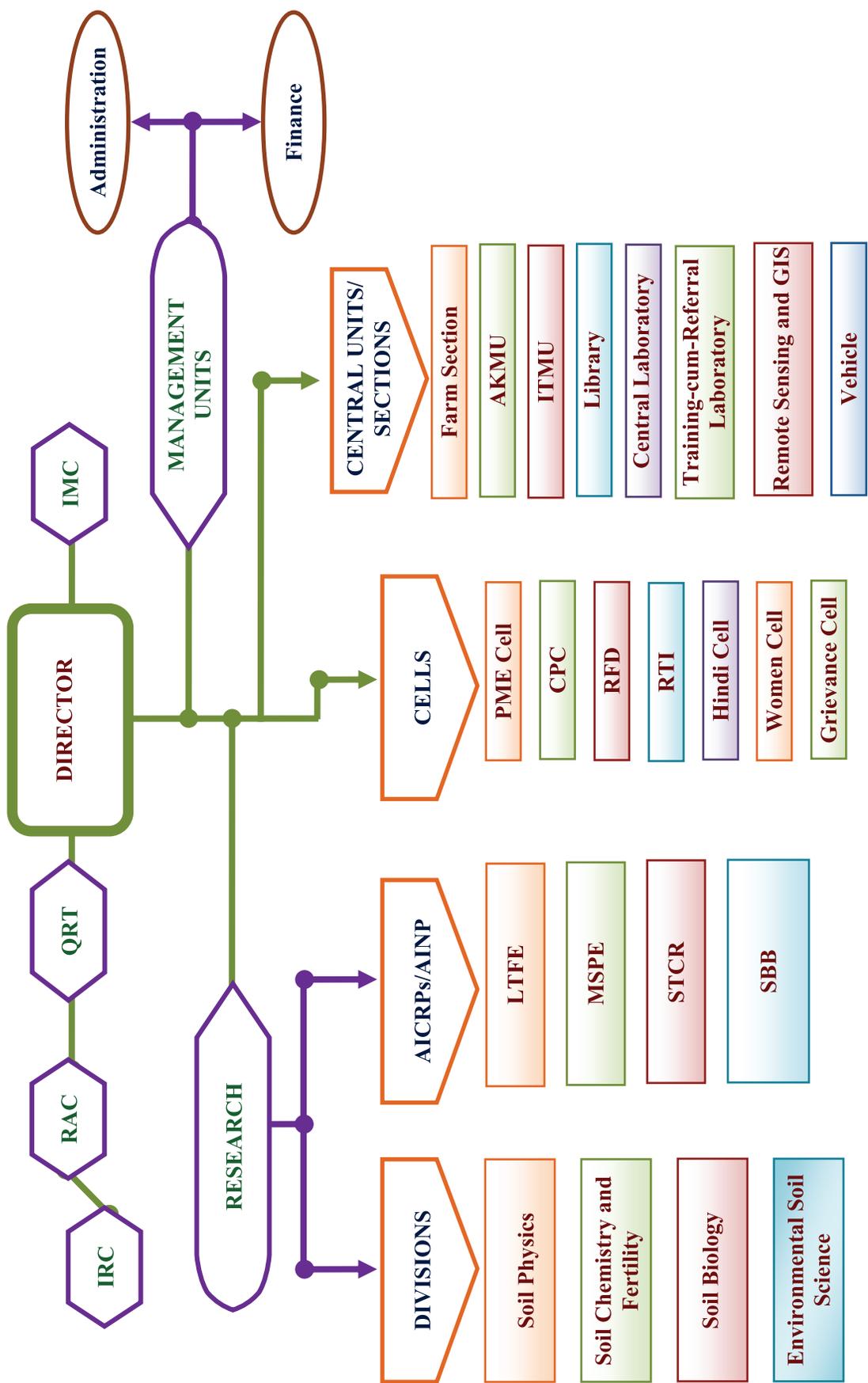
Technical Units/Cells

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

All India Co-ordinated Research Projects (AICRPs)

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

Organizational Setup



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	1	1
3	Agricultural Extension	0	0	1	1	0	0	1	1
4	Agricultural Microbiology	1	1	2	4	0	1	2	3
5	Agricultural Statistics	0	1	2	3	0	0	2	2
6	Agromony	1	2	4	7	0	1	4	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	9	7	15	31
	Total	13	16	28	57	11	11	26	48

b) Technical

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

c) Administrative

S. No.	Designation	Sanctioned	In Position
1	Sr. Administrative Officer	1	1
2	Finance & Accounts Officer	1	1
3	Assistant Finance & Accounts Officer	1	1
4	Assistant 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	2
12	Skilled Supporting Staff	25	18
	Total	53	38
	Grand total	106	103

1.5 Finance: Budget statement (₹ in Lakhs) for the financial year 2017-18 is as follows

Institute/AICRPs	Budget	Expenditure
Main IISS Institute	1693	1690.71
AICRP- LTFE	449	423.64
AICRP- STCR	658	651.62
AICRP- MSPE	645	669.44
AINP on Biofertilizer	310	309.99
CRP on CA Platform	275	274.92
Total	4030	4020.32

1.6 Resource Generation

Head of Account	Amount (₹)
Sale of farms produce	987963
Sale of fish	700
Income from royalty, sale of publication and advertisement	16599
License fee	445363
Interest earned on loans and advances	1840242
Analytical and testing fee	7500
Application fee from candidates	5000
Diploma charges	42210
Interest earned on short term deposits	8073431
Income generated from internal resource generation	5704415
Recoveries of loans & advances	16192247
Leave salary and pension contribution	356714
Miscellaneous receipts	38192247
Total	71864631



2. Research Achievements

Theme-I: Soil Health and Input Use Efficiency

2.1 Improving Input Use Efficiency

2.1.1 Integrated nutrient management (INM) practices for enhancing crop productivity and soil health in maize-chickpea cropping sequence

Maize and chickpea yields were significantly differed with the application of various integrated nutrient management (INM) modules in long term fertilizer experiment at IISS research farm (Table 2.1.1). Maize grain yield was significantly higher in STCR based integrated nutrient management module i.e. 75% NPK of STCR along with FYM at 5 t ha⁻¹ followed by integration of 75% NPK + poultry manure at 1 t ha⁻¹ as compared to general recommended dose and 100% NPK alone (Fig. 2.1.1). However, the integration of NPK fertilizer with urban

compost, maize residue and glyricidia loppings showed higher maize yield than integration of NPK fertilizer with FYM and poultry manure. The response to urban compost and maize residue at 5 t ha⁻¹ along with 75% NPK of STCR based fertilizer was at par. The application of 5 t FYM in every season also enhanced the grain and straw yield of chickpea as compared to residue management (mulching by maize residues). Increase in grain and straw yield of chickpea might be due to residual effect of organic manures application in maize crop (Fig. 2.1.2). There were significant improvement in various soil health parameters including chemical, biological and physical properties in all INM modules over the initial status in surface soil (0–15 cm). The results indicated that balanced use of NPK along with FYM or poultry manure recorded the highest values for the analyzed soil parameters.

Table 2.1.1 Treatment details

Treatment	Maize	Chickpea
T ₁	No fertilizer/ manure	No fertilizer/ manure
T ₂	120-60-30	20-60-20
T ₃	135-55-50 (target 5 t maize)	0-0-0 (target 1.5 t chickpea)
T ₄	75% NPK of T ₃	100% P only
T ₅	75% NPK of T ₃ +5 t FYM	100% P only
T ₆	75% NPK of T ₃ +1 t PM	100% P only
T ₇	75% NPK of T ₃ +5 t UC	100% P only
T ₈	75% NPK of T ₃ +MR	100% P only+ MR as mulch
T ₉	MR+1 t PM+2 t Gly	100% P only+ MR as mulch
T ₁₀	MR+5 t FYM+2 t Gly	100% P only+ MR as mulch
T ₁₁	20 t FYM (every season)	5 t FYM (every season)
T ₁₂	75% NPK of T ₃ +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 loppings

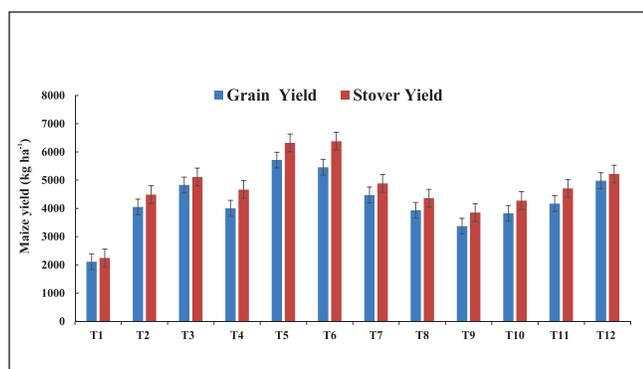


Fig. 2.1.1 Yield performance of maize under different INM modules

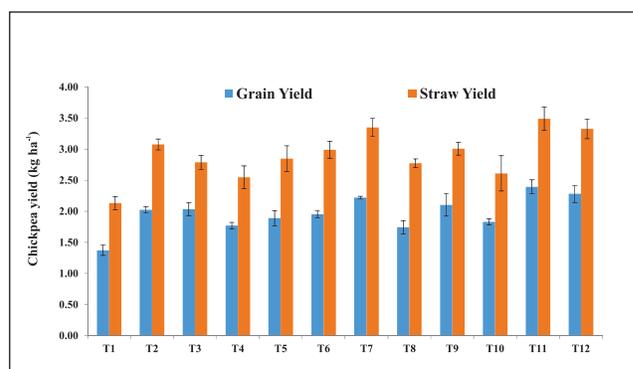


Fig. 2.1.2 Yield performance of chickpea under different INM modules

2.1.2 Assessing modified urea materials and agronomic interventions for enhancing nitrogen use efficiency and sustaining crop productivity

The efficacy of modified slow release urea materials/products viz. pine oleoresin coated urea (POR), zeolite coated urea (ZCU), biochar coated urea (BCU) and prilled urea (PU) were tested in maize with respect to crop yield and nitrogen use efficiency (NUE). Results revealed that among the different modified urea products, BCU was at par with NCU in enhancing the crop yield and apparent N use efficiency of applied N. However, the highest grain and stover yield was observed with the application of NCU. POR also improved the crop yield to some extent as compared to prilled urea. In general, the increase in grain yield was 19%, 9.87% and 7.71% under NCU, BCU and POR, respectively over the prilled urea at higher dose of N (120 kg N ha⁻¹). The increment in total crop yield might be due to slow release of N for longer period during crop growth. Application of ZCU resulted in slight reduction in the maize yield. Management strategies that maximize nitrogen utilization through proper method and time of application by minimizing nitrogen losses are necessary for enhancement of crop productivity and higher use efficiency. Results revealed that crop yield and NUE were significantly higher where basal dose of N was skipped and total amount of N was applied in two equal splits (60 kg N ha⁻¹) at 20 and 40 DAS, respectively. The highest grain yield was observed with soil test crop response equation based (STCR) fertilizer application.

2.1.3 Effect of biochar application in different soils on crop performance

A study was conducted to assess the method of biochar application for enhancing nutrient use efficiency. During first year when N was applied after absorbing it in biochar, a decline in maize productivity was observed with increasing dose of biochar. During second year, biochar was mixed in plough layer at different rates and maize crop was grown with usual N application. Results revealed that maize grain yields varied between 1336 and 4363 kg ha⁻¹. The highest

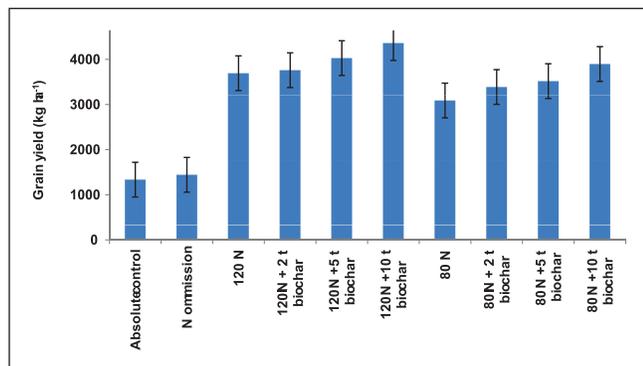


Fig. 2.1.3a Effect of biochar on grain yield of maize

grain yield was recorded with application of 120 kg N + 10 t biochar ha⁻¹. Fertilizer application showed significant effect on seed and biomass yield. Biochar application along with N @ 120 kg ha⁻¹ resulted in increased yield but significant increase was recorded with 5 and 10 t ha⁻¹ biochar over application of 120 kg N ha⁻¹ alone. At lower N level of 80 kg N ha⁻¹ with or without biochar, there was significant decrease in grain yield of maize (Fig. 2.1.3a).

Effect of biochar application was studied on acid soil of Chhattisgarh and was found as effective as lime in terms of

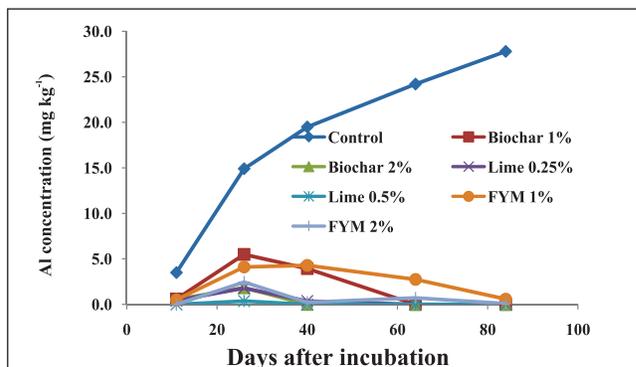


Fig. 2.1.3b Effect of different amendments on aluminum concentration in soil

wheat biomass yield and nutrient uptake by wheat (Plate 2.1.3). Further a laboratory incubation study revealed that biochar increased the pH of the incubated soils and decreased the activity of aluminum ions (Fig. 2.1.3b) besides increasing the concentration of nutrients such as P, K, Ca and Mg in the soil solution.



Plate 2.1.3 Effect of treatments on (a) P availability and (b) wheat crop performance

2.1.4 Impact of nano-particles on plant growth and metabolism

The impact of nano-micronutrient fertilization on growth and metabolism of soybean, wheat and maize was studied using Fe, Cu and Zn nano-particles (NPs) based nutrient formulation. The responses were evident on morphological, physiological and biochemical characteristics of the crops towards the graded concentrations of Fe, Cu and Zn NPs. In soybean, the nano-micronutrient fertilization of plants with optimal concentration of Fe NPs/ Cu NPs / Zn NPs positively influenced the shoot growth, grain yield and biochemical traits viz. total soluble protein, membrane stability, proline accumulation in plants. However, sub-optimal concentration of NPs positively influenced root growth and gas exchange parameters viz. photosynthesis rate (Fig. 2.1.4), transpiration rate and stomatal conductance of plants. In wheat, the nano-micronutrient fertilization of plants with NPs at optimal concentration had positively influenced most of the morphological parameters while the sub-optimal concentration of NPs positively influenced biochemical traits viz. proline accumulation, chlorophyll content of plants. Gas exchange parameters were also positively influenced by NPs in wheat. These findings indicated that the effect of nanoparticles and its dose was crop specific. Moreover, it was also observed that nanoparticles at sub-optimal concentration may act as catalyst for plant growth and metabolism which may be useful for achieving higher crop yield.

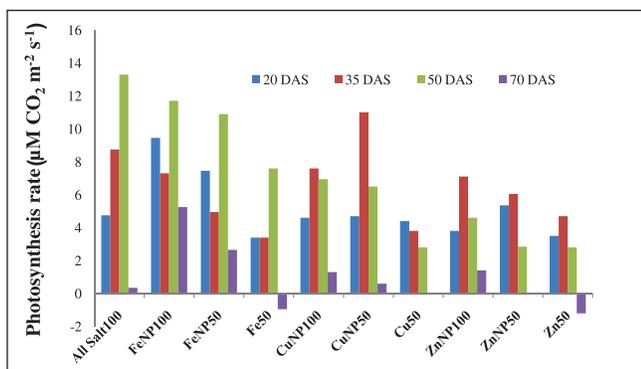


Fig. 2.1.4 Photosynthesis rate of soybean grown with Fe, Cu and Zn NPs

2.1.5 Enhancing resource use efficiency in pulse based cropping systems in central India

Morpho-physiological study showed that BBF had distinct advantage for both kharif and rabi crops under pulse based intercropping systems. There was a significant enhancement in crop productivity under BBF over the flat bed system to the tune of 21.3, 25.7 and 23.6 per cent in soybean alone, soybean equivalent yield (SEY) based on kharif inter crops and total

productivity during kharif, respectively (Table 2.1.5). In terms of total system productivity for both kharif + rabi (soybean + intercrop - lentil) crops, significantly higher total soybean productivity was recorded with soybean + pigeon pea - lentil followed by soybean + urd bean - lentil under Vertisols of central India. In addition to the significant effect of BBF in soybean + pigeon pea system, one supplementary irrigation to lentil crop at pod development stage has further enhanced its productivity over the rainfed crop. Thus, the study revealed that there was ample possibility for sustainability of soybean system in central India through crop diversification by inter-cropping and crop rotation with short duration pulses like pigeon pea and urd bean.

Table 2.1.5 Effect of land configuration and intercropping system on total system productivity (kg ha⁻¹)

Configuration/ Intercropping	Soybean	Intercrop	Lentil	System productivity
Land configuration				
Flat bed	421	1110	693	2363
BBF	502	1312	808	2785
CD (<i>p</i> =0.05)	68	96	64	108
Intercropping system				
Soybean-pigeonpea-lentil	432	3556	584	4691
Soybean-sorghum-lentil	465	565	604	1756
Soybean-urd bean-lentil	481	684	1049	2425
Soybean-maize-lentil	483	544	765	1945
Soybean-sesame-lentil	445	707	750	2053
CD (<i>p</i> =0.05)	NS	274	83	192

2.1.6 Assessment of soil quality parameters in selected agro-ecological sub-regions (AESRs)

A specific methodology was developed for soil sampling and assessment of soil quality in selected AESRs of India. Using this methodology, soil samples were collected from AESR 4.1 and 9.1 covering 12 districts of Haryana and 16 districts of Punjab state. Samples collected from Rajasthan and Punjab (Plate 2.1.6) were analyzed for soil quality parameters and thematic GIS maps were developed for selected soil quality parameters for 9 districts of Rajasthan under AESR 4.1 (Fig. 2.1.6).



Plate 2.1.6 Soil sampling from farmers' field in Jalandhar district of Punjab

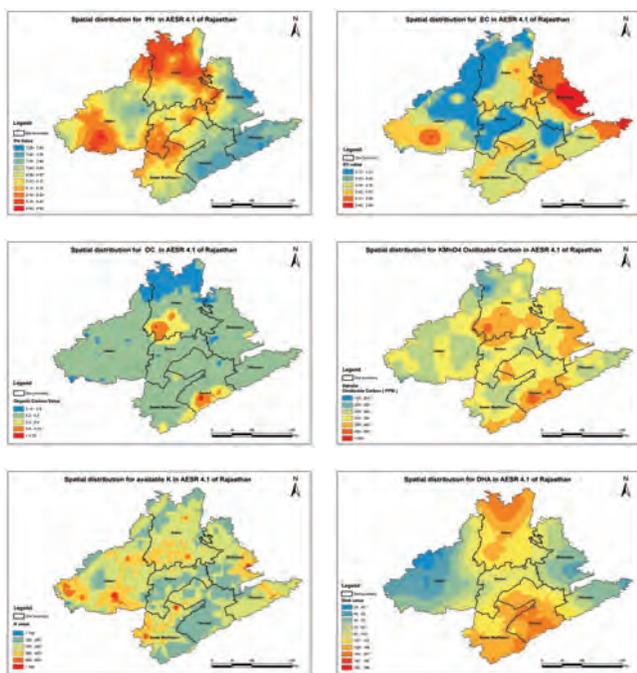


Fig. 2.1.6 Thematic maps for selected soil quality parameters from AESR 4.1 of Rajasthan

2.1.7 Spectral soil quality index for characterising Vertisols of central India

A rapid quantitative method using soil spectra was used for successful characterisation of soil properties of Vertisols of central India. The soils were characterised for their physical and chemical properties using visible (VIS)-near infrared (NIR) spectroscopy. The objective was to study specific indicator properties and soil quality index both from laboratory analysed data and from spectral analysed soil properties. The laboratory analysed soil samples (N=143) with sand, silt, clay, bulk density (BD), available N, P, K, pH and EC values were used for development of soil quality index (SQI) following the principal component analysis (PCA) method. Random forest methodology was used to

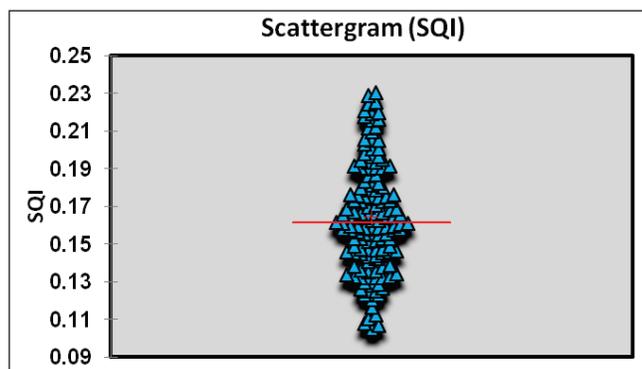


Fig. 2.1.7a Scattergram showing laboratory based soil quality index from Vertisols

predict soil indicators and SQIs (Fig. 2.1.7a) The soil properties with their mean, median and range values are presented in Fig. 2.1.7b. The same soil properties were also analysed using soil spectra following multivariate analysis. SQI was predicted from both spectrally derived indicator values and directly from soil spectra, and the accuracy was assessed by comparison with laboratory derived measurement. The results indicated a significant and positive correlation ($R^2 = 0.81^{**}$) between laboratory derived SQI and spectra derived SQI for the studied Vertisols of central India (Fig. 2.1.7c).

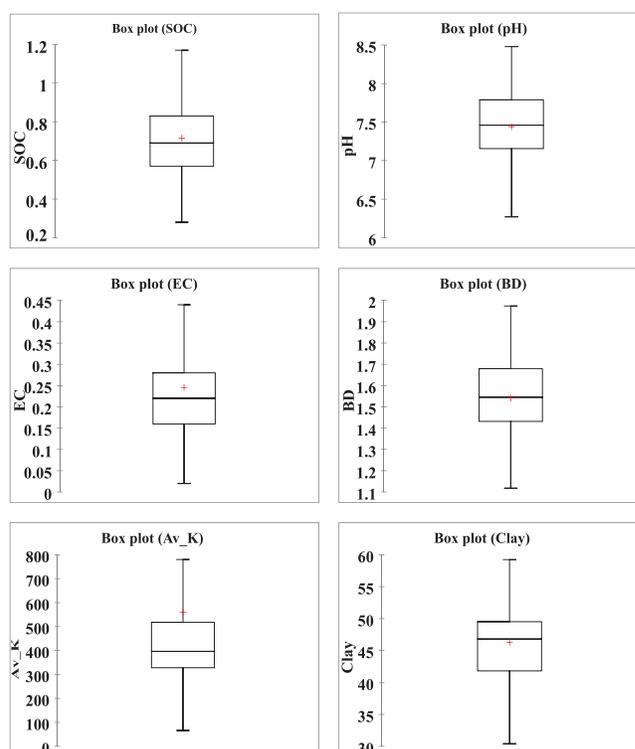


Fig. 2.1.7b Box plot diagram to show different soil properties used for spectral soil quality estimation

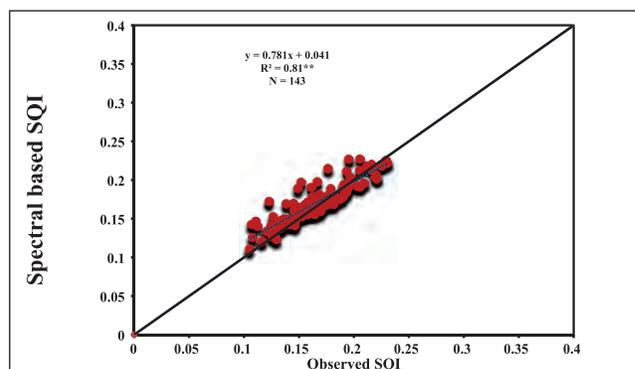


Fig. 2.1.7c Relationships between laboratory based SQI and SQI spectral based

2.1.8 Indexing soil quality under soybean-wheat cropping system in Vertisols of central India

A study was undertaken to identify suitable indicators of soil quality from a long-term fertilizer experiment conducted since 1972 in a Vertisol of Jabalpur. Surface (0–0.15 m) soil samples were collected after harvest of wheat crop and were analyzed for 15 numbers of physical, chemical, and biological properties. Soil quality index (SQI) was calculated based on analysed soil properties. Highest and lowest overall SQI values were found in balanced fertilization along with farmyard manures and control treatments, respectively. Balanced fertilization along with manures showed positive change in soil quality and maintained sustainability of productivity. Calibrated and validated APSIM model was used to predict wheat yield from these treatments and was found to estimate grain yield of wheat satisfactorily. Also there was a good correlation between APSIM predicted wheat grain yield and developed soil quality index ($R^2 = 0.99^{**}$) while considering treatments like control, 50% NPK, 100% NPK, 150% NPK and 100% NPK + 5 t FYM ha⁻¹ (Fig. 2.1.8a & b).

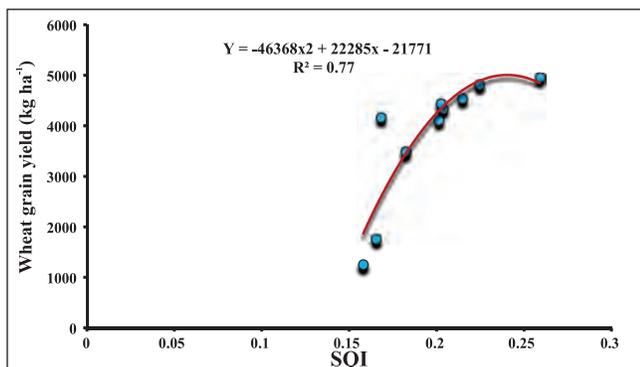


Fig. 2.1.8a Relationships between soil quality and wheat grain yield from LTFE Jabalpur

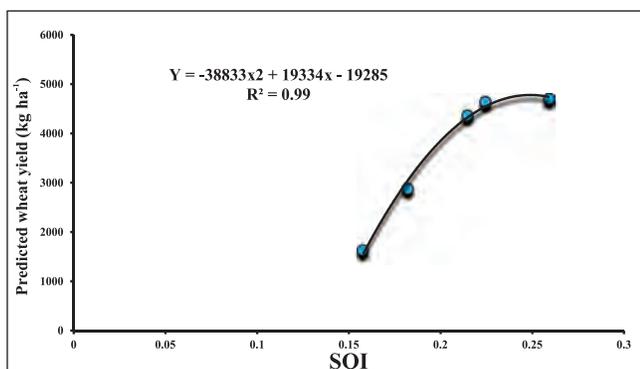


Fig. 2.1.8b Relationships between soil quality and wheat grain yield as predicted by APSIM

2.1.9 Soil organic carbon stock assessment in the Vertisols and associated soils of Madhya Pradesh

Soil organic carbon stock was estimated in the surface 30 cm soil layer collected from Vertisols and associated soils of Madhya Pradesh (Fig. 2.1.9a). More than 5000 soil samples were collected and analysed for Walkley Black carbon and TOC for this study. The soil organic carbon stock for the top 30 cm soil layer of the studied Vertisols and associated soils are presented in Fig. 2.1.9b. The study revealed that soils from eastern and central part of the state contain relatively higher SOC stock than the western and northern part of the state which may be due to greater amount of rainfall received in eastern and central part of the state.

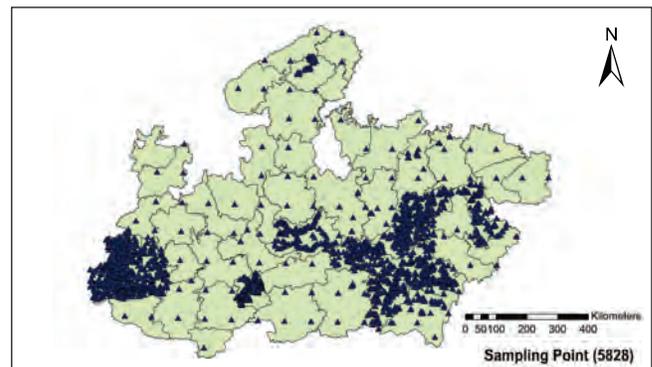


Fig. 2.1.9a Sampling point from Vertisols and associated soils of Madhya Pradesh

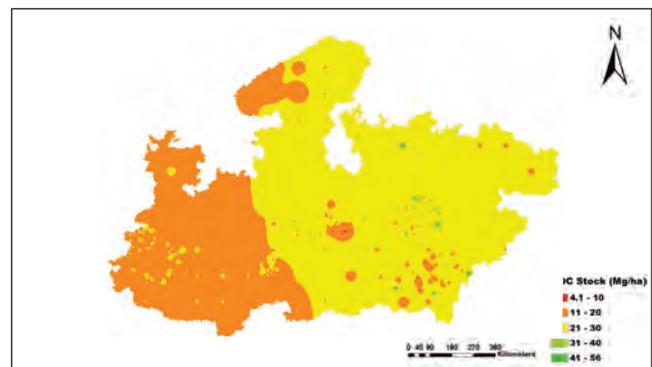


Fig. 2.1.9b Carbon stocks in the surface soil layer (0-30 cm) of Vertisols and associated soils of M.P.

2.1.10 Development of chemometric models for estimation of major soil properties of Alfisols using mid infra-red (MIR) spectroscopy

Geo-referenced soil samples collected from Alfisols were processed and mid infrared spectra between 400–4000 cm⁻¹ wave number of the ground soil samples were recorded. Soil organic carbon (SOC), available N, P, K, EC, pH, sand, silt and clay content of the soil samples were determined following standard laboratory procedures. The Kennard-

Stone (KS) algorithm method was then used for selection of representative data subsets for calibration and validation of models from the generated soil MIR spectra. About 70% data were used for development of chemometric model and 30% of soil sub-samples for the model validation. First the MIR soil spectra were transformed to first derivative using Savitzky-Golay method. Then random forest regression method was used to develop prediction model for the various soil properties. Validation of the models was done with independent data set and the predictability was tested through coefficient of determination (R^2) values.

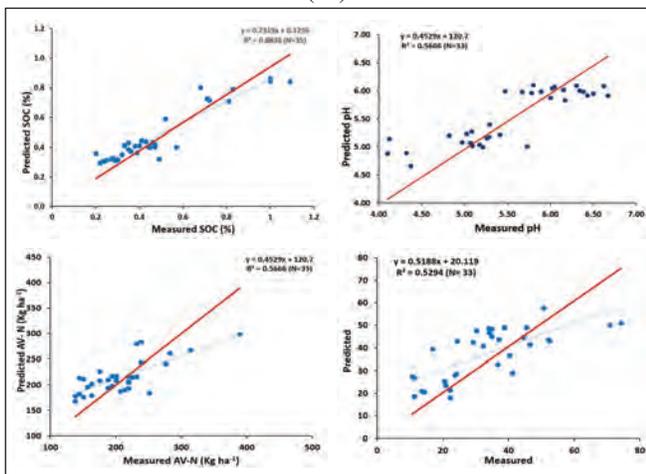


Fig. 2.1.10 Validation of chemometric model developed for rapid estimation of soil properties in Alfisols

2.1.11 Evaluation of organic, inorganic and integrated crop management practices in soybean

Field experiments were conducted during kharif season of 2017 at ICAR-IISS research farm. The seed yield of soybean was significantly differed under different production system (Tabel 2.1.11). The seed yield of soybean was recorded highest in 100% organic treatment followed by 75% organic +25% inorganic and 75% organic + innovative treatment

(spray of cow urine and vermiwash 10% each twice) which were significantly higher than 100% inorganic and state recommendation treatments (Plate 2.1.11).



Plate 2.1.11 Soybean crop under organic farming

2.1.12 Evaluation of varietal response of major crops under organic farming

Different varieties of soybean and maize were evaluated for their yield response to screen out promising varieties for organic management practices in central India. Among the varieties of soybean grown under similar organic nutrient sources and levels, the cultivar RVS 2002-4 (1890 kg ha^{-1}) performed better in terms of seed yield followed by JS 97-52, RVS 2002-6, JS 20-34, RVS 2002-7 and JS 335. Among the maize varieties, yield of Kanchan variety recorded the highest yield (3920 kg ha^{-1}) followed by Proagro 4212, JM 8, Pratap 6, Pratap 5, JM 216, JM 12 and CPBG 4202 and was the lowest yield was recorded in Sweet Corn. Analysis of nutritional quality constituents such as protein and oil content of the said varieties of soybean indicated higher protein content in cv JS 9305 variety followed by JS 20-29, JS 335 and NRC 37. However, higher oil content was recorded in RVS 2002-7 soybean variety. Similarly in maize, the higher values of protein was recorded in Proagro 4212 variety (Table 2.1.12).

Table: 2.1.11 Soybean yield (kg ha^{-1}) under different nutrient management practices

Cropping System (CS)	Organic (As per NPOF standard)		Inorganic		Integrated	
	Practice 1	Practice 2	Practice 3	Practice 4	Practice 5	Practice 6
CS1	1483	1456	1311	1294	1323	1460
CS2	1492	1436	1224	1267	1301	1459
CS3	1533	1342	1252	1284	1402	1445
CS4	1471	1415	1283	1342	1318	1363
CD (p=0.05)	Manure		78			
	Cropping System		NS			
	Manure x Cropping System		105			

Cropping systems: (CS1) Soybean-wheat, (CS2) Soybean-mustard, (CS3) Soybean-chickpea and (CS4) Soybean-linseed; 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 vermi-wash 10% each twice); Practice 3= 50% Organic + 50% inorganic; Practice 4=75% Organic + 25% inorganic; Practice 5= 100% inorganic package; Practice 6=State recommendations

Table 2.1.12 Performance of maize and soybean cultivars under organic farming practices

Variety	Maize			Variety	Soybean		
	Seed yield (kg ha ⁻¹)	Protein (%)	Tryptophan (g/16 g N)		Seed yield (kg ha ⁻¹)	Protein (%)	Oil (%)
Kanchan	3920	9.91	0.90	JS 335	1547	37.2	19.7
Pratap 5	3297	9.49	0.88	JS 93-05	1513	37.4	19.4
Arawali	2920	9.89	0.78	JS 95-60	1540	37.0	19.0
Sona 222	3147	9.71	0.86	JS 20-41	1520	36.3	19.8
Pratap 6	3357	9.36	0.79	NRC 7	1523	36.2	19.2
JM 216	3273	9.79	0.77	NRC 37	1320	36.9	19.0
Popcorn 1	2483	9.80	0.76	JS 20-29	1500	37.3	19.8
JM 8	3570	9.83	0.86	RVS 2002-4	1890	36.6	19.8
JM 12	3187	9.44	0.82	RVS 2002-6	1773	36.5	19.8
Proagro 4212	3880	9.99	0.91	RVS 2002-7	1623	36.5	20.1
Sweet Corn	2443	9.30	0.75	JS 97-52	1777	36.5	19.1
CPBG 4202	3243	9.90	0.81	JS 20-34	1663	36.7	18.7
CD (<i>p</i> =0.05)	603	0.29	0.06	CD (<i>p</i> =0.05)	121	NS	0.41

2.1.13 Effect of slow N release formulations on maize

A field experiment consisting of 15 treatment combinations involving two N levels, two formulations and a control was initiated to assess the formulations from M/s Rhodia Speciality Chemical Fertilizer Pvt Ltd. Maize (CV 4212) grain yield under different treatments varied between 2717 and 7484 kg ha⁻¹ (Fig. 2.1.13). A application of N at lower level i.e. 80 kg ha⁻¹ with test formulations, the maize grain yield ranged between 4636 and 5839 kg ha⁻¹. The formulation 0.3% AgRho N protect B resulted in significantly higher yield over 0.2% AgRho N protect B at 80 N ha⁻¹. The maize grain yield increased with 120 kg N ha⁻¹ for urea, NUC as well as test formulations and varied between 5578 and 6277 kg ha⁻¹. The formulation AgRho NN protect B produced higher yield over N protect B at both the concentrations. At 120 kg ha⁻¹ N application, the highest grain yield was recorded with 0.3% AgRho NN protect B which was statistically at par with 0.2% AgRho NN protect B. The agronomic N use efficiency varied between 21.03 and 41.71 per cent which was highest at 80 kg N ha⁻¹ followed by 120 kg N ha⁻¹.

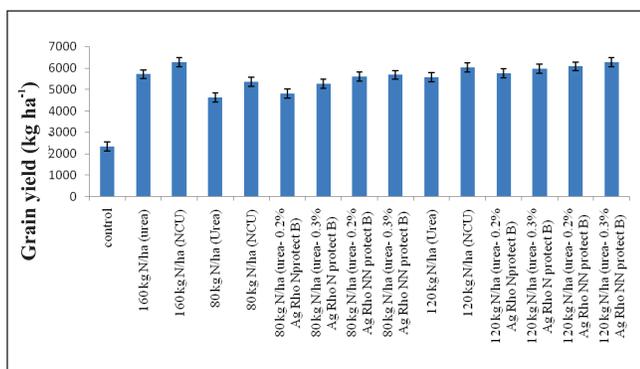


Fig. 2.1.13 Effect of different N formulations on maize grain and stover yield and N uptake

2.2 AICRP on Long Term Fertilizer Experiments (LTFE)

2.2.1 Impact of nutrient management on crop productivity and sustainability under LTFE in India

The impact of fertilizers and organic manures on productivity of different cropping systems in major soils and agro-ecological regions of India emanated from AICRP-LTFE at different locations is presented below:

Inceptisol

Barrackpore (Rice-wheat-jute)

The results revealed that rice, wheat and jute responded to applied N but the response of crop to applied P was observed only in Jute (Table 2.2.1). No response to the applied P in rice and wheat crop was due to low yield of both the crops. Delay in sowing/harvesting of one crop delayed sowing of next two crops which ultimately effects the crop yield. Perusal of data further indicated that there is response of rice and jute to applied S but wheat did not show any response to applied S. It is interesting to note that response of applied K in rice and jute was probably due to downward movement of soluble K during rainy season. Application of FYM over and above NPK and higher dose of nutrient (150% NPK) resulted increase in yield of all the three crops in cropping system.

Coimbatore (Finger millet-maize)

Finger millet and maize cropping system is being grown at Coimbatore (Vertic ustochrept). The results clearly demonstrated that both the crops showed response to the applied N and P but not to the applied S and Zn (Table 2.2.1). Incorporation of FYM over and above NPK enhanced the

Table 2.2.1 Average grain yield (kg ha⁻¹) of crops at Barrackpore and Coimbatore

Treatment	Barrackpore			Coimbatore	
	Rice	Wheat	Jute	Finger millet	Maize
Control	1152	534	857	1332	3078
100% N	2112	1624	1260	1651	4337
100% NP	2662	1732	1525	2264	5366
50% NPK	2043	1507	1384	1997	5236
100% NPK	2816	2079	2014	2356	5488
150% NPK	3102	2301	2213	2527	5600
100% NPK + Zn	2613	2167	1854	2372	5628
100% NPK-S	2331	1809	1552	2263	5458
100% NPK+ HW	2309	1854	1640	2181	5420
100% NPK+ FYM	3106	2243	2237	2760	6231

crop yield which is due to additional supply of nutrient and improvement in soil physical properties thereby creating favourable condition for plant growth and nutrient mineralization. However, increase in dose of nutrient to 150% NPK did not show much effect on yield.

Ludhiana (Maize-wheat)

Maize and wheat yield recorded at Ludhiana revealed that both the crops responded to applied N and P (Table 2.2.2). Response of applied K was also noted in maize only. This is due to significant contribution of K through irrigation water applied in wheat. Response of S was not recorded in either of the crops. Application of FYM with NPK resulted in increase in yield of both the crops compared to NPK alone. However, 50% NPK+FYM could not sustain the productivity compared with 100% NPK.

New Delhi (Maize-wheat)

The results from the LTFE under maize-wheat cropping system in New Delhi indicated that 150% NPK gave the

highest yield of maize and wheat followed by 100% NPK+FYM (Table 2.2.2). Maize and wheat crop responded significantly to the applied N and P, whereas the response to the applied Zn and S was not statistically significant. Application of FYM along with NPK and increase in nutrient dose to 150% NPK increased the yield significantly as compared to 100% NPK. The result indicates that there is scope to increase the nutrient dose to realise potential yield.

Udaipur (Maize-wheat)

The yield data of maize and wheat crop in Udaipur revealed that both the crops responded to applied N and P (Table 2.2.2). Both the crops did not respond to either applied Zn or S. Integration of FYM with NPK has resulted in significant increase in yield. However, yield remained more or less similar to 100% NPK even after partial substitution of nutrients through FYM. Inoculation of Azotobacter along with NPK also did not have additional yield advantage. Application of nutrients through FYM alone could not result in yield as obtained on application of NPK.

Table 2.2.2 Effect of application of organic manures and inorganic fertilizers on maize and wheat yield (kg ha⁻¹)

Ludhiana			New Delhi			Udaipur		
Treatment	Maize	Wheat	Treatment	Maize	Wheat	Treatment	Maize	Wheat
Control	2033	1433	Control	1745	2500	Control	1376	1605
100% N	3746	3936	100% N	3400	4705	100% N	2241	2963
100% NP	4255	4866	100% NP	4290	5335	100% NP	2867	3586
100% NPK	4999	4931	50% NPK	3050	4570	100% NPK	3293	4299
150% NPK	5148	4968	100% NPK	4680	5730	100% NPK+Zn	3445	4503
100% NPK+Zn	4949	4923	150% NPK	5765	6580	100% NPK + S	3355	4408
100% NPK(-S)	5080	4909	100% NPK+Zn	4940	6045	100% NPK + Zn + S	3573	4604
100% NPK+W	5099	4907	100% NPK+S	4865	5415	150% NPK	3670	4653
50% NPK+FYM	3177	3766	100% NPK+HW	4455	5580	100% NPK + FYM	4028	4973
100% NPK+FYM	5835	5399	100% NPK+FYM	5405	5985	100% NPK – FYM	3478	4600
						FYM @ 20 t ha ⁻¹	2404	3080
						100% NPK+Azotobacter	3448	4420

Jagtial (Rice-rice)

Rice crop significantly responded to the applied N and P fertilizer (Table 2.2.3). Increase in nutrient dose from 100% NPK to 150% NPK has significantly increased rice yield. Thus, in order to obtain the potential yield of rice there is a need to increase nutrient dose particularly N and K. Application of nutrient exclusively through FYM could not maintain yield at par with 100% NPK.

Bhubaneswar (Rice-rice)

Rice-rice cropping system in Inceptisols at Bhubaneswar showed response to the applied N, P, K, Zn, S and B fertilizer in both the rice crops (Table 2.2.3). Both lime and FYM application has increased the yield, however, incorporation of FYM has significantly increased the productivity of both the rice crops and thus indicated that amending soil with FYM was found to be superior than lime. It is due to additional supply of nutrients and moderating soil condition by chelating the Al⁺³ and Fe⁺³ responsible for acidity in soil.

Vertisols

Raipur (Rice-wheat)

Rice and wheat crop in Raipur under LTFE showed clear response to applied N and P (Table 2.2.4). However, the response of rice and wheat crop to applied K and Zn was not statistically significant. Application of 150% NPK and incorporation of FYM over and above NPK (i.e. NPK+FYM) resulted in significant increase in yield of rice and wheat as compared to 100% NPK. Addition of BGA in rice crop did not have any effect on yield of rice and wheat crop.

Parbhani (Soybean-safflower)

The results from LTFE at Parbhani revealed that soybean and safflower did not show any response to applied N (Table 2.2.4). But application of P has contributed to the yield of both soybean and safflower. On the other hand, there is slight response to applied K and S in both the crops. Application of FYM alone did not have much impact on productivity of both the crops, however, FYM along with NPK performed better among all the nutrient management options in both the crops.

Table 2.2.3 Effect of long term fertilizer application on rice grain yield (kg ha⁻¹)

Treatment	Jagtial		Treatments	Bhubaneswar	
	Kharif	Rabi		Kharif	Rabi
Control	2763	2447	Control	1446	959
100% N	3698	2818	100% N	2120	1890
100% NP	5269	5561	100% NP	2588	3003
50% NPK	4414	4537	50% NPK	2409	2407
100% NPK	5232	5404	100% NPK	2723	3219
150% NPK	5769	6641	150% NPK	3426	3546
100% NPK + Zn	5428	5690	100% NPK + lime	3064	3513
100% NPK - S	5290	5496	100% NPK + lime + FYM	3598	4010
100% NPK + HW	5512	5775	100% NPK +Zn	3090	3587
FYM @ 20 t ha ⁻¹	4534	3899	100% NPK + S + Zn	3011	3402
100% NPK + FYM	5608	6184	100% NPK + B + Zn	2741	3280
CD (p=0.05)	716	655	100% NPK +FYM	3819	4010

Table 2.2.4 Average grain yield of rice and wheat (kg ha⁻¹) at Raipur and Parbhani

Treatment	Raipur		Treatments	Parbhani	
	Rice	Wheat		Soybean	Safflower
Control	2154	979	Control	506	635
100% N	3554	1839	100% N	542	604
100% NP	5237	2891	100% NP	1594	1346
50% NPK	4742	2174	100% NPK	1730	1453
50% NPK+BGA	4510	2156	150% NPK	1942	1604
50% NPK+GM	5220	2439	100% NPK+Zn	1818	1519
100% NPK	5384	3042	100% NPK - Sulphur	1502	1319
150% NPK	5976	3516	Only FYM @ 10 t ha ⁻¹	1222	1047
100% NPK+FYM	5970	3469	100% NPK + FYM	1968	1639

BGA=Blue green algae; GM= Green manure

Akola (Sorghum-wheat)

The yield data of sorghum and wheat crop indicated that there was significant response of both the crops to applied N, P and K. However, both the crops did not show any significant response to S and Zn application (Table 2.2.5). Nutrient supplied through 20 t FYM (10 t per crop) also could not produce equivalent yield recorded in 50% NPK treatment, even though nutrient supplied are more in quantity than 50% NPK. However, 25% substitution of N through organic could keep the pace with 100% NPK as far as yields are concerned.

application of FYM as compared to lime is due to additional supply of nutrient particularly K and moderation of soil condition conducive to plant growth.

Palampur (Maize-wheat)

At Palampur, continuous use of nitrogen alone to maize-wheat cropping system resulted in no yield (Table 2.2.6) due to decline in soil pH and availability of P and K. The crop productivity increased with application of P and K. Application of lime and FYM both resulted in increase in

Table 2.2.5 Average yield of crops (kg ha⁻¹) at Akola and Junagadh

Treatment	Akola		Treatment	Junagadh	
	Sorghum	Wheat		Groundnut	Wheat
Control	391	63	Control	710	1771
100% N	1711	663	100% N	619	1596
100% NP	2845	1293	100% NP	746	2537
50% NPK	2721	1492	50% NPK	789	2188
100% NPK	3548	2344	50% NPK+10 t ha ⁻¹ FYM*	1121	3571
150% NPK	4406	2870	50% NPK++Rhizo +PSM [§]	827	2699
100% NPK + Zn @ 2.5 kg ha ⁻¹	3800	2539	100% NPK	904	2867
100% NPK + S @ 37.5 kg ha ⁻¹	3950	2632	150% NPK	992	3060
100% NPK S free	3219	2125	100% NPK+ ZnSO ₄	915	2897
FYM @ 10 t ha ⁻¹	2584	1035	NPK as per soil test	911	2903
75% NPK + 25% N through FYM	3479	2155	100% NPK (P as SSP)	866	2894
100% NPK + FYM @ 5 t ha ⁻¹	4618	3192	FYM 25 t ha ⁻¹ to groundnut	1025	3408
CD (<i>p</i> =0.05)	446	362	CD (<i>p</i> =0.05)	125	393

* 50% NPK+10 t ha⁻¹ FYM to groundnut and 100% NPK to wheat; § 50% NPK% + Rhizobium + Phosphate solubilizing microorganism (PSM)

Results indicated that there is need to increase the dose of organic manure for higher yields.

Junagadh (Groundnut-wheat)

Poor response to the treatments was observed at Junagadh in terms of groundnut yield (Table 2.2.5). The results clearly indicated that there is no response of N probably because of poor P status which was evident from increased yield following P application. On the contrary exclusive incorporation of FYM maintained yield higher than other treatments.

Alfisols**Bangalore (Finger millet-maize)**

Finger millet did not show any response to applied N and P without K application revealing necessity of balanced use of nutrients in Alfisol of Bangalore. Application of lime and FYM both have resulted increase in yield of finger millet and maize but magnitude of increase in yield was higher in FYM amended soil (Table 2.2.6). The increase in yield on

productivity of maize but the magnitude is more in FYM amended plot than lime. It is evident from the result that application of 150% NPK did not increase the maize yield as compared to 100% NPK which indicates that application of lime and FYM as ameliorating measures is far better than increasing fertilizer dose. Application of lime increased the availability of nutrients by raising the pH whereas FYM not only moderate the soil condition but also supplied additional nutrients. Thus, application of FYM could be an alternative to lime. A similar behaviour of treatments was observed in wheat also.

Ranchi (Soybean-wheat)

Soybean and wheat yield from Ranchi revealed that increase in dose from 50% to 100% of nutrients (NPK) resulted in increase in the yield of soybean and wheat (Table 2.2.6). Application of N alone resulted in decline in productivity of soybean compared to the absolute control indicating that application of N had adverse effect on productivity. A similar effect of N was also noted in wheat which is due to decline in

Table 2.2.6 Effect of long term fertilizer application on grain yield (kg ha⁻¹) at Bangalore, Palampur and Ranchi

Treatment	Bangalore		Treatment	Palampur		Treatment	Ranchi	
	Finger millet	Maize		Maize	Wheat		Soybean	Wheat
Control	679	918	Control	896	421	Control	366	428
100% N	872	765	100%	0	0	100%	353	802
100% NP	776	1509	100%	2109	1155	100%	975	2948
50% NPK	2152	2583	50% NPK	3496	1688	50% NPK	1502	1962
100% NPK	2842	2964	100% NPK	3999	2065	100% NPK	1877	2995
150% NPK	3344	3626	150% NPK	3808	1763	150% NPK	1873	3039
NPK + lime	2930	2981	NPK+Zn	4002	2025	NS(P)K	1967	2906
NPK (S-free)	2863	3118	NPK (-S)	2080	1180	NPK+HW	1788	3015
NPK + FYM + lime	3674	3823	NPK+lime	5403	3139	NPK+lime	2133	3061
NPK+FYM	3657	3744	NPK+FYM	5701	3325	NPK+FYM	2251	3412

soil pH and mining of soil P and K at faster rate during early years of N application. Even though significant increase in yield of both soybean and wheat was recorded on integration of P with N but more increase in yield was recorded on combined application of N, P and K. Thus, application of N alone without P and K is not advisable to sustain productivity of soil in Alfisols.

Pattambi (Rice-rice)

The results from Pattambi LTFE under rice-rice system revealed that application of urea alone did not have much effect on rice yields in both the seasons. But application of P along with N resulted in increase in yield of both the rice crops statistically implying low soil P availability. There was no response to K application due to significant contribution from irrigation water. In situ green manuring and FYM with 50% NPK sustained the yield (4160 and 4282 kg ha⁻¹) at par with 100% NPK (3857 kg ha⁻¹).

Mollisols

Pantnagar

Rice and wheat yield clearly indicated the response to applied N, P, Zn and S (Table 2.2.7). Application of FYM over and above NPK performed better than 100% NPK. The results further indicated that application of Zn is essential along with N and P in order to sustain the productivity of rice and wheat at

Pantnagar. Also growing rice with bio fertilizer (Azola) did not show any additional benefit on yield over control.

Table 2.2.7 Effect of long term fertilization on yields (kg ha⁻¹) of rice and wheat at Pantnagar

Treatments	Rice	Wheat
Control	1283	1204
100% N +Zn	3173	3122
100% NP +Zn	4037	3443
50% NPK+ Zn	3350	2822
100% NPK	3679	3298
150% NPK	3530	3267
100% NPK + Zn	4266	4101
100% NPK-S + Zn	3835	3653
Bio-fertilizer	1314	1235
100% NPK+ HW + Zn	3913	3696
100% NPK + FYM	5171	4738

The sustainable yield index (SYI) is also one of the ways to evaluate soil quality. Higher SYI value implies better soil quality. Thus, from sustainability index data it is concluded that balanced application of nutrient resulted in higher SYI irrespective of crop and soil type which means management of nutrients appropriately is responsible for sustainability and soil quality (Table 2.2.8).

Table 2.2.8 Sustainability yield index of crops at different AICRP LTFE Centres

Centre	Crop	Control	N	NP	50% NPK	100% NPK	150% NPK	NPK +Zn	NPK+ FYM	NPK +Lime
Barrackpore	Rice	0.15	0.29	0.34	0.27	0.35	0.41	0.30	0.40	-
	Wheat	0.11	0.30	0.36	0.28	0.38	0.47	0.37	0.41	-
Pantnagar	Rice	0.13	0.39	0.43	0.35	0.41	0.38	0.47	0.50	-
	Wheat	0.15	0.46	0.51	0.42	0.51	0.50	0.56	0.62	-

Centre	Crop	Control	N	NP	50% NPK	100% NPK	150% NPK	NPK +Zn	NPK+ FYM	NPK +Lime
Ludhiana	Maize	0.03	0.18	0.24	0.22	0.29	0.32	0.37	0.44	-
	Wheat	0.14	0.43	0.63	0.47	0.70	0.76	0.74	0.78	-
Palampur	Maize	0.01	0.07	0.15	0.20	0.35	0.36	0.34	0.53	0.47
	Wheat	0.04	0.05	0.15	0.19	0.28	0.28	0.27	0.42	0.40
Ranchi	Soybean	0.10	0.01	0.21	0.37	0.49	0.47	-	0.62	0.60
	Wheat	0.03	0.02	0.29	0.25	0.35	0.36	-	0.43	0.41
Bangalore	F. Millet	0.06	0.06	0.07	0.31	0.50	0.61	-	0.56	0.49
	H. Maize	0.00	0.01	0.01	0.10	0.21	0.22	-	0.27	0.25
New Delhi	Maize	0.25	0.34	0.38	0.37	0.44	0.50	0.47	0.51	-
	Wheat	0.38	0.58	0.67	0.62	0.74	0.81	0.76	0.82	-
Coimbatore	F. Millet	0.08	0.12	0.36	0.30	0.37	0.41	0.36	0.46	-
	Maize	0.06	0.09	0.36	0.32	0.39	0.43	0.41	0.47	-
Junagadh	Groundnut	0.22	0.20	0.21	0.25	0.27	0.30	0.28	-	-
	Wheat	0.27	0.23	0.37	0.31	0.40	0.43	0.38	-	-
Udaipur	Maize	0.34	0.50	0.62	-	0.67	-	0.72	0.79	-
	Wheat	0.26	0.45	0.54	-	0.60	-	0.62	0.69	-
Raipur	Rice	0.60	0.43	0.61	0.48	0.61	0.68	0.62	0.66	-
	Wheat	0.26	0.38	0.68	0.43	0.67	0.81	0.69	0.75	-
Jagtial	Kharifrice	0.32	0.46	0.52	0.46	0.55	0.57	0.54	0.58	-
	Rabi rice	0.24	0.31	0.45	0.36	0.46	0.50	0.46	0.48	-
Jabalpur	Soybean	0.13	0.14	0.26	0.26	0.32	0.30	0.29	0.35	-
	Wheat	0.14	0.15	0.49	0.40	0.54	0.56	0.53	0.59	-
Akola	Sorghum	0.01	0.15	0.21	0.17	0.29	0.40	0.33	0.40	-
	Wheat	0.00	0.13	0.18	0.16	0.31	0.41	0.31	0.00	-
Parbhani	Soybean	0.23	0.25	0.36	0.33	0.41	0.44	0.39	0.44	-
	Safflower	0.29	0.35	0.37	0.42	0.45	0.49	0.44	0.49	-
Pattmbi	Kharif/rice	0.33	0.44	0.46	0.44	0.48	0.50	-	0.61	0.49
	Rabi/rice	0.47	0.58	0.62	0.62	0.68	0.69	-	0.82	0.67
Bhubneshwar	Kharif/rice	0.26	0.31	0.34	-	0.46	0.51	-	0.00	-
	Rabi/rice	0.23	0.33	0.48	-	0.55	0.61	-	0.00	-

2.3 AICRP-Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (MSPE)

2.3.1 Development of regional/management zones for precise micronutrient prescription

Emerging micronutrient deficiencies in different soils of the world is a threat for sustainability of agriculture. As distribution of micronutrients in soil varies spatially, site-specific management of micronutrients by delineating management/regional zones (MZs/RZs) is an effective strategy for precision agriculture. The current investigation was performed to delineate RZs in a Deccan plateau region (DPR) of India by considering spatial variability of some soil properties and available micronutrients for efficient management of micronutrients. Altogether, 4939 representative soil samples (with geographical coordinates) from surface (0-0.15 m depth) layers were obtained from

Telangana state lying in DPR of India. Soil samples were collected from agricultural land, predominantly cultivated with field crops, of small (< 1 ha), medium (1 – 3 ha) and large (> 3 ha) land holdings and analysed for major soil properties. Geostatistical analysis divulged different distribution pattern of soil properties and available micronutrients with strong to moderate spatial dependency. The four principal components (PCs) (with > 1 eigen value) responsible for 73% of total variance were considered for analysis. Six RZs from the study area (Fig. 2.3.1) were created through geostatistical, principal component and clustering analysis. The measured soil properties and available micronutrients in the RZs varied significantly highlighting the usefulness of RZ delineation technique for precise micronutrients management in DPR of India.

Similarly, a study was carried out to delineate MZs in Shivalik Himalayan region (SHR) of India by capturing

spatial variability of soil properties, available S and micronutrients for site-specific S and micronutrient management. A total of 2575 geo-referenced representative surface (0-15 cm depth) soil samples were collected from Uttarakhand state (covering 53483 km² area) of India lying in Shiwalik Himalayan tract and foot hills of the great Himalayas and analysed for major soil properties. Geostatistical analysis revealed spherical, Gaussian, exponential, stable, circular and K-Bessel best-fit models for soil properties. Most of the soil properties were having moderate spatial dependency except soil pH and S (strong) and Zn (weak). The principal component (PC) analysis and fuzzy-c- mean clustering was performed to develop the MZs. Four PCs with eigen values greater than 1 and accounting 65.4% of total variance were retained for further analysis. On the basis of fuzzy performance index (FPI) and normalized classification entropy (NCE), four potential MZs were identified (Fig. 2.3.1). Analysis of variance confirmed the heterogeneity in most of the studied soil properties among the MZs. The study indicated that the methodology of delineating MZs can be effectively used in site-specific S and micronutrient management in SHR of India.

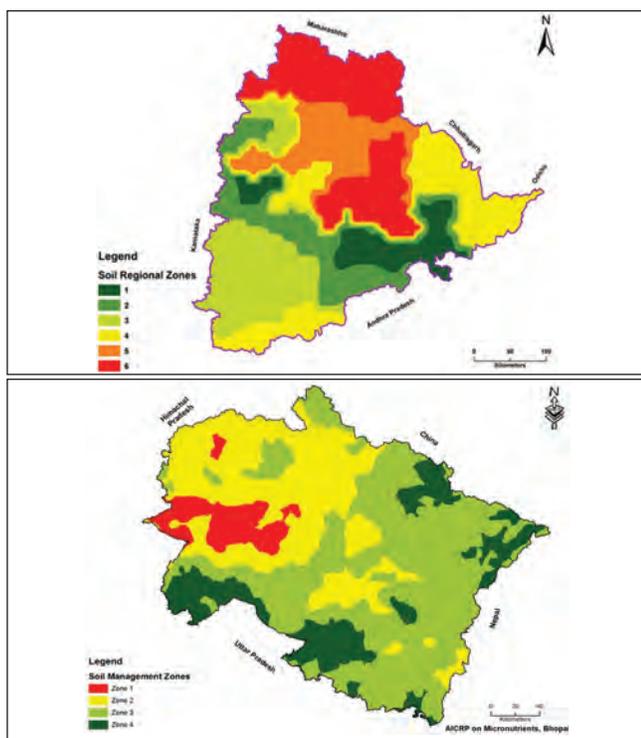


Fig. 2.3.1 Soil regional zones for micronutrients management in Telangana and Uttarakhand

2.3.2 Evaluation of efficacy of sulphur and zinc containing complex fertilizers for maximizing yield through balanced nutrition of different crops in India

Zinc and S deficiency is widespread in field crops all over the India because of increased Zn and S demands of intensive

cropping systems and adoption of high yielding cultivars with relatively greater Zn and S demand. The use efficiency of the Zn and S applied to soil is less which needs to be improved upon. Therefore, three grades of fertilizer i.e. NPS-1 (N: P: K: S 19:38:00:07), NPS-2 (N: P: K: S 12:46:00:07) and NPSZn (N: P: K: S: Zn 12:45:00:05:01) (supplied and funded by M/s Zuari Agro-Chemicals Limited, Goa) were tested for their efficacy in ameliorating Zn and S deficiency in selected crops in different Zn and S deficient soils of India. Multi-location field experiments with eleven nutrient treatments were carried out at seven centres viz., OUAT Bhubaneswar, IARI New Delhi, TNAU Coimbatore, AAU Anand, IISS Bhopal, IISR Lucknow and PDKV Akola under different cropping systems namely, rice–mustard, maize–wheat, rice–black gram, mustard–groundnut, soybean–wheat, potato–sugarcane and cotton–onion, respectively. The yield of economic part of all the test crops increased with the application of all nutrient treatments over absolute control at all the centers. Different crops performed differently under application of customized grade fertilizers (NPS1, NPS2 and NPSZn) at different centers. The three fertilizer grades were found to influence the crop yields in varied extent at different centers. A higher rice equivalent crop yield was obtained in all treatments over absolute control and RDF. In general, the three grades of fertilizers namely NPS-1, NPS-2 and NPSZn recorded 11.4 to 135.3, 14.8 to 117.7 and 23.9 to 129.4% increase in the rice equivalent yield over absolute control, respectively (Fig. 2.3.2). Among the three grades, NPSZn was found to be superior to the other two grades for crops at all the centers except for mustard grown at OUAT, Bhubaneswar, where NPS-1 was found to be the best.

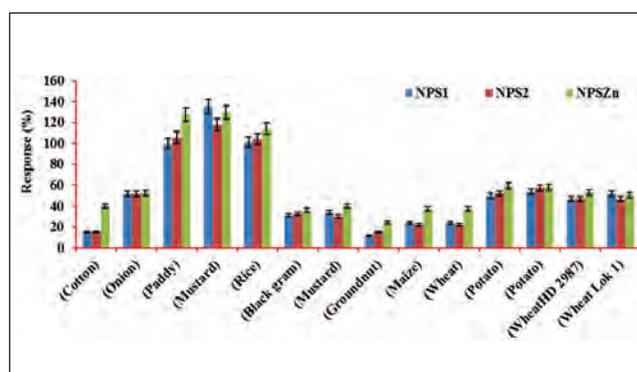
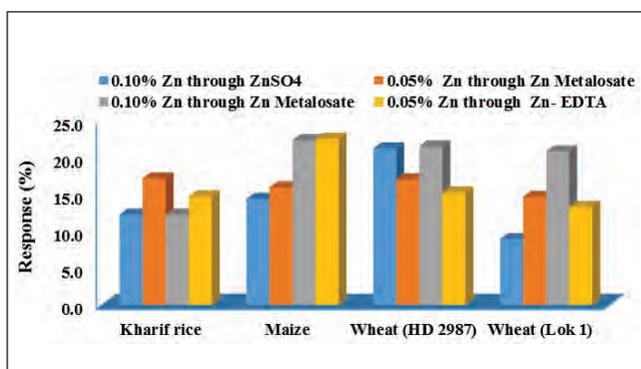


Fig 2.3.2 Increase in yield of different crops over control with using different grades of fertilizers

2.3.3 Assessment of efficacy of zinc metalosate as foliar supplement for Zn nutrition of different crops

Most of the agricultural soils of the country are poor in phyto-available content of Zn to supply enough of these elements for the proper growth and development of crop plants.

Among the several chemical and synthetic Zn sources evaluated for their efficiency under different soil-crop situations, by and large, ZnSO₄·7H₂O proved better or equal to the other sources in correcting the Zn deficiency. However, there is still dearth of economically suitable source of Zn supplementation which has greater nutrient use efficiency. Therefore, zinc metalosate (a liquid formulation of Zn having 6.8% Zn) supplied and funded by M/s Indofill Industries Limited, Mumbai was evaluated for its efficacy in different crops and cropping systems in comparison to standard Zn sources i.e. ZnSO₄ and Zn-EDTA. Experiments were conducted in cereals (rice, wheat, maize), vegetables (tomato, potato) and fruit crops (mango, grape, pomegranate) with twelve nutrient treatment combinations at six locations across the country i.e. CRRRI Cuttack, IARI New Delhi, GKVK Bengaluru, CSKHPKV Palampur, CISH Lucknow LU Lucknow and IISS, Bhopal. In general, application of Zn through either of the methods or sources has increased the crop productivity over recommended NPK application (no Zn). The extent of increase varied with soil Zn level and crop type. All three major cereal crops viz. rice, wheat and maize responded positively to Zn supplementation either through ZnSO₄, Zn metalosate, and Zn-EDTA, however, the extent of response varied among the crops (Fig. 2.3.3a). Among the foliar Zn application, ZnSO₄ @ 0.1% Zn concentration was at par with 0.05% Zn through Zn metalosate and 0.05% through Zn-EDTA (i.e. half of the standard Zn concentration supplied through ZnSO₄). Vegetable crops responded variably with respect to level and sources of different Zn supplements (Fig. 2.3.3b). For instance, 0.1% Zn supplied through Zn metalosate resulted in 19.71% increase in potato tuber yield at Palampur and tomato fruit yield under open field conditions at New Delhi. While under polyhouse conditions, the highest increase was registered when half of the recommended Zn supplied (0.05% Zn) through Zn metalosate. As compared to cereal and vegetable crops, fruit crops responded much prominently to Zn metalosate as compared to other sources of Zn supply (Fig. 2.3.3c).



2.3.3a Response of different cereal crops to foliar supplementation of Zn

On average, application of Zn metalosate at 0.1% Zn concentration registered 151, 207 and 38% increase in grape, pomegranate, and apple fruit yield while in mango, half of this dose was sufficient to enhance the fruit yield by 49.0%.

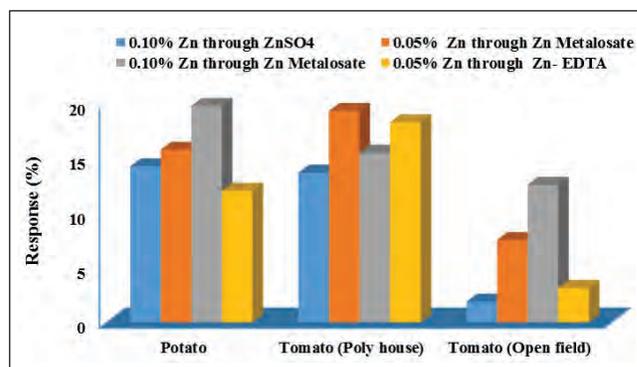


Fig. 2.3.3b Response of different vegetable crops to foliar supplementation of Zn

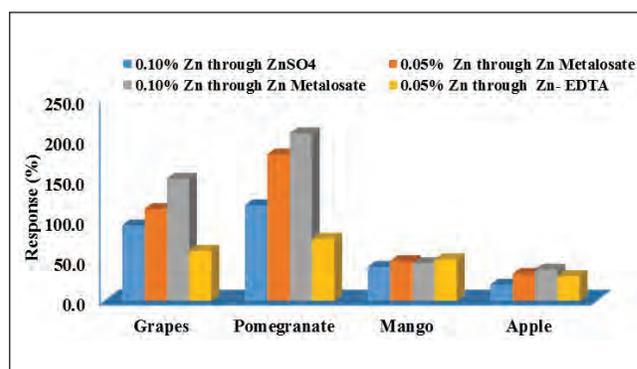


Fig. 2.3.3c Response of different fruits to foliar supplementation of Zn

2.3.4 Evaluation of efficacy of boron metalosate as foliar supplement for B nutrition in different crops

Field experiments with twelve nutrient treatment combinations were conducted to evaluate the performance of boron metalosate (a liquid formulation of B having 5.0% B) (supplied and funded by M/s Indofill Industries Limited, Mumbai) against the standard sources of B (borax and boric acid) on cereals (rice, wheat and maize), vegetables (cauliflower and tomato) and fruits (grapes, pomegranate, mango, apple) at GKVK Bengaluru, IARI New Delhi, CISH Lucknow, CSKHPKV Palampur, NRII Cuttack and IISS Bhopal under AICRP-MSPE. The results revealed that all cereal crops responded to B application significantly irrespective of the sources (Fig. 2.3.4a). Maximum response was obtained through the foliar application of the standard boron concentration i.e. 0.034% B through B metalosate by maize and wheat crops at Bhopal centre, while Kharif rice crop has shown maximum response towards half of the

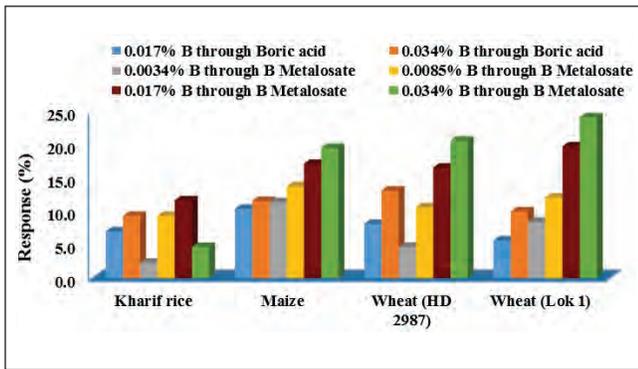


Fig. 2.3.4a Response of different cereal crops to foliar supplementation of B

standard B application through B metalosate over recommended NPK. Apparently, lowest response to Kharif rice and durum wheat (HD 2987) was registered using 1/10 of standard B applied (i.e. 0.0034 % B) through B metalosate in contrast to the maize and aestivum wheat (Lok 1) by using half of the standard B applied through boric acid. The response of vegetable crops to B application varied with crop, levels and sources of B application (Fig. 2.3.4b). Response to B application was much higher in cauliflower as compared to

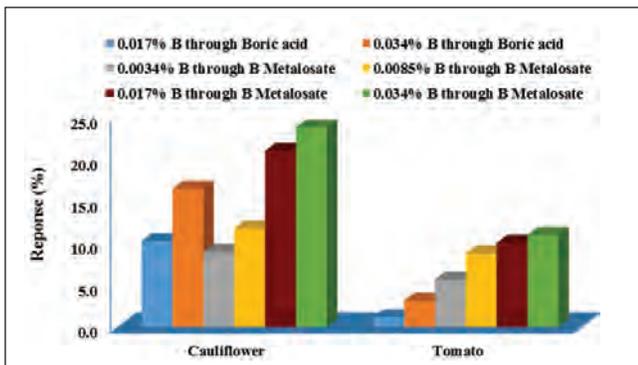


Fig. 2.3.4b Response of different vegetable crops to foliar supplementation of B

tomato crop however, the highest response was observed with application of B @ 0.034% B through B metalosate in

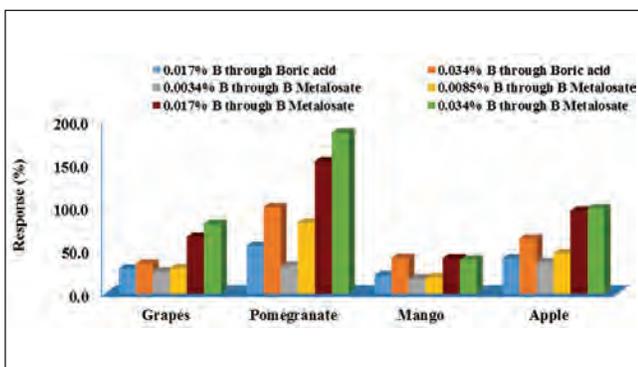


Fig. 2.3.4c Response of different fruit crops to foliar supplementation of B

both the crops. The crop response decreased with reducing the level of B application in both the crops. On an average, response to boric acid was much inferior in tomato than in cauliflower. On an average, application of standard dose of B through B metalosate resulted in 38.8, 80.0, 98.0 and 185.0% increase in the fruit yields of mango, grapes, apple and pomegranate, respectively (Fig. 2.3.4c). The crop response at lower doses of both the B sources was comparable in grapes and mango.

2.3.5 Zinc in soil-plant-animal/human continuum

In order to assess relationship between soil and animal/human health, a case study on Zn in soil-plant-animal/human continuum was carried out jointly by AICRP - MSPE and AIIMS, Bhopal in two tribal districts of Madhya Pradesh. The study was specific to adolescents of Gond and Korku tribes of Mandala and Betul districts of Madhya Pradesh, India. To collect samples, multistage cluster random sampling was performed in two blocks of each district. From each block, 15 clusters of villages were selected for dietary recall and finally 3 ml blood sample was collected from selected adolescents in identified families. Soil, food, feed and plant samples were also collected from field/household of people selected for blood sampling. Analysis of Zn was done in soil, plant, food, feed and serum blood sample. The detail soil analysis performed for these two districts exhibited huge variation (low to high) in soil Zn status. Similarly, dietary recall study revealed that average daily intake of nutrients was deficit as compared to standard RDA set by ICMR. Median intake of all nutrients was less than RDA except for protein intake in Mandla district. Median intake of nutrients is less than RDA in all age groups and especially in adolescence girls in the age group of 15 to 19 years. There was variation in median intake of nutrients in all age and gender groups in two tribes. Median intake of all nutrients was higher in Gond (Mandla district) tribe in both boys and girls and across all age groups (Table 2.3.5).

Dietary Zn and Fe intake is an important component of evaluating the risk of Zn and Fe deficiency in populations. The prevalence of inadequate Zn/Fe intakes estimated in population revealed the relative magnitude of the risk of Zn/Fe deficiency in both the tribal groups. Prevalence of inadequate zinc intakes greater than 25% was considered to represent an elevated risk of population zinc deficiency. Since our dietary assessments were based on single day data, we have assumed coefficient of variation of 25% for consideration as usual intake. It was evident that there was huge proportion of adolescents with inadequate zinc intake as compared to estimated average requirement. It was found that during latter half of adolescence this magnitude is too high when zinc requirements are more (Fig. 2.3.5).

Table 2.3.5 Average intake (mg/day) of Zn and Fe by different age group of adolescent of Gond and Korku tribes (MP)

Age group (years)	Gond tribe (Mandla)				Korku tribe (Betul)			
	Boys		Girls		Boys		Girls	
	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe
10 - 12	6.7 ± 3.6	14.8 ± 9.9	7.1 ± 3.3	15.7 ± 10.6	7.1 ± 3.3	12.9 ± 6.1	6.8 ± 3.6	12.4 ± 6.5
13 - 15	8.3 ± 3.8	17.5 ± 10.6	7.6 ± 3.9	16.7 ± 10.9	8.4 ± 3.9	15.6 ± 7.2	7.6 ± 3.8	13.9 ± 7.0
16 - 17	8.8 ± 4.0	18.7 ± 1.8	8.7 ± 8.2	19.3 ± 7.4	8.4 ± 4.2	14.5 ± 7.8	8.0 ± 3.9	14.2 ± 7.0
18 - 19	10.0 ± 3.9	20.3 ± 13.3	7.9 ± 3.0	17.6 ± 9.0	8.7 ± 4.6	15.7 ± 8.7	8.0 ± 4.1	14.2 ± 7.9

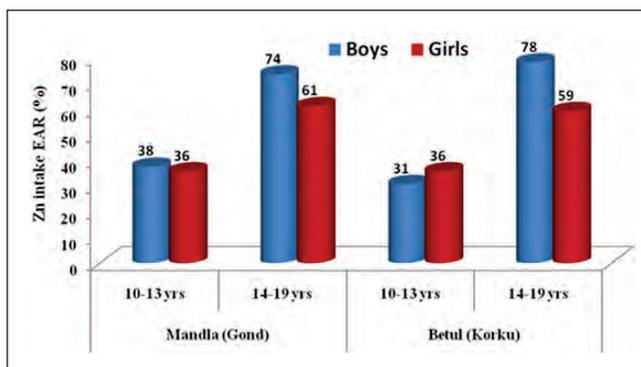


Fig. 2.3.5a Distribution of adolescents in Gond and Korku tribes with zinc intake below EAR

Analysis of Zn content in soil, grain, straw feed, animal and human blood serum established a strong correlation and interdependence among soil-plant-animal/human continuum (Fig.2.3.5b). The results indicated a strong relationship of soil Zn concentration with plant and human blood serum Zn content. The coefficient of determination (R^2) were found between soil Zn content and grain Zn concentration ($R^2 = 0.36$), Zn concentration in human blood serum and grain Zn concentration ($R^2 = 0.48$). However, no relationship was recorded between straw Zn content and animal blood serum Zn concentration. When contribution of Zn through feed and Zn content in grazing grass was included with fodder Zn content, significant relationship emerged with animal blood serum Zn ($R^2 = 0.61$).

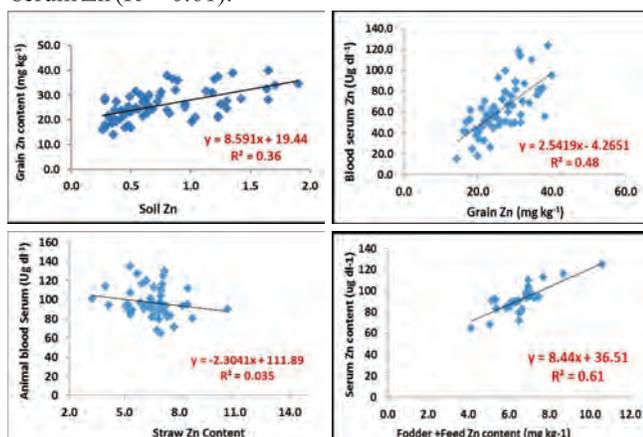


Fig. 2.3.5b Relationship among Zn content in soil, plant, animal and human system

Theme II. Conservation Agriculture, Carbon Sequestration and Climate Change

2.4. Conservation agriculture and climate change

2.4.1 Impact of conservation agricultural practices on soil health, carbon Sequestration and green house gas emissions in different production systems

The deteriorating soil health coupled with production fatigue poses a great threat to Indian agriculture. A long-term (10 years) resource conservation experiment was evaluated for changes in soil chemical and biological properties under rice-wheat cropping system. Altogether 10 treatment combinations comprising of conventional (CT), reduced (RT) and no tillage (NT) were evaluated with and without residue, at CSSRI Karnal, for changes in soil organic carbon (SOC), water soluble carbon, available phosphorus and potassium and dehydrogeanse activity in 0-5 and 5-15 cm of soil depths. Highest concentration of SOC (8.8 g kg⁻¹) was recorded in 0-5 cm of soil depth in treatments of zero tilled rice (direct seeded) and wheat plots which retained of 1/3rd residue of the previous crop. However, it fails to improve soil carbon concentration (5.4 g kg⁻¹) in 5-15 cm of depth. Direct seeded rice (DSR) without wheat residue in RT maintained higher concentration of SOC (7.6 g kg⁻¹) in both 0-5 and 5-15 cm of soil depths followed by zero tilled wheat with entire rice residue retention (Fig.2.4.1a).

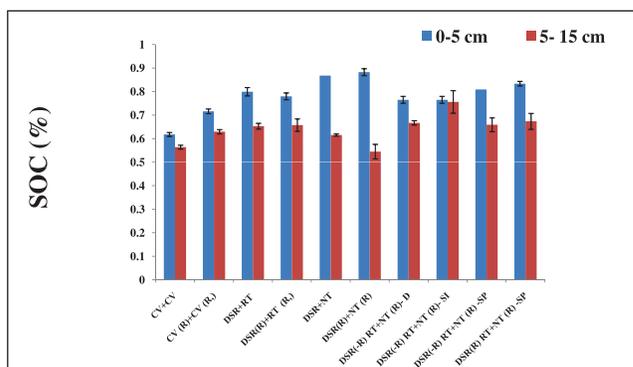


Fig. 2.4.1a Effect of resource conservation measures on concentration of SOC

However, the trend for water soluble carbon was different. It was maximum (107.5 mg kg⁻¹) under the treatment of conventional rice transplanting after wheat residue incorporation (1/3rd) followed by conventional wheat sowing after 1/3rd of rice residue incorporation. This treatment was found to be at par with the treatment of direct seeded rice without wheat residue in RT followed by zero tilled wheat with entire rice residue retention (Fig. 2.4.1b). In all the treatments, water soluble carbon was higher in 0-5 cm of soil depth in comparison to 5-15 cm of soil depth. However, in treatments of zero tilled rice and wheat plots, concentration of water soluble carbon was higher (75 mg kg⁻¹) in 5-15 cm of soil depth in comparison to 0-5 cm of soil depth (45 mg kg⁻¹). The trend for ammonium acetate extractable potassium was found similar to water soluble carbon. In general, available potassium was higher in plots receiving higher input of residues. Here also, treatments of zero tilled rice and wheat failed to maintain higher level of potassium (240 kg ha⁻¹) in soil. It was observed that conventional tilled rice and wheat plots with 1/3rd of residue incorporation (both rice and wheat) maintained higher concentration of exchangeable potassium (333 kg ha⁻¹) in soil. Treatments of direct seeded rice without wheat residue in reduced tillage followed by zero tilled wheat with entire rice residue retention also maintained higher level of potassium in soil.

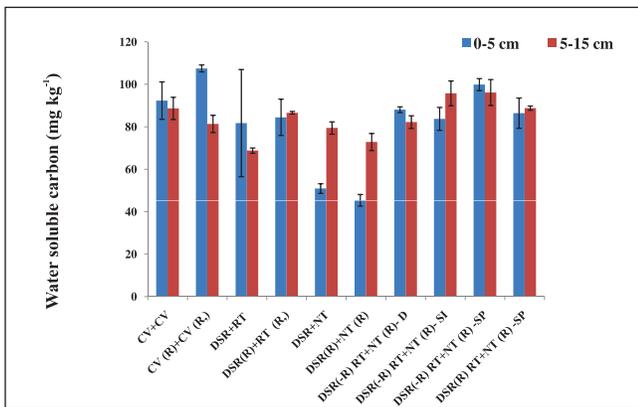


Fig. 2.4.1b Effect of resource conservation measures on concentration of water soluble carbon

Conventionally tilled plot receiving 1/3rd of residue incorporation maintained maximum available P concentration in 0-5 cm of soil depth. It was observed that plots where residues were either retained or incorporated, significantly improved status of available P in soil. Dehydrogenase activity was significantly higher (152 µg TPF g⁻¹ soil day⁻¹) in treatment of conventionally tilled plot along with 1/3rd of residues incorporation. This was followed by treatment of direct seeded rice without wheat residue in reduced tillage followed by zero tilled wheat with entire rice

residue retention. Thus, soil health could be maintained or improved by any practice that facilitate retention or incorporation of residues irrespective of tillage practice. Fluorescein diacetate activity, an indicator of enzymatic activity, was found maximum (77.52 µg g⁻¹ of soil) in treatment of DSR with wheat residue (33%) incorporation in RT followed by wheat in NT with rice residue retention (100%). In treatment of conventional rice transplanting after wheat residue incorporation followed by wheat sowing after rice residue incorporation (33%) recorded higher FDA activity in sub-soil (5-15 cm) in comparison to surface soil (0-5 cm). FDA activity was found lower in treatment of direct seeded rice and zero tillage in wheat with and without residue retention (Fig. 2.4.1c)

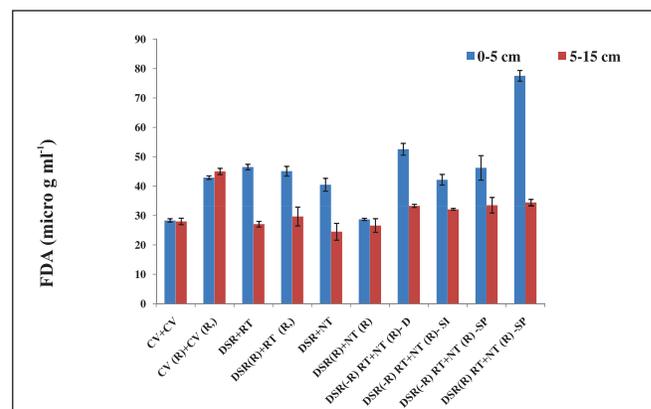


Fig. 2.4.1c Effect of resource conservation measures on FDA activity in soil

2.4.2 Evaluation of soil water retention characteristic (SWRC) models in Vertisols

Soil water retention characteristic (SWRC) is the key soil property used in many applications in the fields of irrigation, hydrology, geotechnical engineering and soil science in general. The SWRC describes the amount of water retained in a soil under equilibrium at given matric potential. In this study, six non-linear SWRC models viz. van Genuchten, brooks-corey, fredlund-Zing, Kosugi, Durner and Seki water retention model were evaluated. The soil samples with minimum disturbances was collected from five different treatments namely broad bed and furrow – no tillage (BBF-NT), broad bed and furrow – reduce tillage (BBF-RT), no tillage (NT), reduce tillage (RT) and conventional tillage (CT). Further, soil water content was obtained at 0, 0.1, 0.3, 0.5, 0.8, 1, 3, 5, 7, 10 and 15 bar using the pressure plate apparatus. Based on higher value of R² and lower value of Akaike information criterion (AIC), model developed by Seki (2007) were best suited for Vertisols of central India (Table 2.4.2).

Table 2.4.2 Evaluation of different SWRC water retention models in Vertisols

Models	BNT		BRT		NT		CT		RT	
	R ²	AIC								
Brooks and Corey (1964)	0.933	-67.48	0.924	-66.21	0.902	-63.64	0.914	-65.44	0.898	-64.02
Van Genuchten (1980)	0.934	-67.64	0.924	-66.16	0.904	-63.81	0.910	-64.95	0.891	-63.29
Kosugi (1999)	0.931	-67.13	0.921	-65.64	0.899	-63.24	0.907	-64.57	0.884	-62.58
Fredlund and Xing (1994)	0.936	-65.89	0.925	-64.35	0.905	-62.00	0.912	-63.24	0.892	-61.40
Durner (1994)	0.934	-62.48	0.931	-61.15	0.906	-58.86	0.919	-60.12	0.898	-58.05
Seki (2007)	0.939	-61.67	0.937	-60.66	0.910	-58.06	0.922	-60.00	0.902	-58.00

2.4.3 Multi-locational validation of APSIM-chickpea model for spatial studies

APSIM is a modelling framework with the ability to integrate models derived in fragmented research efforts. Therefore, user can configure a model by choosing a set of sub-models from a suite of crops, soil, and utility modules. In this study, a well calibrated APSIM-chickpea module was validated for JG-11 cultivar using the multi-locational data. The chickpea yield along with other required information were collected from Balaghat, Bhopal, Jabalpur, Mandala, Dindhori, Gwalior and Chhindwara districts and run the model for these locations. A high value of R²= 0.85 (Fig. 2.4.3) indicates the satisfactory validation of crop model. The APSIM model now can be used for spatial studies by linking with the geographical information system for exploring agronomic adaptations such as changes in planting dates, cultivar types, fertilizer/irrigation management under different climatic scenarios.

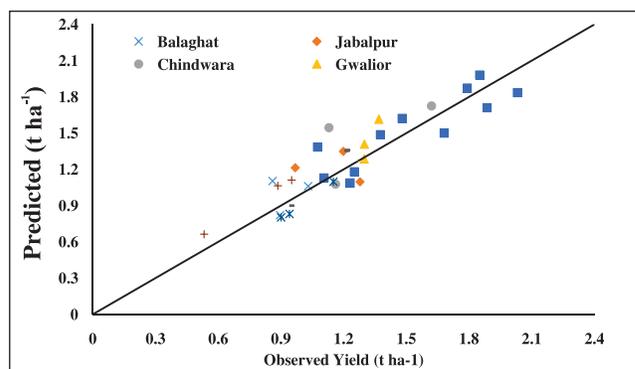


Fig. 2.4.3 Multi-locational validation of APSIM-Chickpea model

2.4.4 Impact of climate change on soil properties in Madhya Pradesh

Using data from 80 soil profiles, obtained from the National Bureau of Soil Survey and Land Use Planning soil organic carbon (SOC) at surface (Table 2.4.4a) and subsurface soil

Table 2.4.4a. Pearson correlation coefficients (r) for climate and soil properties under different land uses (0 to 15 cm depth)

Parameters	PET (mm)	MAP (mm)	MAT (°C)	Mean Annual T _{max} (°C)	AI PET/MAP	Sand (%)	Silt (%)	Clay (%)	SOC (Mg/ha)	pH	BD (Mg/m ³)	AWC (%)
MAP (mm)	-0.88**											
MAT (°C)	0.76**	-0.94**										
Mean Annual T _{max} (°C)	-0.90**	0.98**	-0.95**									
AI (PET/MAP)	0.59**	-0.63**	0.58**	0.64**								
Sand (%)	-0.22**	0.23**	-0.23**	0.25**	-0.42							
Silt (%)	0.34**	-0.38**	0.41**	-0.39**	-0.42**	0.13 ^{NS}						
Clay (%)	-0.43**	0.47**	-0.41**	0.44**	-0.19**	-0.03 ^{NS}	-0.21**					
SOC (Mg/ha)	-0.73**	0.79**	-0.71**	-0.77**	-0.56	0.21**	-0.20**	0.34**				
pH	-0.88**	0.98**	-0.94**	0.99**	-0.64**	0.23**	-0.35**	0.47**	0.76**			
BD (Mg/m ³)	0.53**	-0.61**	0.66**	-0.62**	0.07 ^{NS}	-0.08 ^{NS}	0.67**	-0.22**	-0.42**	-0.60**		
AWC (%)	0.30**	-0.42**	0.51**	-0.43**	-0.20**	0.11 ^{NS}	0.74**	-0.16*	-0.22**	-0.40**	0.65**	
CEC (cmol p(+) kg ⁻¹)	0.78**	-0.85**	0.87**	-0.90**	0.60**	-0.27**	0.33**	-0.32**	-0.73**	-0.86**	0.54**	0.43**

MAP: Mean annual precipitation; PET: Potential evapotranspiration; MAT: Mean annual temperature; AI: Aridity index; CEC: Cation exchange Capacity; AWC: Available water content; BD: Bulk density; SOC: soil organic carbon

Table 2.4.4b Pearson correlation coefficients (r) for climate and soil properties under different land uses (>15 cm depth)

Parameters	PET (mm)	MAP (mm)	MAT (°C)	Mean Annual Tmax (°C)	AI PET/MAP	Sand (%)	Silt (%)	Clay (%)	SOC (Mg/ha)	pH	BD (Mg/m ³)	AWC (%)
MAP (mm)	-0.76**											
MAT (°C)	0.86**	-0.53**										
MATmax (°C)	0.95**	-0.67**	0.97**									
AI (PET/MAP)	0.79**	-0.96**	0.59**	0.72**								
Sand (%)	-0.10 NS	-0.05NS	-0.18*	-0.14NS	0.00 NS							
Silt (%)	0.10 NS	-0.06 NS	-0.13 NS	0.12 NS	0.08 NS	-0.85**						
Clay (%)	0.09NS	0.09 NS	0.19*	0.14NS	-0.04NS	-0.94**	0.63**					
SOC (Mg/ha)	0.04NS	0.01 NS	0.02 NS	0.00 NS	-0.03 NS	0.06 NS	-0.14NS	-0.01NS				
pH	0.39**	-0.25**	0.36**	0.37**	0.29**	-0.53**	0.43**	0.51**	-0.13 NS			
BD (Mg/m ³)	0.08 NS	0.21*	0.18*	0.12NS	-0.12 NS	-0.61**	0.34**	0.70**	0.07NS	0.40**		
AWC (%)	0.21*	-0.07NS	0.29**	0.26**	0.10NS	-0.47**	0.33**	0.49**	-0.07NS	0.37**	0.35**	
CEC (cmol p(+) kg ⁻¹)	0.31**	-0.10 NS	0.37**	0.34**	0.14 NS	-0.71**	0.49**	0.73**	-0.01NS	0.67**	0.56**	0.47**

MAP: Mean annual precipitation; PET: Potential evapotranspiration; MAT: Mean annual temperature; AI: Aridity index; CEC: Cation exchange Capacity; AWC: Available water content; BD: Bulk density; SOC: Soil organic carbon

was investigated in relation to climate and soil properties under various climate regimes of Madhya Pradesh developed under similar parent material (Basalt). Across all sites, cropped land had significantly lower C and N stocks in the surface and subsurface soil layers than native forest sites. Mean annual temperature (MAT), the ratio of potential evapotranspiration to mean annual precipitation (PET: MAP), soil bulk density (BD), and clay content were important covariates for SOC stocks within land use. In Madhya Pradesh, the SOC content of the surface layers (0-15 cm; Table 2.4.4a) was mainly determined by climate factor, but the SOC content of the deeper soil layers (>15 cm; Table 2.4.4b) was more affected by texture factor, specifically sand content. Soil C and N stocks under land uses were strongly negatively related to MAT and positively related to PET: MAP, suggesting that they are equally vulnerable to increased temperature and decreasing water availability. Increased temperature and conversion from forest to cropland could decrease the existing SOC sink, but better soil management practices and increased water availability may help to offset these losses in the Madhya Pradesh.

2.4.5 Climate change impacts water use efficiency in wheat

Water use efficiency (WUE) was significantly affected by climate change parameters. The Open Top Chamber (OTC) study revealed that rise in temperature reduced WUE in wheat crop. On the other hand, elevated CO₂ (eC) alone and in combination with elevated temperature (eT) increased the

WUE to the extent of 10%. The highest WUE was observed under elevated CO₂ treatment. As compared to ambient (AC), there was a significant reduction in the WUE under elevated temperature condition. The WUE values varied from 168 to 201 kg ha⁻¹mm⁻¹. Considering a positive water-nutrient interaction, the finding has implications for nutrient use, particularly for nitrogen use efficiency (Fig. 2.4.5a).

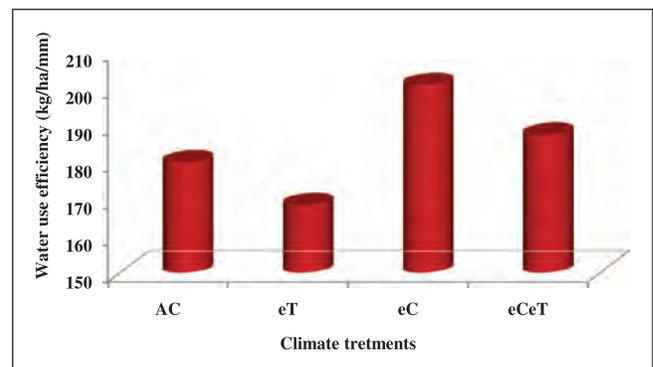


Fig. 2.4.5a Effect of various climatic treatments on water use efficiency in wheat crop

Elevation in CO₂ effect on grain yield

A field experiment with wheat crop (cv HI 1544) was taken in the OTC in the rabi season of 2016-17 to study the effect of climate change parameters on plant growth, nutrient uptake and water use. Results from the crop experiment with recommended fertilization indicated that elevation in

atmospheric CO₂ concentration by about 150 ppmv, increased the grain yield by 12%, whereas increased temperature showed a decline in the yield by about 6% (Fig. 2.4.5b). The positive feedback from CO₂ elevation showed a tendency of getting neutralized with rise in growing temperature by about 2.5 °C.

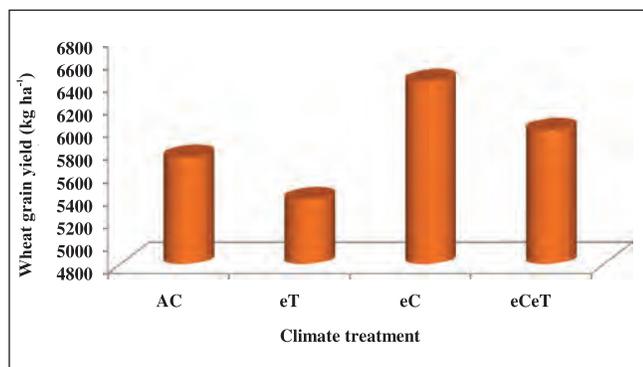


Fig. 2.4.5b Effect of various climate treatments on wheat grain yield

Increased temperature and CO₂ on nutrient content and uptake

Elevation in CO₂ concentration showed a reduction in N content in grain and tissue of wheat crop, whereas, when coupled with rise in temperature, the effect got reversed. The information derived from the study has significance in terms of value of crops to human nutrition and role in the N cycling under climate change conditions. Uptake of plant nutrients got significantly influenced by the climate parameters as well as by level of nitrogen application. Elevated CO₂ showed significantly higher N uptake but similar P uptake as that of the ambient condition (Fig. 2.4.5 c & d). Despite a significantly lower grain yield under elevated temperature treatments, the N uptake was statistically at par with ambient.

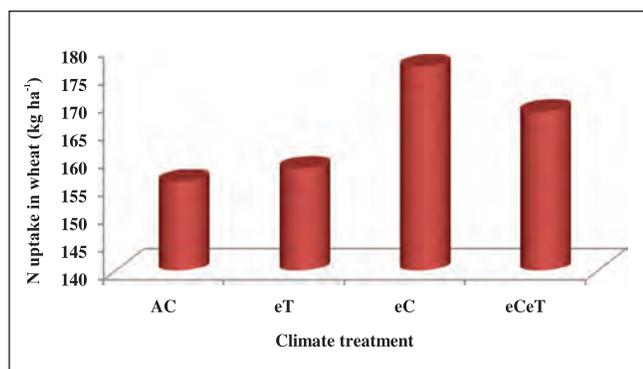


Fig. 2.4.5c Effect of various climatic treatments on nitrogen uptake in wheat

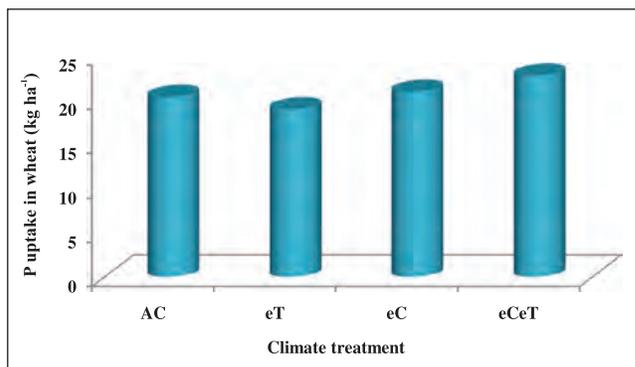


Fig. 2.4.5d Effect of various climatic treatments on phosphorous uptake in wheat

On the contrary, under elevation of both CO₂ and temperature, despite at par grain yield with ambient, the former showed significantly higher N uptake than ambient. The data thus indicated increase in atmospheric CO₂ concentration has a significant positive feedback in N uptake in wheat, whereas temperature showed a negative effect. The climate parameters also significantly influenced uptake of K, with higher uptake under elevated temperature treatments followed by elevated CO₂ treatment. This was due to significantly higher K concentration in plant residues under elevated temperature conditions, indicating the role of K under heat stress situations (Fig. 2.4.5e).

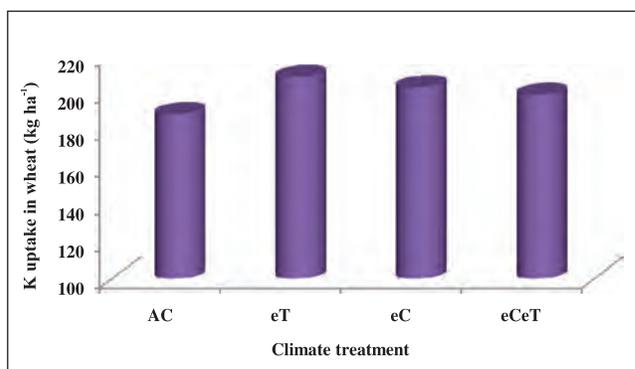


Fig. 2.4.5e Effect of various climatic treatments on potassium uptake in wheat

Theme -III: Microbial Diversity and Genomics

2.5 Microbial diversity and soil genomics

2.5.1 Long term use of fertilizer and manure on nitrogen mineralization and soil enzymatic activity under different soils and cropping system

A comprehensive knowledge of nitrogen transformations mediated through microbes in soil as affected by cropping systems and fertilizer application is imperative for maintaining soil health, computing fertilizer requirement and achieving optimum crop yield. The effect of long-term use of

farmyard manure (FYM) and inorganic fertilizers in Inceptisol (rice–wheat–jute rotation) and Vertisol (soybean–safflower) has been investigated for nitrogen mineralization potential (NMP) and soil enzymes (Amidase, Urease, β -Glucosaminidase) regulating nitrogen mineralization. The targeted treatments are fallow, control, 100% N, 100% NP, 100% NPK, 100% NPK + FYM. In terms of nitrogen dynamics, 100% NPK + FYM had significantly higher amidase, urease, protease and β -Glucosaminidase activity than control and other treatments in LTFE-Barrackpore. Fallow treatment had significantly higher amidase and protease activity as compared to all the treatments except 100% NPK + FYM (Fig. 2.5.1a). Similarly, in LTFE Parbhani the highest value of amidase, protease and β -Glucosaminidase activity was noticed in 100% NPK + FYM treatment. All the treatments recorded significantly

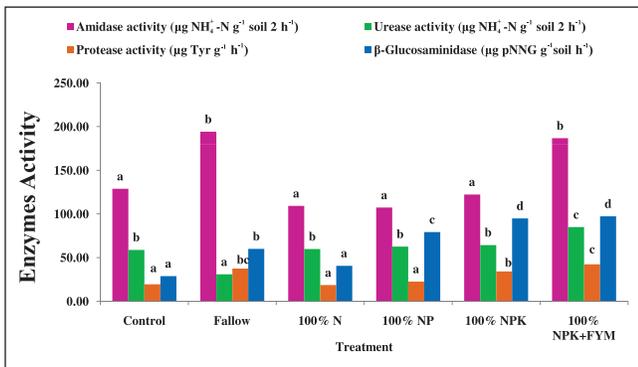


Fig. 2.5.1a Effect of long-term use of FYM and inorganic fertilizers in Inceptisol (Barrackpore) for soil enzymes regulating nitrogen mineralization.

higher urease activity as compared to the fallow, however, they were statistically comparable among themselves (Fig. 2.5.1b). In LTFE Barrackpore, NMP and arginine ammonification were found to be highest under 100% NPK + FYM and were significantly higher as compared to all other treatments (Fig. 2.5.1c).

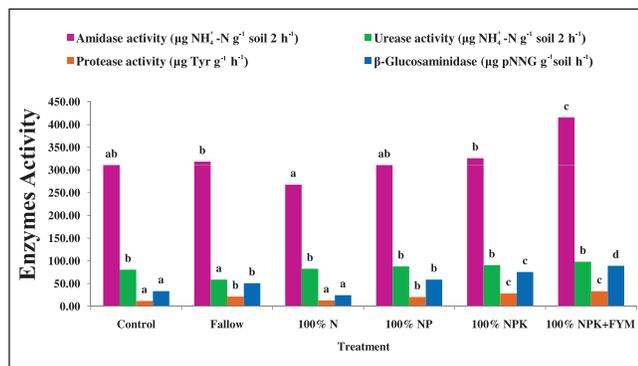


Fig. 2.5.1b Effect of long-term use of FYM and inorganic fertilizers in Vertisol (Parbhani) for soil enzymes regulating nitrogen mineralization

In case of NMP, 100% NPK + FYM and control recorded statistically similar results, however, both were significantly higher from 100% N, 100% NP and 100% NPK. Similarly, in LTFE Parbhani, fallow had the highest arginine ammonification, however 100% NPK + FYM was significantly higher than control, 100% N, 100% NP and 100% NPK. For NMP, 100% NPK + FYM showed the highest value but it was statistically similar with fallow and 100% NP (Fig. 2.5.1d).

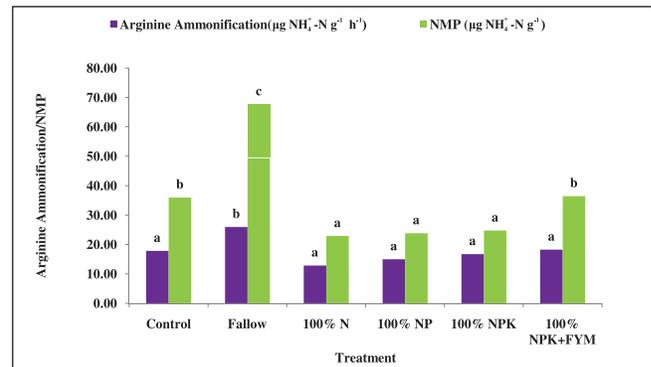


Fig. 2.5.1c Effect of long-term use of FYM and inorganic fertilizers in Inceptisol (Barrackpore) for NMP and arginine ammonification

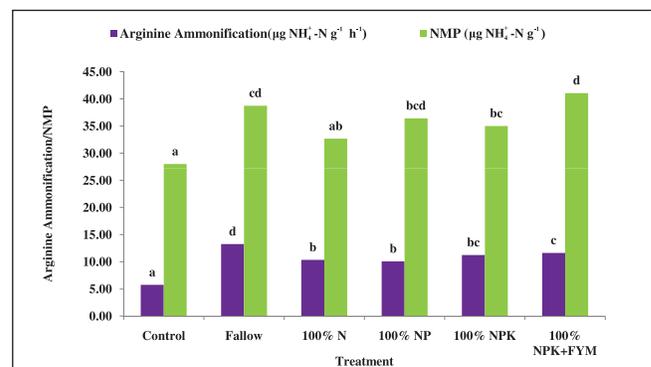


Fig. 2.5.1d Effect of long-term use of FYM and inorganic fertilizers in Vertisol (Parbhani) for NMP and arginine ammonification

2.5.2 Effects of long term use of fertilizer and manure on aggregate size distribution carbon and glomalin under different soils and cropping system

The effect of long-term use of FYM and inorganic fertilizers in Inceptisol (rice–wheat–jute rotation) and Vertisol (soybean–safflower) was investigated for aggregate size distribution, aggregate-carbon and aggregate-glomalin content in the soil samples of long term fertilizer experiment (LTFE) at Barrackpore and Parbhani. The targeted treatments are fallow, control, 100% N, 100% NP, 100% NPK, 100% NPK + FYM.

Significant variations in aggregate size distribution were noticed among different treatments in LTFE Barrackpore (Fig.2.5.2a). Both the 250-2000 μm macro aggregates and 53-250 μm micro aggregates contributed almost equally in aggregate size distribution and accounted for 28.7 to 47.01% and 35.2 to 47.9% of the dry weight of soil, respectively. Among all the treatments, fallow had the highest per cent contribution to each aggregate size class and it was followed by the 100% NPK+FYM treatment. In contrast, in LTFE Parbhani (Fig. 2.5.2b) the highest contributing aggregate class was 250-2000 μm macro-aggregates which accounted for 48.05 to 58.04% of dry weight of soil, whereas, 53-250 μm micro-aggregates accounted for 28.5 to 39.75% of dry weight of soil. Fallow had the highest per cent contribution to each aggregate size class except for >2000 μm macro-aggregates followed by 100% NPK+FYM treatment. Nevertheless, irrespective of aggregate size classes, the concentration of carbon was the highest in 100% NPK+FYM treatment, in both LTFE Barrackpore and LTFE Parbhani. In terms of aggregate carbon, 100% NPK + FYM had significantly higher aggregate carbon than control and other treatments in both Barrackpore and Parbhani LTFE soils (Fig.2.5.2c & d).

Total glomalin bradford related soil protein (TG-BRSP) concentrations ($\mu\text{g g}^{-1}$) across all treatments are shown in Fig 2.5.2e & f. Significant amounts of bovine serum albumin (BSA) persisted after the extraction process which was detected by the Bradford method. Regardless of soil type, fallow treatment showed significantly higher TG-BRSP over other treatments. In Barrackpore LTFE soil, significant difference in TG-BRSP content was observed amongst soil aggregates. Highest TG-BRSP was recorded in fallow treatment and in soil aggregates size >2000 μm followed by 250-2000 μm , 53-250 μm and < 53 μm in both Barrackpore and Parbhani LTFE soils (Fig. 2.5.2e and f). However, there is no significant difference between control, 100% N and 100% NP treatments in Parbhani LTFE soil.

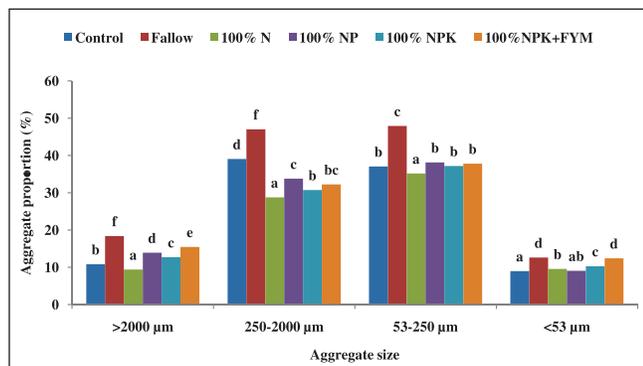


Fig.2.5.2a Aggregate size distribution under different treatments at Barrackpore

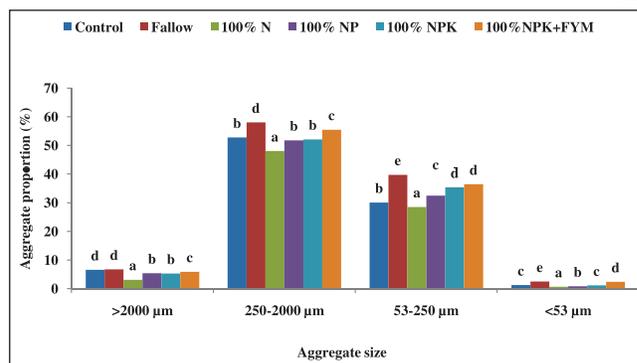


Fig.2.5.2b Aggregate size distribution under different treatments at Parbhani

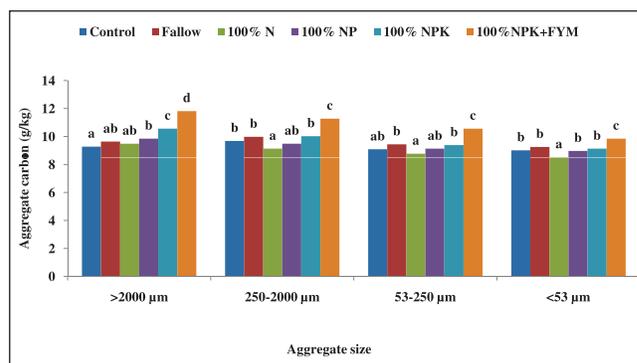


Fig. 2.5.2c Aggregate carbon under different treatments at Barrackpore

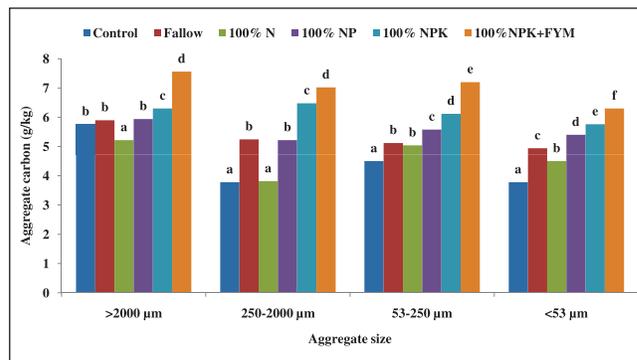


Fig. 2.5.2d Aggregate carbon under different treatments at Parbhani

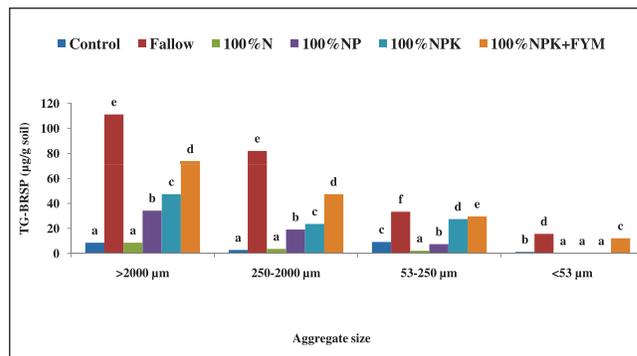


Fig. 2.5.2e Total glomalin bradford related soil protein (TG-BRSP) under different treatments at Barrackpore

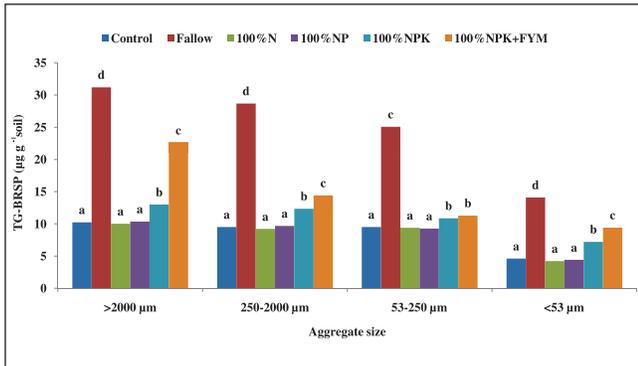


Fig. 2.5.2f Total glomalin Bradford related soil protein (TG-BRSP) under different treatments in Parbhani

2.5.3 Biodegradation of pesticides under changing climate and metagenomic profiling of functional microbes

Temporal variation in the chlorpyrifos degradation in different treatments under elevated CO₂ and temperature was estimated. In general, a major portion of chlorpyrifos was degraded in 15 days irrespective of treatments. The degradation of chlorpyrifos was initially faster and it gets slowed down after 15 days. Within 15 days, 71% to 88% chlorpyrifos was degraded at 25°C and 41% to 81% at 45°C in control soil. Among the treatments, chlorpyrifos was degraded completely in organic amended fields at 25°C while it was degraded from 85% to 99% at 45°C in organic amended fields. Degradation rate of chlorpyrifos was influenced by the fertilizer regime and environmental factors. Elevated CO₂ inhibited degradation of chlorpyrifos irrespective of

treatments. At 45°C, elevated CO₂ inhibited chlorpyrifos degradation rate by 17.62% in the control treatment (Table 2.5.3). The inhibiting effect of elevated CO₂ and temperature was lessened by organic fertilizer amendment.

Culturable count of the chlorpyrifos biodegrading bacteria ranged from 4.2 ± 0.701 x 10⁵ colony forming unit (CFU) g⁻¹ dry soil. In chlorpyrifos, unamended soil bacterial count was about 35 x 10⁶ CFU g⁻¹ soil. Based on the colony morphology, 17 bacterial isolates were selected for 16S rRNA sequences analysis and classification. Among the bacterial isolates, C1, C2, C5, C9 were closely related to *Microvirga* species whereas, C4, C6 isolates were similar to *Cuprividus* sp. (Fig. 2.5.3). The bacterial isolate C7 showed similarity with *Sphingophysis* sp. and C10, C12, C14, C15, C16 isolates were related to various *Bacillus* sp and *Paenibacillus* sp. The isolate C13 was mostly homologous to *Microbacterium*

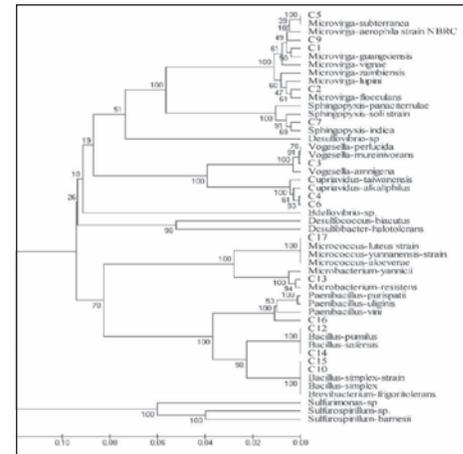


Fig. 2.5.3 Molecular phylogenetic analysis of chlorpyrifos biodegrading bacteria isolated from a Vertisol

Table 2.5.3 Effect of climate factors on chlorpyrifos degradation in Vertisol under different fertilizer management

Treatment	Soil moisture content (%)	CO ₂ (ppm)	Chlorpyrifos degradation rate (µg g ⁻¹ soil d ⁻¹)	
			25°C	45°C
Control	60	400	0.34±0.04i	0.301±0.018f
		800	0.28±0.01j	0.285±0.008h
	100	400	0.52±0.01e	0.319±0.02f
		800	0.44±0.02g	0.307±0.018g
Inorganic	60	400	0.51±0.01e	0.319±0.021f
		800	0.47±0.06f	0.303±0.012g
	100	400	0.59±0.03c	0.326±0.019e
		800	0.40±0.01h	0.310±0.018
Integrated	60	400	0.59±0.01c	0.352±0.018c
		800	0.54±0.02d	0.348±0.01d
	100	400	0.54±0.04d	0.352±0.015c
		800	0.47±0.01f	0.357±0.020b
Organic	60	400	0.63±0.01b	0.358±0.015a
		800	0.58±0.03c	0.355±0.015b
	100	400	0.65±0.02a	0.360±0.017a
		800	0.64±0.02a	0.359±0.017a
Tukeys HSD (df error 47 p= 0.05)			0.01	0.012

sp. where as the strain C17 showed similarity with *Micrococcus* sp.

2.5.4 In-situ decomposition process using ligno-cellulolytic microbial consortia

Field experiments were carried out at farmers’ fields of Haryana and Madhya Pradesh to decompose rice and wheat residues using *in-situ* decomposition technique. A consortia of ligno-cellulolytic microorganisms (4 fungi, 4 bacteria, 4 actinomycetes species) are used to decompose *in-situ* crop residues. Rice or wheat residues (34-38 q ha⁻¹) were decomposed systematically with following steps.

For *in-situ* decomposition, fresh cow dung about 4 t (on dry weight basis) was mixed thoroughly with water. To this slurry, about 37 kg urea, 50 kg molasses, 25 kg curd, 1.7 kg mycelial mat (cellulolytic fungi) and 34 L of microbial inoculum (lignocellulolytic bacteria and actinomycetes) were added and spread over the residues. The required

quantities of ingredients and approximate cost incurred in preparation has been given in Table 2.5.4a. All residues and ingredients were incorporated into soil by a tractor drawn rotavator. First irrigation was given immediately after mixing these consortia of microbes and other materials in the field. Then, second irrigation was given after 15 days of *in-situ* decomposition. After one month of *in-situ* decomposition, rice was grown. Similar process was followed for wheat crop after harvest of rice. It has been observed that the rice and wheat crop yield was better in *in-situ* decomposition treated plot than removal/burning of crop residues. Further, it was observed that the rice and wheat yield from farmer’s field in Panipat district was relatively better than the other districts (Table 2.5.4b). It was also observed that the soil health parameters such as soil organic carbon, available N, P and K, and activity of dehydrogenase and soil respiration was relatively greater in *in-situ* decomposition plots as compared to burning of residue under rice-wheat system (Fig.2.5.4a,b,c,d,e & f).

Table 2.5.4a Ingredients required for *in-situ* decomposition per ha

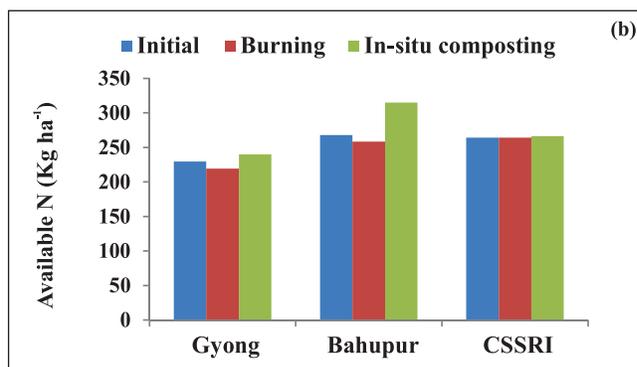
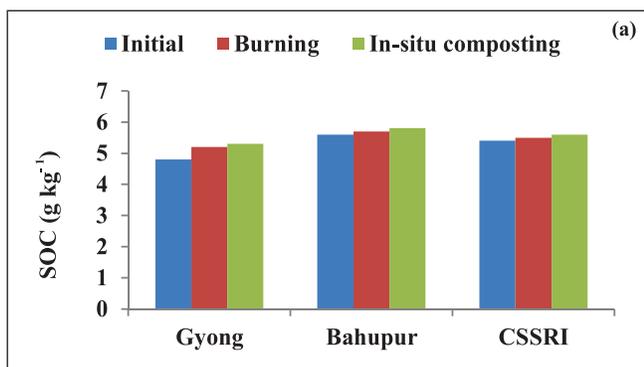
Residue	Cowdung	Urea	Fungal Culture	Bacterial/ actinomycetes culture	Gur	Curd	Shredding by reaper for one hectare	Rotavator for 4 hours	Irrigation
Qty. 33.8 quintal	4 t	37 kg	1.7 kg	34 L	50 kg	25 kg	One hectare	For one hectare	2 times
Cost (Rs.) available with farmer	Cowdung is available with farmer	233	1000	1000	1500	1000	1500	2500	3000
Total= Rs. 11733/- (approx. Rs. 12000)*									

* This is estimated cost with an assumption that cow dung is available with the farmer. Total cost may be reduced in subsequent years due to large scale production of microbial inocula so that cost may be reduced to Rs 6000 during subsequent year.

Table 2.5.4b Grain yield of rice and wheat at different locations in Haryana under residue burning and *in-situ* decomposition

Locations	Rice* (q ha ⁻¹)		Wheat (q ha ⁻¹)	
	Residue burning	<i>In-situ</i> decomposition	Residue burning	<i>In-situ</i> decomposition
Gyong (Kaithal, 10 farmers)	33.57	33.85	49.34	50.06
Bahupur (Panipat, 7 farmers)	41.97	42.27	50.55	51.72
CSSRI (Karnal, 3 plots)	33.53	34.20	48.90	50.56

*Basmati rice cultivar was grown in Gyong and CSSRI farm, whereas in Bahupur, Pusa 1121 cultivar was grown



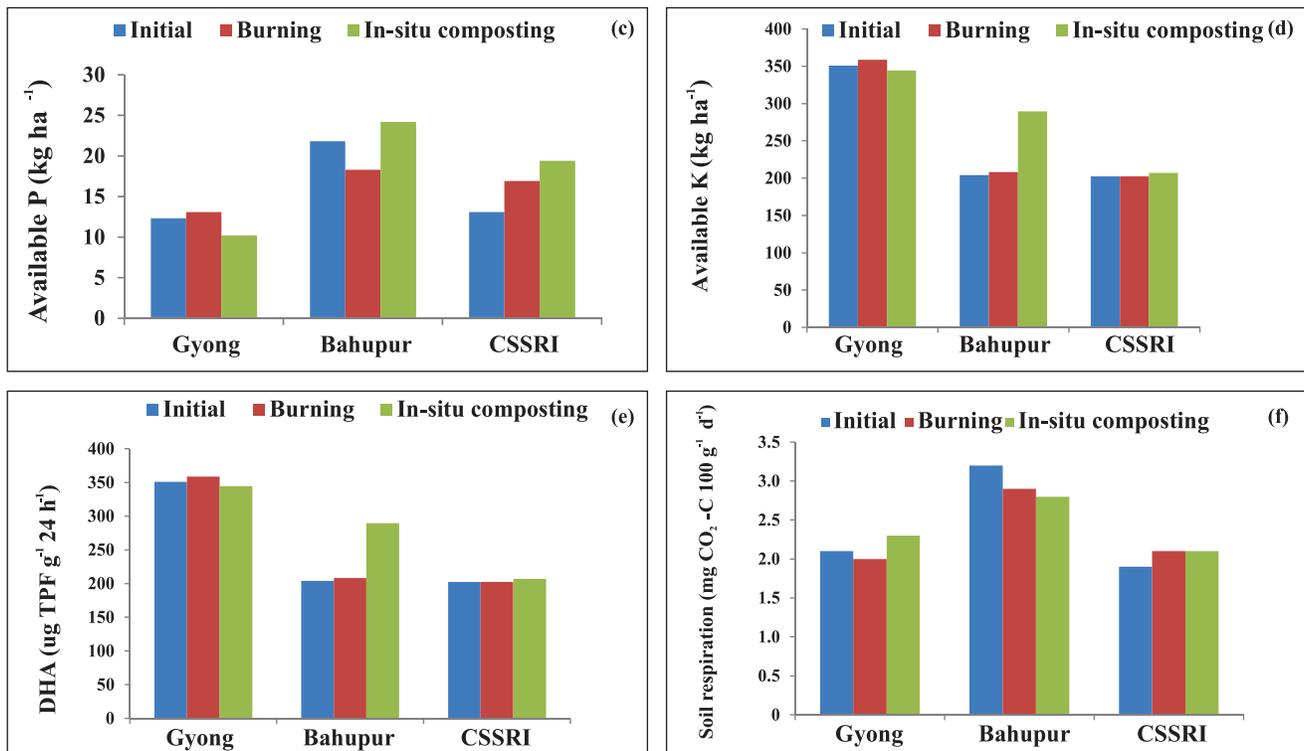


Fig.2.5.4 Effect of burning and in-situ composting on SOC (a), available N (b), available P (c), available K (d), dehydrogenase activity (e) and soil respiration (f) under rice-wheat system

2.5.5 Endophytic microbial diversity for improving crop production

Four morphologically distinct endophytic bacterial isolates from maize root was characterized for their plant growth promoting attributes. Out of the four endophytic isolates, MER 4 was able to solubilise tricalcium phosphate in media (phosphate solubilization index 2.86) (Plate 2.5.5a) and release potassium from glauconite (Plate 2.5.5b) to the extent of 6.0 µg ml⁻¹ broth containing 10⁷ viable cells ml⁻¹. The isolate also recorded very good IAA production ability

($p < 0.05$; 12.7 µg ml⁻¹ broth). Microscopic and biochemical characterization revealed the isolate being gram negative rod (Plate 2.5.5c), catalase-negative, oxidase-positive and motile. Antibiotic resistance profiling of MER4 showed resistant towards streptomycin sulphate up to 50 µg ml⁻¹ (Plate 2.5.5d). The resistance towards streptomycin will serve as selectable biochemical marker for tracking the colonization and survival of isolates in rhizosphere. Realizing its plant growth promoting attributes, the isolate may be a potential bioinoculum for improving nutrient use efficiency.

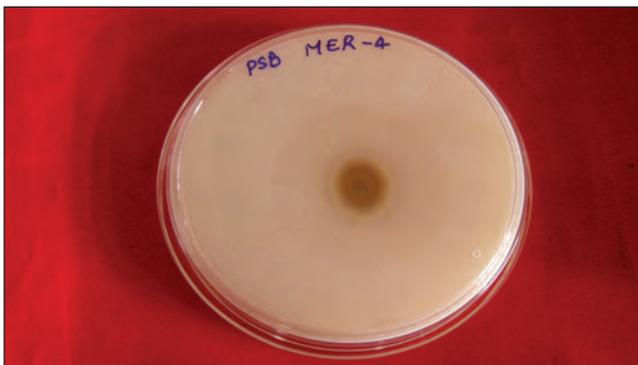


Plate 2.5.5a Solubilization of tricalcium phosphate by MER4



Plate 2.5.5b Potassium solubilization from glauconite by MER4



Plate 2.5.5c Micrograph of edophytic isolate MER 4 (100X)

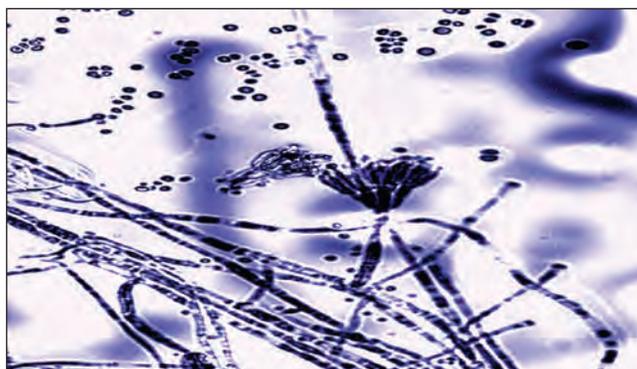


Plate 2.5.6a Endophyte strain (*Penicillium* sp.) used for bioremediation

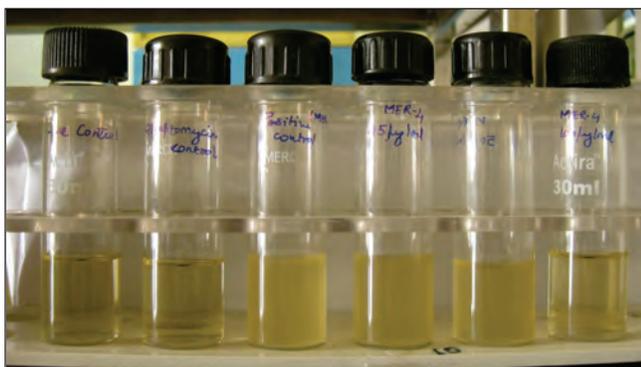


Plate 2.5.5d Antibiotic susceptibility of MER 4 at varying concentration of streptomycin sulphate



2.5.6 Bio remediation of heavy metal contaminated soil using endophytic fungi

A study was conducted to explore the role of endophytic fungi in decontamination of heavy metal soil isolated from the municipal solid waste dumping site. In this study, root of maize (*Zea mays* L.) seedlings was inoculated with heavy metal tolerant *Penicillium* sp. strain (Plate 2.5.6a) in cadmium and lead contaminated soil to study the effect of endophytic fungi on physiological properties of plant, translocation and accumulation of cadmium and lead in contaminated soil. The growth indicators (height, root length, dry weight of biomass) of maize plant was recorded. N, P, K, extracellular enzymatic activity of soil (dehydrogenase, fluorescein di-acetate, acid & alkaline phosphomonoesterases activity), Cd and Pb uptake by plant of inoculated and non-inoculated maize were also determined (Fig 2.5.6). Inoculation with endophytic fungal strain (*Penicillium* sp.) significantly increased the plant height, dry weight biomass, NPK content in maize under cadmium and lead stress (Plate 2.5.6b). Colonization of fungal strain improved the soil microbial activity and altered the translocation and accumulation of Cd and Pb in the plants. Further analysis showed that inoculation of *Penicillium* strain

Plate 2.5.6b Fungal inoculated *Zea mays* plant (upper) and Fungal non-inoculated plants (lower) (T1= Control, T2=Cd spiked soil, T3=Pb spiked soil, T4= Cd + Pb spiked soil, T5= naturally contaminated soil)

improved the tolerance of maize to heavy metal by restricting the translocation of heavy metal ions from roots to shoots and phytotoxicity of Cd and Pb to the aerial part of the plant was alleviated. The improvement of total microbial activity and the decrease of translocation factor of Cd and Pb, caused by endophytic fungal colonization, were efficient strategies to improve cadmium and lead heavy metal tolerance of host plants and reduce the phytotoxicity effect on plants.

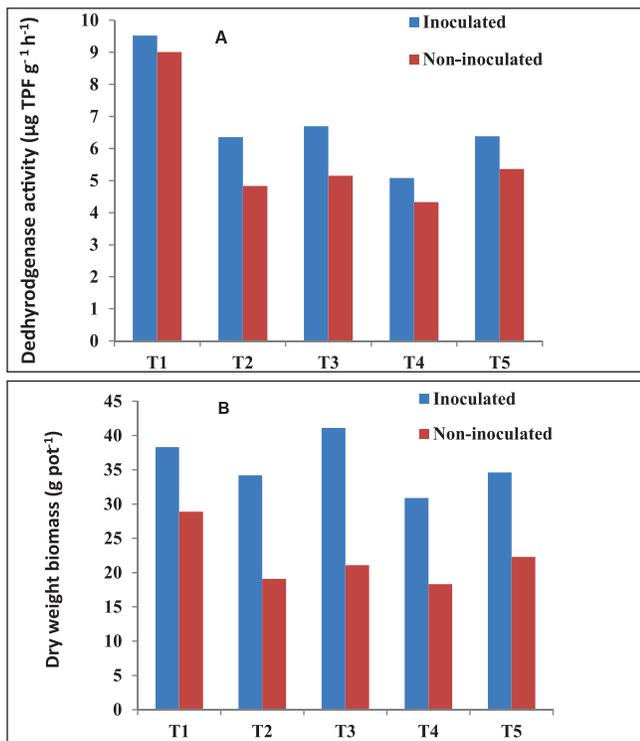


Fig. 2.5.6 Effect of endophytic fungi during phytoremediation by maize on A) dehydrogenase activity (µg TPF g⁻¹ h⁻¹) and B) Dry weight biomass (g pot⁻¹) in maize

2.5.7 Soil enzymes activities under organic farming

Soil enzyme activity is an indirect indication of the activities of microbes which is directly correlated with soil microbial dynamics. Enzyme activity in the soil environment is considered to be a major contributor of overall soil microbial activity. Enzyme activity like fluorescein diacetate (FDA), dehydrogenase, alkaline phosphatase and β-Glucosidase were determined in soil as influenced by different nutrient management practices. Fluorescein diacetate hydrolysis activity was found to be highest under 100% organic treatment which was closely similar to 100% organic treatment followed by 75% organic +25% inorganic and 75% organic + innovative treatment, but significantly higher than 100% inorganic and state recommendation treatments in wheat crop. For other crops also FDA hydrolysis was highest in 100% organic followed by 75% organic + 25% inorganic and 75% organic + innovative treatment indicating beneficial effect of addition of organics on soil microorganisms (Fig. 2.5.7). Among the cropping systems, soybean-wheat recorded higher FDA followed by soybean-mustard and soybean-chickpea system. Similarly, dehydrogenase activity, alkaline phosphatase and β-Glucosidase enzymes activities was the highest in organic management compared to inorganic and integrated management (Fig.2.5.7).

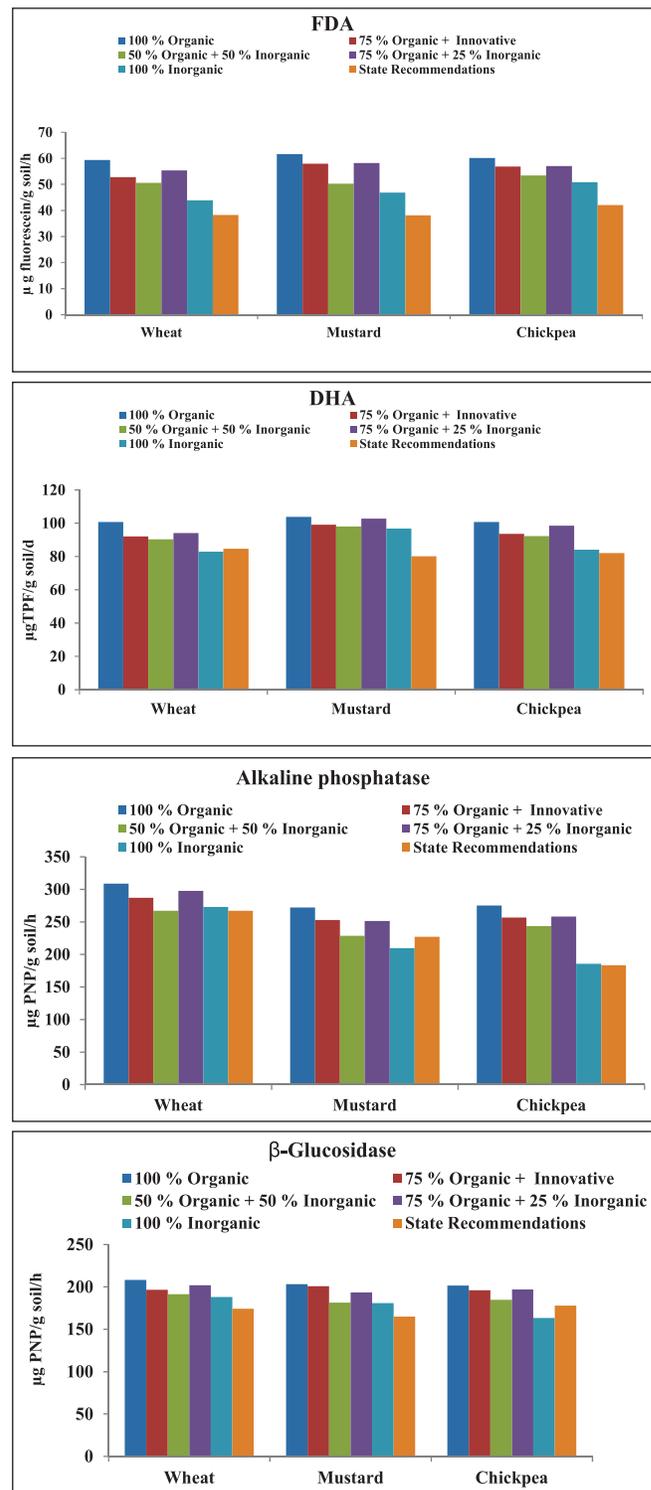


Fig. 2.5.7 Soil enzyme activities as affected by different nutrient management practices

2.6 AINP on SBB

2.6.1 Nitrification under the influence of long-term fertilizer application

An experiment was conducted to estimate nitrification and elucidate the N mineralization in a long-term fertilizer

experiment (LTFE). The treatments were; fallow, control (no fertilizer), NPK 100%, and NPK 100% + FYM. The nitrification got increased by addition of $\text{NH}_4\text{-N}$ during incubation. The PNR ($\mu\text{g NO}_3$ produced g^{-1} soil d^{-1}) was 0.887 in fallow, 1.866 in control, 1.278 in NPK 100%, and 1.493 in NPK 100% + FYM (Fig. 2.6.1a). Real time PCR quantification of abundance of bacterial amoA gene ($\times 10^4$ amoA gene copies g^{-1} soil) was 19.33 in fallow, 43.33 in control, 30.33 in NPK 100%, and 29.33 in NPK 100% + FYM. The gene copies ($\times 10^4$ gene copies g^{-1} soil) of amoA of

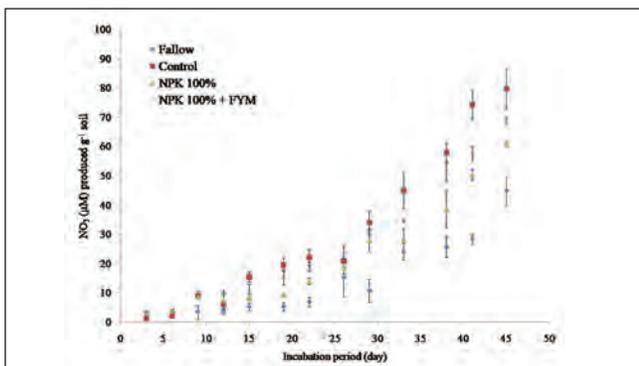


Fig. 2.6.1a Nitrification under the influence of long-term fertilizer application

archaea ranged from 11.67 to 38.67. The abundance of ammonia oxidizing bacterial amoA gene and ammonia oxidizing archaeal amoA gene was stimulated during nitrification. The X ray diffraction (XRD) of soils indicated occurrence of NH_4 containing minerals (Fig. 2.6.1b). The intensity of the NH_4 minerals was the highest in control and the lowest in fallow. The study thus indicated that long-term fertilizer application may inhibit nitrification in Vertisol. Secondly, the agricultural practice like limited fertilizer input and intensive cropping may alter microbial metabolism which can mineralizes complex $\text{NH}_4\text{-N}$ bearing minerals

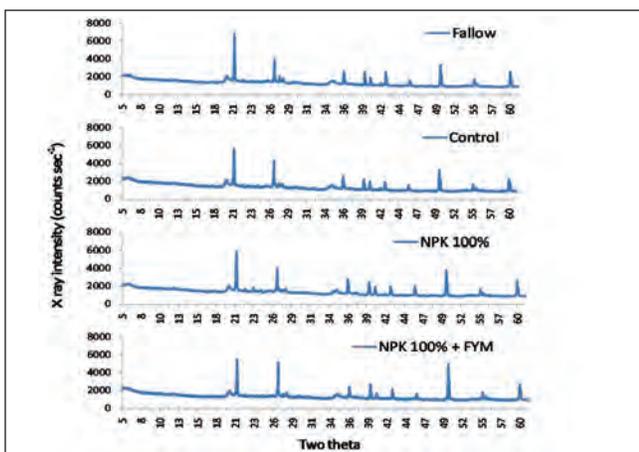


Fig. 2.6.1b XRD pattern of soils under long term fertilizer application

for nitrification and N acquisition. This study provided new insights into the microbial mediated nitrification in a fertilizer gradient soil ecosystem, It opened new avenues suggesting to re-visit the N cycling under nutrient limited and enriched soil ecosystem to better understand the biogeochemical processes for efficient nutrient management.

2.6.2 Microbial diversity and genomics for soil health

- Whole genome of *Pseudomonas fluorescens* strains Pt 14 and Ps Chi were sequenced. Genome sequences revealed the presence of genes for improving plant growth and biocontrol of phytopathogens.

Theme - IV: Soil Pollution, Remediation and Environmental Security

2.7 Soil pollution and remediation

2.7.1 Determination of tolerance limit of Cd and Pb

Bt Cotton (RCH-2) was evaluated for its suitability for the remediation of soils contaminated with Cd and Pb. The plant was exposed to different levels of Cd (0, 50, 100 & 200 mg kg^{-1} soil) (Plate 2.7.1a), Pb (0, 500, 750 and 1000 mg kg^{-1} soil) (Plate 2.7.1b) and Cr (0, 12.5, 25 & 50 mg kg^{-1} soil). The study indicated that, cotton plant could tolerate up to 200 mg Cd kg^{-1} soil and 1000 mg Pb kg^{-1} soil without any mortality. Therefore, in order to know to what levels of Cd and Pb the cotton plant would tolerate, another experiment was conducted by taking the highest levels of Cd



Plate 2.7.1a Effect of different levels of Cd (mg kg^{-1} soil) on growth of cotton

and Pb in the previous study as base levels i.e., 200 mg Cd kg^{-1} soil and 1000 mg Pb kg^{-1} soil. For tolerance limit determination, the experiment was conducted with different levels of Cd (0, 200, 400, 600, 800 and 1000 mg kg^{-1} soil) and Pb (0, 1000, 1500, 2000, 2500 and 3000 mg kg^{-1} soil). The crop was grown for 45 days and the data on germination/emergence, plant height, root length, number of leaves/plant, dry weight of shoot and root were recorded. The



Plate 2.7.1b Effect of different levels of Pb (mg kg⁻¹ soil) on growth of cotton

data revealed that, 100% emergence was observed in all the treatments and there was no mortality even at the highest levels of Cd and Pb. The application of Cd significantly decreased the plant height of cotton, but Pb did not show any significant effect on plant height (Table 2.7.1a & 2.7.1b). The applied Cd and Pb did not show any significant effect on root growth (root length and root dry weight) but significantly decreased the dry weight of shoot. The partitioning of Cd and Pb in cotton revealed that, invariably the roots accumulated the higher concentration of Cd followed by shoots (Fig.2.7.1a & b).

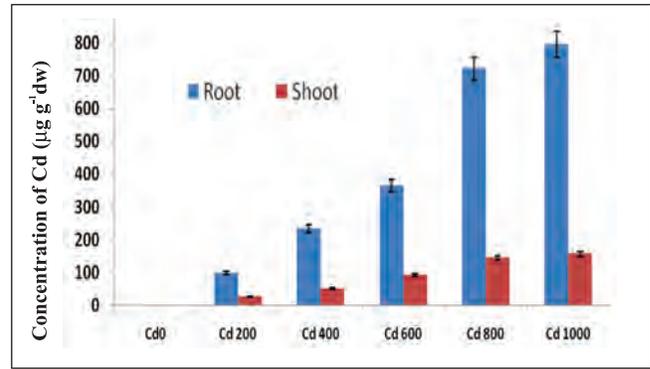


Fig. 2.7.1a Effect of different levels of cadmium on shoot and root Cd content of cotton

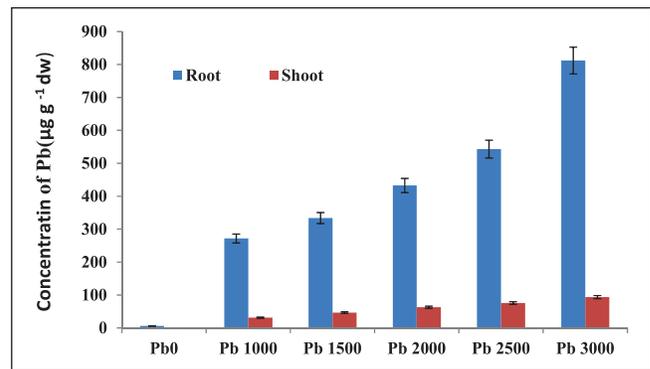


Fig. 2.7.1b Effect of different levels of lead on shoot and root content of cotton

Table 2.7.1a Effect of different levels cadmium on some morphological parameters of cotton

Treatment (mg kg ⁻¹)	Plant height (cm)	Root length (cm)	No of leaves pot ⁻¹	Dry weight of shoot (g pot ⁻¹)	Dry weight of root (g pot ⁻¹)	Total dry weight (g pot ⁻¹)
Cd0	16.88 ^a	14.50	14.33	1.47 ^a	0.15	1.62 ^a
Cd 200	14.17 ^{ab}	14.17	14.00	1.20 ^b	0.14	1.34 ^b
Cd 400	13.83 ^{ab}	14.33	14.00	1.05 ^{bc}	0.16	1.20 ^{bc}
Cd 600	13.50 ^{bc}	11.17	13.67	1.04 ^{bc}	0.12	1.17 ^{bc}
Cd 800	10.50 ^{cd}	10.83	13.33	0.93 ^c	0.10	1.03 ^c
Cd 1000	10.17 ^d	10.67	13.33	0.91 ^c	0.08	0.99 ^c
CD (0.05)	3.23	NS	NS	0.22	NS	0.23

Table 2.7.1b Effect of different levels of lead on some morphological parameters of cotton

Treatment (mg kg ⁻¹)	Plant height (cm)	Root length (cm)	No of leaves pot ⁻¹	Dry weight of shoot (g pot ⁻¹)	Dry weight of root (g pot ⁻¹)	Total dry weight (g pot ⁻¹)
Pb0	17.00	13.67	15.00 ^a	1.54 ^a	0.16	1.70 ^a
Pb 1000	16.00	13.17	14.67 ^a	1.39 ^{ab}	0.13	1.52 ^{ab}
Pb 1500	16.17	12.50	14.00 ^{ab}	1.35 ^b	0.12	1.47 ^b
Pb 2000	15.83	10.83	13.67 ^{abc}	1.24 ^b	0.11	1.36 ^{bc}
Pb 2500	15.00	10.83	13.67 ^{bc}	1.03 ^c	0.11	1.15 ^{cd}
Pb 3000	14.00	11.67	13.00 ^c	1.07 ^c	0.11	1.18 ^d
CD (0.05)	NS	NS	1.4	0.18	NS	0.19

2.7.2 Critical limits of cadmium for major soil orders of India

Pot culture experiments were conducted to derive phytotoxicity limits of cadmium for major soil orders (Alfisol, Vertisol and Inceptisol) of India. The results showed that cadmium application had significant yield reduction over control. The dry weight of spinach biomass of at highest level (40 mg kg⁻¹) of cadmium application was 49.7%, 39.7% and 38.5% as compared to control in alluvial, lateritic and black soil, respectively. Phytotoxicity limit of cadmium for spinach biomass was more in alluvial soil of Kanpur as compared to black soil of Indore. Plant accumulation of cadmium increased with increasing levels of cadmium in all the 3 soil types. At their corresponding levels, cadmium accumulation in spinach biomass leaf was more in lateritic soil followed by alluvial and black soil. At the highest level (40 mg kg⁻¹) of cadmium application, the leaf Cd concentration was 151.2, 78.1 and 64.8 mg kg⁻¹ of biomass in lateritic, alluvial and black soil, respectively. Transfer coefficient value for cadmium was significantly high in lateritic soil (4.87) followed by alluvial (3.22) and black soil (2.32). Also different extractants (0.01M CaCl₂, 1M CaCl₂, DTPA and 0.43MHNO₃) were evaluated to predict the bioavailable concentration of Cd in soil. Among the different extractants, the magnitudes of bioavailable fraction were highest in 0.43M HNO₃ followed by 1M CaCl₂, DTPA and 0.01M CaCl₂ extractant (Fig. 2.7.2). Among the soil types, the bioavailable concentration was significantly higher in lateritic soil followed by alluvial and black soil in all

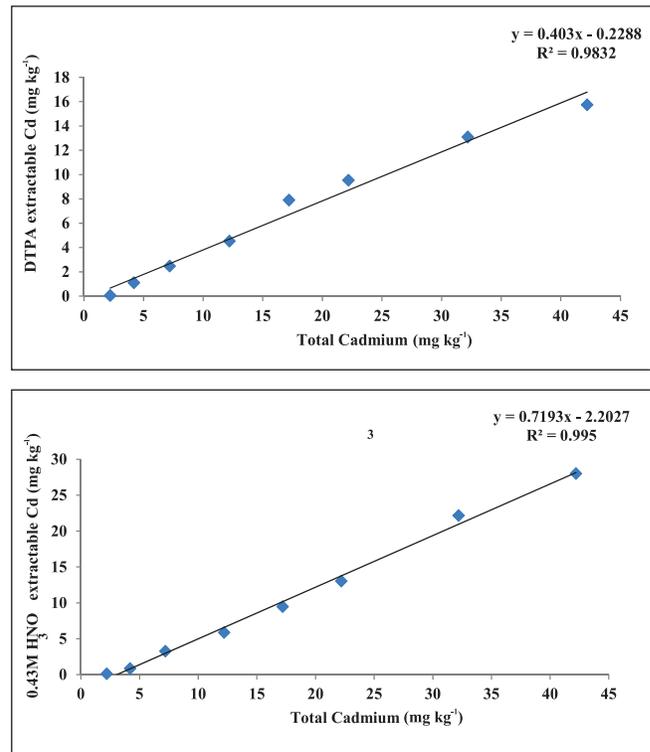
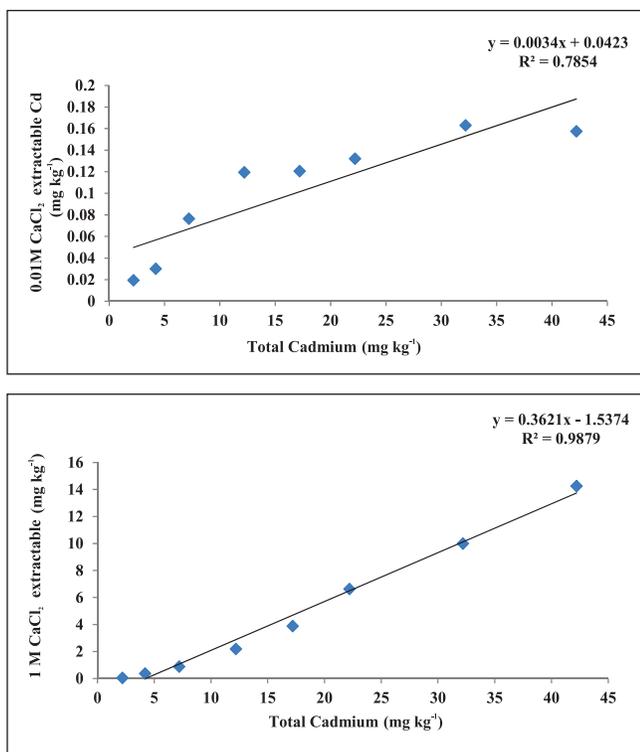


Fig. 2.7.2 Different extractants for predicting bioavailable fractions of Cd in black soil

the extractants used. Significant linear relationship was observed between the extractable fraction by 1M CaCl₂ extractant and total Cd content with R² value of 0.985, 0.982 and 0.962 in lateritic, alluvial and black soil. Similarly, significant linear relationship was observed in between the extractable fraction by 1M CaCl₂ extractant in soil and plant content with R² value of 0.97, 0.87 and 0.99 in lateritic, alluvial and black soil.

2.7.3 Baseline concentration of heavy metals in Indore soils

A preliminary survey was conducted to estimate the baseline concentrations and spatial distribution of heavy metals (HMs) in agricultural soils of Indore district. 50 geo-referenced surface soil samples (0-15 cm) were randomly collected across the district and their physico-chemical properties and total HM contents were analyzed. Most of the soils in the region had neutral to alkaline pH, with medium organic carbon and high clay (>40%) content. The concentrations of HMs (mg kg⁻¹) ranged from Cu 56.8-226.2; Cd 0.98-2.04; Pb 15.4-63; Cr 39.6-141; Ni 48.2-94.6; and Zn 78.2- 127.0; respectively. The upper baseline concentrations of HMs (mg kg⁻¹) were Cu, 119.8; Cd, 1.67; Pb, 22.4; Cr, 95.6; Ni 55.44; and Zn, 80.3; respectively. The spatial distribution showed that concentrations of Cd, Ni and Zn were within the safe range but the concentrations of Cu, Cr and Pb were little high. Different heavy metal extraction methods (di-acid,



aqua regia, HF) also conducted for higher recovery of metals which revealed for higher recovery by HF than that by aqua regia and diacid.

2.7.4 Management of municipal solid waste contaminated landfill area of Bhanpur, Bhopal

Plantation of various crops has been done for the establishment of green cover at the municipal solid waste (MSW) dumping site, Bhanpur with growing of different plants like Beshram (*Ipomoea carnea*), Vetiver (*Chrysopogon zizanioides*), Subabul (*Leucaena leucocephala*), Castor (*Ricinus communis*) etc. (Plate 2.7.4).



Plate 2.7.4 Established crop at Bhanpur experimental site

2.7.5 Reclamation and rehabilitation of copper mining affected land in Malanjkhanda, Madhya Pradesh

A study was conducted for reclamation and rehabilitation of copper mining affected land in Malanjkhanda area of Madhya Pradesh through establishment of green cover by multitiered plantation crops (grass –shrubs- small trees -tall trees) and rejuvenation of the soil system (improved soil fertility and microbial growth). Initially, Vetiver grass (*Chrysopogon zizanioides*) was planted in the experimental site. Growth of Vetiver at Tailing Dam Embankment was excellent and the survival percentage was 90%. However, the water scarcity of and soil depth is the major problem in Vetiver establishment.



Plate 2.7.5 Vetiver plantation in the tailing embankment

2.8 AICRP (MSPE)

2.8.1 Evaluation of heavy metal load in water and nearby soils of Bhanpur Nala, Bhopal

In order to study heavy metal load in water of Bhanpur Nala and soils nearby Nala, a study was carried out on both sides of

Bhanpur Nala, starting from Bhanpur bridge to Halali dam. Sampling sites were selected keeping in view the point where water is used for irrigation. Soil samples were collected nearby Bhanpur Nala, 1.0 and 2.0 km away from Nala on both the sides of Nala at 500-meter interval starting from Bhanpur to Halali dam. Analysis of water samples revealed that Pb content in sewage water varied from 0.13 to 1.75 mg L⁻¹ with an average of 1.24 mg L⁻¹. The level of Pb was much below the safe limit of Pb, i.e. 5 mg L⁻¹ (FAO, 1985). The safe limit of Cd in drinking water as per Indian standard is 0.01 ppm. The Cd content in Bhanpur Nala water ranged from 0.11-0.16 mg L⁻¹ with a mean value 0.13 mg L⁻¹. The Ni content in sewage water ranged from 0.04 to 0.79 mg L⁻¹ with a mean value of 0.48 mg L⁻¹, which is greater than the safe limit of 0.20 mg L⁻¹(FAO, 1985), hence Nala water is not safe with regard to Ni at most of its discharge points. The Cu content in

sewage water ranged from 0.02 to 0.37 mg L⁻¹. Although, Mn is not considered a toxic metal but its excess amount in water limits its use for domestic purposes. Mn content in Nala water ranged from 0.03 to 0.34 mg L⁻¹ with mean value of 0.16 mg L⁻¹ which is near to safe limit (0.20 mg L⁻¹) as prescribed by FAO (1985). The Zn content in Nala water varied from 0.21-1.12 mg L⁻¹ with mean content of 0.80 mg L⁻¹. The iron content except two sites where it was more than 5.0 mg L⁻¹, was below the safe limit. Analysis of soil samples collected from near Nala, 1 km and 2 km away from Nala showed that heavy metal concentration was within the permissible limits. Although soil samples collected nearby Nala, 1 and 2 km away from Nala did not exhibit much difference in heavy metal content, however the concentration of most of the heavy metal decreased as the distance of sampling increased from Nala (Fig. 2.8.1)

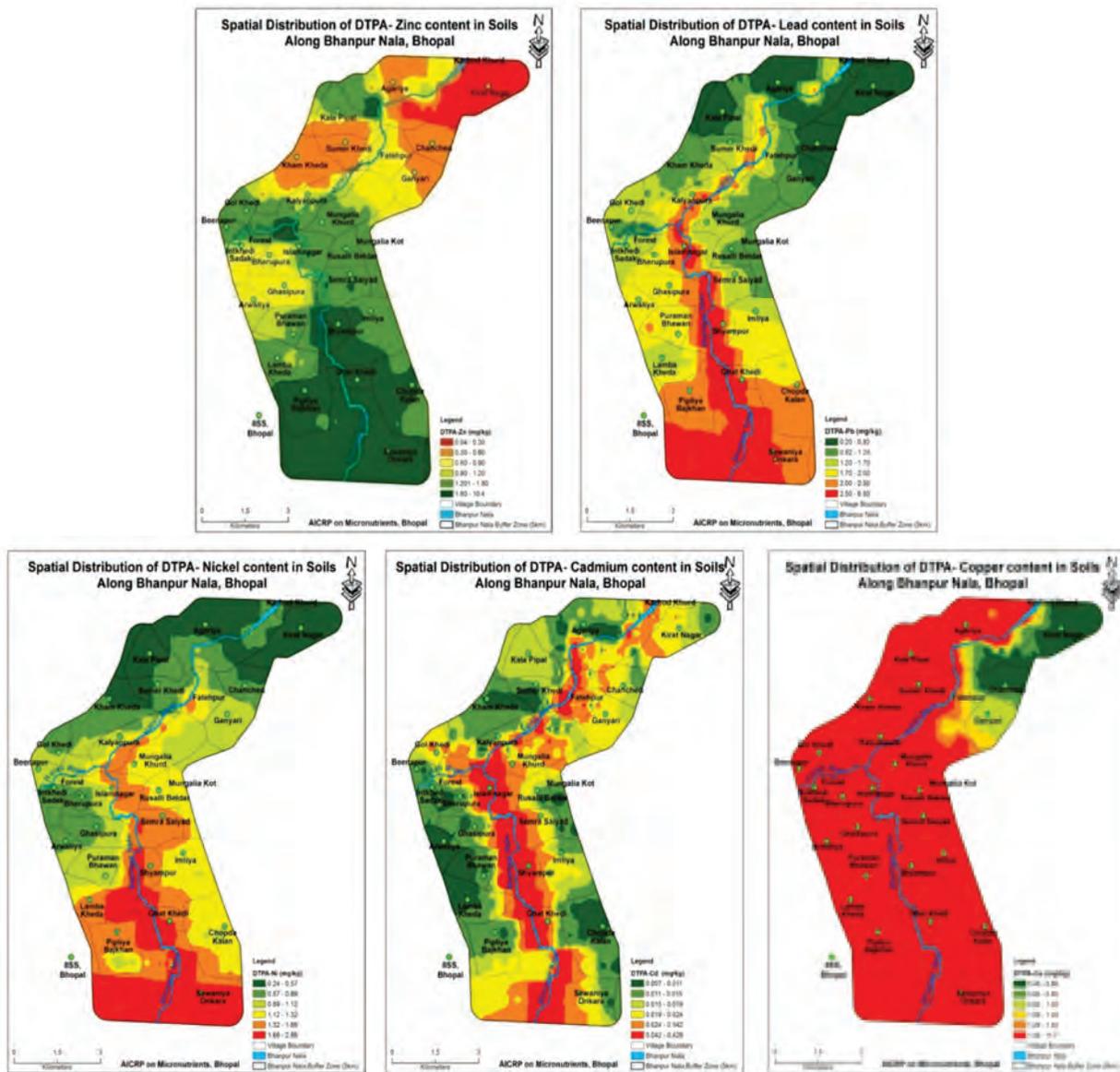


Fig. 2.8.1 Spatial distribution of heavy metals in soils of nearby Bhanpur Nala



3. Transfer of Technology

3.1 Technology demonstration through Farmer FIRST approach

3.1.1 Survey of farm clusters and soil resources

The preliminary survey carried out on households in the cluster villages indicated that about 78% of the villagers are farmers and rest of the 22% population depends on farming and also allied activities for their livelihood. More than 50% of the villagers live as joint family with average family size between 10 to 15 family members. More than 90 per cent of the farmers belong to the small and marginal category. Almost 92% farmer adopts crop rotation while few farmers (3.2%) follows mixed and multi-storeyed farming systems. The on-farm resource base of a few farms observed to be strong (5%) and about 52 per cent farms fully depend upon off-farm resources. Adoption of land management practices like minimum tillage, growing of cover crops and mulching are found to be unfamiliar to the farmers. Majority of the farmers control pest and diseases by using agricultural chemicals, however, some farmers (6.5%) are also using biological means. Involvement of the villagers' found to be low as far as social groups like farmer interest groups, self-help groups are concerned. Similarly, their exposure to mass media in accessing agricultural knowledge also found to be poor.

The Agro ecology map and PRA of the selected villages (Fig 3.1.1 and Plate 3.1.1) indicated that rice-wheat is the predominant cropping system in the project area. It is because the availability of irrigation water is sufficient for rice cultivation due to nearby water bodies like river, canal etc. Another predominant cropping system adopted by the farmers found to be soybean-wheat.

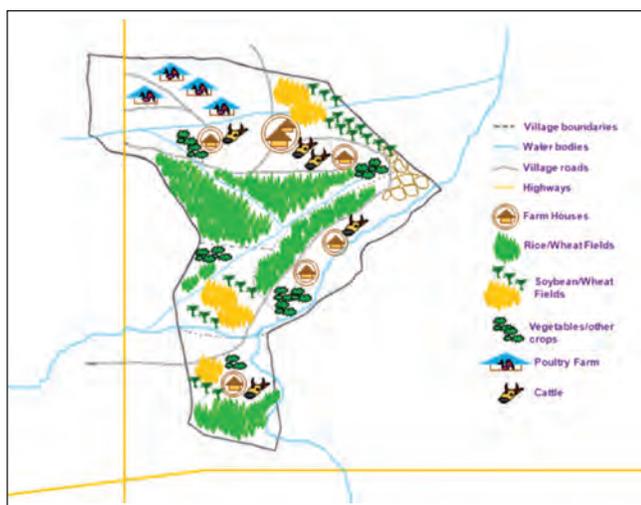


Fig. 3.1.1 Agro ecology map of the selected villages



Plate 3.1.1 PRA in selected villages

Geo referenced soil samples were collected from the village cluster and were analyzed for different soil parameters. Farmers were advised to apply plant nutrients to the crop based on soil test values of individual fields.

3.1.2 Conservation agriculture based crop production technology demonstrations

About 85 demonstrations were conducted during kharif 2017-18 (44 on soybean and 41 on rice; Plate 3.1.2a). The rice and soybean productivity from these field trials was recorded to be 37.24 qha⁻¹ and 6.91 q ha⁻¹, respectively.

Also, resource conservation based 99 demonstrations were conducted during rabi 2017-18 (80 on wheat and 19 on chickpea; Plate 3.1.2b). The productivity of wheat ranged between 47.85 to 53.40 q ha⁻¹ in different villages. Fertilizers were applied to the crop to achieve a target yield of 50 q ha⁻¹. This resulted in not only saving of fertilizer but also increased crop yield as compared to farmers practice. Similarly, chickpea crop also recorded seed yield in the range of 13.75 to 14.14 q ha⁻¹ with an average of 14.10 q ha⁻¹ under farmer's field condition in the selected villages.

Direct seeded Basmati rice (PB⁻¹)

Soybean (JS 95-60)

Plate 3.1.2a Crop performance in experimental fields



Plate 3.1.2b Sowing and crop performance under zero till condition in farmers field

3.1.3 Horticultural plantation in village cluster

A survey was conducted and selected nine farmers from Bhairapura, Kanchbawli, Kalyanpura and Khamkheda cluster of villages were selected. About 300 saplings of mango (var Amrapali) (Plate 3.1.3a), 1000 plants of papaya and 1000 saplings of drumstick were planted in the farmers' field (Plate 3.1.3b). Plantation of fruit trees was done as per recommended management practices.

3.1.4 Vegetable production under horticulture based modules

Package of practices for improving vegetable yield was adopted under horticulture based modules at farmers' field

(Plate 3.1.4). Twenty-five farmers were selected in four villages namely Khamkheda, Kalyanpura, Bhairapura and Kanchbavli to conduct the vegetable production demonstrations. Vegetables like okra, bitter gourd, cucumber and pumpkin were grown under the demonstration trials in summer season. Crop yield got increased with an intervention (i.e. package of practice module) compared to imbalanced application of nutrients under farmers' practice. Similarly, tomato and brinjal were grown on twenty five farmers' fields in winter season (November and December, 2017). Balanced use of fertilizers, weed and insect-pest control practices were also adopted in tomato and brinjal crops. During rabi season, 40000 seedlings of tomato and brinjal were distributed to 25 farmers.



Plate 3.1.3a Mango plantation on farmer's field at Kalyanpura village



Plate 3.1.3b Plantation of papaya and drumstick on farmer's fields



Plate 3.1.4 Field demonstration on vegetable production technology

3.1.5 Livestock and backyard poultry interventions

Two training programmes were conducted in Khamkheda and Bhairapura villages for creating awareness about animal health and milk production (Plate 3.1.5). A total of 600 chicks

and their feed (9.5 q) was arranged and distributed to the farmers with a total cost of ₹ 76800/-. Similarly, cattle feed mixture (20 q) with an expenditure of ₹ 70000/- was also arranged and distributed to the farmers in the study area for enhancing milk production.



Plate 3.1.5 Training programmes organized and distribution of poultry feed and chicks

3.1.6 Enterprise based modules

A five days farmers, training on Enhancing Farmer Income through “Honeybee Keeping” was organized during 20-24, March, 2018 at Fruit Research Station, Entkhedi, Berasia Road Bhopal and each farmer has been provided with Honey bee box unit and kit for bee keeping. Farmers were trained in vermicompost preparation and 20 pairs of Silpaulin vermibed were distributed to the identified progressive farmers in the adopted villages (Plate 3.1.6a).



Plate 3.1.6a Distribution of vermibed and demonstrations of vermicompost preparations



Plate 3.1.6b. Demonstration of rapid composting technology in Khamkheda village



Rapid composting technology was also demonstrated in the farmers’ field using consortia of thermophilic ligno-cellulolytic microbes (Plate 3.1.6b). Matured compost was prepared within 30-45 days. C:N ratio of the matured compost was recorded as 18:1 and lignin: cellulose ratio increased to

1.4%. Nutrient value of the matured compost was found to be 1.75%, 1.9% and 0.8% NP and K respectively. technology was demonstrated through video and e-published through youtube (link:https://www.youtube.com/watch?v=q-TI3xk_90A) and distributed to selected farmers and state government officials of India (Plate 3.1.7).



Plate 3.1.7 Distribution of family net compost vessel

3.2 AICRP on STCR

3.2.1 Long-term STCR-IPNS field demonstration at TNAU, Coimbatore, Tamil Nadu

The long-term STCR-IPNS block demonstration is being conducted since Kharif 1998 at the Wetland farm of TN, Coimbatore on a Typic Haplustalf (Noyyal series). Two crops of rice are being raised every year and the treatments imposed were i) Blanket recommendation ii) STCR - NPK alone for 6 t ha⁻¹ for kharif rice and 5 t ha⁻¹ for Rabi rice iii) STCR - NPK alone for 7 t ha⁻¹ for kharif rice and 6 t ha⁻¹ for Rabi rice iv) STCR - IPNS for 7 t ha⁻¹ for kharif rice and 6 t ha⁻¹ for Rabi rice and v) Absolute control.

For IPNS plots, FYM @ 12.5 t ha⁻¹ and *Azospirillum* and Phospho bacteria each @ 2 kg ha⁻¹ were applied and the fertilizer doses were adjusted accordingly. The pre-sowing soil test values and the recommended doses of fertiliser nutrients applied for kharif and rabi rice (Table 3.2.1a and 3.2.1c). Grain yield, response ratio, and per cent achievement for kharif and rabi rice are given in Table 3.2.1b and 3.2.1d.

Grain yield

The grain yield (Table 3.2.1b) of kharif rice ranged from 2300 kg ha⁻¹ in control to 7025 kg ha⁻¹ in STCR-IPNS-7 t ha⁻¹ (target yield) treatment. The highest response ratio of 19.52 kg grain yield per kg of nutrient applied was also recorded in STCR-IPNS-7 t ha⁻¹ treatment. The achievement of yield targets was more than 90 per cent in all the STCR treatments and the highest achievement (100.4%) was observed in STCR-IPNS-7 t ha⁻¹ treatment. Similarly, the grain yield in Rabi rice ranged from 2410 kg ha⁻¹ in control to 6205 kg ha⁻¹ in STCR-IPNS 6 t ha⁻¹ (target yield) treatment (Table 3.2.1d). The highest response ratio of 18.88 kg grain yield per kg of nutrient applied was recorded in STCR-IPNS 6 t ha⁻¹ treatment. The achievements of yield targets were more than 95 per cent in all the STCR treatments and the highest achievement

(103.4%) was observed in STCR-IPNS 6 t ha⁻¹ treatment. The yield targets achievement in other treatments was 97.4 and 98.6 per cent in STCR 5 t ha⁻¹ and STCR 6 t ha⁻¹, respectively.

Soil fertility status

Among the treatments, STCR and IPNS based treatments registered relatively higher available N, P and K status when compared to blanket and absolute control. When compared to initial fertility status of 1998 kharif, the initial soil fertility status of Kharif season (Table 3.2.1a) revealed relatively a decline in available N and the magnitude of decline was relatively very low in STCR-IPNS treatments. With respect to available P, a little build up was observed in all fertilized treatments. The built up was higher in STCR-IPNS to the tune of 8.8 kg ha⁻¹ and depletion to the tune of 4.2 kg ha⁻¹ was observed in control. With respect to available K, STCR and STCR-IPNS treatments recorded relatively higher available K as compared to blanket and control. Though a decline from the initial status of K was noticed in all the treatments. The magnitude of decline was relatively low in STCR and STCR-IPNS treatments by maintaining the fertility status in “high” category only. The initial soil available N, P and K analysis of rabi season (Table 3.2.1c) showed the same trend as that of kharif season with relatively higher available N, P and K status in STCR-IPNS treatment.

Regarding the soil fertility changes, after 18 years of cropping with rice-rice sequence (Table 3.2.1e), as compared to the initial status in 1998, STCR-IPNS treatment showed maintenance of available N status and built up in available P status (20.2 to 29.0 kg ha⁻¹). With respect to available K, the magnitude of depletion was low (670 to 574 kg ha⁻¹) when compared to other treatments. A slight increase in soil organic carbon status was also noticed in all the treatments as compared to the initial status and the highest OC status (8.7g kg⁻¹) was observed in STCR-IPNS.

Table 3.2.1a The initial soil test values and the recommended doses of fertilizer nutrients applied for kharif rice

Treatments	Available nutrients (kg ha ⁻¹)				Nutrients added (kg ha ⁻¹)	
	SN	SP	SK	FN	FP ₂ O ₅	FK ₂ O
Blanket	234	19.2	482	150	50	50
STCR -NPK alone 6 t ha ⁻¹	239	20.2	496	139	59	25*
STCR -NPK alone 7 t ha ⁻¹	248	23.9	508	178	69	25*
STCR-IPNS** 7 t ha ⁻¹	269	29.0	574	130	33	25*
Control	168	16.0	415	0	0	0

** IPNS: NPK+FYM @12.5 t ha⁻¹; * maintenance dose (50 % of blanket)

Table 3.2.1b Grain yield, response ratio and per cent achievement of kharif rice

Treatments	Grain yield (kg ha ⁻¹)	Response ratio (kg kg ⁻¹)	% Achievement
Blanket	5460	12.64	-
STCR -NPKalone 6 t ha ⁻¹	5580	14.71	93.0
STCR -NPKalone 7 t ha ⁻¹	6790	16.51	97.0
STCR-IPNS 7 t ha ⁻¹	7025	19.52	100.4
Control	2300	-	-

Table 3.2.1c The initial soil test values and the recommended doses of fertilizer nutrients applied for Rabi rice

Treatments	Available nutrients (kg ha ⁻¹)			Nutrients added (kg ha ⁻¹)		
	SN	SP	SK	FN	FP ₂ O ₅	FK ₂ O
Blanket	225	19.8	510	150	50	50
STCR -NPK alone 5 t ha ⁻¹	230	21.0	521	103	30	25*
STCR -NPK alone 6 t ha ⁻¹	242	23.5	533	142	44	25*
STCR-IPNS** 6 t ha ⁻¹	260	29.3	580	95	25*	25*
Control	165	16.2	430	0	0	0

** IPNS: NPK+FYM @12.5 t ha⁻¹; * maintenance dose (50% of blanket)

Table 3.2.1d Grain yield, response ratio and per cent achievement of Rabi rice

Treatments	Grain yield (kg ha ⁻¹)	Response ratio (kg kg ⁻¹)	% Achievement
Blanket	4800	9.56	-
STCR -NPKalone 5 t ha ⁻¹	4870	15.57	97.4
STCR -NPKalone 6 t ha ⁻¹	5915	16.93	98.6
STCR-IPNS 6 t ha ⁻¹	6205	18.88	103.4
Control	2410	-	-

Table 3.2.1e Soil fertility after 18 years of cropping under long-term experiment with rice - rice sequence

Treatments	Available nutrients (kg ha ⁻¹)			Soil organic carbon (g kg ⁻¹)
	N	P	K	
Blanket	234	19.2	482	6.4
STCR -NPKalone 6 t ha ⁻¹	239	20.2	496	7.6
STCR -NPKalone 7 t ha ⁻¹	248	23.9	508	8.0
STCR-IPNS 7 t ha ⁻¹	269	29.0	574	8.7
Control	168	16.0	415	5.4
Initial status (1998 kharif)	280	20.2	670	4.6

3.2.2 Demonstrations on soil test crop response technology in pearl millet– wheat cropping sequence at CCSHAU, Hisar

To demonstrate STCR technology of fertilizers and FYM recommendations on targeted yield equations, field demonstrations were laid out at the Research Farm, CCSHAU, Hisar under pearl millet-wheat cropping sequence. The available N, P and K of half of the field (where no FYM was applied) were 133, 17 and 258 kg ha⁻¹, respectively, whereas in the second half of the field (where 15t FYM ha⁻¹ was applied), the values were 140, 20 and 272 kg ha⁻¹, respectively.

The grain yield targets of 30 and 35 q ha⁻¹ of pearl millet in both the varieties were fully to marginally achieved (Table 3.2.2a). The grain yield targets of 30 and 35 q ha⁻¹ in pearl millet (HHB 223) was achieved within deviations of -5.2 to +2.4 and -4.1 to -0.5 %, respectively. Similarly, the grain yield targets of 30 and 35 q ha⁻¹ in pearl millet (HHB 226) was achieved within deviations of -5.4 to +0.7 and -6.6 to -3.1 %, respectively. The yield targets of 55 and 60 q ha⁻¹ were achieved within deviations of -1.6 to +1.8 and -3.3 to +2.0 percent, respectively, in wheat (WH 1105). However, the grain yield targets of 55 and 60 q ha⁻¹ in wheat (WH 711) were achieved by -3.3 to +1.5 and -6.0 to -2.7 %, respectively (Table 3.2.2b).

Table 3.2.2a Effect of fertilizer treatments on yield and nutrients uptake in pearl millet

Treatments	Crop variety	Yield (kg ha ⁻¹)		Percent deviation (grain)	Total uptake (kg ha ⁻¹)		
		Grain	Straw		N	P	K
TY-30	HHB 223	2845	5121	-5.2	74	14	78
TY-35	HHB 223	3357	5875	-4.1	78	16	87
TY-30 FYM	HHB 223	3071	5528	+2.4	75	16	83
TY-35 FYM	HHB 223	3483	6269	-0.5	91	19	96
TY-30	HHB 226	2837	4965	-5.4	69	14	73
TY-35	HHB 226	3392	6106	-3.1	78	18	90
TY-30 FYM	HHB 226	3022	5349	+0.7	76	17	79
TY-35 FYM	HHB 226	3268	5719	-6.6	83	18	83

TY= Target yield

Table 3.2.2b Effect of fertilizer treatments on yield and nutrients uptake in wheat

Treatments	Crop variety	Yield (kg ha ⁻¹)		Percent deviation (grain)	Total uptake (kg ha ⁻¹)		
		Grain	Straw		N	P	K
TY-55	WH 1105	5410	7899	-1.6	133	30	129
TY-60	WH 1105	5800	8702	-3.3	144	32	140
TY-55 FYM	WH 1105	5600	8288	+1.8	145	30	144
TY-60 FYM	WH 1105	6120	9058	+2.0	159	35	153
TY-55	WH 711	5320	7767	-3.3	135	29	129
TY-60	WH 711	5840	8526	-2.7	150	31	145
TY-55 FYM	WH 711	5580	8258	+1.5	138	28	132
TY-60 FYM	WH 711	5640	8347	-6.0	133	31	135

TY= Target yield

3.2.3 Multi-location follow-up trials at TNAU, Coimbatore

Cotton (hybrid Rasi XL 708 and hybrid MICO 7819) under drip fertigation

During the period under report, to validate the fertiliser prescription equations under IPNS for cotton under drip fertigation on Perianaickenpalayam series (VerticUstrophept-mixed black calcareous soils), validation trials have been initiated at two farmers' holding viz., A.Karadipatti (location I) and Vadugathanpatti (location II), Pethanaickenpalayam block, Attur Taluk, Salem district (Plate 3.2.3a). The fertiliser prescription equations for validation are as below:

Fertiliser prescription equations

$$FN = 8.51 T - 0.47 SN - 0.73 ON$$

$$FP_2O_5 = 4.41 T - 2.25 SP - 0.75 OP$$

$$FK_2O = 6.59 T - 0.18 SK - 0.66 OK$$

where, FN, FP₂O₅ and FK₂O are fertilizer N, P₂O₅ and K₂O in kg ha⁻¹ respectively; T is the yield target in q ha⁻¹; SN, SP and SK respectively are alkaline KMnO₄-N, Olsen-P and NH₄OAc-K in kg ha⁻¹ and ON, OP and OK are the quantities of N, P and K in kg ha⁻¹ supplied through FYM.

Cotton hybrid Rasi XL 708 and hybrid MICO 7819 have been sown at location I and II respectively. There were ten treatments viz., blanket (RDF alone), blanket (RDF + FYM @12.5 t ha⁻¹), STCR-NPK alone - 3.0, 3.5 and 4.0 t ha⁻¹, STCR-IPNS - 3.0, 3.5 and 4.0 t ha⁻¹, farmer's practice and absolute control. Based on the initial soil test values of available N, P and K and the quantities of N, P₂O₅ and K₂O supplied through FYM, fertiliser doses were calculated and applied for STCR treatments for various yield targets. STCR-NPK alone treatments received only inorganic fertilisers based on STCR equations, while STCR - IPNS treatments received FYM @ 12.5 t ha⁻¹ basally and NPK fertilisers were applied after adjusting the nutrients supplied through FYM based on STCR-IPNS equations. At both the locations, fertiliser doses have been imposed as per the treatments and fertigation has been given at weekly interval starting from 14 days after sowing as per the schedule for hybrid cotton on Inceptisol. The sources of nutrients used for fertigation were urea, single super phosphate and muriate of potash. All the improved agronomic practices were carried out periodically. Harvest has been completed at proper stage and seed cotton yield was recorded appropriately.

The results of the verification trials revealed that the targeted yield has been achieved within 10 percent variation proving

the validity of the equations (Table 3.2.3a). The mean increase in yield due to STCR-IPNS - 4.0 t ha⁻¹ over blanket (RDF + FYM @12.5 t ha⁻¹) and farmer's practice was 22.60 and 38.60 per cent respectively. Therefore, Soil Test Crop Response based fertiliser prescriptions under Integrated Plant Nutrition System (STCR-IPNS for 4.0 t ha⁻¹) i.e. application of fertiliser N, P₂O₅ and K₂O based on initial soil test values along with FYM @12.5 t ha⁻¹ can be recommended for achieving higher yield, response ratio and BCR with cotton under drip fertigation on Perianaickenpalayam series (mixed black calcareous soil)

where, FN, FP₂O₅ and FK₂O are fertilizer N, P₂O₅ and K₂O in kg ha⁻¹ respectively; T is the yield target in q ha⁻¹; SN, SP and SK, respectively are alkaline KMnO₄-N, Olsen-P and NH₄OAc-K in kg ha⁻¹ and ON, OP and OK are the quantities of N, P and K in kg ha⁻¹ supplied through FYM.

Seedlings of brinjal (var. CO-2) have been transplanted timely at all the locations. There were ten treatments viz., blanket (RDF alone), blanket (RDF + FYM @12.5 t ha⁻¹), STCR-NPK alone - 30, 35 and 40 t ha⁻¹, STCR-IPNS - 30, 35 and 40 t ha⁻¹, farmer's practice and absolute control. Based on

Table 3.2.3a Verification trials on cotton under drip fertigation

Treatments	Seed cotton yield (t ha ⁻¹)	Percent achievement	RR (kg kg ⁻¹)	BCR
Blanket (RDF alone)	3.04	-	3.86	2.05
Blanket (RDF+FYM @ 12.5 t ha ⁻¹)	3.20	-	4.21	2.07
STCR- NPK alone 3.0 t ha ⁻¹	2.95	98.30	5.69	2.12
STCR - NPK alone 3.5 t ha ⁻¹	3.35	95.70	5.28	2.32
STCR - NPK alone 4.0 t ha ⁻¹	3.74	93.50	5.03	2.51
STCR-IPNS - 3.0 t ha ⁻¹	3.10	103.30	6.21	2.18
STCR-IPNS- 3.5 t ha ⁻¹	3.48	99.40	5.62	2.40
STCR-IPNS- 4.0 t ha ⁻¹	3.92	98.00	5.40	2.61
Farmer's practice	2.82	-	3.80	1.95
Control	1.30	-	-	1.03



Plate 3.2.3a Test verification trials on cotton under drip fertigation

Brinjal (CO-2)

During the period under report, to validate the fertiliser prescription equations under IPNS for brinjal on Palaviduthi series (Typic Rhodustalf-red non-calcareous soils), validation experiments were conducted at five locations viz., N.G.Valasu (location I), Kasthurinaickenpatti (location II), V. Pudur (location III), Thoppupatti I (location IV) and Thoppupatti II (location V) in Dindigul district (Plate 3.2.3b). The fertiliser prescription equations for validation are as below:

$$\begin{aligned}
 \text{FN} &= 0.69T - 0.72\text{SN} - 0.64\text{ON} \\
 \text{FP}_2\text{O}_5 &= 0.41T - 3.57\text{SP} - 0.72\text{OP} \\
 \text{FK}_2\text{O} &= 0.65T - 0.34\text{SK} - 0.52\text{OK}
 \end{aligned}$$

the initial soil test values of available N, P and K and the quantities of N, P₂O₅ and K₂O supplied through FYM, fertiliser doses were calculated and applied for STCR treatments for various yield targets. STCR-NPK alone treatments received only inorganic fertilisers based on STCR equations, while STCR - IPNS treatments received FYM @ 12.5 t ha⁻¹ basally and NPK fertilisers were applied after adjusting the nutrients supplied through FYM based on STCR-IPNS equations. At all the locations, fertiliser doses have been imposed as per the treatment schedule and all the improved agronomic practices were carried out periodically. Harvest has been completed at all the locations and fruit yield has been recorded.

The mean results of the verification trials revealed that the targeted yield has been achieved within 10 per cent variation proving the validity of the equations (Table 3.2.3b). The fruit yield ranged from 14.98 to 37.33 t ha⁻¹. Among the treatments, though STCR-IPNS-40 t ha⁻¹ had registered numerically higher yield, it was comparable with STCR-IPNS-35 t ha⁻¹. Moreover, STCR-IPNS-35 t ha⁻¹ had recorded relatively higher per cent achievement, RR and BCR over all other treatments. In general, STCR treatments recorded relatively higher yield RR and BCR as compared to blanket and farmer's practice. Among STCR treatments, relatively higher yield and response ratio (RR) were recorded with STCR-IPNS treatments. The mean increase in yield due to STCR-IPNS-35 t ha⁻¹ over blanket (RDF + FYM @12.5 t ha⁻¹) and farmer's practice was 23.06 and 43.56 per cent respectively. Therefore, Soil Test Crop Response based fertiliser prescriptions under Integrated Plant Nutrition System (STCR-IPNS for 35 t ha⁻¹) i.e. application of fertiliser N, P₂O₅ and K₂O based on initial soil test values along with FYM @12.5 t ha⁻¹ can be recommended for achieving higher yield,

Glory lily (Local)

Two test verification trials were conducted at Kappalpatti I & II in Dindigul District. There were nine treatments viz., blanket (RDF alone), STCR-NPK alone for 5.5, 6.5 and 7.5 q ha⁻¹, STCR -IPNS for 5.5, 6.5 and 7.5 q ha⁻¹ and farmer's practice and control. Based on the initial soil test values of available N, P, K and yield targets aimed, fertilizer doses were calculated and applied for STCR treatments. For IPNS treatments, 12.5 tonnes of FYM were applied basally and fertilizer N, P₂O₅ and K₂O doses were adjusted accordingly.

The results of the verification trials (Plate 3.2.3c) at Kappalpatti I & II revealed that the targeted yield has been achieved within 10 per cent variation proving the validity of the equations (Table 3.2.3c). The seed yield ranged from 399 to 761 kg ha⁻¹. Among the treatments, STCR-IPNS-7.5 q ha⁻¹ had recorded relatively higher seed yield (761 kg ha⁻¹). The mean increase in yield due to STCR-IPNS-7.5 q ha⁻¹ over blanket (RDF alone) and farmer's practice was 45.00 and 61.10 average respectively. Post-harvest soil fertility also

Table 3.2.3b Verification trials on brinjal

Treatments	Fruit yield (t ha ⁻¹)	Percent achievement	RR (kg kg ⁻¹)	BCR
Blanket (RDF alone)	28.04	-	72.55	2.34
Blanket (RDF+FYM@ 25 t ha ⁻¹)	29.97	-	83.29	2.38
STCR- NPK alone 30 t ha ⁻¹	29.43	98.06	85.67	2.42
STCR - NPK alone 35 t ha ⁻¹	36.01	102.42	91.96	2.95
STCR - NPK alone 40 t ha ⁻¹	36.59	91.49	76.50	2.93
STCR-IPNS - 30 t ha ⁻¹	30.54	101.82	92.24	2.47
STCR-IPNS- 35 t ha ⁻¹	36.88	105.34	96.54	2.98
STCR-IPNS- 40 t ha ⁻¹	37.33	93.31	79.07	2.96
Farmer's practice	25.69	-	69.80	2.15
Control	14.98	-	-	1.31



Plate 3.2.3b Test verification trials on brinjal

response ratio and BCR with brinjal on Palaviduthi series (red non-calcareous soil).

indicated that there is maintenance of soil fertility in STCR and IPNS treatments when compared to recommended dose of fertilizer, farmers practice and control (Table 3.2.3d).

Table 3.2.3c Verification trial on Glory lily

Treatments	Seed yield (kg ha ⁻¹)	Percent Achievement	Response ratio (kg kg ⁻¹)	B:C ratio
Blanket (RDF alone)	525.00	-	0.42	1.24
STCR-NPK alone 5.5 q ha ⁻¹	552.00	100.40	0.43	1.30
STCR-NPK alone 6.5 q ha ⁻¹	638.00	98.10	0.56	1.50
STCR-NPK alone 7.5 q ha ⁻¹	744.00	99.20	0.69	1.74
STCR-IPNS-5.5 q ha ⁻¹	567.00	103.10	0.47	1.34
STCR-IPNS-6.5 q ha ⁻¹	665.00	102.30	0.62	1.56
STCR-IPNS-7.5 q ha ⁻¹	761.00	101.50	0.72	1.78
Farmers practice	473.00	-	0.30	1.12
Control	399.00	-	-	0.96

Table 3.2.3d Post harvest soil fertility of the test verification trial on Glory Lily

Treatments	Kappalpatti I			Kappalpatti II		
	SN	SP	SK	SN	SP	SK
Blanket (RDF alone)	189	15.3	174	184	17.3	180
STCR-NPK alone 5.5 q ha ⁻¹	205	17.6	190	195	20.0	192
STCR-NPK alone 6.5 q ha ⁻¹	218	18.9	195	209	21.8	198
STCR-NPK alone 7.5 q ha ⁻¹	226	19.9	197	216	22.4	200
STCR-IPNS-5.5 q ha ⁻¹	216	17.5	189	208	20.2	191
STCR-IPNS-6.5 q ha ⁻¹	228	20.9	201	218	24.0	204
STCR-IPNS-7.5 q ha ⁻¹	232	22.7	212	225	25.6	215
Farmers' practice	189	14.6	186	184	17.1	184
Control	185	13.6	174	177	15.2	178
Initial status	193	14.0	179	186	16.0	182



Plate 3.2.3c Test verification trials on Glory Lily

Rainfed groundnut (TMV 7)

To validate the fertiliser prescription equations developed under IPNS for rainfed groundnut on Somayanur soil series (Udic Haplustalf - red calcareous soils), five test verification trials were conducted at farmers' holding viz., Anaipalayam (location I) in Namakkal district; Kollingipatti (location II), Nazhikalpatti (location III), Panamarathupatti (location IV) and Pagalpatti (location V) in Salem district (Plate 3.2.3d). The fertilizer prescription equations developed for rainfed groundnut are as follows.

$$FN = 7.50 T - 0.33 SN - 0.45 ON$$

$$FP_2O_5 = 3.50 T - 1.67 SP - 0.55 OP$$

$$FK_2O = 6.78 T - 0.31 SK - 0.43 OK$$

where, FN, FP₂O₅ and FK₂O are fertilizer N, P₂O₅ and K₂O in kg ha⁻¹ respectively; T is the yield target in q ha⁻¹; SN, SP and SK respectively are alkaline KMnO₄-N, Olsen-P and NH₄OAc-K in kg ha⁻¹ and ON, OP and OK are the quantities of N, P and K in kg ha⁻¹ supplied through FYM.

The treatments imposed are as follows. i) Blanket, ii) STCR-NPK alone-8 q ha⁻¹, iii) STCR- NPK alone- 10 q ha⁻¹, iv) STCR-NPK alone-12 q ha⁻¹, v) STCR- IPNS - 8 q ha⁻¹, vi) STCR- IPNS -10 q ha⁻¹ vii) STCR- IPNS - 12 q ha⁻¹, viii) Farmers practice, ix) Absolute Control. Based on the initial soil test values of available N, P and K and the quantities of N, P₂O₅ and K₂O supplied through FYM, fertilizer doses were calculated and applied for STCR treatments for various yield targets. STCR-NPK alone treatments received only inorganic fertilisers based on STCR equations, while STCR - IPNS treatments received FYM @ 12.5 t ha⁻¹ basally and NPK fertilisers are applied after adjusting the nutrients supplied through FYM based on STCR-IPNS equations. Agronomic practices were carried out periodically. The performance of the treatments has been monitored in terms of pod yield,

IPNS -12 q ha⁻¹ over blanket and farmer's practice was 463 and 656 kg ha⁻¹ respectively.

Therefore, Soil Test Crop Response based fertiliser prescriptions under Integrated Plant Nutrition System (STCR-IPNS for 12 q ha⁻¹) can be recommended for achieving higher yield, response ratio and BCR in rainfed groundnut.

Big onion (Agri Found Dark Red)

To validate the fertiliser prescription equations developed for big onion under IPNS on Irugur soil series (Typic Ustropept), validation experiments were conducted at three locations (Viralipatty, Kasthurinaickenpatty and Rajakkapatty) in Dindigul District (Plate 3.2.3e) with 10 treatments viz.,

Table 3.2.3e Verification trials on rainfed groundnut

Treatments	Dry pod yield (q ha ⁻¹)	Percent Achievement	Response ratio (kg kg ⁻¹)	B:C ratio
Blanket	7.18	-	5.59	1.24
STCR-NPK alone - 8 q ha ⁻¹	7.44	92.97	8.77	1.32
STCR-NPK alone -10 q ha ⁻¹	9.77	97.70	9.24	1.67
STCR-NPK alone-12 q ha ⁻¹	11.81	98.37	10.09	1.99
STCR-IPNS - 8 q ha ⁻¹	7.95	99.39	9.94	1.42
STCR-IPNS-10 q ha ⁻¹	10.50	104.97	10.34	1.79
STCR-IPNS-12 q ha ⁻¹	12.74	106.17	11.24	2.15
Farmer's practice	5.25	-	5.24	1.07
Absolute Control	3.55	-	-	0.72



Plate 3.2.3d Test verification trials on rainfed groundnut

response ratio and per cent achievement of the yield target.

The mean dry pod yield of the five locations in STCR-IPNS - 12 q ha⁻¹ was 12.74 q ha⁻¹, while in blanket and farmer's practice, the mean dry pod yield was 7.18 and 5.25 q ha⁻¹ respectively (Table 3.2.3e). The highest mean RR (11.24 kg kg⁻¹) was recorded in STCR-IPNS -12 q ha⁻¹ while in blanket and farmer's practice, the RR was 5.59 and 5.24 kg kg⁻¹, respectively proving the superiority of STCR-IPNS based fertilizer prescription. The mean yield increase in STCR-

blanket (RDF alone), blanket (RDF +FYM @ 25 t ha⁻¹), STCR-NPK alone for 28, 30 and 32 t ha⁻¹, STCR -IPNS for 28, 30 and 32 t ha⁻¹, farmer's practice and control. The seedlings of big onion var. Agri Found Dark Red were transplanted on time at Viralipatti, Kasthurinaickenpatti and Rajakkapatti. Fertiliser doses were calculated and imposed as per the treatments. For NPK alone treatments, fertiliser N, P and K was applied as Urea, Super phosphate and Muriate of Potash and for IPNS plots contribution from FYM was deducted and remaining fertiliser was applied as N, P and K

as Urea, Super phosphate and Muriate of Potash. The crop was raised and after maturity, the crops were harvested at all the locations. Fresh bulb yield was recorded at harvest. Soil samples were collected at harvest and analysed for available N, P and K.

Among the treatments, STCR-IPNS-32 t ha⁻¹ had recorded relatively higher mean bulb yield of 32.20 t ha⁻¹ and the mean increase in yield due to STCR-IPNS-32 t ha⁻¹ over blanket, blanket (RDF + FYM @12.5 t ha⁻¹) and farmer's practice was 25.5, 11.3 and 57.6 per cent respectively. The mean increase

in RR due to STCR-IPNS-32 t ha⁻¹ over blanket, blanket (RDF + FYM @ 25 t ha⁻¹) and farmer's practice was 15.57, 5.52 and 15.97 kg kg⁻¹ respectively while that of BCR was 0.59, 0.27 and 1.05 respectively (Table 3.2.3f). The targeted yield has been achieved within +/- 10 per cent variation proving the validity of the equations in all the three locations. Post-harvest soil fertility also indicated that there was maintenance of soil fertility in STCR and IPNS treatments when compared to blanket recommendations, farmer's practice and control (Table 3.2.3g).

Table 3.2.3f validation experiments on onion

Treatments	Bulb yield (t ha ⁻¹)	Percent Achievement	Response ratio (kg kg ⁻¹)	B:C ratio
Blanket (RDF alone)	25.66	-	41.72	2.57
Blanket (RDF+FYM @ 25 t ha ⁻¹)	28.93	-	51.77	2.89
STCR-NPK - 28 t ha ⁻¹	26.80	95.7	53.38	2.71
STCR-NPK - 30 t ha ⁻¹	29.30	97.7	55.44	2.93
STCR-NPK - 32 t ha ⁻¹	30.96	96.8	53.80	3.07
STCR-IPNS - 28 t ha ⁻¹	27.98	99.9	57.51	2.79
STCR-IPNS - 30 t ha ⁻¹	30.84	102.8	60.43	3.05
STCR-IPNS - 32 t ha ⁻¹	32.20	100.6	57.29	3.16
Farmers practice	20.43	-	41.32	2.11
Control	12.10	-	-	1.25

Table 3.2.3g Post harvest soil fertility of the test verification trial on onion

Treatments	Viralipatty			K.N.Patty			Rajakkapatty		
	SN	SP	SK	SN	SP	SK	SN	SP	SK
Blanket (RDF alone)	219	28	212	204	33	230	199	16	177
Blanket (RDF +FYM)	228	36	216	212	36	236	207	22	186
STCR-NPK - 28 t ha ⁻¹	223	27	212	205	34	232	210	16	180
STCR-NPK - 30 t ha ⁻¹	227	32	216	212	34	236	217	20	184
STCR-NPK - 32 t ha ⁻¹	230	36	220	215	36	237	221	23	186
STCR-IPNS - 28 t ha ⁻¹	224	34	216	210	37	235	215	22	184
STCR-IPNS - 30 t ha ⁻¹	232	38	221	216	41	238	221	25	188
STCR-IPNS - 32 t ha ⁻¹	236	40	225	221	43	240	223	29	188
Farmers practice	216	27	210	198	28	234	191	15	179
Control	209	19	206	192	20	229	186	13	171
Initial status	214	26	211	195	22	238	189	15	174



Plate 3.2.3e Test Crop Experiment on Big onion

3.2.4 Follow up experiments on soil test based fertilizer recommendations for targeted yield of crops at CCS HAU, Hisar

Bt. cotton (Bio 6588)

To test the validity of soil based fertilizer adjustment equations of Bt. cotton (Bio 6588), eight follow up experiments were carried out at different locations of farmers' fields during kharif season.

Average yield and B:C ratio of the eight fields are presented in Table 3.2.4a. The seed cotton yield in different treatments increased with the application of fertilizers and FYM. The mean seed cotton yield recorded was the lowest in control and it increased in the following order: control < FP < P.R < TY-28 < TY-28 FYM < TY-32 < TY-32 FYM. The mean response in different treatments also followed the same order as that of the seed cotton yield. The mean response yardstick was the highest in TY-28 FYM (6.90 kg kg⁻¹) followed by TY-28 (6.23 kg kg⁻¹), TY-32 FYM (5.38 kg kg⁻¹) and TY-32 (5.09 kg kg⁻¹). These values of response yardsticks revealed the high responsiveness of cotton to fertilizer application. The mean B:C ratio was 11.59, 11.37, 9.49, 9.34, 8.95 and 7.30 ₹/Re in TY-28 FYM, TY-28, TY-32 FYM, TY -32, FP and PR treatments, respectively, which clearly revealed that the application of fertilizers is economical in cotton crop upto yield target of 32 q ha⁻¹. However, the FYM application is essential on long term basis for sustainable crop production and maintenance of soil health.

Pearl millet (HHB 226)

To test the validity of soil test based fertilizers adjustment equations for targeted yields of pearl millet (HHB 226), eight follow up experiments were conducted during kharif season at farmers' fields. The soils of the experimental fields were alkaline in reaction, non-saline, and low to medium in organic carbon, low in available N, medium in available P and medium to high in available K.

Average yield, response, response yardstick and benefit: cost ratio due to fertilizers and FYM application in different treatments are presented in the Table 3.2.4b. The grain yield in different treatments increased with the application of fertilizers and FYM. The mean grain yield recorded was the lowest in control and it increased in the following order: control < FP < P.R = TY-30 < TY-30 FYM < TY-35 < TY-35 FYM. The mean response in different treatments also followed the same order as that of the grain yield. The mean response yardstick was the highest in TY-30 FYM (6.43 kg kg⁻¹) followed by TY-35 FYM (6.39 kg kg⁻¹), TY-35 (6.07 kg kg⁻¹) and TY-30 (5.94 kg kg⁻¹). These values of response yardsticks revealed the high responsiveness of pearl millet to fertilizer application. The mean B:C ratio was 6.53, 6.34, 6.26, 6.15, 5.49 and 4.25 Rs/Re in TY-35, TY-30 FYM, TY-30, PR, TY -35 FYM and FP treatments, respectively, which clearly revealed that the application of fertilizers is economical in pearl millet crop upto yield target of 35 q ha⁻¹. However, the FYM application is essential for sustainable crop production and maintenance of soil health.

Table 3.2.4a Seed cotton yield, response and economics of fertilizers and FYM in Bt. cotton

Treatment	Seed cotton yield (kg ha ⁻¹)	Response (kg ha ⁻¹)	Response yardstick (kg kg ⁻¹)	Marginal B:C ratio (₹ Re ⁻¹)
Control	1514	-	-	-
F.P.	2442	928	4.64	8.95
P.R.	2715	1202	4.08	7.30
TY-28	2719	1206	6.23	11.59
TY-32	3013	1500	5.09	9.34
TY-28 FYM	2822	1308	6.90	11.37
TY-32 FYM	3086	1572	5.38	9.49

Table 3.2.4b Grain yield, response and economics of fertilizers and FYM in pearl millet (HHB 226)

Treatment	Grain yield (kg ha ⁻¹)	Response (kg ha ⁻¹)	Response yardstick (kg kg ⁻¹)	Marginal B/C ratio (₹ Re ⁻¹)
Control	1786	-	-	-
F.P.	2401	1230	3.78	4.25
P.R.	2843	2114	4.83	6.15
TY-30	2843	2114	5.94	6.26
TY-35	3332	3092	6.07	6.53
TY-30 FYM	2958	2343	6.43	6.34
TY-35 FYM	3444	3314	6.39	5.49

Wheat (WH 1105)

To test the validity of soil test based fertilizers adjustment equations for targeted yields of wheat (WH 1105), eight follow up experiments were conducted during rabi season at farmers' fields. The grain yield in different treatments increased with the application of fertilizers and FYM (Table 3.2.4c). The mean grain yield recorded was the lowest in control and it increased in the following order: control < FP < P.R < TY-55 < TY-55 FYM < TY-60 < TY-60 FYM. The mean response in different treatments also followed the same order as that of the grain yield. The mean response yardstick was the highest in TY-55 FYM (13.75 kg kg⁻¹) followed by TY-60 FYM (12.96 kg kg⁻¹), TY-55 (12.39 kg kg⁻¹) and TY-60 (12.16 kg kg⁻¹). These values of response yardsticks revealed the high responsiveness of wheat to fertilizer application. The mean B:C ratio was 9.45, 9.30, 9.25, 8.40, 8.25 and 7.15 ₹/Re in TY-55, TY-55 FYM, TY-60, PR, TY -60 FYM and FP treatments, respectively, which clearly revealed that the

application of fertilizers is economical in wheat crop upto yield target of 60 q ha⁻¹. However, the FYM application is essential on long term basis for sustainable crop production and maintenance of soil health.

3.3 AICRP-MSPE

3.3.1 Crop responses to Mg application

The front line demonstration (FLDs) were conducted at 4 locations in Tamil Nadu and it was recorded that that inclusion of magnesium in the fertilizer schedule enhanced the fresh tuber yield of potato to a considerable extent at all the locations (Table 3.3.1, Plate 3.3.1). The higher mean yield of fresh tuber (19 t ha⁻¹) was recorded in the treatment combination receiving 30 kg MgSO₄ along with recommended NPK, which was approximately 19% higher over control. It is speculated that the availability of magnesium in soil is sufficient as not much distinction in yield is registered in the treatment following its application.

Table 3.2.4c Mean grain yield, response and economics of fertilizers and FYM in wheat

Treatment	Grain yield (kg ha ⁻¹)	Response (kg ha ⁻¹)	Response yardstick (kg kg ⁻¹)	Marginal B/C ratio (₹ Re ⁻¹)
Control	2778.00	-	-	-
F.P.	4896.50	2119.50	10.46	7.15
P.R.	5267.50	2490.00	11.15	8.40
TY-55	5377.00	2599.50	12.39	9.45
TY-60	5795.00	3017.00	12.16	9.25
TY-55 FYM	5634.50	2856.50	13.75	9.30
TY-60 FYM	5996.50	3218.50	12.96	8.25

Table 3.3.1 Responses of crops to Mg application

Sites	Tuber yield (t ha ⁻¹)			Dry matter yield (t ha ⁻¹)		Dry foliage yield (t ha ⁻¹)		Total uptake (kg ha ⁻¹)	
	NPK	NPK + Mg	% response over control	NPK	NPK + Mg	NPK	NPK +Mg	NPK	NPK +Mg
Site 1	15.11	18.70	23.76	4.31	5.38	2.40	3.18	11.85	18.61
Site 2	16.25	19.25	18.46	4.61	5.49	2.57	3.20	13.92	20.44
Site 3	17.25	19.80	14.78	4.94	5.67	2.38	3.12	13.49	20.91
Site 4	15.35	18.20	18.57	4.36	5.19	2.43	3.09	13.37	21.06
Mean	15.99	18.99	18.89	4.56	5.43	2.45	3.15	13.16	20.26



Plate 3.3.1 Response of potato to Mg application

3.3.2 Crops response to B application

About 71 FLD trials were conducted for evaluating the response of boron applications at different locations of Uttarakhand, Assam and Haryana in oilseed (mustard, rapeseed and raya) and vegetable crops (cauliflower and cabbage) (Table 3.3.2). Boron was applied @ 1.0, 1.5 and 2.0 kg ha⁻¹ through the soil application and also in the form of foliar sprays @ 0.2 %. In general, the response of crops to various applications of boron through different sources and doses were encouraging though the highest response to the crops was registered with soil B application @ 1.5 kg ha⁻¹. In Uttarakhand, an increase of 33% in mustard yield was registered by application of boron @ 1.5 kg ha⁻¹ where as the increase was approximately 24% higher over control when it was applied @ 1.0 kg ha⁻¹. By applying B @ 2.0 kg ha⁻¹, an enhancement in yield from 1.14 to 1.48 t ha⁻¹ was observed, which was 30% higher over no B control. Foliar application of boron @ 0.2% has enhanced the yield of mustard crop by 36.8%. In 40 FLDs conducted at Assam, varied magnitude of crop response was exhibited by B application in soil. The highest response was registered with the application of 1.5 kg B ha⁻¹ which enhanced the crop yield from 0.88 to 1.23 t ha⁻¹. B applied @ 1.0 kg ha⁻¹ increased the crop yield by 37.5% while response reduced to 19.3% by doubling the B dose (2.0

kg ha⁻¹). In sandy loam soils of Haryana, FLDs were conducted to demonstrate the effect of boron on raya crop. The boron was applied to the soil @ 1.0 and 1.5 kg ha⁻¹. The increase in seed yield of raya crop was more pronounced by the application of boron @ 1.0 kg ha⁻¹ (17%), however when it was applied @ 1.5 kg ha⁻¹ the yield increase was only 13%. The foliar application of 0.2% of boron increased the raya yield from 1.65 to 1.79 t ha⁻¹ i.e. by 8.5%.

3.3.3 Crops responses to Zn + Fe application

The FLDs were taken up with wheat crop at eleven different villages of Vijaynagar and Khedbrahma taluka of Sabarkantha district, Gujarat. The maximum average yield of wheat (2.97 t ha⁻¹) was obtained when multi-micronutrient (MM) grade-5 applied @ 20 kg ha⁻¹ followed by Zn application @ 5 kg ha⁻¹ (2.91 t ha⁻¹) and Fe application @ 10 kg ha⁻¹ (2.86 t ha⁻¹) (Table 3.3.3). The per cent improvement in yield ranged from 14.6 to 18.8 over control due to different treatments at various locations. Three FLDs conducted in Dahod district of Gujarat on Paddy recorded 15.6% higher yield with application of 10 kg Fe + 5 kg Zn over control. At Hyderabad, 21 FLDs conducted on paddy and maize crops, reported varied response of 8.1 to 14.7% in paddy and 6.0 to 18.5% in maize with application of Fe + Zn together over NPK alone.

Table 3.3.2 Responses of crops to B application

Crop	State	No. of FLDs	Grain yield t ha ⁻¹ (Boron application kg ha ⁻¹)				% Response				
			0	1.0	1.5	2.0	0.2% Spray	1.0	1.5	2.0	0.2% Spray
Mustard	Uttarakhand	2	1.08-1.21 (1.14)	1.33-1.50 (1.41)	1.42-1.63 (1.52)	1.48	1.42-1.7 (1.56)	23.68	33.33	29.82	36.84
Rapeseed	Assam	40	0.75-1.05 (0.88)	0.95-1.35 (1.21)	1.10-1.35 (1.23)	0.85-1.32 (1.05)	-	37.50	39.77	19.30	-
Raya	Haryana	9	1.20-2.50 (1.65)	1.49-2.81 (1.93)	1.45-2.83 (1.87)	-	1.39-2.7 (1.79)	16.97	13.33	-	8.48
Cauliflower	Assam	10	4.62-9.25 (5.66)	4.81-9.43 (6.19)	6.10-9.80 (6.87)	5.92-9.99 (6.64)	-	9.36	21.38	17.31	-
Cabbage	Assam	10	4.81-10.36 (5.71)	5.55-10.9 (6.24)	6.40-11.84 (7.28)	6.29-11.65 (7.01)	-	9.28	27.50	22.77	-

Figures in parenthesis are mean values

Table 3.3.3 Responses of crops to Zn + Fe application

Location	Crop	No. of FLDs	Grain yield, t ha ⁻¹				% Response		
			Control	Zn 5	Fe 10	Zn+Fe	Zn 5	Fe 10	Zn+Fe
Sabarkantha	Wheat	11	1.92-3.30 (2.50)	2.40-3.99 (2.91)	2.30-3.80 (2.86)	2.60-3.95 (2.97)	16.4	14.6	18.8
Dahod, Gujarat	Paddy	3	1.68-1.72 (1.70)	-	-	1.95-1.99 (1.97)	-	-	15.6
Hyderabad, Andhra	Paddy	10	4.47-5.44 (4.98)	4.95-5.97 (5.62)	5.02-6.12 (5.71)	4.95-5.64 (5.38)	12.4	14.7	8.1
Pradesh	Maize	11	5.06-7.01 (6.11)	6.68-7.30 (6.93)	6.28-7.52 (7.25)	5.88-7.24 (6.48)	13.2	18.5	6.0

Figures in parenthesis are mean values

3.4 AICRP on Long Term Fertilizer Experiments

3.4.1 Potassium application enhanced yield of rice in Vertisols of Madhya Pradesh

The results of experiments conducted at farmer's field (Bhopal, MP) revealed that application of potassium has significant effect on yield and yield attributes of rice i.e. cv Pusa Basmati 1. Data (Table 3.4.1) on number of tillers, number of filled grains per panicle, test weight, grain and stover yield of rice in descending order are K_{80} (96 kg K_2O ha^{-1}) followed by K_{40} (48 kg K_2O ha^{-1}), K_0 (0 kg K_2O ha^{-1}) and K_{FP} (Farmers' practice). It implies that K along with N and P enhanced rice yield in Vertisols. Yield improved significantly over farmers' practice and no K application. Although highest yield was recorded on application of 80 kg K ha^{-1} but was at par with 40 kg K ha^{-1} indicating gradual response to K application in both the years. Increase in the test weight of rice grain was recorded with K application, indicating its role in proper grain filling and utilization of N and P by crop as well. From the study, it could be inferred that application of potassium has not only boosted the rice yield but also increased use efficiency of applied N and P. Thus, ensured K supply to crop is essential in order to improve sustainability and food security.

Table 3.4.1. Effect of K application on yield and yield attributes of rice (cv Pusa Basmati-1)

Treatments	Tillers (No. m^{-2})	Filled grains (No. per panicle)	Test weight (g)	Yield (kg ha^{-1})	Stover (kg ha^{-1})	Harvest index (%)
K_0	207	158	21.46	4827	6021	44.11
K_{40}	210	172	21.88	5000	6510	43.21
K_{80}	212	192	22.35	5499	6542	45.75
K_{FP}	197	157	21.55	4546	5085	47.72

3.4.2 Long-term application of fertilizers on soybean and wheat at Jabalpur

Farmers are using DAP continuously for many years which resulted in accumulation of P and hidden hunger of S. Data revealed that reduction in P dose to half did not have any adverse effect on productivity and at the same time absence of S for long time resulted decline in productivity soybean but did not effect wheat, probably due to aerobic condition. (Table 3.4.2) Thus, from the results it is concluded that P accumulated over the years can be reutilized and S is needed at least during wet season. Farmer apply generally less N and do not apply K which is responsible for less productivity.

3.4.3 Balanced nutrient use in rice –rice at Jagtial

In general, rice yields are higher during rabi season compared to kharif season (Table 3.4.3). Under the situation, balanced

Table 3.4.2 Effect of long term application of fertilizer and manure on crop yield (kg ha^{-1})

Treatments	Soybean	Wheat
100% NPK + 5 t FYM ha^{-1}	881	4121
100% NPK	820	3646
100% NK + 50% P	747	3521
100% NPK - S	637	3394
Farmer's Practice (FP)	601	3072
CD ($p = 0.05$)	90	360

Farmers' practice = Only 50 kg Urea and 30 kg DAP per acre

use of fertilizer is required to get the potential utilization of other nutrients and also to save fertilizer without any loss in yield. For example, increase in N dose from 100 to 150% keeping P and K 100%, the yield obtained in both the seasons is maximum. Application of 15 kg extra K over farmer's practice made the difference in yield during both the seasons. The extra amount of P applied by the farmer did not have any benefit. Thus, results confirmed that balance use of nutrients not only saved the nutrients but also increased the utilization efficiency of other nutrients like N and P, which ultimately saved the input cost and this saving will be added to the farmer's profit.

3.4.4 Balanced use of nutrients in rice-wheat at Raipur

Field demonstrations were conducted at tribal farmers fields on balanced use of nutrients (Table 3.4.4). Survey revealed that farmers generally don't apply fertilizer, when they apply fertilizer they use urea only. Balanced use of nutrients doubled the rice yield compared to farmer's yield. Even though Raipur is not traditionally a wheat growing area, balanced use of nutrients increased the wheat by 2.0 – 2.5 yield folds and the net income of the farmers. Thus, results indicated that soils are having hidden hunger of P in addition to their N needs.

Table 3.4.3 Influence of balanced use of nutrients in rice

Treatment	N-P ₂ O ₅ -K ₂ O (kg ha ⁻¹)	Grain yield (q ha ⁻¹)	% Yield increase over FP	Fertilizer cost (₹ ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)
Rabi rice						
Farmers' practice	185-92-25	69.10	-	6905	97431	90526
RDF	120-60-40	64.29	-6.96	4911	90644	85733
150% N + 100% PK	180-90-60	69.85	1.08	5688	98489	92801
150% RDF	180-60-40	68.44	-0.95	7366	96496	89130
Kharif rice						
Farmers' practice	185-92-25	64.98	-	6905	91619	84714
RDF	100-50-40	65.64	1.01	4911	92552	87641
150% N P K	150-75-60	66.39	2.16	5688	93616	87928
150% N +100% PK	150-50-40	65.35	0.56	7366	92138	84772

Farmers' practice= 185-92-25 as N-P₂O₅-K₂O (kg ha⁻¹); RDF= 100-50-40 (kharif) & 120-60-40 (rabi) as N-P₂O₅-K₂O (kg ha⁻¹)

Table 3.4.4 FLD on paddy and wheat at Durg

Treatment	Paddy (kg ha ⁻¹)	Wheat (kg ha ⁻¹)
Farmer's practice	1990	1000
100% N	2890	1743
100% NPK	3660	2500

100% NPK= 100:60:40 kg N: P₂O₅: K₂O per ha; FP= 50-60 kg Urea per ha; N- 50-60, P-0, K-0

3.4.5 Demonstration of INM in sorghum-wheat at Akola

Demonstrations conducted at farmer's field in Akola district revealed in that intervention made on nutrient management resulted increase in yield of both sorghum and wheat (Table 3.4.5). The results also showed that application of S during kharif season improved the yield of sorghum but did not have any effect on wheat yield which means hidden hunger of S exists in soil. Application of FYM over and above NPK also resulted in increase in yield of both sorghum and wheat. However, substitution of 25% N through FYM had little edge over NPK in sorghum yield but did not show any effect on subsequent wheat. This could be probably due to larger biomass of sorghum and less number of years. In long-run this may also sustain.

Table 3.4.5 Effect of INM on yield (kg ha⁻¹) of sorghum and wheat

Treatments	Sorghum	Wheat
Farmers' practice (Control)	2308	2410
RDF (P through DAP)	2870	2935
RDF (P through SSP)	3168	3090
RDF + FYM @ 5 t ha ⁻¹	3683	3355
75% RDF + 25% N through FYM	3353	3139
CD (<i>p</i> = 0.05)	507	241

FYM applied to sorghum only; Farmers' practice= 50: 25: 0 (Sorghum) & 60: 30: 0 (Wheat) kg N: P₂O₅: K₂O per ha

3.4.6 INM in rice at Bhubaneswar

Demonstrations conducted on integrated nutrient management (INM) in Rayagada and Khordha district of Orissa revealed that INM resulted in increase in rice yields compared to farmer and chemical fertilizer alone (Table 3.4.6). Thus results indicate integrated nutrient management is best to get higher yield and more benefit.

Table 3.4.6 Front line demonstration on rice yield (t ha⁻¹)

Name of Farmers	Variety	FP	RDF	RDF+FYM
Nupuri Pradhan	Puja	5.0	5.4	6.8
Damnbur Pradhan	Lalat	4.0	5.0	6.0
Saranga Pradhan	Puja	3.8	5.0	6.0
Sanju Pradhan	Puja	4.0	4.6	5.6
Rabi Pradhan	Lalat	4.0	5.0	6.0
Adhikari Pradhan	Lalat	5.5	5.9	6.4
Ramesh Pradhan	Lalat	5.0	5.3	6.4
Saraswati Pradhan	Puja	4.0	5.3	6.0
Abhi Pradhan	Lalat	3.5	5.0	5.6
Chai Pradhan	Lalat	4.0	4.5	5.6
Prafulla Pradhan	Lalat	3.9	5.0	5.2
Balarsen Nayak	Puja	5.0	5.2	6.0
Kandhuri Nayak	Puja	4.0	5.4	6.0
Mean		4.3	5.1	6.0

RDF= Recommended dose of fertilizer (80:40:40 kg N: P₂O₅: K₂O per ha; FP 50:25:25 kg N: P₂O₅: K₂O per ha, FYM @ 5 t per ha

3.4.7 INM in groundnut-wheat at Junagadh

Demonstration conducted at farmer's field on balanced and integrated nutrient management revealed that application of ZnSO₄ resulted in increase in yield of both groundnut and wheat significantly (Table 3.4.7). But the increased yield on integration of fertilizer nutrients with organic manure was much more than that of balanced used of nutrients in both groundnut and wheat. Substitution fertilizer nutrients to the

tune of 50% by application of 10 t ha⁻¹ FYM had significant effect on yield of both the crops. Thus, from the results it is concluded that integrated nutrient management is better option. It can also be interpreted that integrated nutrient management is always balanced nutrition, whereas balanced use of nutrients may not be always balanced.

Table 3.4.7 FLD on groundnut and wheat

Treatments	Groundnut pod (kg ha ⁻¹)	Wheat (kg ha ⁻¹)
100% NPK	1247	4095
100% NPK+50 kg ZnSO ₄ ha ⁻¹	1496	4434
50% NPK + 10 t FYM ha ⁻¹	1778	5137
Farmers' practice	1122	3634
CD (<i>p</i> = 0.05)	141	438

RDF= 12.5:25:00 for groundnut & 120:60:60 for wheat kg N: P₂O₅: K₂O per ha; FP = No application of fertilizer

3.4.8 Green manure as an option for sustainability of rice productivity at Pattambi

Data on average yields revealed that application of FYM and green manuring (GM) with full dose of NPK gave higher yield, however, when dose reduces to 50% through FYM and 50% through green manure, a little decline in yield was recorded but always better than sole NPK (100%) (Table 3.4.8). Thus, results of demonstration clearly indicated that 50% saving on chemical fertilizer and increased gross return in addition to intangible benefit on soil health.

Table 3.4.8 Results of the FLD at Pattambi

Treatments	Rice (Kharif)	Gross return (Rs.)	Rice (Rabi)	Gross return (Rs.)
100% NPK	4730	73315	4607	71408
100% NPK+ 5 t FYM ha ⁻¹	5747	89698	5647	87528
50% NPK + 5 t FYM ha ⁻¹	5187	80398	5053	78321
100% NPK+ <i>in situ</i> GM	5867	90938	5417	83963
50% NPK + <i>in situ</i> GM	5323	80956	5187	80398

3.5 AINP on SBB

- NutGrow- Formulation of DAPG-producing fluorescent pseudomonads has been developed and is recommended for groundnut cultivation in India.
- A liquid formulations has been developed for the cultures of *Pseudomonas putida* DAPG4 and *Pseudomonas putida* FP86 with a shelf-life of more than one year at room temperature and maintained a population of 1010 cfu ml⁻¹.
- Developed on farm crop residue recycling process for effective soil health management- Microbial consortia of Decompo A and Decompo B was developed and found to

decompose sorghum straw within a period of 45 days.

- A solid biofertilizer formulation is being developed for consortia: N fixers (*Rhizobium/ Azospirillum/ Azotobacter*), phosphate solubilizing bacteria, potash solubilizing bacteria and Zn solubilizing bacteria.
- Biofertilizer for drought tolerance in pepper- A biofertilizer formulation developed with diazotrophic bacterium (*Paenibacillus* sp) and actinomycetes (*Microbacterium* sp and *Cellulosimicrobium* sp) using talc base.
- Application of three biofertilizers (N-P-K) +75% RDF saved 25% of RDF with extra grain yield of 18% over 100% RDF in sorghum under rainfed condition.
- Biofertilizer of 223.3 metric tons worth of Rs. 196.28 lakhs were produced and supplied to the farmers of Andhra Pradesh.

3.6 Scheduled Tribe Component (STC) Program

3.6.1 STC under main Institute

Appraisal of natural resource base of tribal inhabited areas of Madhya Pradesh

Under STC, a pilot survey was carried out in five tribal villages viz. Khursodi, Dhuti, Budiyaagaon, Takabarra, of Balaghat block and Butte Hazari of Lalbarra block. Group discussions with the farmers as well as village heads were conducted to collect information about crops and cropping pattern, livelihood strategies, adoption of agricultural technologies and constraints in continuing with farming (Plate 3.6.1). The major cropping systems of the study area was identified as rice-rice and rice-wheat. Chickpea was grown as an intercrop in the bunds of small fields. Mechanization in farming was found less. Some villages have access to the information sources like KVK, SAU. Farmers were not practicing residue burning instead they incorporate previous crop residue with soil.



Plate 3.6.1 Group discussion with tribal farmers

3.6.2 STC under AICRP on STCR

FLDs at IGKV, Raipur (Chhattisgarh)

STCR technology has been tested on tribal farmer's fields successfully with rice, wheat and maize crops during kharif-rabi season. Hundred field demonstrations (one acre each) for tribal farmers in 4 districts (Kanker, Koriya, Surguja, Jagdalpur) of Chhattisgarh were selected for successful conduction of FLD's during Kharif-rabi season (Table 3.6.2a and b; Plate 3.6.2).

Rice: Rice yields from 60 locations in FPD were ranged from 30.25 to 51.9 q ha⁻¹ with the average yield of 41.37 q ha⁻¹ whereas 44.75 to 61.8 q ha⁻¹ with mean yield of 52.36 q ha⁻¹ were recorded under soil test and yield target based fertilizer applications. A wide range of percentage yield increases over FPD (13.27 - 47.93%) with mean value of 27.61 % were noticed in different locations of tribal farmers. Results showed that majority of the locations have resulted as per the soil test based fertilizer application to achieve a definite yield goal for the rice crop. Some of the locations with farmer's fertilizer practice doses showed almost similar yield level with those of yield target based dose that indicate higher fertilizer application by the farmers however, soil test based

fertilizer application will certainly increase the cost benefit ratio and can save the unnecessary nutrient application which are not required.

Maize: Maize yields from 20 locations in FPD ranged from 51.4 to 60.5 q ha⁻¹ with the average yield of 55.18 q ha⁻¹ whereas 61.2 to 69.2 q ha⁻¹ with mean yield of 65.84 q ha⁻¹ were recorded under soil test and yield target based fertilizer applications. A wide range of percentage yield increases over FPD (10.6 - 31.2%) with mean value of 19.43 % were noticed in different locations of tribal farmers. Results showed that majority of the locations have resulted as per the soil test based fertilizer application to achieve a definite yield goal for the Maize crop.

Wheat: Wheat yields from 20 locations in FPD ranged from 14.6 to 17.55 with the average yield of 16.21 q ha⁻¹ whereas 24.5 to 26.25 q ha⁻¹ with mean yield of 25.37 q ha⁻¹ were recorded under soil test and yield target based fertilizer applications. A wide range of percentage yield increases over FPD (42.74 - 74.66%) with mean value of 56.79% were noticed in different locations of tribal farmers. Results showed that majority of the locations have resulted as per the soil test based fertilizer application to achieve a definite yield goal for the wheat crop.

Table 3.6.2a FLDs conducted in Chhattisgarh state during kharif and Rabi season

Crop/variety	Block/village	Name of tribal districts	No. of FLDs	Range of % yield increased over FPD
Rice (Bamleshwari)	Telawat	Kanker	20	13.27-31.26
Rice (MTU-1010)	Pandonagar/Pahadgaon	Ambikapur	20	28.22-47.93
Rice (Chandrasasini)	Ghutra	Korea	20	22.06-33.56
Maize (DKC9114)	Tekameta	Jagdalpur	20	10.60-31.20
Wheat (HI- 1544)	Barbaspur	Koriya	20	42.76-74.60

Table 3.6.2b List of trainings cum field day conducted under Tribal Sub Plan, Raipur

Training date	Village	District	Total no. of participant	No. of women farmers
22.02.2018	Gangpur, (Lohara)	Kabirdham	125	40
19.03.2018	Madhota (Bastar)	Bastar	83	35
20.03.2018	Dumali(Kanker)	Kanker	75	23



Plate 3.6.2 Field Day Programme at Villages Gangpur (Kabirdham), Madhota (Bastar) and Dumali (Kanker)

Follow up trials on rice crop

Fourty one follow up trials (Table 3.6.2c, d and e) were conducted on farmer's field in villages –Jhariyawan, Majhgawan, Parsiya, Hadahi and Shahpur, block Naugarh, District – Chandauli (U.P.) on Rice crop (Aman, Sudha and Induri Sambha). Rice crop (kharif) was grown and it was observed that fertilizer recommended through STCR for obtaining the yield target is economical over farmers practice. Therefore, developed equation can be used for fertilizer recommendation for Inceptisol.

Follow up trials on maize crop

Thirty three follow up trials (Table 3.6.2f) were conducted on farmer's field in villages -Jhariyawan, Aurawantand, Parsiya, Hadahi, Shahpur, Dhobahi, Majhgawan and Bhaganda, block Naugarh, District – Chandauli (U.P.) on Maize crop (Jaunpury). Maize crop (kharif) was grown and it was observed that fertilizer recommended through STCR for obtaining the yield target is economical over farmers practice. Therefore, developed equation can be used for fertilizer recommendation for Inceptisol.

Follow up trials on barley crop

Five follow up trials (Table 3.6.2g) were conducted on farmer's field in villages –Jhariyawan and Hadai, block Naugarh, District – Chandauli (U.P.) on Barley crop (RD2050). Barley crop (Rabi) was grown and it was observed that fertilizer recommended through STCR for obtaining the yield target is economical over farmers practice. Therefore, developed equation can be used for fertilizer recommendation for Inceptisol.

Follow up trials on wheat crop

Twelve follow up trials (Table 3.6.2h) were conducted on farmer's field in villages–Parsiya and Majhgawan, block Naugarh, District–Chandauli (U.P.) on Wheat crop (Malviya-234). Wheat crop (Rabi) was grown and it was observed that fertilizer recommended through STCR for obtaining the yield target is economical over farmers practice. Therefore, development equation can be used for fertilizer recommendation for Inceptisol. Several trainings as field days were conducted at Chandauli district of UP (Table 3.6.2i).

Table 3.6.2c Verification Trail for Rice (Aman) crop (Average of 12 locations)

Treatment	Actual mean grain yield (kg ha ⁻¹)	Actual mean straw yield (kg ha ⁻¹)	Net benefit (₹) over T1	B/C ratio
T1-0-0-0 (Control)	1721.54	2871.69	-	-
T2-100-35-35 (FP)	2620.77	4080.00	10633.87	2.30
T3-120-55-55 (GRD)	3903.46	5271.54	30454.72	4.60
T4-119-52-64 (TY-45 q ha ⁻¹)	4491.69	6048.62	40903.24	6.62
T5-143-60-79 (TY-50 q ha ⁻¹)	5149.85	6758.85	50834.19	6.74

Table 3.6.2d Verification Trail for Rice (Sudha) crop (Average of 6 locations)

Treatment	Actual mean grain yield (kg ha ⁻¹)	Actual mean straw yield (kg ha ⁻¹)	Net benefit (₹) over T1	B/C ratio
T1-0-0-0 (Control)	1414.83	2393.33	0.00	0.00
T2-100-35-35 (FP)	2175.83	3368.33	9081.25	1.96
T3-120-55-55 (GRD)	3224.67	4368.33	25223.75	3.81
T4-119-52-64 (TY-45 q ha ⁻¹)	3738.17	5041.67	34349.75	5.56
T5-143-60-79 (TY-50 q ha ⁻¹)	4275.00	5568.33	42337.42	5.61

Table 3.6.2e Verification Trail for Rice (Induri Sambha) crop (Average of 23 locations)

Treatment	Actual mean grain yield (kg ha ⁻¹)	Actual mean straw yield (kg ha ⁻¹)	Net benefit (₹) over T1	B/C ratio
T1-0-0-0 (Control)	1674.48	2638.74	-	-
T2-100-35-35 (FP)	2572.91	4066.26	11544.93	2.50
T3-120-55-55 (GRD)	3847.83	6093.39	32495.36	4.90
T4-119-52-64 (TY-45 q ha ⁻¹)	4501.13	7167.78	43659.90	6.06
T5-143-60-79 (TY-50 q ha ⁻¹)	5076.65	8034.87	52769.50	6.24

Table 3.6.2f Verification Trail for Maize (Average of 33 locations)

Treatment	Actual mean grain yield (kg ha ⁻¹)	Actual mean straw yield (kg ha ⁻¹)	Net benefit (₹) over T1	B/C ratio over T1
T1-0-0-0 (Control)	1573.52	2533.62	-	-
T2-100-35-35 (FP)	2182.79	3518.24	5804.50	1.26
T3-120-60-60 (GRD)	2558.21	4125.10	9821.36	1.40
T4-126-53-51 (TY-30 q ha ⁻¹)	3086.24	4978.51	19483.17	3.04

Table 3.6.2g Verification Trail for Barley (Average of 5 locations)

Treatment	Actual mean grain yield (kg ha ⁻¹)	Actual mean straw yield (kg ha ⁻¹)	Net benefit (₹) over T1	B/C ratio
T1 -0 - 0 - 0 (Control)	1724.00	2689.00	-	-
T2 -80-40-40 (FP)	2622.00	4014.00	8762.40	1.86
T3 -100-50-50 (GRD)	3378.00	4970.00	18925.50	3.22
T4 -93-33-69-2 (TY-40 q ha ⁻¹)	4079.00	5529.00	28011.90	3.83
T5 -16-38-85-2 (TY-45 q ha ⁻¹)	4664.00	6299.00	35679.20	4.24

Table 3.6.2h Verification Trial for wheat (Average of 12 locations)

Treatment	Actual mean grain yield (kg ha ⁻¹)	Actual mean straw yield (kg ha ⁻¹)	Net benefit (₹) over T1	B/C ratio
T1-0-0-0 (Control)	1786.00	3005.00	-	-
T2-100-35-35 (FP)	2756.83	4298.33	11863.27	2.56
T3-120-60-60 (GRD)	3399.83	5000.00	20373.77	2.89
T4-83-28-48-2 (TY-40 q ha ⁻¹)	3972.50	5267.50	29802.40	4.05
T5-126-37-74-2 (TY-45 q ha ⁻¹)	4548.17	6155.83	38711.63	4.70

Table 3.6.2i List of training cum Field day conducted under Tribal Sub Plan in Varanasi

Training date	Village	District	Total no. of participant	No. of women farmers
18.02.2018	Persiya and Majhgawan	Chandauli	130	41
25.03.2018	Naugarh	Chandauli	54	19
22.02.2018	Persiya	Chandauli	54	33
23.02.2018	Majhgawan and Sahpur	Chandauli	53	32
28.02.2018	Naugarh	Chandauli	54	35

3.7 STC under AINP on SBB

- Nine actinobacteria isolates from NEH found to inhibit four pathogenic fungi and two bacterial pathogens viz. *Fusarium oxysporum*, *Rhizoctonia solani*, *Curvularia lunata*, *Sclerotinia sclerotiorum*, *Xanthomonas oryzae* and *Erwinia sp.*
- Biofertilizer demonstrations done in tribal areas in Madhya Pradesh, Odisha and Kerala.

3.8 MGMG Activities

Mera Gaon Mera Gaurav (MGMG) has been undertaken to promote the direct interface of scientists with the farmers to hasten the lab to land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by scientists adopting 55 villages under MGMG programme. Under this scheme, scientists

have selected villages as per their convenience and remained in touch with the selected villages and provided information to the farmers on technical and other related aspects in a time frame through personal visits or on telephone. Being a resource person for the village, the scientists monitor the process of adoption of agricultural technologies by the farmers with the cooperation of KVKs, ATMA, etc. Besides providing information to farmers on market rates, market trends, the information on various agricultural organisations associated with agriculture are given so that the farmers can contact these organisations for finding solutions to their agriculture related problems. Scientists also create awareness among farmers about organic farming, climate change, soil health, vermicomposting, bee keeping, other customized services, protective measures and other issues of local and national importance. The list of scientists groups and their adopted villages are given in the table 3.8.

Table 3.8 ICAR-IISS, Bhopal Adopted Villages under MGMG

S.No.	Group	Name of five villages adopted by Group Leader
1	Dr. A.K. Patra, Director, ICAR-IISS Dr. A.B. Singh, PS, SBD & Nodal Officer Dr. Abhay Shirale, Scientist, SC&F Dr. Sudeshna Bhattacharjya, Scientist, SBD Mr. Utkarsh Tiwari Scientist ESS	Dobra, Khejra, Perwalia Sadak, BadarkhaSadak, Mubarakpur
2	Dr. M.C. Manna, HOD, SBD Dr. Prabhat Tripathi, PS, & Co-nodal officer Dr. N.K. Sinha, Scientist, SPD Dr. Dolamani Amat Scientist, SBD	Acharpura, Parewakheda, Arwali, Hazampura and Parewaliasahani
3	Dr. M. Singh PC, LTFE Dr. S. Kundu, PS, ESS Dr. R.H. Wanjari, PS, LTFE Dr. K. Bharati, PS, SBD	Choupdakala, GhatKheri, SayyaidSemara, Emaliya Chopra and Amoni
4	Dr. J.K. Saha, HOD, ESS Dr. M.L. Dotaniya, Scientist, ESS Dr. Hiranmoy Das, Scientist (STCR) Dr. Sonalika Sahoo, Scientist, ESS	Islam Nagar, Dewalkhedi, Bharonpura, Kalyanpura, PuramanBhavan
5	Dr. K M Hati, PS, SPD Dr. Sanjay Srivastava, PS, SC &F Dr. K.C. Shinogi, Scientist, ITMU Dr Gurav Priya Pandurang, Scientist, SC&F	Bankhedi, Baroda, Sojna, Amaravadi and Kuravadi
6	Dr. A.K. Shukla, PC, MSPE Dr. R. Elanchezhian, PS, SC&F Dr. S.K. Behera, SS, PC Unit, MSPE Dr. R.K. Singh, PS, SPD Dr. J.K. Thakur, Scientist, SBD	Sagoni, Munirgarh, Gudawal, Chhattarpura, Chiklodkhurd
7	Dr. A. K. Biswas, HOD, SC&F Dr. Brij Lal Lakaria, PS, SC&F Dr. Asha Sahu, Scientist, SBD Dr. Bharat P. Meena, Scientist, SC&F	Golkhedi, Binapur, Kanchbavli, Khamkheda and Raslakhedi
8	Dr. R.S. Choudhary, HOD, SPD Dr. P. Jha, PS, SC&F Dr. S.R. Mohanty, PS, SBD Dr. A.K. Vishwakarma, PS, SPD	Raipur, Kanera, Momanpur, Kadhaiya and KarodKhurd
9	Dr. P. Dey, PC, STCR Dr. N.K. Lenka, PS, SC&F Dr. M. Mohanty, SS, SPD Dr. M. VassandaCoumar, SS, ESS	Ratibad, RasuliyaPathar, Mugaliahat, RatanpurSadak, Chandukhedi
10	Dr. A.K. Tripathi, PS, SBD Dr. S. Ramana, PS, SBD Dr. J. Somasundaram, PS, SPD Dr. A. Mandal, Scientist, SBD	Dobra Jagir, KoluaKhurd, Sagoni Kalan, ChorSagoni, AdampurChhawani
11	Dr. Ajay, PS, ESS Dr. TapanAdhikari, PS, ESS Dr. S. Lenka, Scientist, ESS Dr. Ankush Lala Kamle, Scientist, SC&F	Shahpur, Devpur, KasiBarkeda, Sagoni, and BarkediHajam





4. Training and Capacity Building

4.1. Capacity Building of Staff

A. Participation in Training

S. No.	Category	No. of employees
1	Scientist	8
2	Technical	5
3	Administrative & Finance	13
4	Skilled Supporting Staff	0
	Total	26

B. HRD fund allocation and utilization (₹ in Lakhs)

RE for HRD 2017-18	Actual Expenditure 2017-18 for HRD
3.00	2.29

C. Training attended

C₁- Scientific Staff

S. No	Name of employee	Title	Organizer	Duration
1	Dr. N.K. Sinha	Advanced remote sensing and GIS applications in integrated land resource management	ICAR-NBSS&LUP, Nagpur	17- 28 July, 2017
2	Dr. A. B. Singh	Stability/Combined Analysis Methodology for Network Project on Organic Farming Experimental data	ICAR-IIFSR, Modipurum	25-26 July, 2017
3	Dr. Priya Gurav	Developing winning research proposals in agricultural research	NAARM, Hyderabad	1-5 August, 2017
4	Dr. Priya Gurav	ICAR Short course on Advances in nutrient dynamics for improving nutrient and water use efficiency of crops	ICAR-IISS, Bhopal	5-14 September, 2017
5	Dr. Priya Gurav	Winter school on Advanced statistical tools and techniques for modeling and forecasting agricultural data	ICAR-IARI, New Delhi	08-28 November, 2017
6	Dr. Dolamani Amat	Skill development training programme	CCMB, Hyderabad	12-17 December, 2017
7	Dr. Tapan Adhikari	MDP Training Programme	NAARM, Hyderabad	10-24 December, 2017
8	Dr. M.L. Dotaniya	Ecological Agriculture For Sustainability	GBPUA&T, Pantnagar	09 February-01 March, 2018
9	Dr. Hiranmoy Das	ICAR-NICRA sponsored training program on Agricultural System Modelling to Assess Climate Change Impact on Soils and Crops	ICAR-IISS, Bhopal	16 - 25 January, 2018

C₂- Technical Staff

S.No.	Name of employee	Title	Organizer	Duration
1	Mr. Jai Singh and Mr. Hukum Singh	Precision agriculture technologies	ICAR-IARI, New Delhi	18-23 September, 2017
2	Mr. O.P. Shukla, Mr. P.K. Chauhan and Mr. Hukum Singh	Use and maintenance of advanced instruments in soil and plant analysis	ICAR-IISS, Bhopal	22-27 January, 2018

C₃- Administrative Staff

S.No.	Name of employee	Title	Organizer	Duration
1	Mr. P.S. Sunil Kumar	Administration and Finance Management for Section Officers, AAOs, AF&AOs & Assistants	NAARM, Hyderabad	23-29 June, 2017
2	Mr. P.S. Sunil Kumar	Buyer training on GeM	ICAR-NAARM, Hyderabad	12 July, 2017
3	Mr. P.S. Sunil Kumar	Income Tax	ISTM, New Delhi	27-28 July, 2017
4	Mr. P.S. Sunil Kumar	E-procurement	ISTM, New Delhi	21-22 August, 2017
5	Mr. P.S. Sunil Kumar	E-procurement	ISTM, New Delhi	07-08 September, 2017
6	Mr. P.S. Sunil Kumar	Procurement & PFMS	ICAR-CPRI, Shimla	11-15 September, 2017
7	Mr. Bansi Lal Sarsodia, Mr. Heera Lal Gupta and Smt. Babita Tiwari	GeM	DGS&D, Hyderabad	12 July, 2017
8	Mrs. Geeta Yadav	Enhancing efficiency and behavioral skills for Stenographer Grade-III, PA, PS	ICAR-NAARM, Hyderabad	25-31 October, 2017
9	Mr. Bansi Lal Sarsodia	GST	NIFM, Faridabad	6-8 December, 2017
10	Mr. Bansi Lal Sarsodia and Mr. Anupam S. Rajput	Finance & Administration course	ICAR, NAARM, Hyderabad	18-23 January, 2018

4.2. Professional Attachment Training Organized for Scientist Probationers

S.No.	Name of the Scientist	Name of the College /Institute/University	Duration (month)	Name of the Mentor
1	Dr. Dolamani Amat	ICAR-NRCPB, New Delhi	15 May, 2017 to 24 August, 2017	Dr. Debasis Pattanayak
2	Mr. Utkarsh Tiwari	ICAR-NIAP, New Delhi	13 November, 2017 to 13 February, 2018	Dr. Subhash Chand

4.3. Research Guidance for Degree Students

S.No.	Name of the Student	Name of the College/ Institute/University	Degree	Name of the Co-Guide
1	Mr. Dharmendra Singh	College of Agriculture, Gwalior	M.Sc.	Dr. Sangeeta Lenka
2	Mr. Chittaranjan Raul	AEHM Division, ICAR-CIFE, Mumbai	M.F.Sc	Dr. Sangeeta Lenka
3	Ms. Shaheen Praveen	IGKV, Raipur	M.Sc.	Dr. Tapan Adhikari
4	Ms. Pooja Verma and Ms. Vinu Jacob	IIFM, Bhopal	Ph.D.	Dr. M. Vassanda Coumar
5	Mr. Jaypal Singh Pipalde	RAK College of Agriculture, Sehore	M. Sc.	Dr. M.L. Dotaniya
6	Dr. Rajae Dakhli	Institute of Arid Areas- Medenine, Tunisia (Africa),	Post Doctoral Fellow (C.V. Raman fellowship)	Dr. M. C. Manna
7	Ms. Navnaga Neha Prakash	IGKV, Raipur	M.Sc.	Dr. Asit Mandal
8	Ms. Diksha Vishwakarma	R.A.K. College of Agriculture, Sehore	M. Sc.	Dr. J.K. Thakur
9	Mr. Sabe Singh	RVSKVV, Gwalior	M.Sc.	Dr. Asha Sahu
10	Mr. Kshitipati Padhan	SG College of Agriculture & Research Station, Jagdalpur, IGKV, Raipur	M.Sc.	Dr. Sudeshna Bhattacharjya
11	Mr. Rameshar Soliya	College of Agriculture, Gwalior	M.Sc.	Dr. N.K. Sinha
12	Mr. Rajesh Patidar	RAK College of Agriculture, Sehore	M.Sc.	Dr. B.L. Lakaria
13	Ms. Priyanka Jain	RVSKVV, Gwalior	M.Sc.	Dr. B.L. Lakaria
14	Ms. Payal Giri	IGKV, Raipur	M.Sc.	Dr. M. Mohanty
15	Mr. Nagendra	RVSKVV, Gwalior	M.Sc.	Dr. N.K. Sinha
16	Mr. Vinod Birla	R.A.K. College of Agriculture, Sehore	M.Sc.	Dr. R.H. Wanjari

Training to farmers/Students

- Dr. A.K. Patra, Dr. S. Kundu, Dr. K. Bharati, Dr. M.L. Dotaniya, Dr. Rajendiran S. organized Summer training for B.Sc. forestry students of SHUATS, Allahabad on “Forest Soils and Their Management” during 5-14 June, 2017 at ICAR-IISS, Bhopal.
- Dr. A.K. Biswas, Dr. Shinogi KC, Dr. B.P. Meena and Dr. Abhay Omprakash Shirale organized training Programme on Soil Testing and Organic Farming sponsored by Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh during July 01-07, 2017.

- Dr. S. Kundu, Dr. M. Vassanda Coumar and Dr. M.L. Dotaniya organized a training programme on "Soil Testing Technologies" for the student of SHUATS, Allahabad during 26 December, 2017 to 1 January, 2018 at ICAR-IISS, Bhopal.
- Besides, the scientist of the institute have coordinated the visits of the farmers/scientists/agriculture officers/extension workers/ students in the institute and explained the technologies generated by the institute particularly on organic farming, vermicomposting, phospho-sulpho-nitro-composting and enriched compost production.



Farmers Training/Meeting organized under Farmers FIRST project (FFP)

Date	Name of Programme	No. of Participants
13 April, 2017	Animal Health Camp	25
06 June, 2017	Farmers meeting at Bhairopura village	109
07 Nov, 2017	Awareness programme on Conservation agriculture (Bhairopura)	20
27-28 Feb, 2018	Farmer's Training on Organic farming, soil health, conservation agriculture and balance nutrient management	55
08 March, 2018	Workshop on Role of rural women for doubling farmers income	75
13 March, 2018	Animal Health Camp KhamKheda and Bhairopura	146
22 March, 2018	Field Day and Farmer Scientist Interaction on CA, Fruit and Vegetable Production (Bhairopura)	60
20-24 March, 2018	Farmer's Training on enhancing farmer income through Honeybee keeping	20
26 March, 2018	Field Day and Farmer Scientist Interaction on CA, Fruit and Vegetable Production (Khamkheda)	65

Exposure visits conducted for Farmers/Extension workers/ Students

S. No.	Department	Number of participants	Period
1.	Atal Bihari Vajpayee Hindi University, Bhopal	11 Students	18 Sep, 2017
2.	PNB Farmers Training Centre, Vidisha, Madhya Pradesh under Vermicompost Producer	30 Progressive Farmers	28 Sep, 2017
3.	Farmer Welfare and Agriculture Development Dindori, Madhya Pradesh	35 Progressive Farmers	31 Oct, 2017
4.	Farmers from Jhalawar, Rajasthan under ATMA Project	51 Progressive Farmers	22 Feb, 2018
5.	Farmers from Visakhapatnam, District Andhra Pradesh under ATMA Project	20 Progressive Farmers	22 Feb, 2018
6.	State Agriculture Management Institute, Lucknow	40 Extension Officers	17 March, 2018
7.	Farmer Welfare and Agriculture Development Betul, Madhya Pradesh	40 Progressive Farmers	27 March, 2018
8.	Farmer Welfare and Agriculture Development Betul, MP under Mukhyamantri Kheti Teerth Yojana	30 Progressive Farmers	24 March, 2018



Organization of Training cum workshop on methodological framework for implementation of FFP



5. Awards, Honours and Recognitions

5.1 Awards

- Dr A.K. Patra received Dr. Sushil Kumar Mukherjee Commemoration Award from Indian Science Congress Association at Kolkata on 16th March 2018.



- Brij Lal Lakaria received IASWC Fellow-2017 from the Indian Association of Soil and Water Conservationists, Dehradun, Uttranchal.



- Dr. M. Vassanda Coumar received Young Scientist Award in the Field of Soil Science and Agricultural Chemistry by the Society for Scientific Development in Agriculture and Technology (SSDAT).
- Dr. M.C. Manna received Desbhakt Balasaheb Varde Smriti Puraskar, on 27th May 2017 from Padmabhusan Balasaheb Varde Pratisthan, Pune.



- Dr. Pradip Dey received Dr. Banyal Memorial Award from Society for Advancement of Human and Nature, Himachal Pradesh, India.
- Dr. M. Vassanda Coumar received Outstanding Achievement Award by PRAGATI-2017.
- Dr. M. Vassanda Coumar received Young Scientist Award in the Field of Soil Science and Agricultural Chemistry during 2nd International conference on food and agriculture- 2018 held at Dhanbad, Jharkand during March 29-31, 2018.
- Dr. M. Vassanda Coumar received EET CRS 2nd Academic Brand Award- 2017 as Special Mention Certificate for Researcher.
- Dr. A.K. Shukla received Dhuru Morarji Best Paper Award-2017 by Fertilizer Association of India, New Delhi



- Dr. M. Vassanda Coumar received EET CRS 6th Academic Brilliance Awards-18 for Excellence in Research
- Dr. M.L. Dotaniya received Young Scientist Award-2017 by Astha foundation, Meerut.
- Dr. M. L. Dotaniya received Young Scientist Award-2017 by Academic Brand Award.
- Dr. M. Dotaniya received 'Special Achievement Award-2017 by EET CRS Science & Technology.
- Dr. B.P. Meena received Certificate of Excellence in reviewing award by Advances in Research Journal in 2017.
- Dr. Sudeshna Bhattacharjya received Best Oral Presentation Award in National Conference on "Organic Waste Management for Environmental and Food Security", 8-10th February, 2018.

- Drs. B.P. Meena, A.K. Biswas, Muneshwar Singh, A.B. Singh, R.S. Chaudhary, A.K. Patra received 'Best Poster Award' at the National Conference on organic waste management for food and environmental security" during 08-10 February, 2018 at ICAR-IISS, Bhopal.
- Dr. M. Vassanda Coumar received Best paper Award during the 2nd International Conference on Food and Agriculture- 2018 at Dhanbad, Jharkhand during 29-31 March, 2018.
- Dr. Asha Sahu received Best Oral Presentation Award during National Conference on "Organic Waste Management for Food and Environmental Security" during 8-10, Feb. 2018 at ICAR-IISS, Bhopal.
- Dr. Asha Sahu received Women Achiever award 2017-2018 during International Women Day 2018 at ICAR-IISS, Bhopal.
- Dr. M. Vassanda Coumar was awarded "Certificate of Reviewing" 2017 in recognition of the review made for the Journal of Environmental Pollution.

5.2 Honours and Recognitions

- Dr. A.K. Patra recognised as one among 13 soil scientists of the world (Food Tank, USA) on World Soil Day 2017. (<https://foodtank.com/news/2017/12/sustainable-soil-scientists/>).
- Dr. A.K. Patra acted as member, Working Group, South-East Asia Laboratory Network (SEALNET), FAO, Rome (2018-2020).
- Dr. A.K. Patra acted as Associate Editor, European Journal of Soil Science, UK, 2014.
- Dr. A.K. Patra acted as Jury Panelist in the Second Jury Convention (Stage 4) for farmer & non-farmer nominations for Mahindra Samridhi India Agri Award (MSIAA) at New Delhi on 1-2 February, 2018.
- Dr. A.K. Patra acted as examiner for Ph.D. viva-voce at Division of Soil Science and Agricultural Chemistry, MPKV, Rahuri on 2 May, 2017
- Dr. A.K. Patra acted as an 'Expert Member' of the Maharashtra Agricultural University Recruitment Board, Pune in connection with the promotion for the post of Head of Department/Professor in SAUs of Maharashtra, MPKV, Rahuri during 2-3 May, 2017.
- Dr. Pradip Dey was honored with Certificate of Commendation from the GIZ for performance as Expert in Soil Science in recognition of significant Knowledge Exchange in regards to soil conservation and soil policy advice for protecting and rehabilitating degraded soils as well as mainstreaming of importance of soil conservation during study tour to Kenya during 19 November to 2 December, 2017.
- Dr. Pradip Dey was designated as Focal Point Expert for IPNS by SAARC Agriculture Centre, Dhaka during SAARC Expert Consultation during 9-11 April, 2017 at Mymensingh, Bangladesh.
- Dr. Pradip Dey acted as Panelist and Facilitator of the Brainstorming Session on "Combating residue burning in agriculture", held at ICAR-IISS, Bhopal during 9 February, 2018.
- Dr. Pradip Dey acted as Member IMC, ICAR-Central Soil Salinity Research Institute, Karnal.
- Dr. Pradip Dey acted as Member IMC, ICAR-Central Coastal Agricultural Research Institute, Goa.
- Dr. Pradip Dey acted as Co-Chairman and Judge of Poster Session of National Conference on "Organic waste Management for food and Environment Security", held at ICAR-IISS, Bhopal during 8-10 February, 2018.
- Dr. Pradip Dey acted as Member of Programme Committee of International Conference on Advances in potassium research for efficient soil and crop management, organized by IPNI, FAI, TAAS, CIMMYT and ICAR at New Delhi during 28-29 August, 2017.
- Dr. Pradip Dey graced as Chief Guest of Plenary Session of the National Seminar on "Managing Soil Health for Sustainable and Nutritional Food Production" at JNKVV, Jabalpur during 29, October, 2017.
- Dr. Sanjay Srivastava acted as examiner for Ph.D. thesis of Angelin Sylvia R of TNAU, Coimbatore and G. Yoganathan of TNAU, Coimbatore.
- Dr. Sanjay Srivastava evaluated the interim report on "Impact Study of Soil Health Management and Soil Health Card Scheme" Submitted to Department of Agriculture Cooperation and Farmer's Welfare Ministry of Agriculture and Farmer's Welfare by National Institute of Agricultural Extension Management (MANAGE), Hyderabad.
- Dr. Sanjay Srivastava examined the report "Improvement in the efficiency of SSP by coating" (NATP project) in the light of enhancement of P use efficiency and submitted the comments to NRM Division on 17 July 2017 (Ref: F. No. NRM/12(1) 2016-SWDF dated 13.07.2017).
- Dr. A.K. Biswas, Dr. R. Elanchezhian, Dr. P. Jha, Dr. S.R. Mohanty and Dr. S. Lenka were invited as expert in the

- brain storming session on “Recent advances in biomass energy research and management” on 9 November 2017 at CIAE, Bhopal.
- Dr. M.L. Dotaniya received Certificate of Excellence in Reviewing-2017 by Land degradation and Development.
 - Dr. S.R. Mohanty acted as external examiner for DBT funded JRF-SRF promotion of Ms Nevedha on 9 October 2017 at Indian Institute of Science Education and Research (IISER), Bhopal.
 - Dr. B.P. Meena received a Certificate of Recognition Awarded for the contribution to Current Agriculture Research Journal as Reviewer for the year 2017.
 - Dr. B.P. Meena acted as National Steering Committee Member at International conference on Advances in Agricultural and Biodiversity conservation for sustainable development C.C.S university Meerut, Uttar Pradesh during 27-28 October, 2017.
 - Dr. B.P. Meena acted as an associate Editor, Kisaan Kheti (अंतर्राष्ट्रीय कृषि ई-पत्रिका)
 - Dr. B.P. Meena acted as an associate Editor, Applied Chemical Engineering (En Press Publisher, LLC)
 - Dr. B.P. Meena acted as an external examiner to set question paper of course no. AGRON-203 title Field Crops-II (Rabi season) to B.Sc. (Hons.) Agriculture of Banda University of Agriculture and Technology, Banda - 21001, UP.
 - Dr. B.P. Meena received a Certificate of excellence in reviewing awarded by International Journal of Plant and Soil Science in 2017.
 - Brij Lal Lakaria was invited as an evaluator for assessment of Young Scientist’s research award by MP Council of Science and Technology at Jabalpur on 15 March, 2018.
 - Dr. R. Elanchezhian acted as Expert for Review and Revision of Curricula of Agriculture under RMSA of MHRD GOI by PSS Central Institute of Vocational Education Shyamala Hills, Bhopal.
 - Dr. R. Elanchezhian acted as Panelist for the Session Agriculture, Health and Environment during National Science day celebration at Malviya National Institute of Technology, Jaipur.
 - Dr. R. Elanchezhian acted as External Examiner for Ph.D. Thesis Viva Voce of Ms Shabnam Khan in Plant Physiology from IGKV, Raipur.
 - Dr. R. Elanchezhian acted as Examiner for evaluation of Ph.D. thesis of Mr. Yugandhar Poli in Biotechnology from Jawaharlal Nehru Technological University, Hyderabad.
 - Dr. A.K. Vishwakarma nominated as member selection committee for selection of KVK scientist in KVKs of Sehore, Bankhedi.
 - Dr. A.K. Vishwakarma acted as Co-Convener National conference on Doubling Farmers Income for Sustainable and Harmonious Agriculture (DISHA-2017) during September 9-10, 2017 held at Convention Hall, Sri Venkateswara University, Tirupati.
 - Dr. A.K. Vishwakarma acted as local organizer in capacity building programme on “Methodological framework for implementation of Farmer FIRST Project (FFP)” during 18-21 September, 2017 organized in collaboration with ICAR-NAARM, Hyderabad at ICAR-IISS Bhopal.
 - Dr. N.K. Lenka acted as rapporteur of the technical session on Soil Engineering and Technology in the 82nd Annual Convention of the Indian Society of Soil Science, held at Amity University, Kolkata during 11-14 December, 2017.
 - Dr. N.K. Lenka elected as Councillor of the Indian Society of Soil Science, New Delhi.
 - Dr. Pradip Dey acted as member of selection Committee of Assistant/Associate Professor at Banda University of Agriculture and Technology, Banda on 21 April, 2017.
 - Dr. Sanjay Srivastava acted as expert in meeting on suggestions made by Hon’ble PM held under the co-chairmanship of Secretary, DAC&FW and Secretary, DARE, Krishi Bhavan, New Delhi on 22 September, 2017.
 - Dr. Brij Lal Lakaria acted as external member in synopsis seminar of Ph.D. student at Swami Keshwanand Rajasthan Agricultural University, Bikaner on 26 February, 2018.
 - Dr. Pradip Dey acted as Facilitator in the meeting on discussion among the carbon-workers of the country as a prelude to the formation of the “Indian Carbon Group” at BCKV, Kalyani on 9 June, 2017.
 - Dr. Sanjay Srivastava, Dr. B.L. Lakaria, Dr. R. Elanchezhian acted as expert members in meetings at State Department of Agriculture, Govt. of MP, Bhopal.



6. Linkages and Collaboration

The Institute has linkages with several ICAR institutes and SAUs located throughout the country. The three AICRPs (LTFE, STCR and MSPE) and one AINP on SBB located at ICAR-IISS Bhopal have 82 cooperating centers spread across almost all the SAUs of the country. As lead centre, the Institute is undertaking platform project of CRP on “Conservation Agriculture” and external funded projects (INDO-UK Nitrogen centre, Extramural fund of the ICAR, National Agricultural Science Fund, DST, DBT, NICRA) involving linkage with several ICAR Institutes. Also, efforts have been made to strengthen research collaborative activities with SAUs through guidance of PG students by the Institute scientists. Besides, several private firms, viz. PRII,

Gurgaon; Zuari Agro Chemicals Ltd.; Indofil Industries Ltd.; SNF Pvt. Ltd, Vishakhapatanam; Hindustan Copper Ltd., Malanjkhand; Rhodia Specialty Chemicals India limited, Mumbai; Warkem, Mumbai; M/s Grasim Industries Limited, Nagda, Ujjain, M.P. and NTPC Govt. of India are collaborating with the Institute on various R&D activities.

Institute is also coordinating establishment of Soil Water Tissue Laboratory (SWTL) in Tunisia under India Africa Forum Summit (IAFS III). Three documents, Government to Government (G to G), institution to institution (I to I) and project document have been formulated and submitted to DARE for setting up of SWTL in Tunisia under IAFS.

List of Co-operating Centres under AICRPs/AINP	No. of cooperating centres		
	ICAR	SAUs/ SGUs	Total
AICRP on LTFE: Hyderabad, Raipur, IARI New Delhi, Junagarh, Palampur, Ranchi, Bangaluru, Pattambi, Jabalpur, Akola, Parbhani, Bhubaneshwar, Ludhiana, Udaipur, Coimbatore, Pantnagar, Barrackpore, IASRI New Delhi.	3	15	18
AICRP on STCR: Hyderabad, Pusa, Raipur, New Delhi, Hisar, Palampur, Bangaluru, Vellanikkara, Jabalpur, Rahuri, Bhubaneshwar, Ludhiana, Bikaner, Coimbatore, Pantnagar, Kalyani, Barrackpore, Puduchery, BHU, Jorhat, Gujarat, Srinagar, Ranchi, Lucknow, Manipur.	4	21	25
AICRP on MSPE: Hyderabad, Pusa, Anand, Hisar, Jabalpur, Akola, Bhubaneshwar, Ludhiana, Coimbatore, Pantnagar, Jorhat, Kalyani, ranchi, Palampur, Kanpur, KAU Kerala, UAS Bengaluru, Manipur, NIANP Bengaluru, IARI New Delhi, RLBCAU, Jhansi.	2	19	21
AINP on Soil Biodiversity-Biofertilizers: AAU, Jorhat, ANGRAU, Amaravathi, BAU, Ranchi, HAU, Hisar, JNKVV, Jabalpur, KAU, Thrissur, KAU, Vellayani, MAU, Parbhani, MPUAT, Udaipur, OUAT, Bhubaneswar; RAU, Pusa; TNAU, Coimbatore; YSPUHF, Solan, CRRI, Hazaribagh, University of Delhi, IARI, New Delhi, DGR, Junagarh, GBPUAT, Pantnagar, UAS, Dharwad, Coordinating Unit, IISS, Bhopal.	3	15	18



7. Ongoing Research Projects

Programme I: Soil Health and Input Use Efficiency

(A) Institute Project

1. Long-term evaluation of integrated plant nutrient supply modules for sustainable productivity in Vertisol
Muneshwar Singh, A. K. Biswas, B. P. Meena, A. B. Singh and R. S. Chaudhary
2. Biochar on soil properties and crop performance
B. L. Lakaria, P. Jha, A.K. Biswas, K.M. Hati, J.K. Thakur, M.V. Coumar, A.K. Dubey and S. Gangil
3. Nano particle delivery and internalization in plant systems for improving nutrient use efficiency
R. Elanchezhian, A.K. Biswas, Tapan Adhikari, K. Ramesh, S. Kundu, A.K. Shukla and K. Raju Kumar
4. Evaluating rock phosphates for their suitability for direct application
Sanjay Srivastava, K. Ramesh, A.K. Tripathi, I. Rashmi and P. Dey
5. Evaluation of modified urea materials and agronomic interventions for enhancing nitrogen use efficiency and sustaining crop productivity
B.P. Meena, K. Ramesh, Pramod Jha and R. Elanchezhian
6. 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
7. Assessment of important soil properties of India using mid-infrared spectroscopy
K.M. Hati, M. Mohanty, Pramod Jha, R.S. Chaudhary, Nishant Sinha, J.K. Thakur, M. Vassanda Coumar, Pradip Dey, Muneshwar Singh, A.K. Patra and Javed Rizvi
8. Evaluation of potential of indigenous source of potassium for crop production and K supply
A.O. Shirale, Priya Pandurang Gurav, Sanjay Srivastava, BP Meena and A.K. Biswas
9. Enhancing the productivity of major crops through improving the natural resource base of tribal inhabited areas of central India

Shinogi K.C., Sanjay Srivastava, A.L. Kamble, B.P. Meena, N.K. Sinha, K. Bharati, Gurav Priya Pandurang, A.K. Tripathi, R.L. Raut (KVK, Balaghat), Rameshwar Ahirwar (KVK, Balaghat) and Aparna Jaiswal (COA, Balaghat)

(B) Externally Funded Projects

10. Network Project on Organic Farming
A. B. Singh, K. Ramesh, Brij Lal Lakaria, S. Ramana and J.K. Thakur
11. Simulating the effect of elevated CO₂ and temperature on water productivity and nutrient use in soybean-wheat cropping system (NASF)
N.K. Lenka, Sangeeta Lenka, A.K. Shukla, R. Elanchezhian, J.K. Thakur, I. Rashmi and Pradip Dey
12. Soil quality assessment and developing indices for major soil and production regions of India funded by ICAR-Extra Mural Project
N.K. Lenka, A.K. Biswas, Rajendiran S, S. Kundu, S. Lenka, N.K. Sinha, Abhay Shirale, A.K. Viswakarma, R.H. Wanjari, B.L. Lakaria, A.B. Singh, A.K. Patra, Muneshwar Singh, D.L.N. Rao, A.K. Shukla and Pradip Dey
13. Ensuring food security, sustainability and soil health through resource conservation based farmer FIRST approach in central India, sponsored by ICAR New Delhi
A.K. Patra, A.K. Vishwakarma, R.K. Singh, A.B. Singh, B.L. Lakaria, R.H. Wanjari, K. Bharati, Asha Sahu, Shinogi K.C. and Abhay O. Shirale

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

A. Institute Projects

14. Assessing greenhouse gas emission and soil carbon storage with reversal in tillage practice
Sangeeta Lenka, N. K. Lenka, Sonalika Sahoo and S. Bhattacharjya

B. Externally Funded Projects

15. CRP-Conservation Agriculture (LCPC: Dr. A.K. Biswas and DLCPC: Dr. R.S. Chaudhary)

a. Development, refinement and validation of conservation agriculture in Vertisols of Central India and quantifying impact of CA practices on soil and environment

K. M. Hati (PPI), J. Somasundaram, A.K. Vishwakarma, Sanjay Srivastava and Pramod Jha

b. Demonstration of best-bet conservation agriculture practices on farmers' fields in Vertisols of Central India

A.K. Vishwakarma, R.H. Wanjari, R.K. Singh, K.C. Shinogi and A.K. Tripathi

c. Fine-tuning of conservation agricultural practices for Vertisols of Central India

J. Somasundaram, K. Ramesh, S. Ramana, B.P. Meena and Abhay Shirale

d. Development of water and nutrient management practices in conservation agriculture for Vertisols of Central India

Sanjay Srivastava, K.V. Ramana Rao and N.K. Sinha

e. Impact of conservation agricultural practices on soil health, carbon sequestration and greenhouse gas emissions in different production systems

Pramod Jha, Brij Lal Lakaria, M. Mohanty, J.K. Thakur and K. Bharati

16. Integrated assessment of soil and crops for enhancing productivity and C-sequestration potential of Vertisols of Central India under changing climate scenarios

M. Mohanty, Pramod Jha, Sangeeta Lenka, J. Somasundaram, N.K. Sinha, R.S. Chaudhary and Muneshwar Singh

17. Hyper-spectral remote sensing approaches to evaluate soil quality and crop productivity of Central India

M. Mohanty, N.K. Sinha, K.M. Hati, R.K. Singh, Pradip Dey, R.S. Chaudhary, A.K. Patra and Bharat Bhaskar Gaikwad

18. Vulnerability and impact assessment of climate change on soil and crop production in Madhya Pradesh

Sangeeta Lenka, N. K. Lenka, M. Mohanty, R. H. Wanjari and A. K. Patra

Programme III – Soil Microbial Diversity and Biotechnology

A. Institute Projects

19. Long term effects of fertilizer and manure amendments

on soil functional diversity and nutrient supplying capacity under different soils and cropping systems

S. Bhattacharjya, Asha Sahu, M.C. Manna, M. Singh, R.H. Wanjari and M.P. Sharma

B. Externally Funded Projects

20. Archaea and Actinobacteria in Vertisols of Central India- Assessment of Diversity, Biogeochemical Processes and Bioinoculant Potential funded by AMAAS

D.L.N. Rao, S.R. Mohanty and K. Bharati

21. In-situ residue decomposition of rice-wheat and sugarcane for enhancing crop productivity and soil health funded by ICAR-Extra Mural Project

M.C. Manna, Asha Sahu, R.C. Singh, J.K. Thakur, Asit Mandal, Sudeshna Bhattacharjya, A.K. Tripathi, A.K. Patra and D.H. Phalke

22. India-UK Nitrogen Fixation Centre (IUNFC), sponsored by BBSSRC DBT, New Delhi

S.R. Mohanty and D.L.N. Rao

23. Metagenomic mapping of microbial diversity in rhizosphere of major crops of India and Argentina offsetting production potential

S.R. Mohanty, A.K. Patra, K. Bharati, Muneshwar Singh and J.K. Thakur

24. Exploring soil microbial community and mechanism in soil carbon sequestration under long term land uses in semi-arid sub-humid Central India

S. Bhattacharjya

Programme IV: Soil Pollution, Remediation and Environmental Security

A. Institute Project

25. Determination of baseline concentration for delineating contaminated areas in black soils of central India

M. L. Dotaniya, Rajendiran S., J.K. Saha, S. Kundu and Hironmoy Das

26. Assessment of Cotton for the remediation of soils contaminated with heavy metals

S. Ramana, A.K. Tripathi, K. Bharati and Asha Sahu

27. Critical limits of Cd for major soil orders of India

M. Vassanda Coumar, Rajendiran S., M.L. Dotaniya, J.K. Saha, Tapan Adhikari and Ajay

B. Externally Funded Projects

28. Management of Municipal Solid Waste (MSW) contaminated landfill area of Bhanpur, Bhopal sponsored by Municipal Corporation of Bhopal

Ajay, Tapan Adhikari, K. Bharati, Asit Mandal and J.K. Saha

29. Reclamation and rehabilitation of copper mining affected land in Malanjkhanda area of Madhya Pradesh, sponsored by Hindustan Copper Ltd. Malanjkhanda

Ajay, Tapan Adhikari, Asit Mandal and J. K. Saha

30. Use of fly ash in agriculture for sustainable crop protection and environmental protection

J.K. Saha, M. Vassanda Coumar, Sonalika Sahoo, A.K. Patra, Tapan Adhikari, Ajay, K.M. Hati, M.L. Dotaniya, Sangeeta Lenka, Asit Mandal and A.K. Vishwakarma

Collaborative projects in other institutes where IISS scientists are associated

31. Enhancing Resource Use Efficiency in Pulse Based Cropping System in Central India. Collaborating with ICAR-Indian Institute of Pulses Research, Kanpur (U.P.)

R. Elanchezhian and Abhay Shirale

32. Isolation and characterization of heavy metal resistant bacteria & evaluation for their use in agriculture. Collaborating with NBAIM, Mau (U.P.)

M.C. Manna, Asit Mandal, Asha Sahu and J.K. Thakur

33. Development of an Automated Soil Nutrient Sensing System

Sanjay Srivastav, A.O. Shirale, P.S. Tiwari (ICAR-CIAE, Bhopal), Vijay Kumar (ICAR-CIAE, Bhopal), Ramesh Kumar Sahani (ICAR-CIAE, Bhopal), Baban Kumar (CSIR-CSIO, Chandigarh) and Neelam (CSIR-CSIO, Chandigarh)



8. Consultancy Services, Patents and Technology Commercialization

Consultancies / Contractual Services

S. No.	Title	Sponsorer	Project team
1	Evaluation of efficacy of sulphur and zinc containing complex fertilizers for maximizing yield through balanced nutrition of different crops in India	Zuari Agro Chemicals Limited	A.K. Shukla, A.K. Biswas, Sanjay Srivastava, S. K. Behera and B.P. Meena
2	Evaluation of efficacy of zinc metalosate and boron metalosate foliar supplements for maximizing yield through balanced nutrition of important crops grown in India	Indofil Industries Limited	A.K. Shukla, A.K. Biswas, S. K. Behera and B.P. Meena
3	Response of crop to applied Potassium in Vertisols of India.	PRII, Gurgoan	Muneshwar Singh, R.H. Wanjari, B.L. Lakaria, and Abhay Shirale
4	Effect of aquasorb on water and nutrient use efficiency and crop productivity of soybean and tomato in selected soils of India	SNF India Pvt. Ltd. Vishakhapatanam	R.S. Chaudhary, R.K. Singh, K.M. Hati, B.P. Meena, A.K. Biswas, M. Mohanty and A.K. Patra
5	Effect of slow N release formulations for enhancing productivity and nitrogen use efficiency in cereals	Rhodia Specialty Chemicals India limited, Mumbai	B.L. Lakaria, Pramod Jha, Sanjay Srivastava, A.K. Vishwakarma, A.K. Biswas and A.K. Patra
6	Evaluation of Soil Test Kit of Warkem, Mumbai	Warkem Pvt. Ltd, Mumbai	Sanjay Srivastava, Pramod Jha, A.O. Shirale, M. Vassanda Coumar, Gurav Priya Pandurang, A.K. Biswas, Pradip Dey and A.K. Patra
7	Impact of viscose staple fibre industry treated effluent on soil health and crop production surroundings Nagda, M.P	Grasim Industries Limited, Nagda, Ujjain, M.P.	M.L. Dotaniya, J.K. Saha, Tapan Adhikari, Rajendiran S., R.H. Wanjari, Sonalika Sahoo and A.K. Patra



9. Publications

Papers in Research Journal

International/National (NAAS rating more than 6)

International

Ahirwar U, Dubey G, Singh N, Mohanty SR, Kollah B (2018). Interactive effect of climate factors, biochar and insecticide chlorpyrifos on methane consumption and microbial abundance in a tropical Vertisol. *Ecotoxicology and Environmental Safety*, 157 : 409-416.

Bashir Uzma, Dey P, Wani JA, Dar MA and Qureshi Fozia (2017). Fertilizer prescriptions through inductive cum targeted yield model for rice on Alfisols of Kashmir. *Bangladesh Journal of Botany*, 46(3): 871-876.

Behera SK, Mathur RK, Shukla AK, Suresh K and Prakash C (2018). Spatial variability of soil properties and delineation of soil management zones of oil palm plantations grown in a hot and humid tropical region of southern India. *Catena*, 165: 251-259.

Behera SK, Suresh K, Rao BN, Ramachandrudu K, Manorama K and Harinarayana P (2017). Soil fertility and yield limiting nutrients in oil palm plantations of north-eastern state Mizoram of India. *Journal of Plant Nutrition*, 40 (8): 1165-1171.

Coumar MV, Kundu S, Rajendiran S, Saha JK, Biswas AK, Adhikari Tapan and Patra AK (2017). Effect of soil amendment on microbial resilience of degraded soil under Cu stress. *Bulletin of Environmental Contamination and Toxicology*. DOI 10.1007/s00128-017-2173-8.

Dotaniya ML, Rajendiran S, Meena VD, Coumar MV, Saha JK, Kundu S, Ajay, Patra AK (2018). Interactive effect of cadmium and zinc on chromium uptake in spinach grown on Vertisol of Central India. *International Journal of Environmental Science and Technology*, 15(2): 441-448.

Dubey G, Kollah B, Ahirwar U, Mandal Asit, Thakur JK, Patra AK, Mohanty SR (2017). Phylloplane bacteria of *Jatropha curcas*: diversity, metabolic characteristics, and growth-promoting attributes towards vigor of maize seedling. *Canadian Journal of Microbiology*, 63 (10) : 822-833.

Elanchezhian R, Kumar D, Ramesh K, Biswas AK, Guhey A and Patra AK (2017). Morpho-physiological and biochemical response of maize (*Zea mays*) plants fertilized with nano-iron (Fe₃O₄) micronutrient. *Journal of Plant Nutrition*, 40(14): 1969-1977.

G Dubey, Kollah B, Gour VK, Shukla AK, Mohanty SR (2017). Diversity of bacteria and archaea in the rhizosphere of bioenergy crop *Jatropha curcas*. *3 Biotech*, 6 (2) : 257.

Jha Pramod, Verma S, Lal R, Eidson C and Dheri GS (2017). Natural ¹³C abundance and soil carbon dynamics under long-term residue retention in a no-till maize system. *Soil Use and Management* 33 (1): 90-97.

Joshi D, Srivastava PC, Dwivedi R, Pachauri SP and Shukla AK (2017). Chemical Fractions of Mn in Acidic Soils and Selection of Suitable Soil Extractants for Assessing Mn Availability to Maize (*Zea Mays* L.). *Communications in Soil Science and Plant Analysis*, 48(8): 886-897.

Joshi SK, Bajpai RK, Kumar P, Tiwari A, Bachkaiya V, Manna MC, Sahu Asha, Bhattacharjya S, Rahman MM, Wanjari RH, Singh M, Coumar V, Patra AK, Chaudhari SK (2017). Soil Organic Carbon Dynamics in a Chhattisgarh Vertisol after Use of a Rice-Wheat System for 16 Years. *Agronomy Journal*, 109(6):1-14.

Kollah B, Ahirwar U, Mohanty SR (2017). Elevated carbon dioxide and temperature alters aggregate specific methane consumption in a tropical vertisol. *The Journal of Agricultural Science, Cambridge*, 1-12.

Lenka NK, Jaiswal SP, Thakur JK, Lenka S, Mandal Asit, Dwivedi AK, Lakaria BL, Biswas AK, Shukla AK and Yashona DS (2017). Soil degradation effect on soil productivity, carbon pools and soil enzyme activity. *Current Science*, 112(12) : 2434-2439.

Lenka NK, Lenka S, Thakur JK, Elanchezhian R, Aher SB, Simaiya V, Yashona DS, Biswas AK, Agrawal PK and Patra AK (2017). Interactive effect of elevated carbon dioxide and elevated temperature on growth and yield of soybean. *Current Science*, 113 (12): 2305-2310.

Mohanty M, Sinha NK, MC Dermid, SP, Chaudhary RS, Reddy KS, Hati KM and Rao SR (2017). Climate change impacts vis-a-vis productivity of soybean in vertisol of Madhya Pradesh. *Journal of Agrometeorology*, 19(1): 10-16.

Mohanty M, Sinha NK, Patidar RK, Somasundaram J, Chaudhary RS, Hati KM, and Patra AK (2017). Assessment of maize (*Zea mays* L.) productivity and yield gap analysis using simulation modelling in subtropical climate of central India. *Journal of Agrometeorology*, 19(4) : 342-345.

Mohanty SR, Bandeppa GS, Dubey G, Ahirwar U, Patra AK, Kollah B (2017). Methane oxidation in response to iron

reduction-oxidation metabolism in tropical soils. *European Journal of Soil Biology*, 78: 75-81.

Mohanty SR, Yadav Rakhi, Dubey G, Ahirwar U, Ahirwar Neha, Aparna K, Rao DLN and Kollah B (2018). How sequential reduction of terminal electron acceptors modulates nitrification and dynamics of nitrifying bacteria and archaea in a tropical vertisol. *Journal of Agricultural Science Cambridge*, 156: 215-224.

Saren, Mishra A and Dey P (2017). Integrated Nutrient Management and Formulation of Targeted Yield Equation for Blackgram (*Vigna mungo* L.). *Current Science*, 113 (2):314-317.

Shirale AO, Kharche VK, Zadode RS and Meena BP (2017). Soil biological properties and carbon dynamics subsequent to organic amendments addition in sodic black soils. *Archives of Agronomy and Soil Science*, 63 (14) : 2023-2034.

Singh, Kundu, Dey P and Mahapatra, (2017). Identification of minimum data set under balanced fertilization for sustainable rice production and maintaining soil quality in alluvial soils of eastern India. *Communications in Soil Science and Plant Analysis*, 48(18): 2170-2192.

Sinha NK, Mohanty M, Somasundaram J, Hati KM, Chaudhary RS, Patra AK (2017). Root Phenotyping of Two Soybean (*Glycine max* L.) Cultivars in a Vertisol of Central India, *National Academy Science Letters* DOI: 10.1007/s40009-017-0588-8.

Somasundaram J, Lal, Sinha NK, Dalal, Chitralkha A, Chaudhary RS and AK Patra (2018). Cracks and Pot-holes in Vertisols: Characteristics, Occurrence and Management. *Advances in Agronomy* (DOI : 10.1016/bs.agron.2018.01.001).

Soren, Mishra and Dey P (2017). Integrated nutrient management and formulation of targeted yield equations for black gram (*Vigna mungo* L.). *Current Science*, 113(2): 314-317.

National

Bhaduri, Mandal, Chakraborty, Chatterjee, DeRinku (2017). Interlinked Chemical-Biological Processes in Anoxic Waterlogged Soil- A Relook. *Indian Journal of Agricultural Sciences*, 87(12):1587-1599.

Das, Dhakar, Sarkar, Kumar, Vishal, Dey P, Singh AK and Bhatt BP (2017). Performance of mango (*Mangifera indica*) based agri-horticultural systems under rainfed plateau conditions of eastern India. *Indian Journal of Agricultural Science*, 87 (4): 521-527.

Phalke DH, Patil SR, Manna MC, Mandal and PharandeAL (2017). Effect of in-situ recycling of sugarcane crop residues and its industrial wastes on different soil carbon pools under soybean- maize system. *Indian Journal of Agricultural Sciences*, 87(4): 444-454.

International/ National (NAAS rating less than 6)/ other publications

Ammal U, Coumaravel K, Sankar R and Dey (2017). Soil Test Based Integrated Plant Nutrition System Through Inductive Cum Targeted Yield Model for Black Gram in A Rice-Pulses Sequence on an Inceptisol. *Trends in Bioscience*, 10 (26): 5488-5494.

Baghel, Vishwakarma AK, Vyas MD and Parmar PS (2017). Performance of soybean different levels and method of nitrogen application under rainfed conditions. *Bulletin of Environment, Pharmacology and Life Sciences*, 6 (2) : 91-98.

Basavaraja PK, Dey P, Mohamed Saqeebulla H and Yogendra ND (2017). Geo-reference based soil fertility status in Hassan district of Karnataka, India for development of nutrient plan. *Indian Journal of Soil Conservation*, 45(2): 141-147.

Basavaraja PK, Mohamed Saqeebulla H, Dey P and Patil (2017). Evaluation of different approaches of fertilizer recommendation on finger millet (*Eleusine coracana* L) yield, nutrient requirement and economics. *International Journal of Farm Sciences*, 7(2): 102-107.

Basavaraja PK, Mohamed Saqeebulla, H and Dey P (2017). Integrated Fertilizer Prescription Equations for Finger Millet (*Eleusine coracana* L.) Through Inductive Cum Targeted Yield Model on an Alfisol. *International Journal of Current Microbiology and Applied Sciences*, 6(7): 2571-2580.

Brajendra, Surekha K, Babu MBB, Mir, Sailaja N, Vishwakarma AK and Sharma (2017). Developing a model rice soil health indicator- Methods and methodologies for assessment. *Journal of Pharmacognosy and Phytochemistry*, 1: 378-382.

Brajendra, Vishwakarma AK, Sailaja N, Babu MBB and Kumar (2017). VV Web based DSS for lime recommendation in acidic soils. *Bulletin of Environment, Pharmacology and Life Sciences*, 6 (2) : 60-63.

Choudhary L, Prasad and Gurav P (2018). Distribution of DTPA-extractable Fe, Mn, Zn and Cu in teak and sandalwood supporting soils in Seoni district, Madhya Pradesh. *The Indian forester*, 144 (1): 73-77.

- Dey P, Karwariya S and Bhogal NS (2017). Spatial Variability Analysis of Soil Properties Using Geospatial Technique in Katni District of Madhya Pradesh, India. *International Journal of Plant and Soil Science*, 17(3): 1-13.
- Dey P, Santhi R, Maragatham S and Sellamuthu KM (2017). Status of phosphorus and potassium in the Indian soils vis-à-vis world soils. *Indian Journal of Fertilisers*, 13 (4): 44 - 59.
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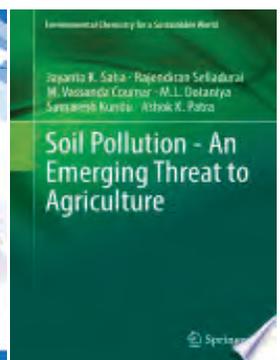
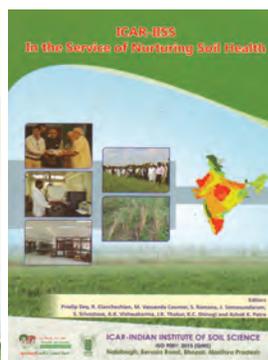
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- Success Story on Mridaparikshak: A mini lab for soil health assessment, ICAR-IISS Bhopal.
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Video film

17 minutes video film was prepared in English showcasing the institute technologies. The film depicted the establishment, infrastructure, mandate, discipline-wise achievements, interview of Director, Head of the Divisions and project Coordinators. It also depicts the awards and honours received by the institute and also scientists. Farmers' field demonstrations, Mera Gaon Mera Gaurav, Swachh Bharat activities are also included in the film.

Prepared by: S. Srivastava, Shinogi K.C., J. K. Thakur, M. V. Coumar, J. Somasundaram and A.K. Patra



10. Committees/Cells/Sections/Units

Quinquennial Review Committee

1	Dr. V.S. Tomar	Chairman
2	Dr. Biswapati Mandal	Member
3	Dr. A.L. Pharande	Member
4	Dr. H.K. Senapati	Member
5	Dr. Masood Ali	Member
6	Dr. M. Chinnadurai	Member
7	Dr. J.K. Saha	Member Secretary

Research Advisory Committee

1	Dr. C.L. Acharya	Chairman
2	Dr. T.K. Adhya	Member
3	Dr. N.S. Raghuwanshi	Member
4	Dr. S.K. Chaudhari, ADG (S&WM), ICAR	Member
5	Dr. Ashok K. Patra, Director	Member
6	Shri Vilasrao Vishwanath Shringarpawar	Member
7	Shri Sunil Tanaji Katkar	Member
8	Dr. Pradip Dey, I/c PC (STCR)	Member Secretary

Institute Management Committee

1	Dr. Ashok K. Patra, Director	Chairman
2	Director of Agriculture, MP Govt., Bhopal	Member
3	Director of Agriculture, Chhattisgarh Govt. Raipur	Member
4	Director (Res) JNKVV, Jabalpur	Member
5	Dr. D.L.N. Rao, Emeritus Scientist, ICAR-IISS, Bhopal	Member
6	Dr. Jagdish Prasad, Pr. Scientist & Acting Head, ICAR-NBSS&LUP, Nagpur	Member
7	Dr. K.S. Reddy, Head and Acting Director, ICAR-CRIDA, Hyderabad	Member
8	Dr. Madhumita Das, Pr. Scientist, IIWM, Bhubaneswar	Member
9	F&AO, ICAR-IISR, Indore	Member
10	Shri Bhupendra Singh Thakur, Mungeli, Chhattisgarh	Member
11	Shri Om Prakash Yadav, Indore	Member
12	Shri S.K. Gupta, SAO	Member Secretary

Institute Building Committee

1	Dr. Ashok K. Patra, Director	Chairman
2	Dr. A.K. Shukla, I/c PC (MSN)	Member
3	Dr. R.S. Chaudhary, I/c HOD (SP)	Member
4	Dr. J. K. Saha, HOD (ESS)	Member
5	Dr. Pradip Dey, I/c PC (STCR)	Member
6	Dr. Muneshwar Singh, PC (LTFE)	Member
7	Dr. M.C. Manna, HOD (SB)	Member
8	Dr. A.K. Biswas, I/c HOD (SC&F)	Member
9	SAO or AAO	Member
10	FAO or AF&AO	Member

PME Committee

1	Dr. Ashok K. Patra, Director	Chairman
2	Dr. R.S. Chaudhary, I/c HOD (SP)	Member
3	Dr. J.K. Saha, HOD (ESS)	Member
4	Dr. M.C. Manna, HOD (SB)	Member
5	Dr. A.K. Biswas, I/c HOD (SC&F)	Member
6	Dr. R. Elanchezhian, Pr. Scientist & I/c PME	Member Secretary

Institute Purchase Committee

1	Dr. M.C. Manna, HOD (SB) Dr. Pradip Dey, I/c PC (STCR) (Alternate)	Chairman
2	Dr. K. M. Hati, Pr. Scientist Dr. R. Elanchezhian, Pr. Scientist (Alternate)	Member
3	Dr. N.K. Lenka, Pr. Scientist Dr. Tapan Adhikari, Pr. Scientist (Alternate)	Member
4	Dr. J.K. Thakur, Scientist Dr. N.K. Sinha, Scientist (Alternate)	Member
5	FAO or AF&AO	Member
6	SAO or AAO	Member Secretary

Institute Technology Management Committee

1	Dr. Ashok K. Patra, Director	Chairman
2	Dr. J.K. Saha, HOD (ESS)	Member
3	Dr. A.K. Biswas, I/c HOD (SC&F)	Member
4	Dr. Pradip Dey, I/c PC (STCR)	Technical Expert
5	Dr. M.C. Manna, HOD (SB)	Technical Expert
6	Dr. Niranjana Mishra, Pr. Scientist & I/c ITMU, NIHSAD	Outside Expert
7	Dr. Sanjay Srivastava, Pr. Scientist & I/c ITMU	Member Secretary

Institute Technology Management Unit

1	Dr. Sanjay Srivastava, Pr. Scientist	Incharge
2	Dr. M. Mohanty, Sr. Scientist	Member
3	Dr. Asit Mandal, Scientist	Member
4	Dr. (Mrs.) Shinogi K.C., Scientist	Member

Technology Assessment & Transfer Unit

1	Dr. K. Ramesh, Pr. Scientist	Incharge
2	Dr. R.H. Wanjari, Pr. Scientist	Member
3	Dr. A.K. Vishwakarma, Pr. Scientist	Member
4	Dr. S. Rajendiran, Scientist	Member
5	Dr. (Mrs.) Shinogi K.C., Scientist	Member

PME Cell

1	Dr. R. Elanchezhian, Pr. Scientist	Incharge
2	Dr. K.M. Hati, Pr. Scientist	Member
3	Dr. A.K. Vishwakarma, Pr. Scientist	Member
4	Dr. Monoranjan Mohanty, Sr. Scientist	Member
5	Dr. M. Vassanda Coumar, Scientist	Member
6	Mr. Sanjay Kumar Kori, Stenographer Gr.-III	Member

RFD Cell

1	Dr. R. Elanchezhian, Pr. Scientist	Nodal Officer
2	Dr. J. Somasundaram, Pr. Scientist	Member
3	Dr. Asit Mandal, Scientist	Member
4	Mr. P.S. Sunil Kumar, AAO	Member
5	Mr. Sanjay Kumar Kori, Stenographer Gr.-III	Member

Institute Works Committee

1	Dr. Muneshwar Singh, PC (LTFE)	Chairman
2	Dr. N.K. Lenka, Pr. Scientist	Member
3	Dr. A.K. Vishwakarma, Pr. Scientist	Member
4	SAO or AAO	Member
5	FAO or AF&AO	Member

Farm & Water Management Committee

1	Dr. A.K. Vishwakarma, Pr. Scientist	Chairman
2	Dr. R.H. Wanjari, Pr. Scientist	Member
3	Dr. R.K. Singh, Pr. Scientist	Member
4	Mr. O.P. Shukla, T-4	Member
5	Mr. C.T. Wankhede, Electrician	Member
6	Mr. D.R. Darwai, I/c Farm Superintendent	Member Secretary

Farm Advisory Committee

1	Dr. A.K. Shukla, I/c PC (MSN)	Chairman
2	Dr. R.S. Chaudhary, I/c HOD (SP)	Member
3	Dr. K. Ramesh, Pr. Scientist	Member
4	SAO or AAO	Member
5	FAO or AF&AO	Member
6	Dr. A.K. Vishwakarma, Pr. Scientist & I/c Farm	Member Secretary

Horticulture Maintenance Committee

1	Dr. S. Ramana, Pr. Scientist	Chairman
2	Mr. Nishant Kumar Sinha, Scientist	Member
3	Mr. R.K. Mandloi, T-7-8	Member
4	Mr. D.R. Darwai, T-5, I/c Farm Superintendent	Member

Inter-Institutional Transfer Committee

1	Dr. Pradip Dey, I/c PC (STCR)	Chairman
2	Dr. M.C. Manna, HoD (SB)	Member
3	Dr. K.M. Hati, Pr. Scientist	Member
4	SAO	Member

Consultancy Processing Cell

1	Dr. Pradip Dey, I/c PC (STCR)	Chairman
2	Dr. R. Elanchezhian, Pr. Scientist	Member
3	Dr. Tapan Adhikari, Pr. Scientist	Member
4	Dr. A.K. Vishwakarma, Pr. Scientist	Member
5	Dr. (Mrs.) Kollah Bharati, Pr. Scientist	Member
6	SAO or AAO	Member
7	FAO or AF&AO	Member

Civil and Electrical Maintenance Committee

1	Dr. A.K. Tripathi, Pr. Scientist	Chairman
2	Dr. S. Ramana, Pr. Scientist	Member
3	Dr. R.H. Wanjari, Pr. Scientist	Member
4	Mr. Deepak Kaul, T-7-8	Member
5	Mr. P.S. Sunil Kumar, AAO	Member
6	Mr. C.T. Wankhede, Electrician	Member
7	Mr. Sanjay Kumar Kori, Stenographer Gr.-III	Member

Library Committee

1	Dr. M.C. Manna, HOD (SBD)	Chairman
2	Dr. Pramod Jha, Pr. Scientist	Member
3	Dr. J. Somasundaram, Pr. Scientist	Member
4	Dr. S.R. Mohanty, Pr. Scientist	Member
5	Dr. Asha Sahu, Scientist	Member
6	Mrs. Nirmala Mahajan, Librarian	Member
7	SAO or AAO	Member
8	FAO or AF&AO	Member
9	Dr. S. Ramana, Pr. Scientist & I/c Library	Member Secretary

Library Advisory Committee

1	Director	Chairman
2	All PCs	Member
3	All HoDs	Member
4	I/c PME Cell	Member
5	FAO	Member
6	SAO	Member
7	Librarian	Member
8	I/c Library	Member Secretary

Campus Security Committee

1	Dr. Mohan Lal Dotaniya, Scientist	Chairman
2	Dr. S. Rajendiran, Scientist	Member
3	SAO	Member
4	Mr. Anurag, Security Supervisor	Member Secretary

Academic Cell

1	Dr. S. Kundu, Pr. Scientist	Incharge
2	Dr. K.M. Hati, Pr. Scientist	Member
3	Dr. (Mrs.) Kollah Bharati, Pr. Scientist	Member
4	Dr. Pramod Jha, Pr. Scientist	Member

Contractual Research Project Monitoring Committee

1	Director, ICAR-IISS, Bhopal	Chairman
2	Project Leader of the Contractual Research Project	Member
3	Co-PI/Associate	Member
4	One representative of the contracting party	Member

Women Cell

1	Dr. (Mrs.) Kollah Bharati, Pr. Scientist	Chairperson
2	Dr. (Mrs.) Asha Sahu, Scientist	Member

3	Mrs. Geeta Yadav, Private Secretary	Member
4	Mrs. Kirti Bais, Personal Assistant	Member
5	Mrs. Raksha Dixit, LDC	Member
6	Mrs. Nirmala Mahajan, T-6	Member
7	Mrs. Kavita Bai, SSS	Member

Committee for Prevention of Sexual Harassment of Women Employees

1	Dr. (Mrs.) Sangeeta Lenka, Scientist	Chairperson
2	Dr. Shalini Chakraborty, Scientist, Fruit Research Station, Itkhedi	Member (External)
3	Dr. (Ms.) Shinogi K. C., Scientist	Member
4	Mrs. Yojana Meshram, Personal Assistant	Member
5	Mrs. Babita Tiwari, Assistant	Member
6	SAO or AAO	Member Secretary

Hindi Committee

1	Dr. Ashok K. Patra, Director	Chairman
2	Dr. A.K. Tripathi, Pr. Scientist	Member
3	Dr. S. Ramana, Pr. Scientist	Member
4	Dr. (Mrs.) Asha Sahu, Scientist	Member
5	SAO	Member
6	Mrs. Babita Tiwari, Assistant	Member Secretary

Renewable Bio/Solar Energy Committee

1	Dr. A.K. Biswas, I/c HOD (SC&F)	Chairman
2	Dr. K. Ramesh, Pr. Scientist	Member
3	Dr. A. K. Vishwakarma, Pr. Scientist	Member
4	SAO	Member
5	Dr. Panna Lal Singh, Pr. Scientist, CIAE, Bhopal	Member (External Expert)
6	Mr. C.T. Wankhede, Electrician	Member

Condemnation of Permanent Articles Committee

1	Dr. M.C. Manna, HOD (SB) Dr. A.B. Singh, Pr. Scientist (Alternate)	Chairman
2	Dr. K. Ramesh, Pr. Scientist	Member
3	Dr. N.K. Sinha, Scientist	Member
4	AAO	Member
5	AF&AO	Member

STC Programme Implementation Committee

1	Dr. J.K. Saha, HOD (ESS)	Chairman
2	Dr. M.L. Dotania, Scientist	Member
3	Dr. S. Rajendiran, Scientist	Member
4	Dr. Abhay Omprakash Shirale, Scientist	Member
5	Dr. R.H. Wanjari, Pr. Scientist	Member Secretary & Nodal Officer

Foreign Deputation Committee

1	Dr. M.C. Manna, Pr. Scientist & HOD	Chairman
2	Dr. Tapan Adhikari, Pr. Scientist	Member
3	Dr. K.M. Hati, Pr. Scientist	Member

4	Dr. (Mrs.) Kollah Bharati, Pr. Scientist	Member
5	Dr. Pramod Jha, Pr. Scientist	Member
6	SAO	Member
Estate Committee		
1	Dr. A.B. Singh, Pr. Scientist	Chairman
2	Dr. R.H. Wanjari, Pr. Scientist	Member
3	Mr. R.K. Mandloi, T-7-8	Member
4	Mr. Anurag, Security Supervisor	Member
5	SAO	Member
Seminar Committee		
1	Dr. Ajay, Pr. Scientist	Chairman
2	Dr. N.S. Bhogal, Pr. Scientist	Member
3	Dr. Sangeeta Lenka, Scientist	Member
4	Dr. Bharat Prakash Meena, Scientist	Member
Sports Promotion Committee		
1	Dr. Brij Lal Lakaria, Pr. Scientist	Chairman
2	Dr. S. Rajendiran, Scientist	Member
3	Mr. Thomas Joseph, Private Secretary	Member
4	Mrs. Babita Tiwari, Assistant	Member
5	Mr. Anurag, Security Supervisor	Member
6	Mr. Sanjay Katenga, LDC	Member
Monitoring/Utilization of Plant/Machinery/Equipments/Instruments		
1	Dr. A.B. Singh, Pr. Scientist	Incharge
2	Dr. K. Ramesh, Pr. Scientist	Member
Remote Sensing and GIS Laboratory		
1	Dr. Monoranjan Mohanty, Sr. Scientist	Incharge
2	Dr. N.K. Sinha, Scientist	Member
3	Dr. B.P. Meena, Scientist	Member
Central Lab		
1	Dr. S.R. Mohanty, Pr. Scientist	Incharge
2	Dr. J.K. Thakur, Scientist	Member
Training Hostel		
1	Dr. Monoranjan Mohanty, Sr. Scientist	Controlling Officer
2	Dr. B.P. Meena, Scientist	Incharge
	Dr. Asit Mandal, Scientist (Alternate)	
3	Mr. Vinod Choudhary, T-3	Care Taker
4	Mr. Sunny Kumar, Stenographer Gr.-III	Asstt. Care Taker
Swachh Bharat Mission		
1	Dr. R.S. Chaudhary, I/c HOD (SPD)	Nodal Officer
AKMU		
1	Dr. J. Somasundaram, Pr. Scientist	Incharge
	Dr. N.K. Sinha, Scientist (Alternate)	
Vehicle Operation Committee		
1	Dr. Asit Mandal, Scientist	Incharge
	Mr. Vinod Babu Pal, T-6 (Alternate)	

RTI Cell

1	Dr. R. Elanchezhian, Pr. Scientist	Nodal Officer cum CPIO (Scientific matters)
2	Mr. Sunil Kumar Gupta, SAO	CPIO (Administrative matters)
3	Mr. Sanjay Kumar Kori, Stenographer Gr.-III	Office Staff

Library Section

1	Dr. S. Ramana, Pr. Scientist Dr. (Mrs.) Shinogi K.C., Scientist (Alternate)	Incharge
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Screen House

1	Dr. S. Ramana, Pr. Scientist Dr. (Mrs.) Asha Sahu, Scientist (Alternate)	Incharge
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HRD (Training)

1	Dr. K.M. Hati, Pr. Scientist	Nodal Officer
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Mera Gaon Mera Gaurav

1	Dr. A. B. Singh, Pr. Scientist	Nodal Officer
2	Dr. K. Ramesh, Pr. Scientist	Co-Nodal Officer

Weed Management

1	Dr. A.K. Vishwakarma, Pr. Scientist	Nodal Officer
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11. Important Meetings/Activities

Institute Research Council Meeting

The Institute Research Council (IRC) meeting of the institute was held during 29 November to 01 December, 2017 and 07 December, 2017 in the committee room of the institute. The Member-Secretary (IRC), Dr. A.K. Biswas welcomed the participants and requested the scientists to take the IRC as a platform for discussion on scientific matter for overall improvement of research activities. Dr. R. Elanchezian (I/c PME Cell) presented brief report on the in-house and external funded projects. Dr. A.K. Patra, Director and Chairman of the IRC congratulated the award winning scientists. He stressed that all scientists must submit quality research proposals. Thereafter, the ongoing and concluded projects were presented and reviewed by the IRC.

Foundation Day

The 30th Foundation Day of ICAR-Indian Institute of Soil Science was celebrated on April 16, 2017 at the Institute campus. The foundation day programme was graced by Dr.



Panjab Singh, Chancellor, Rani Lakshmbai Central Agricultural University, Jhansi and Former Secretary, DARE & DG ICAR as Chief Guest who delivered the Foundation Day lecture. At the outset he emphasized the importance of soil in the service of mankind and the importance of soil organic carbon for the sustainability of soil health and importance of conservation agriculture. He also stressed on the need of interdisciplinary research for solving the complex future research problems. Dr. C.K. Patil, Director General, Madhya Pradesh Council of Science and Technology (MPCST), Bhopal was Guest of Honour and highlighted the need for collaboration among premier research and academic institutions for improving quality of research with wider dimension. Earlier, Dr. Ashok K. Patra, Director, welcomed the dignitaries and participants and apprised them about the progress made by the Institute. Progressive farmers as well as Institute staff who had completed twenty years of service in

ICAR-IISS were felicitated on the occasion. A farmer-scientist interaction programme was also organized.

Independence Day

The 71th Independence Day was celebrated on 15th August, 2017 in the Institute premises with great gaiety and fervor. Different events were organized for the staff and family members of the staff on the day and program was concluded with distribution of prizes to the winners.

World Soil Day

World Soil Day was celebrated on 5th December, 2017 at ICAR-IISS, Bhopal with the theme of “Caring for the Planet starts from the Ground”. The event was graced by Dr. Sudam P. Khade, Collector, Bhopal; Dr. Navin Chandra, DG, Madhya Pradesh Council of Science and Technology, Bhopal; Dr. V. P. Singh, Director, ICAR-NIHSAD; Staff of ICAR-IISS, Bhopal and many progressive farmers. Dr. Khade highlighted the importance of healthy soils for human health and stressed upon the judicious use of chemical fertilizers. He also felt the need of giving more serious attention on protection of soils while addressing the issues of crop productivity. He compared soil with human skin which is the largest organ of human being and protects us from extreme weathers and illness. Dr. Navin Chandra stressed upon the importance of soil, water, and air for sustaining life on earth. He said that almost all of our food comes from soil resource. Dr. V. P. Singh stated that soils are a key component in the chain of soil-plant-animal-human continuum and several nutrition related problems appear in animals and humans due to poor soil health. Dr. Ashok K. Patra, Director, ICAR-IISS, Bhopal welcomed the guests and apprised them about the activities of the Institute and technologies available for enhancing soil health. An interaction meeting with farmers was also organized on the topic “Sustainable Soil management for Enhancing Farmers’ Income and Health”. Several farmers shared their experiences and expressed views on increasing the farmers’ income. According to farmers, diversification of agriculture involving dairy, poultry, horticulture, bee keeping etc. and being up-to-date on the government schemes and policies are important steps, by following which, a significant improvement in the farmers’ income could be realized. Improving soil health with judicious use of fertilizers as per soil health cards, and increasing the share of organic manures and bio-fertilizers emerged as key management areas to achieve sustainable high productivity and doubling farmers’ income. ‘Soil Health Cards’ were distributed to farmers alongwith ‘Family Net Composting Vessel’. On this occasion some progressive

farmers were felicitated for their achievement and active role in the farming community. The event was jointly organized by the Institute and Bhopal Chapter of Indian Society of Soil Science (ISSS).

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, 2017. Several competitions such as debate, quiz, Hindi vocabulary (sabda gyan), typing were conducted in the Institute premises during the fortnight in which majority of staff members participated. The Director, ICAR-IISS distributed prizes to the winners of different competitions.

Swachh Bharat Mission

The Institute staff members participated in the nation-wide program of “Swachh Bharat Mission” launched by the Government of India. The swachhta saphath was administered to all the staff members by the Director of the Institute on 2nd



October, 2017. 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 surrounding of the Institute premises clean.

Vigilance Awareness Week

Vigilance Awareness Week with the theme on “My Vision - Corruption Free India”, was observed during Oct. 30 – Nov. 4, 2017 at the Institute. The week started with the vigilance pledge taken by all the employees of ICAR-IISS, Bhopal which was administered by Dr. A.K. Patra, Director at 11.00 hrs on 30th October, 2017. A series of programmes and activities were organized, namely, essay writing competition, debate competition general knowledge (GK) on vigilance awareness, publicity among the masses, etc. The concluding function of the Vigilance Awareness Week was held on 3rd



Nov., 2017 wherein the Chief Guest of the function was Mr. D.C. Sagar, Additional Director General (P) Bhopal and Director, ICAR-IISS, Bhopal presided over the function. The winners of various competitions were felicitated by the Chief Guest and the Director.

Sports Activities

Sport contingent from ICAR-IISS Bhopal participated in the ICAR Central Zonal sports tournament during 10 to 12th November 2017 at ICAR-CIAE, Bhopal. Dr. K. Alagusundaram, DDG (Engineering and NRM) was the chief guest for the inaugural event. The women athletes namely Dr Sangeeta Lenka secured first position in Shot put event and



second position in Discuss throw. Dr. Kollah Bharati secured second position in long jump while Smt. Babita Tiwari bagged third position in long jump. Smt. Babita Tiwari also stood second in Javelin throw. The Basketball Men team of ICAR-IISS bagged runners up trophy in the tournament. On 12th November 2017, the sports contingent attended the closing ceremony of tournament wherein Dr Masood Ali, former DDG (Engineering) ICAR, was Chief Guest along with Director ICAR-IISS as Guest of honour.

New Year Day

The Staff Recreation Club (SRC) organized the 'New Year Day' celebration on 1st January, 2018 in which various cultural and sports programs were organized for the staff of the institute.

Republic Day

The 69th Republic Day was celebrated on 26th January, 2018 in the Institute premises with great gaiety and fervor. Different sports and cultural events were organized for the staff and family members of the staff on the occasion and the activities included racing and drawing competition for children, musical chair for adults etc.

National Productivity Week

ICAR-IISS, Bhopal celebrated National Productivity Week in a befitting manner during 12-18th Feb., 2018 under the



theme of “Industry 4.0, Leapfrog Opportunity for India”. Dr. R. Elanchezhian, Organizing Secretary, coordinated the National Productivity Week celebration with special focus on Agriculture: Opportunity for India to leapfrog to prosperity with programs like essay, slogan and painting competitions. Dr. A.K. Patra, Director ICAR-IISS & Chairman, National Productivity Week gave his insightful thoughts on productivity enhancement in agriculture and soil science in particular. Dr. A.B. Singh, Principal Scientist coordinated the farmers-scientist interaction meet organized at ICAR-IISS during the week. The staff of ICAR-IISS participated in the function.

International Women's Day

Institute celebrated International Women’s Day on 8th March, 2018 by organizing one day workshop on "Role of rural women for doubling farmers income" at the village Khamkheda, Bhopal. The workshop was attended by farm women of four villages (Kham Kheda, Kalyanpura, Bhairampur, and Kanchbavli) at village Khamkheda, Bhopal. The farm women were given demonstration on post harvest fruits and vegetable processing and preservation techniques. The Chief Guest, Dr. Preeti Chopra, BAMS, PGDND MD highlighted the importance of balanced nutrition; exercise and yoga for maintaining a healthy life. She also felicitated



women achievers (2017-18) of ICAR-IISS with mementos followed by prize distribution to winners of different competitions. Dr. A. K. Patra, Director, ICAR-IISS assured women staff of gender equality, empowerment and non discrimination at work place.

Hon’ble Prime Minister’s address to farmers

The live web cast of the address given by PM to farmer on the occasion of inaugural ceremony of Krishi Unnati Mela at



ICAR-IARI, Pusa, New Delhi was arranged on 17th March 2018. About 1100 farmers from nearby adopted villages under Mera Gaon Mera Gaurav (MGMG) and Farmers FIRST schemes attended the telecast. The Chief Guest Sh. Vishvas Sarang, Honourable Minister of Co-operation, Bhopal Gas Tragedy Relief and Rehabilitation (Independent Charges), Panchayat and Rural Development, Govt. of Madhya Pradesh, emphasized the role of science and technology and dedication of farmers in doubling the farmers’ income by 2022. He also informed the farmers about the different schemes initiated by the Govt. of M. P. for the welfare of the farmers. Dr. Sasikala Pushpa, Hon’ble Member of the Parliament, the Guest of Honour, elaborated upon the success of the country in achieving milestones in production of food grain, fruits, vegetables and milk. She also highlighted the importance of sustainable utilization of natural resources for environmental and food security.



12. Participation of Scientists in Conferences /Symposia/Seminars/Workshops

Name	Programme	Venue	Period
Dr. Pradip Dey	Review meeting of DAC & FW to review the status on publishing Soil Mapping Report and Soil Nutrient Monitoring Production developed by M/s. Agent Tect.	Krishi Bhavan, New Delhi	5-6 April, 2017
Dr. Pradip Dey	SAARC Expert Consultation Meeting on "Best Practices of Integrated Plant Nutrition System (IPNS) in SAARC countries	Bangladesh Agricultural University, Dhaka	9-12 April, 2017
Dr. Asha Sahu	The Joint U.S.-India International Conference on Waste Management Innovation Jointly organized by IIT Mumbai and Ohio University	Mumbai	16-19 April, 2017
Dr. Pradip Dey	National Level Review cum strategy workshop by NABARD for KfW Soil Project Lead a Session on Soil Health and Productivity enhancement	Bengaluru	23-26 April, 2017
Dr. Pradip Dey	Meeting on DAC & FW mapping project proposal	Krishi Bhavan, New Delhi	11-12 May, 2017
Dr. Tapan Adhikari, Dr. B.P. Meena and Shri Vinod Chaudhary	Krishi vikas fair 2017	BHEL Dasehara Ground, Bhopal	19-21 May, 2017
Dr. Pradip Dey	Global Soil Week in Germany	Institute for Advanced Sustainable Sustainability Studies (IASS), Berlin/Potsdam, Germany	19-29 May, 2017
Dr. Pradip Dey	DAC & FW meeting on "Soil Health Campaign on Social Media"	Krishi Bhawan, New Delhi	2 June, 2017
Dr. A.K. Patra, Dr. AK Shukla, Dr. S. Kundu, Dr. A.K. Biswas, Dr. Tapan Adhikari and Dr. N.K. Lenka	NAAS GB meeting and Award Ceremony	NASC Complex, New Delhi	4-5 June, 2017
Dr. Pradip Dey	Partner Workshop on "ProSoil-Reflections and Looking Forward",	GIZ in New Delhi	7-8 June, 2017
Dr. Muneshwar Singh, Dr. AK Shukla, Dr. Pradip Dey, Dr. Tapan Adhikari and Dr. Sangeeta Lenka	National Seminar on "Nutrients and pollutants in soil-plant-animal-human continuum for sustaining soil, food and nutritional security-way forward"	BCKV, Kalyani	9-10 June, 2017
Dr. A. B. Singh	National Sangosthi on Organic Farming	CTAE, Udaipur	10-11 June, 2017
Dr. Pradip Dey	DAC & FW meeting on introduction of web services for Soil Health Card scheme through Bhuvan Portal	National Remote Sensing Centre (NRSC), Shadnagar, Telangana.	19-20 June, 2017

Name	Programme	Venue	Period
Dr. A.K. Patra	International Partnership Convention under Feed the Future India Triangular Training for Point of Contracts of Partner Countries from Asia & Africa and Partner Institutions in India	MANAGE, Hyderabad	28 June to 1 July, 2017
Dr. DLN Rao, Dr. R.S. Chaudhary and Dr. R. Elanchezhian	Workshop for review and revision of curricula of Agriculture course	PSSCIVE (NCERT) Bhopal	28-29 June, 2017
Dr. A.K. Patra, Dr. A.K. Shukla, Dr. Muneshwar Singh and Dr. Sanjay Srivastava	Brainstorming Session on "Reclamation of Acid Soils in Eastern Region of India" organized by ICAR-IISS, Bhopal in association with ICAR-NBSS&LUP Regional Centre, Kolkata.	ICAR-NBSS&LUP Regional Centre, Kolkata	11 August, 2017
Dr. A.K. Patra, Dr. A.K. Biswas, and Dr. Sanjay Srivastava	Workshop on "Mridaparikshak Minilab"	ATARI, Kolkata	12 August, 2017
Drs A.K. Patra, A. K. Shukla and Dr. Pradip Dey	International Conference on "Advances in potassium research for efficient soil and crop management"	NASC complex, New Delhi	28-29 August, 2017
Dr. A.K. Biswas	International Conference on Potassium	ICAR-NAARM, Hyderabad	28 August, 2017-1 September, 2017
Dr. S. K. Behera	International Symposium on Horticulture: Priorities & Emerging Trends	IIHR, Benagluru	5-8 September, 2017
Dr A.K. Patra and Dr. Sanjay Srivastava	Meeting in DARE and MEA on establishment of SWTL in Tunisia.	DARE, Krishi Bhavan, New Delhi	6 September, 2017
Dr. A.K. Patra	Selection Committee Meeting at UPSC	New Delhi	6 September, 2017
Dr. A.K. Patra	2 nd Annual IUNFC review meeting cum workshop under BBSRC-DBT collaborative project	University of Oxford, U.K. followed by laboratory and field visits at John Innes Centre, Norwich	11-14 September, 2017
Dr. A. B. Singh	Kisan Sammelan-2017	KVK, Rajgarh, Madhya Pradesh	18 September, 2017
Dr. A.K. Patra, Dr. A.K. Shukla, Dr. Pradip Dey, Dr. Muneshwar Singh, Dr. A.K. Biswas and Dr. R. Elanchezhian	EFC/SFC meeting	ICAR, New Delhi	20 September, 2017
Dr. A.K. Vishwakarma, Dr. A.B. Singh, Dr. B.L. Lakaria, Dr. RH Wanjari, Dr. Asha Sahu, Dr. Shinogi K.C., Dr. A.O. Shirale and Dr. Gurav Priya	Workshop on 'Methodological Framework for Implementation of FFP'	ICAR IISS, Bhopal	18-21 September, 2017
Dr. A.K. Patra	National Workshop on "Developing a Roadmap for Agricultural Knowledge Management in India"	NASC Complex, Pusa, New Delhi	27-28 September, 2017
Dr. Pradip Dey	Hindi conference on <i>Sankalp Se Siddhi</i>	IGKV, Raipur	23 October, 2017

Name	Programme	Venue	Period
Dr. A.K. Patra, Dr. Pradip Dey and Dr. S.R. Mohanty, Dr. A.K. Shukla, Dr. M. Singh and Dr. J.K. Shah	QRT meeting for North Zone for review of AICRP and AINP	NASC, New Delhi	24-25 October, 2017
Dr. A.K. Patra and Dr. Pradip Dey	Workshop on "Economics for Land Degradation Initiative in India"	NASC Complex, New Delhi	26 October, 2017
Dr. Pradip Dey	National Seminar on "Managing Soil Health for Sustainable and Nutritional Food Production"	JNKVV, Jabalpur	27-28 October, 2017
Dr. M. Vassanda Coumar, Dr. Shinogi K.C. and Dr. A. O. Shirale	3 rd International Conference on "Bioresource and Stress Management"	Jaipur	8-11 November, 2017
Dr. A.K. Biswas, Dr. B.L. Lakaria, Dr. R. Elanchezhian, Dr. Pramod Jha, Dr. S.R. Mohanty and Dr. Sangeeta Lenka	Workshop on Recent Advance in Biomass Energy Research and Management	ICAR-CIAE, Bhopal	9 November, 2017
Dr. Pradip Dey	Study visit to Kenya for knowledge exchange	Kenya	19 November – 2 December, 2017
Dr. A.K. Patra	First lab managers' meeting of the South - East Laboratory NET work (SELNET) - Quality improvement in Asian soil laboratories: towards standardization and harmonization of analyses and their interpretation"	Bogor, Indonesia	20- 24 November, 2017
All Scientists	Brainstorming Session on "Alternatives to crop residue burning"	ICAR-IISS, Bhopal	21 November, 2017
Dr. R. Elanchezhian	National Congress of Plant Physiology	IGKV, Raipur	23-25 November, 2017
Dr. R. S. Chaudhary, Dr. K.M. Hati, Dr. M. Mohanty, Dr. Nishant K. Sinha Dr. Pramod Jha and Dr. M. Vassanda Coumar	Group meeting cum Workshop on "Mid-Infrared Spectroscopy Application in Soil Research"	ICAR-IISS, Bhopal	27-28 November, 2017
Drs. M. Vassanda Coumar and M. L. Dotaniya	International Conference on "Global Research Initiatives for Sustainable Agriculture and Allied Sciences (GRISAAS-2017)"	MPUAT, Udaipur	2-4 December, 2017
Dr. A. B. Singh	International Conference on Advance Research in Applied Sciences, Environment, Agriculture Entrepreneurship Development	Noor-us Sabah, Bhopal	4-6 December, 2017
Dr. A. K. Shukla	National Seminar of Fertilizer Association of India.	New Delhi	5-7 December, 2017
Dr. A. B. Singh	National Agri-Business Summit-2017 for Farmer Producer Organization, Start Up, Agri-Enterprise and Academia	SIAET, Bhopal	9-10 December, 2017

Name	Programme	Venue	Period
Dr. A. B. Singh	National Symposium on Food and Nutritional Security Through Vegetable Crops in Relation to Climate Change	Indian Institute of Vegetable Research, Varanasi	9-11 December, 2017
Dr. A.K. Vishwakarma	National Soybean Mela	ICAR-IISR Indore	11 December, 2017
Dr. A. K. Patra, Dr. A. K. Shukla, Dr. Pradip Dey, Dr. A.K. Biswas, Dr. K.M. Hati, Dr. N.K. Lenka and Dr. S. K. Behera	82 nd Annual Convention of ISSS	ISSS Annual Convention at Amity University, Kolkata	11-14 December, 2017
Dr. Sanjay Srivastava	Meeting with Secretary, ICAR on establishing soil water tissue laboratory in Tunisia	Krishi Bhavan, New Delhi	14 December, 2017
Dr. A. B. Singh	12 th Annual Group Meeting of NPOF	ICAR-IIFSR, Modipuram	18-19 December, 2017
Dr. A. O. Shirale	Science Fiesta	Regional Science Centre Shyamla Hills, Bhopal	20-21 December, 2017
Dr. M. Singh, Dr. A.K. Shukla, Dr. Pradip Dey, Dr. S.R. Mohanty and Dr. J.K. Saha	QRT meeting for Southern Zone	UAS, Bengaluru	19-21 December, 2017
Dr. Pradip Dey	1 st Farm Innovation Congress (FIC) and National Conference on "Innovative Farming For Food And Livelihood Security in Changing Climate"	BCKV, Kalyani	12-13 January, 2018
Dr. M. Vassanda Coumar	Workshop on "Methodologies for preparation of high quality research projects and networking among MPCST and Universities/Colleges"	MPCST, Bhopal	16 January, 2018
Dr. A.K. Patra	Regional meeting jointly organized by FICCI-NITI Aayog "To promote awareness and uses of steel slag across the country"	ICAR-NAARM, Hyderabad	24 January, 2018
Dr. B.L. Lakaria and Dr. A.K. Vishwakarma	National Conference on Farmer First for Conservation Soil and Water Resources in Western Region	AAU, Anand	1-2 February, 2018
Dr. Pradip Dey and Dr. A.K. Biswas	NRM review meeting regarding research achievements and progress of expenditure	KAB-II, New Delhi and NASC, New Delhi	4-5 February, 2018
Dr. Pradip Dey	National Level Programme Management and Review Committee meeting of KfW project on "Integrated Watershed Development for Rehabilitation of Degraded soils and climate change adaption" and GIZ Project on "Soil Protection and Rehabilitation for Food Security in India"	NABARD, Mumbai	6 February, 2018
All scientists	National Conference on "Organic Waste Management for Food and Environmental Security"	ICAR-IISS, Bhopal	8-10 February, 2018

Name	Programme	Venue	Period
Dr. Pradip Dey	Workshop on Green skill development programme, organized by Ministry of Environment, Forest and Climate Change, Govt. of India..	Disaster Management Institute, Bhopal	20 February, 2018
Dr. A.K. Patra and Dr. Sanjay Srivastava	Meeting with DARE officials and MEA officials regarding signing of MOU on SWTL proposal in Tunisia	DARE, Krishi Bhavan, New Delhi	26 February, 2018
Dr. Pradip Dey	47 th Institute Management Committee	ICAR-CCARI, Goa	26 February, 2018
Dr. A.K. Patra	I2I MoU for setting up SWTL in Tunisia and planning of SEALNET meeting and SAARC training at ICAR-IISS, Bhopal	New Delhi	25-27 February, 2018
Dr. R. Elanchezhian and Dr. B.L. Lakaria	National Science Day: Agriculture, Health and Environment	Malviya National Institute of Technology, Jaipur	26-28 February, 2018
Dr. Pradip Dey	Institute Management Committee meeting	ICAR-CSSRI, Karnal	6 March, 2018
Dr. A.K. Biswas	Review meeting of CRPs	Krishi Bhawan ICAR, New Delhi	6-7 March, 2018
Dr. M Singh, Dr. A.K. Shukla, Dr. Pradip Dey, Dr. S.R. Mohanty, Dr. J.K. Saha	QRT meeting for Eastern zone of AICRP (STCR) and AINP on SBB	OUAT, Bhubaneshwar.	7 March, 2018
Dr. Gurav Priya Pandurang	National Conference on “Technological Empowerment of Women”	Vigyan Bhavan, New Delhi	7-8 March, 2018
Dr. M. C. Manna Dr. A. B. Singh Dr. Amat Dolamani	State Level Organic Expo-2018	ATMA-KVK, Balaghat	7-8 March, 2018
Dr. A. K. Shukla	International Conference on NPK, Water Soluble and Micronutrient Fertilizers by Argus-FAI	ITC Maurya, New Delhi	8-9 March, 2018
Dr. A.K. Patra, Dr. A.K. Shukla and Dr. Pradip Dey	Directors’ Conference	ICAR, New Delhi	8-9 March, 2018
Dr. A.K. Biswas and Dr. Pramod Jha	Progress cum Review meeting of CRP on CA	KAB-II, ICAR, New Delhi	12 March, 2018
Dr. Pradip Dey	State Level Workshop on Risk Informed Programming in Madhya Pradesh	Disaster Management Institute, Bhopal.	13 March, 2018
Dr. Pradip Dey	FAI Advisory Committee meeting on Agricultural Sciences	Fertilizer Association of India FAI House, New Delhi	15 March, 2018
Dr. Gurav Priya Pandurang	National Workshop on “Revisiting foundation course for Agriculture Research Services (FOCARS): Reflections and Feedback of trained scientists.”	NAARM, Hyderabad	15-16 March, 2018
Dr. A.K. Patra	Indian Science Congress (ISCA)	Central University, Imphal	15-18 March, 2018
Dr. A.K. Patra	Joint IGAD Pre-Conference and 11 Research Data Alliance (RDA Plenary Meeting	Berlin, Germany	19-23 March, 2018
Dr. M. Vassanda Coumar	2 nd International Conference on Food and Agriculture	Dhanbad, Jharkhand	29-31 March, 2018



13. Workshops, Seminars and Trainings Organized

Training/Short Courses Conducted

International Training

Programme	Course Directors/Coordinators	Duration	Sponsored by
Management of Technology and Extension for Soil Testing based Advisory Services to Farmers under Feed The Future India Triangular Training (FTF ITT)	Dr. A. K. Patra, Dr. Sanjay Srivastava, Dr. Pradip Dey, Dr. A. K. Biswas, Dr. Pramod Jha & Dr. Shinogi, K. C.	30 January - 13 February, 2018	USAID and Ministry of External Affairs

Short Course/Winter School/Summer School/Model Training Course

Programme	Course Directors/Coordinators	Duration	Sponsored by
Short Course entitled "Advances in Nutrient dynamics for improving nutrient and water use efficiency of crops"	Dr. R. Elanchezian, Dr. A.K. Biswas and Dr. A.K. Patra	5-14 September, 2017	ICAR-New Delhi
Model Training Course on "Advances in Rapid Composting Techniques for Efficient Bio-waste Utilization <i>vis-a-vis</i> Enhancing Soil Health	Dr. M.C. Manna, Dr. Asha Sahu, Dr. Sudeshna Bhattacharjya and Dr. Ashok K. Patra	20-27 November, 2017	DAC, MoAFW, New Delhi



ICAR Short Course



Model Training Course

Other Trainings

Programme	Course Directors/Coordinators	Duration	Sponsored by
Agricultural System Modelling to Assess Climate Change Impact in Soils and Crops	Dr. M. Mohanty and Dr. N. K. Sinha	16-25 January, 2018	NICRA
ICAR staff training programme	Dr. J.K. Saha, Dr. M.L. Dotaniya and Dr. K.M. Hati	22-27 January, 2018	ICAR-IISS, Bhopal
Soil Testing method for pH, EC, OC, S and micronutrient (Fe, Mn, Zn & Cu) for the staff of M/S Krishna Digital Material Testing Laboratory	Dr. J.K. Saha and Dr. M. Vassanda Coumar	22-24 June, 2017	ICAR-IISS, Bhopal
Soil Health: Assessment and Preparation of Soil Health Card	Dr. Brij Lal Lakaria and Dr. Gurav Priya Pandurang	19-23 March, 2018	State Department of Agriculture, Badwani, MP
Soil Health Assessment and Management	Dr. K. Ramesh, Dr. A.O. Shirale and Dr. A.K. Biswas	3-7 April, 2017	Department of Farmers' Welfare & Agriculture, Ujjain, Govt. of M.P.

Farmers Training

Programme	Course Directors/Coordinators	Duration	Sponsored by
Methodological framework for implementation of Farmer First Project (FFP)	Dr. A.K. Biswas	18-21 September, 2017	ICAR-IISS Bhopal & NAARM, Hyderabad
Jaivik Khad, Mrida Swasthya Evam Santuleet Podhan Prabandhan for 30 SC/ST farmers from different villages of Betul District, Madhya Pradesh under TSP programme	Dr. A.B. Singh	16-20 May, 2017	ICAR-IISS, Bhopal
Organic Farming, Conservation Agriculture, Methods of Composting, Mrida Swasthya and Santuleet Poshak Tatvon ka Prabandhan under Farmer FIRST project	Dr. A.B. Singh	27-28 May, 2017	ICAR-IISS, Bhopal
Kisan sangosti on "Best Crop Management Practices for Enhancing Farm Income" at Bhairapura under MGMG	Dr. J.K. Saha, Dr. N. S. Bhogal, Dr. M L Dotaniya, Dr. Sonalika Sahoo	6 June, 2017	ICAR-IISS, Bhopal
Farmer-Scientist Interaction meet under NICRA and MGMG program	Dr. M. Mohanty	17 January, 2018	ICAR-IISS, Bhopal
Farmer-scientist interaction meeting on Climate Smart Agriculture held under NICRA and MGMG program.	Dr. M. Mohanty	13 March, 2018	ICAR-IISS, Bhopal
Farmers Scientist interaction meet under NICRA project and MGMG programme	Dr. A.B. Singh	15 March, 2018	ICAR-IISS, Bhopal
A Farmers'-Scientist interface meeting on 'Balance and integrated nutrient management towards doubling farmers income'	Dr. A.K. Biswas	17 March, 2018	ICAR-IISS Bhopal
Kisan Sangosthi under Farmer FIRST project and MGMG programme	Dr. A.B. Singh	17 March, 2018	ICAR-IISS, Bhopal
Enhancing farmer Income Through Honeybee Keeping under Farmer FIRST project, Jointly organized ICAR-IISS, Bhopal & RVSKVV, Fruit Research Station, Entkhedi, Bhopal	Dr. A.B. Singh	20-25 March, 2018	ICAR-IISS, Bhopal
Farmers Sangosthi/Meeting on Farmers Fields	Dr. A.B. Singh	26 March, 2018	ICAR-IISS, Bhopal

Workshop/Seminar/Conference

Programme	Course Directors/Coordinators	Duration	Sponsored by
Group Meeting cum Workshop on "Mid Infrared Spectroscopy Application in Soil Research"	Dr. K.M. Hati, Dr. M. Mohanty, Dr. Pramod Jha, Dr. N.K. Sinha, Dr. R.S. Chaudhary, Dr. M.V. Coumar, Dr. P. Dey, Dr. J.K. Thakur and Dr. A.K. Patra	27-28 November, 2017	ICAR-IISS Bhopal
National Conference on "Organic Waste Management for Food and Environmental Security"	Dr. A.K. Patra, Dr. M.C. Manna, Dr. R.S. Chaudhary and Dr. A.B. Singh	8-10 February, 2018	ICAR-IISS Bhopal
Workshop on "Climate Change: Adaptation and Mitigation Strategies in Agriculture"	Dr. Sangeeta Lenka, Dr. Ajay, Dr. Tapan Adhikari, Dr. N. K. Lenka, Dr. M. Mohanty and Dr. Utkarsh Tiwari	26 March, 2018	Shagonia, Bhopal

Indo-US Collaborative Feed the Future - India Triangular Training (FTF-ITT) Programme

An international training on “Management of Technology and Extension for Soil Testing based advisory Services to Farmers” under Feed the Future India Triangular Training (FTF ITT) of USAID and MEA, Govt. of India was organized in collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad at ICAR-Indian Institute of Soil Science, Bhopal during January 31 to February 13, 2018. Twenty-one Executives from seven countries (Afghanistan, Myanmar from Asia and Kenya, Ghana, Malawi, Liberia, and Uganda from Africa) participated in this training. The programme includes Triangular Cooperation adapting technological advances and



innovative solutions to address Food Security Challenges in Africa and Asia. It was sponsored by USAID. The objectives of the training was to introduce the concept of soil testing, soil health, and soil test based balanced fertilizer management; requirement of establishing a soil water tissue testing laboratory; to impart skills on new and innovative soil health management strategies for sustainable agriculture leading to conservation of natural resources in different cropping



systems to introduce the concept of farmers' participatory diagnosis of constraints and opportunities survey for soil fertility management in relation to crop production; to introduce the use of internet and mobiles in the dissemination of soil test based fertilizer recommendations, also the soil fertility maps and fertilizer nutrient recommendations based on these maps.



One day Workshop was organized on "Climate change: Adaptation and Mitigation Strategies in Agriculture sponsored by UNDP-GEF-MOEFC project



फार्मर फर्स्ट परियोजना के अंतर्गत अंतर्राष्ट्रीय महिला दिवस के उपलक्ष्य में खामखेड़ा गांव में एक दिवसीय कार्यशाला आयोजित की गई जिसका शीर्षक था "कृषक आय को दोगुना करने में ग्रामीण महिलाओं का योगदान"

Krishi Unnati Mela 2018

The institute participated in the “Krishi Unnati Mela” at ICAR-IARI, New Delhi during 16-19th March, 2018, and technologies (Mridaparikshak, rapid compost preparation, Vermicomposting etc) were displayed. In order to disseminate Institute Technologies, about 3000 pamphlets were distributed to the farmers depicting two technologies



Farmers from Bhopal visited the Krishi Unnati Mela held at Mela Ground, ICAR-IARI, New Delhi

i.e. (i) 'Mridaparikshak: A Mini-lab for Soil Testing and Fertilizer Recommendation' and (ii) 'Rapo-composting Technology for Recycling of Biodegradable Waste'.



Display of exhibits of IISS Technology at Krishi Unnati Mela 2018 organized at Mela Ground, IARI, New Delhi



National conference on Organic waste management for food and environmental security during 8-10 Feb 2018



14. Distinguished Visitors

- Dr. Panjab Singh, Chancellor, Rani Lakshmbai Central Agricultural University, Jhansi and Former Secretary (DARE) & Director General (ICAR) visited the insitiute on 16 April, 2017 and graced the occasion as Chief Guest of Foundation Day of ICAR-IISS Bhopal.
- Dr. D. Srinivas, Professor and Head, Dept. of Soil Science and Agri. Chemistry, Agricultural College, Rajamahendrvaram, A.P., Dr. P.P. Mahendran, Professor and Head, Dept. of Soil Science and Agri. Chemistry, AC & RI, Madurai, Tamilnadu and Dr. P. Balasubramanyan, Professor & Head, Dept. of Soil Science and Agril. Chemistry, Trichy, Tamil Nadu visited on 21 June 2017.
- Mr. S. K. Singh Additional Secretary and Financial Advisor (DARE/ICAR) visited ICAR-IISS on July 30, 2017.
- Mr. Chhabilendra Roul, Additional Secretary DARE and Secretary ICAR visited on 18 August, 2017.
- Dr Mario Aguilar, Director of Centre for Biotechnology and Molecular Biology, Argentina visited ICAR-IISS during 21-28 August, 2017.
- Mr. D.C. Sagar, Additional Director General (P) Bhopal visited on 03 November, 2017.
- Dr. K. Alagusundaram, Deputy Director General (AE & NRM) visited institute on 10 November, 2017.
- Dr. Sudam P. Khade, Collector, Bhopal, Dr. Navin Chandra, DG, Madhya Pradesh Council of Science and Technology, Bhopal and Dr. V.P. Singh, Director, ICAR-NIHSAD, Bhopal visited on 05 December, 2017.
- Prof. Sunil Kumar Gupta, Vice-Chancellor, Rajiv Gandhi Pradyogiki Vishwavidyalaya, Bhopal on 06 December 2017.
- Dr. Prem Kumar, Hon'ble Minister of Agriculture, Government of Bihar visited ICAR- Indian Institute of Soil Science, Bhopal on 03 February, 2018. He was accompanied by Mr. Ravindra Nath Roy, Special Secretary and Mr. Narendra Kumar Lohani, Deputy Director (Engineering), Department of Agriculture, Government of Bihar and Mr. Rajeev Choudhary, Director (Agriculture Engineering), Government of Madhya Pradesh.
- Dr. S.K. Chaudhari, ADG (S&WM) NRM, ICAR, New Delhi; Dr. S.S. Khanna, Former VC, NDUAT, Faizabad and Advisor of erstwhile Planning Commission; Dr. P.N. Takkar, Former Director, ICAR-IISS, Bhopal; Dr. C.L. Acharya, Former Director, ICAR-IISS, Bhopal; Dr. A. Subba Rao, Former Director, ICAR-IISS, Bhopal; Dr. A.K. Singh, Ex-VC, RVSKVV, Gwalior and Ex-DDG (NRM) and Dr. M. Velayutham, Former Director, NBSS & LUP, Nagpur visited on 08 February 2018.
- Mr. Vishvas Sarang, Hon'ble Minister of Co-operation, Bhopal Gas Tragedy Relief and Rehabilitation (Independent Charges), Panchayat and Rural Development, Govt. of Madhya Pradesh and Dr. Sasikala Pushpa, Hon'ble M.P. of Rajya Sabha participated in the Live Webcast Programme organized on 17 March 2018.





15. Infrastructure Development

Instrument/Equipment Purchased

During the year, Centrifuge, pH Meter, Spiral Binding Machine, I-Pad, Scanner, Electronic Weighing Balance, Horizontal Electrophoresis Unit, Horizontal Shaker, 9 Tine Cultivar, Drip and Micro Sprinkler System, Printers, Weighing Scale UPS, Voltex Mixture, Furniture, Vermibed, Hot Plate, UV Transiluminator, UV-VIS-Spectrometer, Plant Growth Chamber and Water Storage Tanks were purchased.

Library

The library is well maintained with facilities of document such as lending, reference service, reprographic services etc. The library also exchanges the institute publications with other ICAR Institutes and SAUs. During the period of report, the Institute library has acquired total documents categorized as listed below:

Documents	Addition during 2017-18	Total
Books	Nil	2591
Bound Journals	510	38064 (3064)
Annual Reports	76	2435
Foreign Journals	Nil	Nil
Indian Journals	Nil	Nil

Farm Activities

- Revenue of Rs. 9.76 lakhs was generated through sale of farm produce.
- Resource conservation based farming activities were promoted in the research farm.
- One tine cultivator was procured under CRP on CA.
- One borewell has been installed in the research farm.
- Lining of two ponds with silpaulin completed.



16. Scientific, Technical and Administrative Personnel

Name	Designation	Discipline/ Category	Date of joining ICAR	Date of joining IISS
DIRECTOR'S CELL				
Dr. A. K. Patra	Director	Soil Chemistry/Fertility/ Microbiology	05.10.1989	01.05.2014
Mr. Thomas Joseph	Private Secretary	Office Staff	18.09.1989	18.09.1989
Mrs. Yojana Meshram	Personal Assistant	Office Staff	12.05.1997	12.05.1997
Mr. Darashram	Lab Attendant	Skilled Supporting Staff	15.03.1990	15.03.1990
Mr. Bhoi Lal Uikey	Lab Attendant	Skilled Supporting Staff	13.11.1995	13.11.1995
DIVISION OF SOIL PHYSICS				
Dr. R.S. Chaudhary	Pr. Scientist & I/c Head	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. R.K. Singh	Pr. Scientist	Soil Physics/Soil & Water Conservation	25.01.1993	16.10.2002
Dr. Prabhat Tripathi	Pr. Scientist	Agronomy	19.09.1998	28.06.2017
Dr. J. Somasundaram	Pr. Scientist	Soil Physics/Soil & Water Conservation	12.11.2001	22.12.2008
Dr. M. Mohanty	Sr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1999	10.11.1999
Dr. N.K. Sinha	Scientist	Agriculture Physics	20.04.2010	27.08.2010
Mr. R.K. Mandloi	T-7-8	Asstt. Chief Technical Officer	19.06.1989	19.06.1989
Mr. P.K. Chouhan	T-5	Technical Officer	15.02.1993	15.02.1993
Mr. Janak Singh Mehra	Khalasi	Skilled Supporting Staff	08.09.1997	08.09.1997
DIVISION OF SOIL CHEMISTRY AND FERTILITY				
Dr. A.K. Biswas	Pr. Scientist & I/c Head	Soil Chemistry/Fertility/ Microbiology	21.01.1992	11.01.1993
Dr. Sanjay Srivastava	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. Narendra K. Lenka	Pr. Scientist	Soil Physics/Soil & Water Conservation	30.11.2000	09.10.2009
Dr. A. K. Vishwakarma	Pr. Scientist	Agronomy	16.04.2003	01.08.2013
Dr. Pramod Jha	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	16.04.2003	17.07.2009
Dr. A.L. Kamble	Scientist	Agricultural Economics	20.04.2010	09.10.2017
Dr. (Mrs.) Shinogi, K.C.	Scientist	Agricultural Extension	27.04.2011	05.09.2011

Name	Designation	Discipline/ Category	Date of joining ICAR	Date of joining IISS
Dr. B.P. Meena	Scientist	Agronomy	15.09.2011	22.12.2011
Dr. A.O. Shirale	Scientist	Soil Chemistry/Fertility	01.01.2015	10.04.2015
Dr. (Mrs.) Gurav Priya Pandurang	Scientist	Soil Chemistry/Fertility	01.01.2016	11.04.2016
Mr. Deepak Kaul	T-7-8	Asstt. Chief Technical Officer	29.12.1988	29.12.1988
Mr. Jai Singh	T-6	Sr. Technical Officer	22.05.1999	22.05.1990
Mr. Harish Kumar	Lab Attendant	Skilled Supporting Staff	14.03.1990	14.03.1990
DIVISION OF SOIL BIOLOGY				
Dr. M.C. Manna	Pr. Scientist & Head	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.R. Mohanty	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
Dr. (Mrs.) Kollah Bharati	Pr. 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
Dr. (Mrs.) Sudeshna Bhattacharjya	Scientist	Soil Chemistry/Fertility	01.01.2015	10.04.2015
Dr. Dolamani Amat	Scientist	Agricultural Microbiology	05.01.2017	15.04.2017
Smt. Seema Sahu	T-7-8	Asstt. Chief Technical Officer	14.04.1987	24.01.1989
Mr. Sant Kumar Rai	T-3	Technical Asstt.	15.06.1989	15.06.1989
Mrs. K.S. Chaturvedi	Personal Assistant	Office Staff	05.05.1997	18.02.2002
Mr. Kalicharan	Lab Attendant	Skilled Supporting Staff	10.06.1999	10.06.1999
DIVISION OF ENVIRONMENTAL SOIL SCIENCE				
Dr. J.K. Saha	Pr. Scientist & Head	Soil Chemistry/Fertility/ Microbiology	21.01.1992	02.01.1993
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. S. Ramana	Pr. Scientist	Plant Physiology	06.02.1997	06.02.1997
Dr.(Mrs) Sangeeta Lenka	Scientist	Soil Physics/Soil & Water Conservation	08.01.2007	18.05.2007
Dr. M.Vassanda Coumar	Scientist	Soil Chemistry/Fertility	04.11.2009	15.03.2010
Dr. M. L. Dotaniya	Scientist	Soil Chemistry/Fertility	20.04.2010	28.08.2010
Dr. V.D. Meena	Scientist	Agronomy	15.09.2011	23.12.2011
Dr. Sonalika Sahoo	Scientist	Soil Chemistry/Fertility	01.01.2016	11.04.2016
Dr. Utkarsh Tiwari	Scientist	Agricultural Economics	05.07.2017	12.10.2017

Name	Designation	Discipline/ Category	Date of joining ICAR	Date of joining IISS
Mr. Vinod Babu Pal	T-7-8	Asstt. Chief Tech. Officer	15.02.1993	15.02.1993
Mr. Vinod Choudhary	T-4	Sr. Tech. Assistant	14.06.1989	14.06.1989
Mr. Ram Bharose	Lab Attendant	Skilled Supporting Staff	20.03.1990	20.03.1990
AICRP-LTFE				
Dr. Muneshwar Singh	Pr. Scientist & PC (LTFE)	Soil Chemistry/Fertility/ Microbiology	11.07.1989	11.07.1989
Dr. R.H. Wanjari	Pr. Scientist	Agronomy	07.01.1999	07.01.1999
Mr. Sunny Kumar	Steno. Gr.-III	Office Staff	21.12.2011	21.12.2011
Mr. Jagannath Gaur	Lab Attendant	Skilled Supporting Staff	20.07.1992	20.07.1992
AICRP-MSPE				
Dr. A.K. Shukla	Pr. Scientist & I/c PC (MSN)	Soil Chemistry/Fertility/ Microbiology	05.07.1996	31.03.2011
Dr. S.K. Behera	Sr. Scientist	Soil Chemistry/Fertility/ Microbiology	08.01.2007	27.06.2017
Mr. Sahab Siddiqui	T-7-8	Asstt. Chief Technical Officer	05.10.1992	05.10.1992
Mr. Venny joy	Personal Assistant	Office Staff	14.02.1991	23.03.1998
Mr. Khilan Singh Raghuvanshi	T-5	Technical Officer	29.12.1988	29.12.1988
Mr. Bhanwar Singh Yadav	Messenger	Skilled Supporting Staff	01.09.1993	23.01.1999
AICRP-STCR				
Dr. Pradip dey	Pr. Scientist & I/c PC (STCR)	Soil Chemistry/Fertility/ Microbiology	03.06.1993	01.02.2012
Mr. Abhishek Rathore*	Scientist	Agricultural Statistics	16.12.2002	16.12.2002
Dr. Hironmay Das	Scientist	Agriculture Statistics	15.09.2011	23.12.2011
Mrs. Geeta Yadav	Private Secretary	Office Staff	26.12.1995	26.12.1995
Mrs. Kavita Bai	Safaiwala	Skilled Supporting Staff	20.12.1988	20.12.1988
AINP SBB				
Dr. S.R. Mohanty	Pr. Scientist & I/c Network Coordinator	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
PME CELL				
Dr. R. Elanchezhian	Pr. Scientist & I/c PME Cell	Officer In-Charge	09.11.1998	17.02.2012
Mr. Sanjay Kumar Kori	Steno. Gr.-III	Office Staff	03.01.2012	03.01.2012
ITMU				
Dr. Sanjay Srivastava	Pr. Scientist	Officer In-Charge	22.03.1996	02.09.1996
AKMU				
Dr. J. Somasundaram	Pr. Scientist	Officer In-Charge	12.11.2001	22.12.2008
REMOTE SENSING & GIS LABORATORY				
Dr. M. Mohanty	Sr. Scientist	Officer In-Charge	10.11.1999	10.11.1999
Mr. L.N. Chouksey	Messenger	Skilled Supporting Staff	17.12.1988	17.12.1988

Name	Designation	Discipline/ Category	Date of joining ICAR	Date of joining IISS
LIBRARY				
Dr. S. Ramana	Pr. Scientist	Officer In-Charge	06.02.1997	06.02.1997
Mrs. Nirmala Mahajan	T-7-8	Asstt. Chief Tech. Officer	15.03.1993	15.03.1993
Mrs. Gheesi Devi	Trainee	Supporting Staff	31.05.2014	31.05.2014
CENTRAL LABORATORY				
Dr. S.R. Mohanty	Pr. Scientist	Officer In-Charge	18.06.2009	18.06.2009
Mr. Vinod Babu Pal	T-7-8	Asstt. Chief Tech. Officer	15.02.1993	15.02.1993
REFERRAL LABORATORY				
Dr. Pradip Dey	Pr. Scientist & I/c PC (STCR)	Officer In-Charge	03.06.1993	01.02.2012
FARM SECTION				
Dr. A.K. Vishwakarma	Pr. Scientist	Officer In-Charge	16.04.2003	01.08.2013
Mr. O.P. Shukla	T-5	Technical Officer (Tractor Mech.)	22.04.1989	22.04.1989
Mr. C.T. Wankhede	T-5	Technical Officer (Electrician)	03.08.1992	03.08.1992
Mr. D.R. Darwai	T-5	Technical Officer (Field Assistant)	23.01.1993	23.01.1993
Mr. Hukum Singh	T-4	Sr. Technical Assistant	30.12.1988	30.12.1988
Mr. Bhagwat Prasad	Beldar	Skilled Supporting Staff	24.01.1992	24.01.1992
Mr. Lalaram Sahu	Beldar	Skilled Supporting Staff	24.07.1992	24.07.1992
Mr. R.K. Sen	Beldar	Skilled Supporting Staff	08.09.1997	08.09.1997
VEHICLE SECTION				
Dr. Asit Mandal	Scientist	Officer In-Charge	23.06.2009	30.10.2009
Mr. N.S. Yadav	T-5	Technical Officer (Driver)	23.09.1987	03.05.1999
Mr. Sukh Ram Sen	T-4	Sr. Tech. Asstt. (Driver)	25.01.1991	25.01.1991
ADMINISTRATION				
Mr. S.K. Gupta	SAO	Administration	14.11.1986	01.04.2017
Mr. Neeraj Tahiliani	FAO	Audit & Account	12.06.2012	22.07.2014
Mr. Rajesh Dubey	AF&AO	Audit & Account	21.12.1988	26.11.1998
Mr. P. S. Sunil Kumar	AAO	Administration	30.01.1989	30.01.1989
Mr. A.S. Rajput	Assistant	Establishment Section	14.03.1990	14.03.1990
Mrs. Babita Tiwari	Assistant	Central Store	30.05.1996	30.05.1996
Mr. Bansilal Sarsodia	Assistant	Purchase Section	10.09.1997	10.09.1997
Mr. Hiralal Gupta	UDC	Bill Section	23.12.1988	23.12.1988
Mr. O.P. Yadav	UDC	Audit & Account	19.12.1988	19.12.1988
Mr. Jineshwar Prasad	UDC	Cash Section	13.12.1988	13.12.1988
Mr. Sanjay Katinga	LDC	Bill Section	20.06.1989	20.06.1989
Smt. Raksha Dixit	LDC	Bill Section	24.05.2013	24.05.2013
Mr. Anurag	Security Supervisor	Security Section	29.09.1997	29.09.1997

Name	Designation	Discipline/ Category	Date of joining ICAR	Date of joining IISS
Mr. P.K. Raut	Beldar	Skilled Supporting Staff	21.07.1992	21.07.1992
Mr. Sanjay N Gharde	Lab Attendant	Skilled Supporting Staff	15.06.1999	15.06.1999
Mr. Dharam Raj Singh	Messenger	Skilled Supporting Staff	10.09.1993	14.06.1999
Mr. A. K. Mishra *on deputation	Lab Attendant	Skilled Supporting Staff	01.09.1993	10.06.1999

Joining

- Dr. Prabhat Tripathi, Pr. Scientist, joined the Institute on 20 June, 2017
- Dr. S.K. Behera, Sr. Scientist, joined the Institute on 27 June 2017
- Dr. Ankush Lala Kamble, Scientist, joined the Institute on 09 October, 2017
- Dr. Dolamani Amat, Scientist, joined the Institute on 15 April 2017
- Dr. Ramesh Chandra Yadav, Scientist, joined the Institute on 15 April 2017
- Dr. Utkarsh Tiwari, Scientist, joined the Institute on 05 July 2017 at ICAR-IISS, Bhopal

Promotion

- Dr. R.H. Wanjari promoted to Principal Scientist w.e.f 07 January 2014 through CAS
- Dr. J. Somasundaram promoted to Principal Scientist w.e.f. 22 December 2014 through CAS
- Dr. S.R. Mohanty promoted to Principal Scientist w.e.f. 18 June 2015 through CAS
- Dr. A.K. Vishwakarma promoted to Principal Scientist w.e.f. 02 July 2015 through CAS
- Dr. Pramod Jha promoted to Principal Scientist w.e.f. 17 July 2015 through CAS
- Dr. Kollah Bharati promoted to Principal Scientist w.e.f. 29 October 2015 through CAS
- Shri Bhoilal Uikey, SSS received Financial Upgradation (MACP) on 13 November 2015

- Smt. Kirti Rathore, PA received Financial upgradation (MACP) on 05 May 2017
- Smt. Yojana Meshram, PA received Fianacial upgradation (MACP) on 12 May 2017

Superannuation

- Mr. Raj Kumar Giri, AO superannuated on 30 April 2017
- Dr. N.S. Bhogal, Pr. Scientist superannuated on 31 August, 2017

Transfer

- Dr. K. Ramesh, Pr. Scientist transferred to ICAR-IIOR, Hyderabad on 24 June 2017
- Dr. S. Rajendiran, Scientist transferred to ICAR-IIHR, Bangalore on 24 June 2017
- Dr. Pankaj Kumar Tiwari, Scientist transferred to ICAR-CIFA, Bhubaneshwar on 29 June 2017
- Mr. Somnath Mukherjee, LDC promoted to JAO at ATARI, Kolkata and relieved on 08 September 2017
- Mr. Arun Bhojraj Mate, SSS transferred to ICAR-CICR, Nagpur on 29 April 2017

Resignation

- Dr. Ramesh Chandra Yadav resigned from ICAR-IISS, Bhopal on 01 September 2017

Decease

- Mr. S.K. Batham, Messenger, departed to heavenly abode on 27 June 2017

ICAR-IISS AT A GLANCE



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