हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch

वार्षिक प्रतिवेदन
Annual Report
2018-19

भाकृअनुप–भारतीय मृदा विज्ञान संस्थान

ICAR-Indian Institute of Soil Science

(ISO 9001 : 2008 Certified)

Nabi Bagh, Berasia Road, Bhopal - 462038 (M.P.)


विश्व मृदा दिवस
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Preface

Since inception, the ICAR-Indian Institute of Soil Science is engaged in research with mandate “to provide scientific basis for enhancing and sustaining productivity of soil resources with minimal environmental degradation”. The institute has generated know-how of several important soil processes and developed viable technologies with field level validation for improvement of soil health. However, over the years, new challenges have emerged. The greatest challenge is to monitor the environmental consequences of the extant agricultural production technologies in the context of climate change. Institute took up new projects in this direction and the results have started to emanate. Climate research studies have revealed higher N, P and K recovery efficiency in soybean-wheat system under elevated CO_2 and temperature conditions though the reverse results were obtained when only one of the two variables was elevated. Also, elevated CO_2 and biochar stimulated nitrification and microbial abundance in the rhizosphre of wheat. We found that overall climate vulnerability in Madhya Pradesh would increase towards mid-and end-century as compared to the current conditions.

In the year reported upon we have developed and refined some new technologies and methodologies viz.; chemometric modelling of soil properties through MIR spectroscopy; fine-tuning conservation agricultural practices; nano-particle delivery and internalization in plant systems; bacterial species based probe to assess soil fertility status; in-situ decomposition of crop residue and rapid composting techniques. For example, six fungi, and eight thermophilic bacteria possessing cellulose and lignin degradation ability were isolated from city waste and fresh cow dung. Promising endophytic bacteria were isolated from corn root out of which 29 isolates showed growth on N free media, 16 isolates could solubilize inorganic P, 22 isolates acted as K solubilizer, 8 possessed biocontrol activity. We developed the methods for soil biological quality index (SBQI) and validated to assess the fertility status of soil. It was observed that nanoparticles at sub-optimal concentration may also be useful for the crop and they may act as catalyst for growth and metabolism which can be utilized for higher yield of plants. Also, two crops cotton and vettiver were assessed for the remediation of contaminated soils. Besides, we continue to work on long-term studies with integrated nutrient management and conservation agriculture and several important findings have emerged that are documented in this report.

The present report also outlines a glimpse of the other important activities like organizing training programmes, capacity building for stakeholders, demonstration of technologies in farmers' fields. A notable development has been the collaboration with Food and Agricultural Organization (FAO), Rome in strengthening the South-East Asia laboratory Network (SEALNet), the prime objective of which is to develop protocols of nutrient testing and quality improvement in Asian laboratories. Institute is also involved in imparting technical support for establishing soil and tissue testing laboratories in Africa, integrated nutrient management in SAARC countries through SAARC Agriculture Centre, Bangladesh. Besides, the institute conducted ICAR zonal sports meet during the previous year. I am sure the readers will get several useful information in this annual report many of which could not be highlighted here. Thus, it gives me immense pleasure to bring out the Annual Report 2018-19 of the ICAR-Indian Institute of Soil Science, Bhopal.

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

I wish to express my sincere appreciation to the editorial committee of this annual report comprising of Drs. K.M. Hati, R. Elanchezhian, N.K. Lenka, A.L. Kamble, Vasudev Meena, A.O. Shirale, Sudeshna Bhattacharjya for their dedicated efforts in compiling and editing the report. I also thank Mr. S.K. Kori and Mr. S.K. Parihar for the assistance provided in collecting information and typesetting the manuscript. Thanks are also due to Dr. A.K. Tripathi for translating the executive summary in Hindi.

With deep sense of gratitude and respect, I acknowledge Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for his consistent guidance, motivation and encouragement and for providing necessary financial support for overall growth and development of the institute. I place on record my sincere thanks to Additional Secretary (DARE) & Secretary (ICAR) and Financial Advisor (DARE). I am highly thankful to Dr. K. Alagusundaram, Deputy Director General (Agri. Engg.) and I/c Deputy Director General (NRM), ICAR and Dr. S.K. Chaudhari, Assistant Director General (SWM), for their constant support and encouragement for successful conduct of research and development activities for overall progress of the institute. I also express my sincere appreciation to all my colleagues and staff members of the institute for their dedicated efforts and cooperation in carrying out various activities of the institute.

Bhopal
June 2019

(Ashok K. Patra)
Director

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कार्यकारी सारांश

विषयवस्तु 1: मृदा स्वास्थ्य एवं उत्पादन सामग्री (आदान) दक्षता

- सोयाबीन–गेहूँ फसल चक्र में नाइट्रोजन संतुलन शीट में कार्बन डाई–ऑक्साइड और तापमान दोनों की बढ़ी हुई दशाओं में नाइट्रोजन की 150 प्रतिशत अनुशंसित मात्रा पर नाइट्रोजन उर्वरक का अर्थपूर्ण रूप से अधिक (140 प्रतिशत) उपयोग का संकेत दिया है और उसके बाद परिवेशी परिस्थितियों (34 प्रतिशत) में। दूसरी ओर उन्नत कार्बन डाई ऑक्साइड या ऊँचे तापमान उपचार के तहत काफी कम उर्वरक नाइट्रोजन का उपयोग किया गया था।
- सोयाबीन की फसल में विभिन्न नाइट्रोजन उपचारों में बढ़ी हुई कार्बन डाई–ऑक्साइड के कारण नाइट्रोजन का 18–61 प्रतिशत, फास्फोरस का 23–62 प्रतिशत एवं पोटाश का 22–62 प्रतिशत अधिक दोहन हुआ। बढ़ी हुई कार्बन डाई–ऑक्साइड में नाइट्रोजन का दोहन 147–190 किग्रा. /हे. के बीच रहा जबकि परिवेशी परिस्थितियों में यह 96–157 किग्रा./हे. के बीच रहा।
- दीर्घकालीन उर्वरक प्रयोगों के तहत मक्का के दानों की पैदावार, अनुशंसित उर्वरक प्रबंधन प्रथाओं और 100 प्रतिशत STCR आधारित उर्वरक प्रयोग की तुलना से STCR आधारित एकीकृत पोषक तत्व प्रबंधन मॉड्यूल, यानी 75 प्रतिशत ना. फा. पो. के साथ 5 टन/हे. गोबर की खाद और उसके बाद 75 प्रतिशत ना. फा. पो. के साथ 1 टन/हे. कुक्कुट खाद वाले उपचार में अर्थपूर्ण रूप से अधिक पाई गई।
- गेहूँ की फसल पर नैनो–पोषक तत्वों के प्रयोग के परिणाम फसल और खुराक विशिष्ट प्रभाव का संकेत देते है। उप–इष्टम सांद्रता में नैनो कण भी फसल के लिए उपयोगी हो सकते हैं और वह विकास और चयापचय के लिए उत्प्रेरक के रूप में कार्य कर सकते हैं जो पौधों की उच्च उपज के लिए उपयोग किया जा सकता है।
- मध्य प्रदेश के सिंगरौली जिले से एकत्र की गई ग्लूकोनाइट सामग्री से पोटैशियम के अलग–अलग अंशों जैसे – कुल K, पानी में घुलनशील K, अमोनियम एसीटेट से निकालने योग्य K और धनायन विनिमय क्षमता, पी–एच और विद्युत चालकता का विश्लेषण किया गया। ग्लूकोनाइट के नमूनों में कुल K_2O की मात्रा 7.1 से 12.6 प्रतिशत तक थी।
- दीर्घकालिक जैविक कृषि परीक्षणों के परिणामों में 100 प्रतिशत जैविक उपचार के साथ सोयाबीन ने उच्चतम बीज उपज का संकेत दिया उसके बाद 75 प्रतिशत कार्बनिक + 25 प्रतिशत अकार्बनिक और 75 प्रतिशत जैविक + अभिनव पद्धतियाँ थी जो 100 प्रतिशत अकार्बनिक उपचारों से अधिक थी।
- धीमी नाइट्रोजन मोचन नियमन से जुड़े अध्ययन में मक्का की फसल पर इन योगों के स्पष्ट प्रभाव का पता चला लेकिन गेहूँ की फसल में दानों की पैदावार के साथ–2 पोषक तत्वों की वृद्धि भी महत्वपूर्ण नहीं थी। इसके अलावा दानों की पैदावार के साथ–2 नाइट्रोजन के दोहन को लेकर फार्मूला नीम लोपित यूरिया के लगभग बराबर ही पाया गया।
- मध्य भारत की सोयाबीन–गेहूँ प्रणाली में मिट्टी के गुणों की स्थानिक परिवर्तनशीलता के अध्ययन ने मिट्टी के मापे गए गुणों में क्ले की मात्रा एवं प्रक्षेत्र क्षमता के लिए एक्सपोनेशियल, पी–एच और ई सी के लिए गोलाकार और मृदा कार्बनिक कार्बन के लिए वृत्तीय सबसे अच्छा फिट मॉडल का संकेत दिया। पी–एच और प्रक्षेत्र क्षमता के लिए सेमी वेरियोग्राम्स का नगेट/स्टिल अनुपात 25 प्रतिशत और 75 प्रतिशत के बीच था जो कि मध्यम स्थानिक निर्भरता को प्रकट करता है। मृदा कार्बनिक कार्बन की मात्रा ने 88 प्रतिशत नगेट/स्टिल अनुपात के साथ कमजोर स्थानिक निर्भरता को दिखाया।
- गेहूँ में वर्णक्रमीय पराक्रमीय अध्ययन में पत्ती में नाइट्रोजन की मात्रा, कच्चे हाइपरस्पेक्ट्रल परावर्तन और प्रथम क्रम अंतर हाइपरस्पेक्ट्रल परावर्तन के साथ एक मात्रात्मक सह–संबंध स्थापित किया। उच्च सह–संबंध गुणांक निकट–अवरक्त क्षेत्र यानी 750–850 nm में प्राप्त किया गया था, जो बताता है कि यह बैंड गेहूँ की फसल में नाइट्रोजन की मात्रा का अनुमान लगाने के लिए सबसे उपयुक्त है।
- मध्य प्रदेश की वर्टीसोल मृदा में एक मान्य एपसिम फसल मॉडल द्वारा 30 सेमी. मृदा की ऊपरी सतह में साम्य मृदा कार्बनिक कार्बन स्टॉक का अनुमान 100 प्रतिशत ना. फा. पो. /हे. उपचार में 15–30 टन/हे. एवं 100 प्रतिशत ना. फा. पो. +5 टन गोबर की खाद/हे. उपचार में 20–40 टन/हे. पाया गया।
- एल्फीसोल्स के कुछ महत्वपूर्ण गुणों की भविष्यवाणी के लिए

एम आई आर स्पेक्ट्रोस्कोपी (2500–25000 nm रेंज) के परावर्तन डेटा का उपयोग करके एक मॉडल विकसित किया गया है जो मिट्टी के मृदा कार्बनिक कार्बन सांद्रता और पी–एच की यथोचित भविष्यवाणी कर सकता है।

- बालाघाट जिले के आठ आदिवासी बहुल गाँवों में मृदा पोषक तत्व प्रबंधन और फसल प्रणाली क्षमता के लिए स्वदेशी तकनीकी ज्ञान का आकलन करने के लिए पायलट सर्वेक्षण किया गया।
- विभिन्न केन्द्रों पर दीर्घकालीन उर्वरक प्रयोगों ने प्रदर्शित किया कि संतुलित रूप में उर्वरक के उपयोग से मृदा की भौतिक स्थति विशेष रूप से जल स्थिर समुच्चय, स्थूल घनत्व और जल संचरण गुण में सुधार हुआ।
- 2.0 लाख से अधिक मिट्टी के नमूनों के विश्लेषण से मिट्टी में सूक्ष्म तत्वों की व्यापक कमी का पता चला। मिट्टी में जस्ता, लोहा, मैंग्नीज और बोरोन की क्रमशः 36.5, 12.8, 4.2, 7.1 और 23.2 प्रतिशत कमी है।
- ट्रांस–गंगा के मैदानों की मिट्टी में सूक्ष्म पोषक तत्वों की स्थानिक परिवर्तनशीलता ने लोहा, जस्ता, मैंग्नीज और तॉबा की पादप उपलब्धता में क्रमशः 28, 15, 14 और 13 प्रतिशत की कमी का संकेत दिया। मृदा पी–एच मान ने निष्कर्षण योग्य जस्ता, तॉबा, मैंग्नीज और लोहा की सांद्रता के साथ महत्वपूर्ण और नकारात्मक सह–संबंध दिखाए जबकि मृदा कार्बनिक कार्बन की सांद्रता के साथ सह–संबंध महत्वपूर्ण एवं सकारात्मक था।
- जस्ता दक्ष जीनोटइप की गेहूँ की फसल में जस्ता के बाहरी अनुप्रयोग ने संकेत दिया कि जस्ता के मिट्टी में, पर्णीय अनुप्रयोग करने और दोनों मिट्टी में एवं पर्णीय अनुप्रयोग करने से गेहूँ के दानों में क्रमशः 25.1, 35.7 और 38.2 प्रतिशत जस्ता की सांद्रता की वृद्धि हुई जबकि जस्ता की अदक्ष जीनोटाइप के दानों में जस्ता के मिट्टी पर्णीय अनुप्रयोग और दोनों मिट्टी एवं पर्णीय अनुप्रयोग से क्रमशः 7.2, 21.1 और 30.6 प्रतिशत जस्ता की सांद्रता में वृद्धि हुई।
- जैविक खेती प्रणाली के अन्तर्गत नाइट्रोजन और फास्फोरस आकलन के लिए मिट्टी परीक्षण प्राटोकॉल विकसित किया गया। फॉस्फेट बफर के लिए गोबर की खाद (10 टन/हे.) + माइक्रोबियल आर्गेनिक कार्बन (MOC) (1.25 टन/हे.), कैल्शियम क्लोराइड के लिए वर्मी–कम्पोस्ट (5 टन/हे.) + कुक्कुट खाद (2.5 टन/हे.), सोडियम बाइकार्बोनेट के लिए गोबर की खाद (10 टन/हे.) + वमीकम्पोस्ट (5 टन/हे.), बेसिक ई डी टी ए के लिए माइक्रोबियल आर्गोनिक कार्बन (1. 25 टन/हे.) उपचारों के अन्तर्गत संभावित खनिजीकृत नाइट्रोजन की अधिक मात्रा दर्ज की गई।

विषयवस्तु-2: संरक्षण कृषि, कार्बन सीक्यूस्ट्रेशन और जलवायु परिवर्तन

- दीर्घकालीन संरक्षण कृषि प्रबंधन ने मृदा पुंजीकरण और पुंज स्थिरता पर सकारात्मक प्रभाव दिखाए और मृदा कार्बनिक कार्बन की मात्रा में भी वृद्धि हुई। अलग–अलग जुताई के अलावा, नो टिलेज (एन टी) में कम जुताई (आर टी) और पारंपरिक जुताई (सीटी) से बड़ा मीन वेट डायमीटर (एम डब्ल्यू डी) था। फसल प्रणालियों में सबसे बड़ा एम डब्ल्यू डी मक्का–चना (1.04 मिमी.) फसल प्रणाली में और सबसे कम मक्का–अरहर (0.87 मिमी) एन टी के अन्तर्गत दर्ज किया गया।
- दीर्घकालीन जुताई और फसल प्रणाली के अध्ययन से पता चला है कि पुंज सहयोगी कार्बन की मात्रा पुंज के आकार के साथ बढ़ती है। जुताई की पद्धतियों और फसल प्रणालियों ने सभी पुंज आकार अंशो के लिए कुल पुंज सहयोगी कार्बन पर कोई महत्वपूर्ण प्रभाव नहीं दिखाया जबकि मिट्टी की गहराई ने सभी पुंज सहयोगी कार्बन पर महत्वपूर्ण प्रभाव डाला 0–5 से. मी. गहराई पर बड़े मैक्रो–एग्रीगेट कार्बन एन टी (0.57 प्रतिशत) के अन्तर्गत उच्चतर पाए गए और उसके बाद आर टी (0.53 प्रतिशत) और सी टी (0.51 प्रतिशत) पाए गए।
- विभिन्न जुताई और फसल प्रणाली के साथ नौ साल लंबे प्रक्षेत्र परीक्षण से पता चला है कि सतह गहराई 0.5 से.मी. में सी टी (0.69 प्रतिशत) की तुलना में एन टी (0.83 प्रतिशत) में मृदा कार्बनिक कार्बन की मात्रा काफी अधिक थी। फसल प्रणाली का मूल्यांकन करने के लिए एन टी के अन्तर्गत मक्का–चना और मक्का–गेहूँ में अर्थपूर्ण रूप से अधिक मृदा कार्बनिक कार्बन (0.84 प्रतिशत) उसके बाद सोयाबीन–गेहूँ (0.81 प्रतिशत) में प्राप्त हुआ।
- मृदा स्वास्थ्य पर संरक्षण कृषि के प्रभाव अध्ययन ने संकेत दिया कि 0–5 से.मी. मिट्टी की गहराई में मक्का–चना फसल चक्र प्रणाली के अन्तर्गत सी टी की तुलना से एन टी और आर टी में सुलभ फास्फोरस एवं पोटाश की मात्रा क्रमशः 22–46 प्रतिशत और 12–21 प्रतिशत उच्चतर पाई गई। इसके अलावा 5–15 से.मी. और 15–30 से.मी. गहराई पर सुलभ

फास्फोरस की मात्रा में कमी आई। सोयाबीन–गेहूँ फसल प्रणाली की तुलना में मक्का–चना फसल प्रणाली में 33 प्रतिशत उच्च सुलभ पोटैशियम पाया गया।

- धान–गेहूँ फसल प्रणाली के अन्तर्गत मिट्टी के जैविक गुणों में परिवर्तन के लिए एक दीर्घ–कालीन (10 वर्ष) संसाधन संरक्षण प्रयोग का मूल्यांकन किया गया और यह देखा गया कि धान–गेहूँ में सी ए प्रथाओं के अन्तर्गत मृदा सूक्ष्म जैविक बायोमास कार्बन और आसानी से निकालने योग्य ग्लोमालिन संबंधित मिट्टी प्रोटीन अधिकतम था।
- सोयाबीन–गेहूँ प्रणाली में संरक्षण जुताई के अन्तर्गत आठ साल के दीर्घकालीन प्रयोग को पारंपरिक जुताई में परिवर्तित करने के तीन फसल चक्रों के बाद, एन टी प्रणाली ने 0–5 सेमी. मिट्टी की सतह में मृदा कार्बनिक कार्बन की मात्रा उच्चतम दिखाई। एन टी और आर टी में जुताई उलट होने के साथ मिट्टी में उपलब्ध फास्फोरस अपेक्षाकृत बढ़ गई।
- एपसिम मॉडल का उपयोग करके मध्य भारत में मक्का जल उत्पादकता पर सिमुलेशन प्रयोग के परिणाम से संकेत मिलता है कि अध्ययन किए गए जिलों के बीच मक्का की जल उत्पादकता छिंदवाड़ा जिले में उच्चतम (1.83 किग्रा./घन मी.) और ग्वालियर जिले (1.42 किग्रा./घन मी.) सबसे कम पाई गई।
- एपसिम मॉडल के लिए अरहर कल्टीवार टी जे टी 501 के फसल गुणांक को अलग–2 फिनो–चरणों के अवलोकन और अनुमानित मूल्यों के मिलान के लिए कैलिब्रेशन के माध्यम से उत्पन्न किया गया और भविष्यवाणी की गई कि वास्तविक और अनुमानित उपज के बीच अच्छा संबंध था।
- दक्षिण एशिया के दैनिक मौसम डेटासेट और एन ई एक्स जी डी पी डी डेटा के विश्लेषण से पता चला है कि समग्र स्थितियों की तुलना में मध्यप्रदेश के जिलों की समग्र जलवायु भेद्यता मध्य और अंत शताब्दी में दोनों ही उत्सर्जन परिदृश्यों आर सी पी 4.5 और आर सी पी 8.5 में बढ़ने की सम्भावना है

विषयवस्तु-3 सूक्ष्म जैविक विविधता और प्रोद्यौगिकी

- उष्णकटिबंधीय वर्टिसोल में गेहूँ के राइजोस्फीयर में नाइट्रिफिकेशन और सूक्ष्मजीव बहुतायत पर उच्च CO_2 क्लोरोपाइरीफोस और बायोचार के साथ अध्ययन से पता चला है कि उच्च CO_2 और बायोचार ने नाइट्रोजन सूक्ष्मजीव बहुतायत और पौधों के विकास को प्रेरित किया जबकि क्लोरोपाइरीफोस ने उन मापदण्डों को बाधित किया।
- नगर निगम अपशिष्ट डंपिग साइट से दूषित मिट्टी पर उगाए गए वेटीवर घास की पौधों की जड़ों से एंडोफायटिक कवक को अलग किया गया। इन फंगल आइसोलेट्स को रूपात्मक और 18S RNA अनुक्रमण द्वारा आगे पहचाना गया।
- कार्बनिक के तेजी से अपघटन के लिए, शहर के कचरे और गाय के ताजा गोबर से सेल्युलोज और लिग्निन गिरावट क्षमता के छह कवक और आठ थर्मोफिलिक बैक्टीरिया को अलग किया गया। इन आइसोलेट्स का उपयोग करके, शहर के कचरे (किचन वेस्ट), वनस्पति अपशिष्ट, बागवानी अपशिष्ट और फसल अवशेष जैसे जैव अपशिष्ट का अपघटन किया गया एवं उनका मूल्यांकन अपघटन के लिए परिपक्वता और स्थिरता सूचकांकों के मूल्यांकन के बाद किया गया।
- होनहार एंडोफाइटिक बैक्टीरिया को मक्का की जड़ से अलग किया गया जिसमें 29 आइसोलेट्स ने नाइट्रोजन मुक्त मीडिया पर विकास दिखाया, 16 आइसोलेट्स अकार्बनिक फास्फोरस को घोल सकते थे, 22 आइसोलेट्स ने पोटेशियम घोलक के रूप में काम किया, 8 मैक्रोफोमिनैप्सोलिना के खिलाफ बायोकेन्टोनियल गतिविधि थी और 25 साइडोफोर क्षमता के लिए सकारात्मक थे।
- तुलनात्मक रूप से जैविक खेती आधारित फसल प्रणालियों में, सोयाबीन–गेहूँ प्रणाली में उच्च एफ डी ए हाइड्रोलाइटिंग गतिविधियों को दर्ज किया गया और उसके बाद सोयाबीन–सरसों और सोयाबीन–चना प्रणाली में। डिहाइड्रोजिनेज, क्षारीय फास्फेट और बीटा ग्लूकोसिडेज एंजाइम की गतिविधियां 100 प्रतिशत कार्बनिक में अधिक पाई गई और इसके बाद 75 प्रतिशत कार्बनिक + 25 प्रतिशत अकार्बनिक और 75 प्रतिशत कार्बनिक + अभिनव उपचार में, जो मिट्टी के सूक्ष्मजीवों के अतिरिक्त प्रभाव का संकेत देते है।
- जैविक फास्फोरस आपूर्ति की शक्ति, कुल पी एल एफ ए की मात्रा, कुल बैक्टीरिया, ए एम एफ एक्टीनोमाईसिटीस और एल टी एफ ई मिट्टी के यूकेरियोट्स 100 प्रतिशत ना. फा. पो. + गोबर की खाद उपचार के अन्तर्गत उच्च पाए गए। हालांकि असंतुलित उर्वरक प्रयोग (100 प्रतिशत नाइट्रोजन और 100 प्रतिशत ना. फा.) ने मिट्टी की जैविक फास्फोरस आपूर्ति शक्ति को कम कर दिया और कुल पी एल एफ ए और यूकेरियोट्स की प्रचुरता को कम कर दिया।
- विभिन्न भूमि उपयोग प्रथाओं में कार्बन चक्रण से संबंधित विशिष्ट एंजाइम गतिविधि ने दर्शाया कि बागवानी और घास

के मैदान प्रणाली में मिट्टी की ऊपरी गहराई में कार्बन सीक्यूस्ट्रेशन के लिए उच्च क्षमता है, जबकि कृषि वानिकी और पलाश आधारित वन मिट्टी की कम गहराई में उच्च कार्बन सीक्यूस्ट्रेशन क्षमता है।

- देश के उत्तर पूर्वी पहाड़ी क्षेत्रों (एन ई एच) के विभिन्न जैविक उर्वरक रिजीम की प्रतिक्रिया में धान की मिट्टी के पारिस्थितिकी तंत्र में सूक्ष्म जैविक विविधता से पता चलता है कि सूक्ष्म जैविक वहुतायत में बैक्टीरिया के बाद आरचिया और यूकेरिया का प्रभाव पाया गया। विभिन्न बैक्टीरियल फाइला के बीच प्रोटिओबैक्टीरिया ने जीवाणु विविधता में उच्चतम योगदान दिया और कार्यात्मक सूक्ष्म जैविक विविधता, मीथेन ऑक्सीकरण बैक्टीरिया द्वारा हावी थी।
- मिट्टी की उर्वरता की स्थिति का आकलन करने के लिए मृदा जैविक गुणवत्ता सूचकांक (SBQI) के तरीके विकसित किए गए और मान्य किए गए। विकसित किए गए पाँच SBQI में से क्वाड्रेंट–प्लॉट आधारित विधि सबसे अच्छी पाई गई।
- आठ साल लंबे अध्ययन से पता चला है कि ठोस जैव उर्वरक की तुलना में तरल जैव उर्वरक बीज भिगोने और शीर्ष ड्रेसिंग के माध्यम से मक्का–लोबिया फसल में प्रयोग करने से उपज में सुधार करने में कुशल पाए गए। राइजोबियम के जैव संचार का फसल उत्पादकता पर महत्वपूर्ण प्रभाव पड़ा और फसलों द्वारा पोषक तत्वों (मुख्य एवं सूक्ष्म दोनों) का दोहन बिना किसी जैव–टीकाकरण की तुलना में लगभग दोगुना हो गया।

विषयवस्तु-4 मृदा प्रदूषण एवं बचाव

- भारी धातुओं से दूषित मिट्टी के सुधार के लिए कपास की फसल का आकलन करने से संकेत मिलता है कि पौधा 1000 मि.ग्रा. कैडमियम प्रति कि.ग्रा. मिट्टी और 3000 मि.ग्रा. लैड प्रति कि.ग्रा. मिट्टी तक सहन करता है। भारी धातुओं (कैडमियम, लैड और क्रोमियम) का एक साथ प्रयोग किया गया था तो कुल सूखे वजन, बोल्स / गमला और लिंट उपज / गमला की संख्या में उल्लेखनीय कमी आई। दूसरी ओर क्रोमियम जब अलग से प्रयोग किया गया था तो अन्य जहरीली धातुओं विशेष रूप से लैड के साथ प्रयोग करने की तुलना में अधिक विषाक्त था।
- एम एस डब्ल्यू के साथ दूषित मिट्टी के फाइटो–रेमीडिएशन का प्रयास वेटीवर (***क्राइसोपोगोन जिजानियोइड्स***) जैसे पौधों के साथ किया गया। स्थापित पौधों के राइजोस्फीयर ने हेटरोट्राक्स, कवक और एक्टिनोमाइसेट्स की सूक्ष्मजैविक आबादी के साथ–2 गतिविधियों में सुधार हुआ है।
- स्पाइक्ड कैडमियम का एजिंग प्रभाव मृदा में इसकी जैव उपलब्धता और पालक में इसकी पादप विषाक्ता का मूल्यांकन किया गया। यह देखा गया कि जैव सुलभ कैडमियम की मात्रा और पादप विषाक्ता, समय की अवधि में (3 वर्ष) अल्फिसोल्स के मामले में लगभग समान है, इनसेप्टिसोल में थोड़ा कम हो गई जबकि वर्टिसोल में काफी कमी दर्ज की गई थी।
- मध्य प्रदेश के मलाजखंड में ताँबे की खनन प्रभावित भूमि के पुनर्निर्माण और पुर्नवास के लिए प्रयास किया गया। मृदा और टेल के नमूने स्वभाव में अम्लीय के साथ निम्न से मध्यम कार्बनिक कार्बन स्तर था। टेलिंग बाँध के किनारों पर वेटीवर पौधों को लगाया गया और राइजोस्फीयरिक सूक्ष्मजीव और सूक्ष्मजैविक सक्रियता बढ़ी हुई पाई गई।
- नागदा (म. प्र.) के टेक्सटाइल औद्योगिक क्षेत्र के आस–पास की भूमि का मृदा स्वास्थ्य और फसल उत्पादन पर प्रदूषित सिंचाई के पानी के प्रभाव का आकलन किया गया। मिट्टी (5. 75 डेसी. / मी.) और पानी (7.28 डेसी. / मी.) में उच्च विद्युत चालकता देखी गई। सिकुड़ी हुई और छोटे आकार के साथ खराब सोयाबीन के बीज की पैदावार (1.0–1.5 टन / हे.) प्रदूषित मिट्टी में दर्ज की गई।

Executive Summary

Theme I: Soil Health and Input Use Efficiency

- Nitrogen balance sheet in soybean-wheat crop sequence indicated significantly higher use efficiency of Fertilizer-N (40%) under elevation of both CO_2 (560 ppm) and temperature (+1.5°C) at 150% of recommended N dose (N_{150}) followed by ambient conditions (34%). On the other hand, significantly lower Fertilizer-N use efficiency was noticed under elevated CO_2 or elevated temperature alone.
- Elevated CO_2 (560 ppm) resulted in 18-61% higher N uptake, 23-62% higher P uptake and 22-62% higher K uptake in the soybean crop at different N treatments. The N uptake varied from 96-157 kg ha^{-1} under ambient condition to 147-190 kg ha^{-1} under elevated CO_2 concentration.
- Under long-term fertilizer experiments, maize grain yield was significantly higher with soil test crop response based integrated nutrient management module, i.e. 75% NPK of STCR along with FYM at 5 Mg ha^{-1} and followed by integration of 75% NPK + poultry manure at 1 Mg ha^{-1} as compared to recommended fertilizer management practices and 100% STCR based NPK fertilizers.
- Results from the impact of nano-nutrients on wheat crop indicated crop and dose specific effect. Nanoparticles at sub-optimal concentration may also be useful for the crop and they may act as catalyst for growth and metabolism which can be utilized for higher yield of plants.
- The glauconite material was collected from Singrauli district of Madhya Pradesh and analyzed for different fractions of potassium viz., total K, water soluble K, NH_4OAc extractable K, cation exchange capacity, pH and electrical conductivity. The total K_2O content in glauconite samples ranged from 7.1 to 12.6%.
- The results from long term organic farming trials showed highest seed yield of soybean with 100% organic treatment followed by 75% organic + 25% inorganic and 75% organic + innovative practices which were higher than 100% inorganic treatments.
- The study involving slow N release formulations revealed a clear cut effect of these formulations on maize crop but in wheat crop the increase in grain yield as well as nutrient uptake was not significant. Also, the formulations were found to be at par with neem coated urea with respect to grain yield as well as nitrogen uptake.
- Spatial variability study of soil properties in soybean-wheat system of Central India indicated best-fit models for measured soil properties to be exponential for clay content and field capacity, spherical for pH and EC, and circular for SOC. The nugget/sill ratios of semi-variograms for pH and field capacity were between 25% and 75%, which reveals moderate spatial dependence. The SOC content showed the weak spatial dependency with 88% nugget to sill ratio.
- The spectral reflectance study in wheat established a quantitative correlation with leaf nitrogen content, raw hyperspectral reflectance, and first-order differential hyperspectral reflectance. Higher correlation coefficient was obtained in near-infrared region i.e. 750-850 nm, which indicates that these bands are most appropriate to estimate nitrogen content in wheat crop.
- A validated APSIM crop model estimated equilibrium soil organic carbon stock in top 30 cm of Vertisols of Madhya Pradesh to be 15-30 t ha^{-1} and 20-40 t ha^{-1} under 100% NPK and 100% NPK+5 t ha^{-1} FYM, respectively.
- A model developed using reflectance data of MIR spectroscopy (2500-25000 nm range) for prediction of some important properties of Alfisols which could predict the SOC concentration and pH of the soil reasonably well.
- A pilot survey was carried out to assess the indigenous technical knowledge for soil nutrient management and cropping system potential in eight tribal dominated villages of Balaghat district.
- Long term fertilizer experiments at different centers demonstrated that application of fertilizer in balanced form resulted improvement in soil physical condition particularly water stable aggregates, bulk density and water transmission properties.

- Analysis of more than 2.0 lakhs soil samples revealed wide spread micronutrients deficiency in soils. On an average, 36.5, 12.8, 4.2, 7.1 and 23.2% soils are deficient in Zn, Fe, Cu, Mn and B, respectively.
- Spatial variability of soil micronutrients in the Trans-Gangetic Plains indicated 28, 15, 14 and 13% deficiency in plant available Fe, Zn, Mn and Cu. Soil pH showed significant and negative correlations with the concentrations of extractable Zn, Cu, Mn and Fe; whereas the correlation was significant and positive with soil organic carbon (SOC) concentration.
- External Zn application to wheat crop indicated that grain Zn concentration increased by 25.1, 35.7 and 38.2% with soil, foliar and both soil and foliar application of Zn, respectively in Zn-inefficient genotypes and by 7.2, 21.1 & 30.6% with soil, foliar and both soil and foliar application of Zn, respectively in Zn-efficient genotypes.
- Soil testing protocol using different extractants for estimation of nitrogen and phosphorus under organic farming system were valuated. Higher amount of potentially mineralized N was recorded under FYM (10 t/ha) + Microbial Organic Carbon (MOC) (1.25 t/ha) for phosphate buffer, Vermicompost (5 t/ha) + Poultry Manure (2.5 t/ha) for calcium chloride, FYM (10 t/ha) + VC (5 t/ha) for sodium bicarbonate and VC (5 t/ha) + MOC (1.25 t/ha) for basic EDTA.

Theme II: Conservation Agriculture, Carbon Sequestration and Climate Change

- Long-term conservation agricultural management practices had showed positive effect on soil aggregation and aggregate stability and also increased soil organic carbon content. Among the different tillage, no-tillage (NT) had larger MWD than reduced tillage (RT) and conventional tillage (CT). Among the cropping systems, the largest MWD was recorded under maize-gram (1.04 mm) and the lowest under maize + pigeon pea (0.87 mm) under NT system.
- Long-term tillage and cropping system study showed that the aggregate-associated C content increased with aggregate size. Tillage practices and cropping systems showed no significant effect on aggregate associated-C for all aggregate size fractions, whereas soil depth had a significant effect on all aggregate-associated C. Higher large macro-aggregate associated C under NT (0.57%) followed by RT (0.53%) and CT (0.51%) at 0-5 cm depth were recorded.
- A nine-year long field experiment with different tillage and cropping system showed that SOC content was significantly higher in NT (0.83%) than CT (0.69%) in surface depth (0-5 cm). Among the cropping systems evaluated, maize-gram and maize-wheat recorded significantly higher SOC (0.84%) followed by soybean-wheat (0.81%) under NT.
- The impact study of CA on soil health indicated that at 0-5 cm soil depth, available P and K were higher to the tune of 22-46% and 12-21%, respectively under NT and RT in comparison to CT under maize-chickpea crop rotation. Available P was lower in 5-15 and 15-30 cm of soil depth. Maize-chickpea rotation had 33% higher available K in comparison to soybean-wheat rotation.
- A long term (10 years) resource conservation experiment was evaluated for changes in soil biological properties under rice-wheat cropping system and it was observed that soil microbial biomass carbon and easily extractable glomalin related soil protein was maximum under CA practices.
- After three cropping cycles of converting an eight year long conservation tillage experiment (soybean-wheat cropping system) to conventional tillage, the NT system showed highest SOC content in the surface 0-5 cm layer only. Soil available P relatively increased with reversal of tillage in NT and RT.
- The results from a simulation experiment on maize water productivity in central India using APSIM model indicated that among the studied districts mean water productivity of maize was the highest (1.83 kg m^{-3}) in Chindwara district and the lowest (1.42 kg m^{-3}) in Gwalior district.
- Crop coefficients of pigeon pea cv TJT 501 for APSIM model was generated through calibration to match the observed and predicted values of different pheno-phases and good correlation between the observed and predicted grain yield was observed.

- The analysis of Cordex South Asia daily weather datasets and NEX-GDDP data revealed that the overall climate vulnerability of the Madhya Pradesh districts is projected to increase towards mid-and end-century as compared to the current conditions for both emission scenarios of RCP 4.5 and RCP 8.5.

Theme III: Microbial Diversity and Biotechnology

- Study with elevated CO_2, chlorpyrifos and biochar on nitrification and microbial abundance in rhizosphere of wheat in tropical Vertisol showed that elevated CO_2 and biochar stimulated nitrification, microbial abundance and plant growth while chlorpyrifos inhibited those parameters.
- Endophytic fungi from plant roots of vetiver grass grown on a contaminated soil from municipal waste dumping site were isolated. These fungal isolates were identified further by morphological and 18s rRNA sequencing.
- For rapid decomposition of organics, six fungi, and eight thermophilic bacteria possessing cellulose and lignin degradation ability were isolated from city waste and fresh cow dung. Using these isolates, bio-waste like city waste (Kitchen waste), vegetable waste, horticultural waste and farm waste were subjected to decomposition followed by assessment of maturity and stability indices.
- Promising endophytic bacteria were isolated from corn root out of which 29 isolates showed growth on N free media, 16 isolates could solubilize inorganic P, 22 isolates acted as K solubilizer, 8 possessed biocontrol activity against *Macrophomina phaseolina* and 25 were positive for siderophore production ability.
- Among the organic farming based cropping systems compared, soybean-wheat system recorded higher FDA hydrolytic activities followed by soybean-mustard and soybean-chickpea. Dehydrogenase, alkaline phosphatase and β Glucosidase enzymes activities were found to be higher in 100% organic followed by 75% organic + 25% inorganic and 75% organic + innovative treatment indicating beneficial effect of addition of organics on soil microorganisms.
- Biological P supply power, abundance of total PLFA, total bacteria, AMF, actinomyctes and eukaryotes of the LTFE soil was found higher under 100% NPK+FYM. However, imbalanced fertilizer application (100% N and 100% NP) had declined the biological P supply power of soil and reduced the abundance of total PLFA and eukaryotes.
- Specific enzyme activity related to carbon cycling in various land use practices demonstrated that horticulture and grassland system have higher potential for carbon sequestration in upper soil depth whereas agroforestry and Palash based forest soil have higher carbon sequestration potential in lower depth.
- Microbial diversity in a rice soil ecosystem in response to different organic fertilizer regimes of NEH revealed that the microbial abundance was dominated by bacteria followed by Archaea and Eukarya. Among the different bacterial phyla, proteobacteria contributed to the highest bacterial diversity, while functional microbial diversity was dominated by methane oxidizing bacteria.
- Methods for soil biological quality index (SBQI) were developed and validated to assess the fertility status of soil. Among five SBQIs developed, quadrant-plot based method was found to be the best.
- Eight years long study showed that liquid biofertilizers applied through seed soaking and top dressing, were efficient in improving yield of maize-cowpea than solid biofertilizers. Bioinoculation of *Rhizobium* had significant influence on the crop productivity and the uptake of nutrients (both major and minor) by the crops which was almost doubled compared to no bio-inoculation.

Theme IV: Soil Pollution and Remediation

- Assessment of cotton crop for the remediation of soils contaminated with heavy metals indicated that the plant tolerated up to 1000 mg Cd kg soil^{-1} and 3000 mg Pb kg^{-1} soil. However, when the heavy metals (Cd, Pb and Cr) were applied in combination, there was significant reduction in total dry weight, number of bolls/pot and lint yield/pot. On the other hand, Cr when applied separately was more toxic than it was applied in combination with other heavy metals particularly Pb.

- Phyto-remediation of soils contaminated with MSW was attempted with plants like Vetiver (*Chrysopogon zizanioides*). The rhizosphere of the established plants has shown improvement in microbial population of heterotrophs, fungi and actinomycetes as well as soil respiration and soil enzyme activities.
- The ageing effect of spiked Cd on its bioavailability in soil and phytotoxicity to spinach was assessed. It was observed that the bioavailable Cd content and phytotoxicity, over a period of time (3 years) remains almost similar in case of Alfisols, slightly decreased in Inceptisols, while considerable reduction was recorded in Vertisols.
- An attempt was made for reclamation and rehabilitation of copper mining affected land in Malanjkhand, Madhya Pradesh. Soil and tail samples were acidic in nature with medium to low organic carbon. Vetiver was planted at Tailing Dam Embankment and enhanced rhizopsheric microorganisms and microbial activity was recorded.
- The impact of polluted irrigation water on soil health and crop production surrounding Textile industrial belt of Nagda, M.P was assessed. Higher EC was observed in the soil (5.75 dS/m) and water (7.28 dS/m). Poor soybean seed yield with shrunken and small seed size was recorded in polluted soils (1.5-1.0 t/ha).

1. Introduction

Food and nutritional security are the two major global challenges of the 21st century which depend 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 the 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 efforts 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 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, etc. 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:

a) Basic and strategic research on physical, chemical and biological processes in soils related to management of nutrients, water and energy

b) Advanced technologies for sustainable soil health and quality

c) 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
- Fertilizer fortification
- Resilience of degraded soils
- Developing a workable index of soil quality assessment imbibing influence of different physical, chemical and biological soil attributes

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

- Organic farming and produce quality
- Efficient and improved composting techniques
- The carbon sequestration research in the context of sustainable management of land and soil resources and conserving deteriorating environment
- Conservation agriculture and carbon sequestration

- Tillage and nutrient interactions
- Crop adaptation to climate change and rhizospheric study

Programme 3: Microbial Diversity and Genomics

- Characterization and prospecting of large soil bio-diversity
- 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 water-quality assessment and recycling

1.3 Organization Set-Up

Divisions

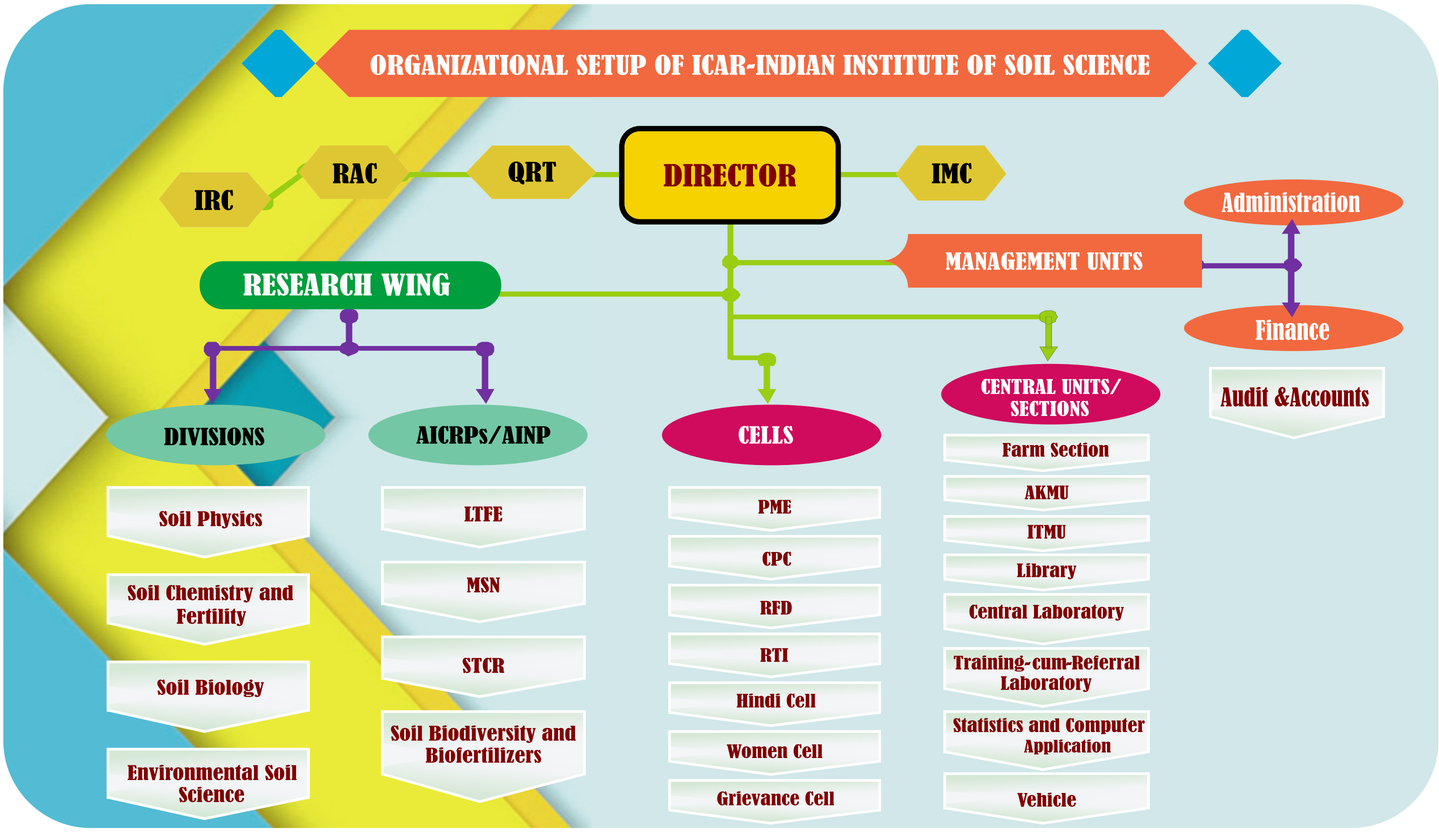
(i) Soil Physics
(ii) Soil Chemistry & Fertility
(iii) Soil Biology
(iv) Environmental Soil Science

Sections/Central Units/Technical Units/Cells

(i) Farm
(ii) Administration
(iii) Remote Sensing & GIS
(iv) Central Laboratory
(v) Prioritization, Monitoring and Evaluation Cell (PME)
(vi) Agriculture Knowledge Management Unit (AKMU)
(vii) Institute Technology Management Unit (ITMU)
(viii) Library, Information and Documentation Unit
(ix) Right to Information (RTI)
(x) Consultancy Processing Cell (CPC)
(xi) Official Language Cell (Hindi Cell)
(xii) Vehicle
(xiii) Training Hostel
(xiv) Referral Lab
(xv) Women 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)



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	2	2
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	Agronomy	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	8	7	15	30
	Total	**13**	**16**	**28**	**57**	**11**	**11**	**26**	**48**

b) Technical

S. No.	Posts	Sanctioned	In Position
1	T-1	11	10
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**	**16**

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	4
8	Stenographer Gr-III	2	1
9	Security Supervisor	1	1
10	Upper Division Clerk	2	2
11	Lower Division Clerk	6	2
12	Skilled Supporting Staff	25	17
	Total	**53**	**37**
	Grand total		**101**

1.5 Finance: Budget statement (Lakhs) for the financial year 2018-19 is as follows

S.No.	Institute/AICRPs	Budget	Expenditure
1.	Main IISS Institute	2124.75	2121.00
2.	AICRP- LTFE	495.18	494.21
3.	AICRP- STCR	719.64	718.65
4.	AICRP- MSPE	747.67	747.64
5.	AINP on SBB	299.45	299.42
6.	CRP on CA Platform	253.61	249.37
	Total	**4640.30**	**4630.29**

1.6 Resource Generation

S.No.	Head of Account	Amount in Rs.
1.	Sale of farm produce	1004188.00
2.	Sale of fish & poultry	6422.80
3.	Sale of publication and advertisement	9110.00
4.	Licence fee	385502.00
5.	Interest earned on loans & advances	1671035.00
6.	Analytical and testing fee	5840.00
7.	Diploma Charges	262.00
8.	Unspent balance of grants of previous years	43825854.00
9.	Interest earned on short term deposits	11390371.00
10.	Income generated from internal resource generation scheme	
	a. Training	60997.00
	b. Consultancy	1708612.00
	c. Others	13786108.00
11.	Recoveries of loans & advances	1093787.00
12.	Miscellaneous Receipts	488927.20
	TOTAL	**75437016.00**

2. Research Achievements

Theme - I: Soil Health and Input Use Efficiency

2.1 Improving Soil Health and Input Use Efficiency

2.1.1 Nutrient use in soybean-wheat crop sequence under elevated CO_2 and temperature

^{15}N balance sheet in a soybean-wheat crop sequence under elevated CO_2 and temperature

Interaction of atmospheric CO_2 concentration, growing temperature and plant available soil nitrogen (N) plays a critical role in regulating the limitations to the CO_2 fertilization effect. A field study was conducted using ^{15}N labeled urea in micro-plots to study the effect of elevated CO_2 and/or temperature on fertilizer-N use in a soybean-wheat cropping sequence. Crops were grown in open top field chambers (OTCs) under two CO_2 (386 and 560 µ mol mol^{-1}), two temperatures (ambient, 1.4-1.5 °C above ambient chamber) and three N levels (N_{50}, N_{100} and N_{150}) during 2017-18. The balance sheet included use of ^{15}N labeled fertilizer-N by the two consecutive crops of soybean and wheat in sequence, retention in soil profile (0-15 cm depth) and the rest was considered as unaccounted for. Combining the fertilizer-N use by soybean and the residual N use by wheat crop (from the soybean applied labeled fertilizer) indicated 13-40% of the applied fertilizer-N was used by the two crops (Fig. 2.1.1a). Significantly higher use of fertilizer-N (40%) was observed under elevation of both CO_2 and temperature (eCeT) at 150% of recommended N dose (N_{150}) followed by ambient chamber (AC) at N_{150} (34%). On an average, fertilizer-N use was significantly higher under eCeT. On the other hand, there was a significantly lower fertilizer-N use under elevated CO_2 (eC) and elevated temperature (eT) treatments.

The data on recovery of fertilizer-N in the soil profile after harvest of wheat showed 20-51% retention in the 0-15 cm surface soil after two crop seasons (soybean followed by wheat). Maximum retention was observed under eT (29-51%) followed by eC (20-45%), open field (OF) (31-39%), eCeT (24-35%), and AC (20-31%). The data on plant use (by both soybean and wheat) and retention in soil profile indicated 43-73% of the fertilizer-N could be traced. Across different climate conditions, 27-57% of the applied fertilizer-N remained unaccounted for due to movement towards deeper layers or other losses (Fig. 2.1.1a).

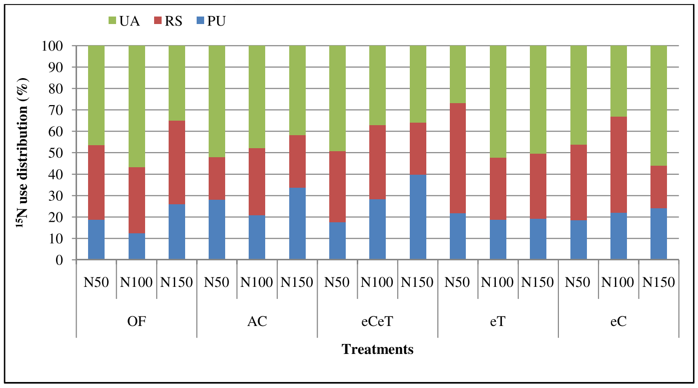


Fig. 2.1.1a Balance sheet of ^{15}N labeled fertilizer use in soybean-wheat cropping system under varied nitrogen and climate (OF: Open field; AC: Ambient chamber; eCeT: elevated CO_2 and elevated temperature; eC: elevated CO_2; eT: elevated temperature) *(PU: Plant use; RS: Retention in soil; UA: Unaccounted for).*

Nitrogen derived from fertilizer (Ndff) under different CO_2 and temperature treatments

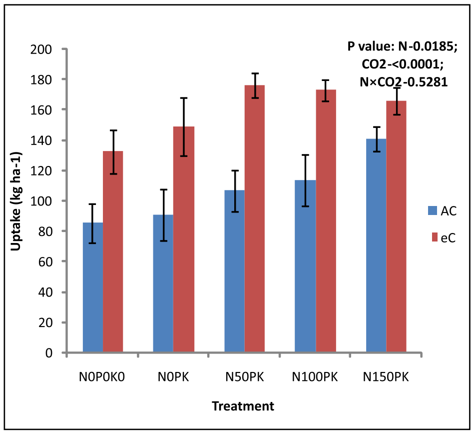
Significant influence of climate, N application and their interaction was observed on the Ndff per cent in both seed and straw. As compared to AC, the average Ndff per cent in seed plus straw was significantly lower under eC and eT treatments but was not affected under eCeT. The Ndff per cent in the whole plant varied from 4.4-20.9% under eCeT, 5.6-11.5% under eT, 4.6-13.6% under eC as compared to 4.4-23.4% under AC treatment. A significant difference in Ndff per cent under different climate treatments was observed at higher N application levels (N_{150}). Averaged over climate conditions, the Ndff per cent was 4.5% under N_{50} but increased to 9.0% under N_{100} and 17.5% under N_{150}. At sub-optimal N application (N_{50}), the per cent Ndff remained mostly similar across climate treatments. At N_{100}, AC was at par with eC, but, was significantly lower than eCeT and significantly higher than eT. At N_{150}, the per cent Ndff was significantly higher under AC (23.4%) followed by eCeT (20.9%), eC (13.6%) and eT (11.5%).

Elevated CO_2 enhances nutrient uptake in soybean

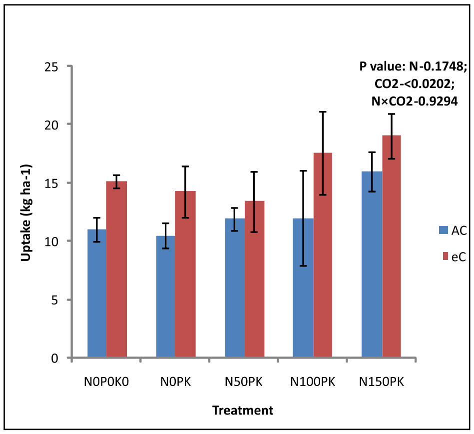
This study was taken up in open top field chambers to investigate the effect of elevated CO_2 on uptake of N, P and K in soybean cv. JS 20-29 (Plate 2.1.1a.). The study indicated total uptake (from seed plus above ground biomass but excluding leaf) of N, P and K was significantly affected by CO_2 and N, but not by CO_2 x N interaction (Fig. 2.1.1b). Seed uptake of N, P and K also followed similar trend. However, straw uptake of N, P and K was affected only by CO_2, not by N level. Elevated CO_2 resulted 18-61% higher N uptake, 23-62% higher P uptake and 22-62% higher K uptake in the soybean crop at different N treatments. The N uptake varied from 96-157 kg ha^{-1} under ambient to 147-190 kg ha^{-1} under elevated CO_2 concentration. With increase in N application from N_0 to N_{150}, the N uptake increased by 17-55% under ambient as compared to 13-17% under elevated CO_2 condition. Out of total N uptake, 89-90% of N was harvested in seed under ambient as compared to 90-93% under elevated CO_2.

The P uptake varied from 8-14 kg ha^{-1} under ambient to 11-17 kg ha^{-1} under elevated CO_2 treatment (Fig. 2.1.1b). With increase in N application from N_0 to N_{150}, the P uptake increased by 26-68% under ambient as compared to 14-27% under elevated CO_2 condition. Out of the total, 89-91% was harvested in seed under ambient as compared to 88-92% under elevated CO_2. The K uptake varied from 24-40 kg ha^{-1} under ambient to 35-49 kg ha^{-1} under elevated CO_2 treatment (Fig. 2.1.1b). With increase in N application from N_0 to N_{150}, the K uptake increased by 23-55% under ambient as compared to 10-18% under elevated CO_2. Out of the total K uptake, 61-69% was harvested in seed under ambient as compared to 61-72% under eCO_2.

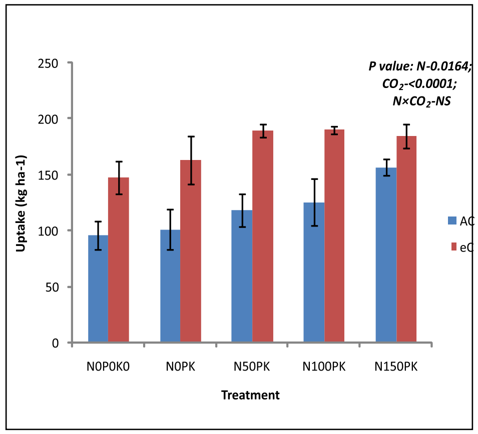
Seed N uptake



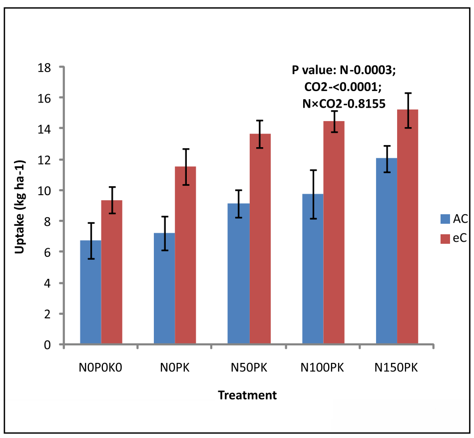
Straw N uptake



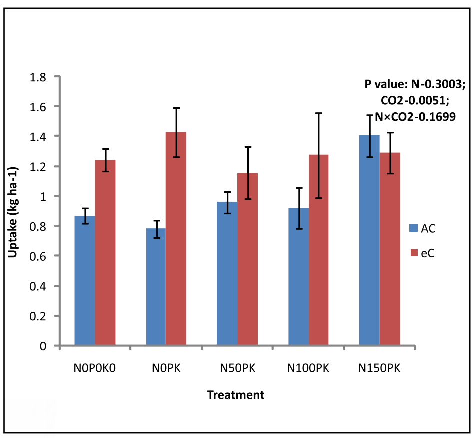
Total N uptake



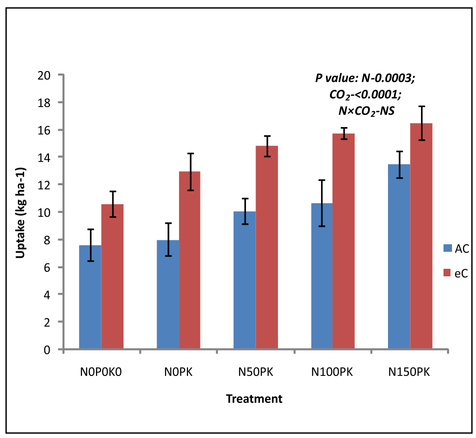
Seed P uptake



Straw P uptake



Total P uptake



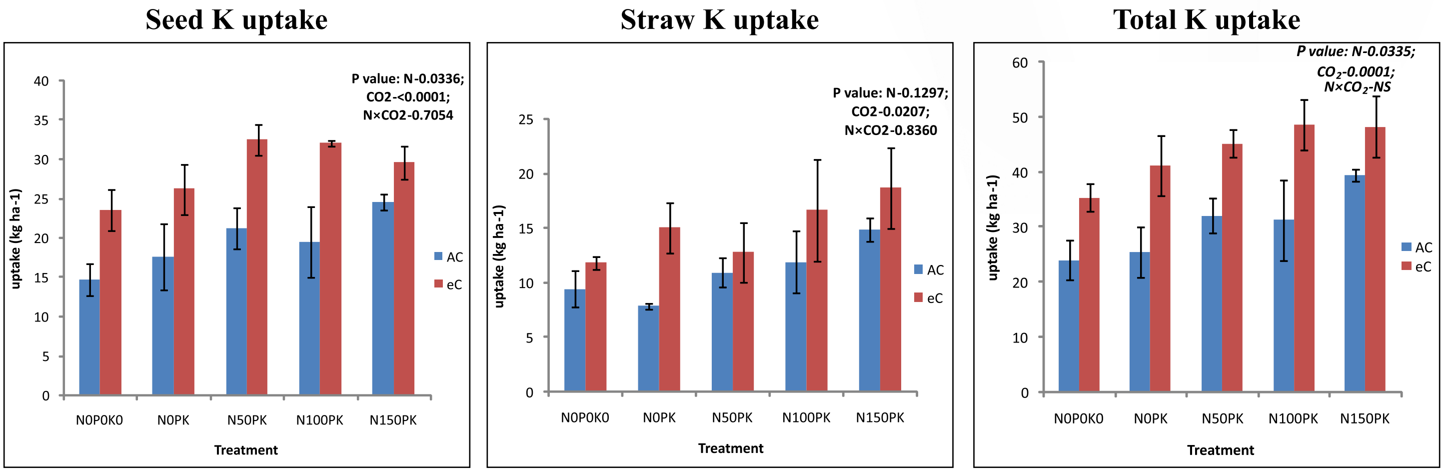


Fig. 2.1.1b Uptake of N, P and K (seed, straw and total) under elevated CO_2 and nitrogen levels (AC-ambient; eC-elevated CO_2; $N_0P_0K_0$-absolute control; N_0PK-nitrogen control; $N_{50}PK$-50% nitrogen stress; $N_{100}PK$- recommended nitrogen; $N_{150}PK$-50% excess nitrogen)

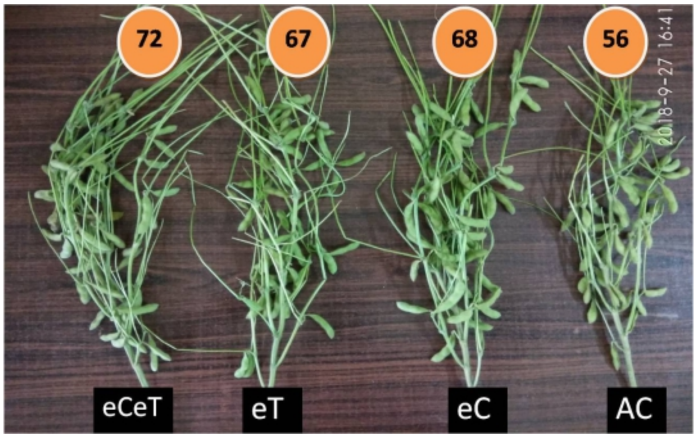


Plate 2.1.1a Variation in soybean pod number under different climate treatments

Carbon dioxide elevation significantly reduces crop evapotranspiration

The soil moisture data for two experiment years in 2016 and 2018 under soybean in open top field chambers indicated significant (P<0.05) reduction in crop ET under elevated CO_2 treatment. However, the effect of N was significant only during 2016 crop season. The interaction effect was not significant at 95% probability in both the years. Significantly higher ET was observed under ambient chamber (AC) than eC or eCeT, with the latter two being at par. The profile moisture storage up to 60 cm soil depth showed a significant effect of climate in both crop years, with effect of N as significant (P<0.05) in 2016 crop season only and the interaction being non-significant in both the years. Significantly lower moisture storage was observed under AC than eC or eCeT, with the latter two being at par.

Among the N treatments, only N_{150} showed lower profile moisture storage, which was significantly distinct. A reduced stomatal conductance and higher leaf area might have resulted in lowering ET under eC and eCeT treatments (Fig. 2.1.1 c and d).

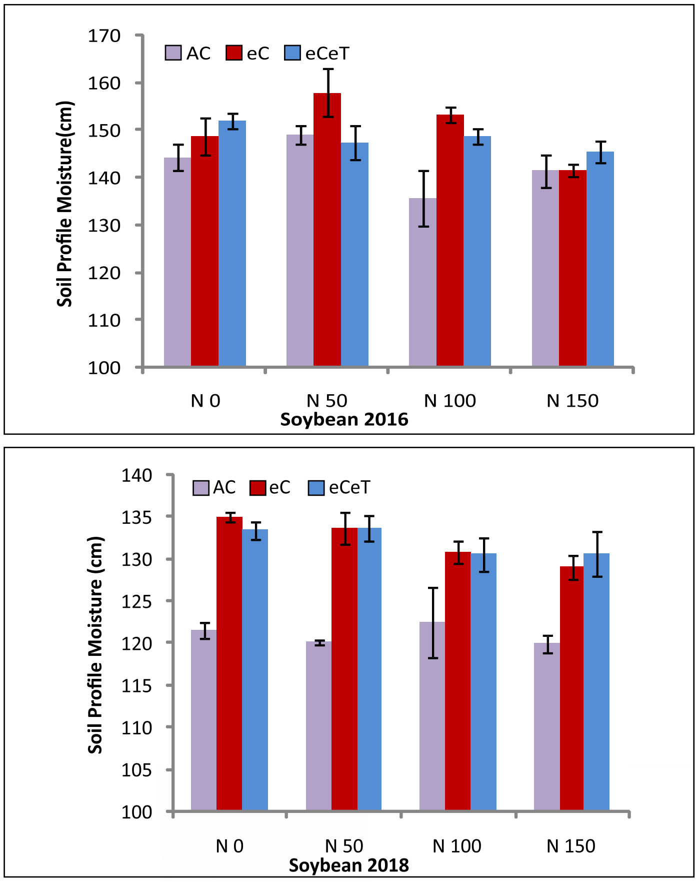


Fig. 2.1.1c Profile moisture storage under varied climate and graded nitrogen

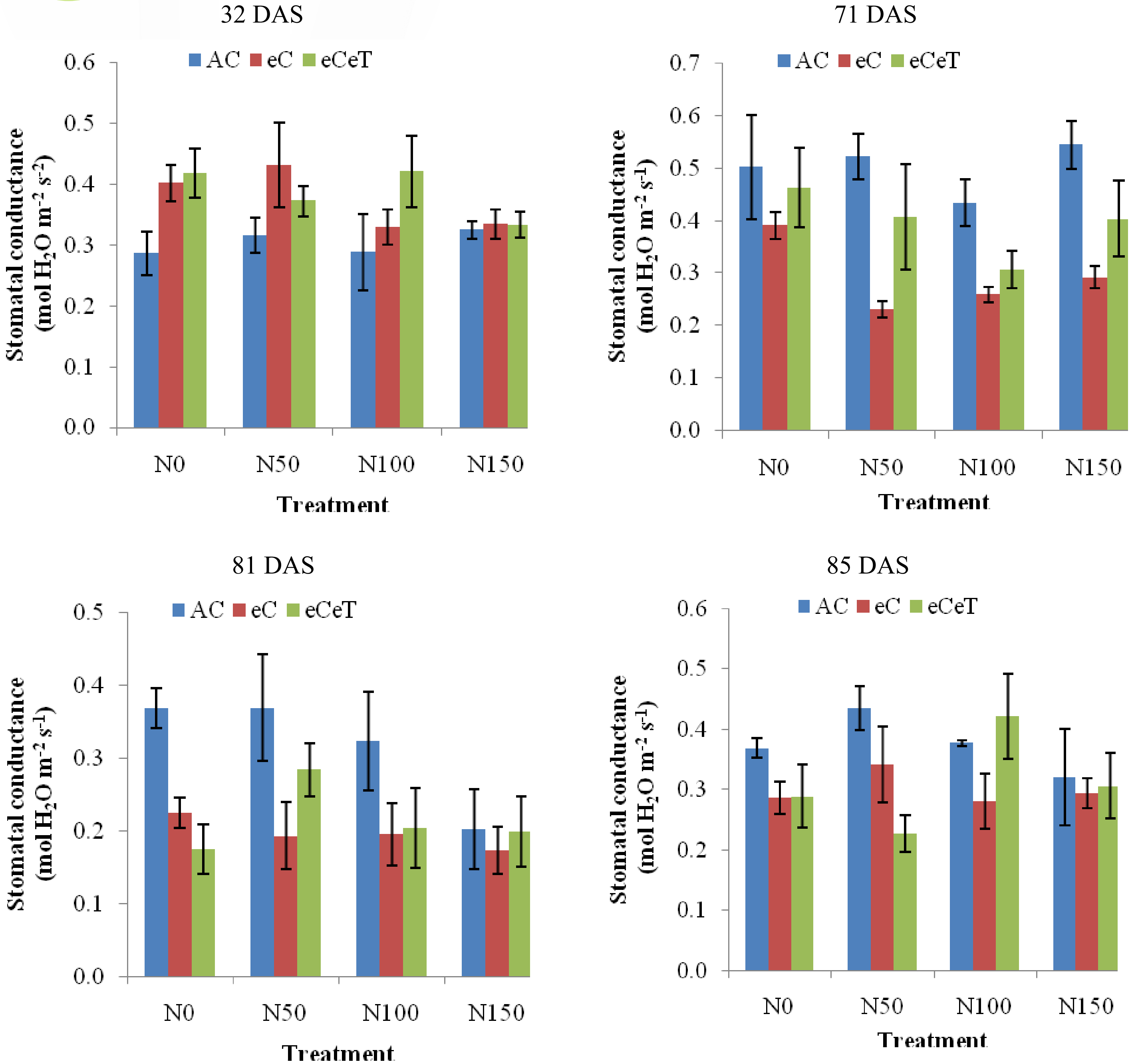


Fig. 2.1.1d Stomatal conductance in soybean as influenced by graded levels of nitrogen fertilization under various climatic conditions ***(DAS- Days after sowing; N_0- No nitrogen, N_{50}- 50% of optimum nitrogen; N_{100}- Optimum nitrogen; N_{150}- 150% of optimum nitrogen; AC- Ambient chamber; eC- Elevated CO_2; eCeT- Elevated CO_2 and temperature)***

2.1.2 Long-term integrated nutrient management (INM) practices for enhancing crop productivity and soil health in maize-chickpea cropping sequence

Crop yields were significantly influenced with the integrated nutrient management (INM) practices in a long term fertilizer experiment at IISS research farm during 2018-19. The treatment details are listed in Table 2.1.2. Maize grain yield was significantly higher with soil test crop response (STCR) based integrated nutrient management module, i.e. 75% NPK of STCR along with FYM at 5 Mg ha^{-1} and followed by integration of 75% NPK + poultry manure at 1 Mg ha^{-1} as compared to recommended fertilizer management practices and 100% STCR based NPK fertilizers (Fig. 2.1.2a). Whereas the integration of NPK fertilizer with urban compost (UC), maize residue (MR) and *Glyricidia* loppings (Gly) did not influence the maize yields as good as FYM and poultry manure based INM modules. The application of 5 tonne farmyard manure in every season to chickpea and residual fertility of 20 t FYM (every season) increased the chickpea yields as compared to residue management (Mulching by maize residues). Increase in grain and straw yield of chickpea might be due to residual fertility effect of organic manures in maize (Fig. 2.1.2b). Application of organic sources of nutrients alone showed significantly lower yields (Plate 2.1.2.).

Table 2.1.2 Treatment details

Designation	Maize	Chickpea
T_1 Control	No Fertilizer/ Manure	No Fertilizer/ Manure
T_2 GRD	120- 60- 30	20-60-20
T_3 RD (STCR)	135-55-50 (Target- 5 t maize)	0-0-0 (1.5 t chickpea)
T4	75% NPK of T3	100% P only
T5	75% NPK of T3 +5 t FYM	100% P only
T6	75% NPK of T3+ 1 t PM	100% P only
T7	75%NPK of T3 + 5 t UC	100% P only
T8	75% NPK of T3 +MR	100% P only+ MR as Mulch
T9	MR +1 t PM+Gly 2 t/ha	100% P only+ MR as Mulch
T10	MR + 5t FYM+Gly 2 t/ha	100% P only+ MR as Mulch
T11	20 t FYM (every season)	5 t FYM (Every Season)
T12	75% NPK of T3 +20 t FYM* (once in 4 years)	100% P only

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

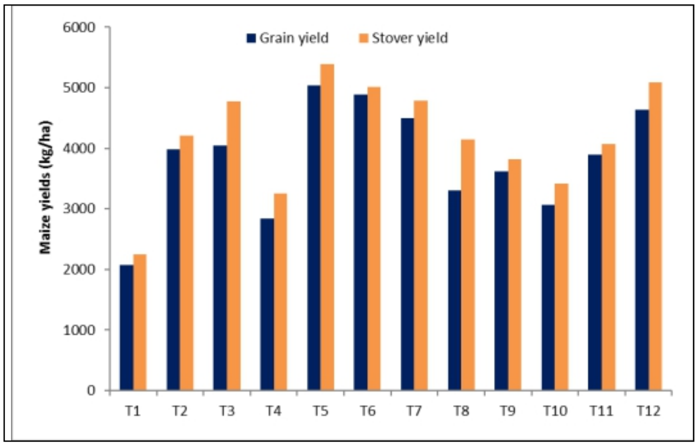


Fig. 2.1.2a Yield performance of maize under different integrated nutrient management modules in maize-chickpea cropping sequence of Vertisols

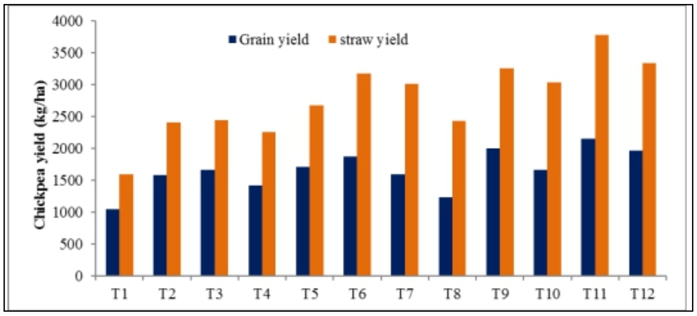


Fig. 2.1.2b Yield performance of chickpea under different residual fertility of different integrated nutrient management modules

Plate 2.1.2 General view of long-term field experiment

2.1.3 Nanoparticle delivery and internalization in plant systems for improving nutrient use efficiency

Information on the impact of nano-micronutrient fertilization using Fe, Cu and Zn nanoparticles (NPs) on growth and metabolism of soybean, rice, wheat and maize plants was analyzed and documented. The responses of crop towards the graded concentrations of NPs viz. Fe, Cu and Zn were evident on morphological, physiological and biochemical characteristics. In soybean, optimal concentration of nano-micronutrient fertilization had 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 had positively influenced root growth and gas exchange parameters viz. photosynthesis rate, transpiration rate and stomatal conductance of plants. In rice, grain number and grain weight were found to be higher with Fe NP, Cu NP and Zn NP treated plants. The gas exchange parameters viz. photosynthesis and transpiration rate was higher with Cu NP and Zn NP treated plants. In wheat, the nano-micronutrients positively influenced most of the morphological parameters while the sub-optimal concentration of NPs had positively influenced biochemical traits viz. proline accumulation, chlorophyll content of plants. Gas exchange parameters were also positively influenced by NPs in wheat. The results indicated that the effect of nanoparticles and its dose was crop specific. It was also observed that nanoparticles at sub-optimal concentration may be useful for the crop and they may act as catalyst for growth and metabolism which can be utilized for higher yield of plants.

2.1.4 Evaluation of glauconite as a source of potassium for crops

The glauconite material was collected from Singrauli district of Madhya Pradesh (Plate 2.1.4). The samples were brought and ground to pass through 2.0 mm, 0.5 mm, 0.25 mm and 0.125 mm size. Different size fractions were analyzed for different fractions of potassium viz., total K, water soluble K, NH_4OAc extractable K, cation exchange capacity, pH and electrical conductivity (Table 2.1.4a,b; Fig. 2.1.4). The total K_2O content in glauconite samples ranged from 7.1 to 12.6%. Irrespective of different extractants, the amount of K release was higher with decreasing size of glauconite. The pH and EC of different glauconite varied from 7.97-8.85 and 0.09-0.26 dS m^{-1}, respectively.

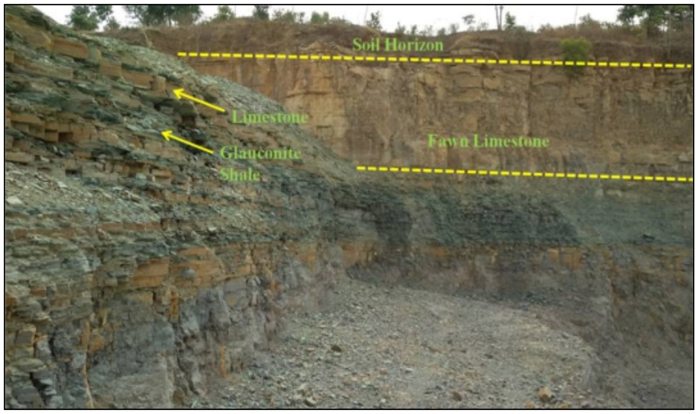


Plate 2.1.4. Exposed view of intercalated glauconite with fawn limestone in Singrauli district of Madhya Pradesh

Table 2.1.4a pH, electrical conductivity and total K_2O content in glauconite mineral

Sample No.	pH	EC (dSm^{-1})	Total K_2O (%)
1.	7.97	0.09	10.2
2.	8.37	0.13	11.1
3.	8.74	0.25	10.8
4.	8.35	0.11	12.6
5.	8.85	0.26	7.1

Table 2.1.4b Amount of K extracted by different extractants from glauconite mineral

Sample No.	1N NH_4OAc K (mg kg^{-1})				Water soluble K (mg kg^{-1})			
	2.0 mm	0.5 mm	0.25 mm	0.125 mm	2.0 mm	0.5 mm	0.25 mm	0.125 mm
1	200.3	201.8	211.3	307.3	24.5	29.3	36.5	48.5
2	210.5	268.8	386.8	662.5	31.5	48.0	50.8	69.0
3	620.0	662.5	681.3	905.0	60.0	75.8	93.0	106.0
4	123.5	159.8	243.0	425.0	23.3	31.8	36.5	94.8
5	216.0	313.5	392.8	781.3	35.0	58.3	75.8	134.3

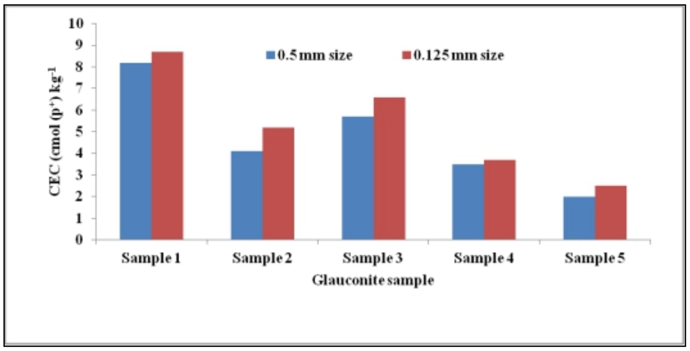


Fig 2.1.4 Cation exchange capacity of different glauconite samples

2.1.5 Evaluation of organic, inorganic and integrated crop management practices on soybean yield

Field experiments were conducted during kharif season of 2018 at research farm of ICAR-Indian Institute of Soil Science. The seed yield of soybean was significantly differed under different nutrient management systems. The highest seed yield of soybean was recorded with 100 % organic treatment followed by 75 % organic + 25 % inorganic and 75 % organic + innovative practices which were higher than 100% inorganic and state recommendation (Fig. 2.1.5).

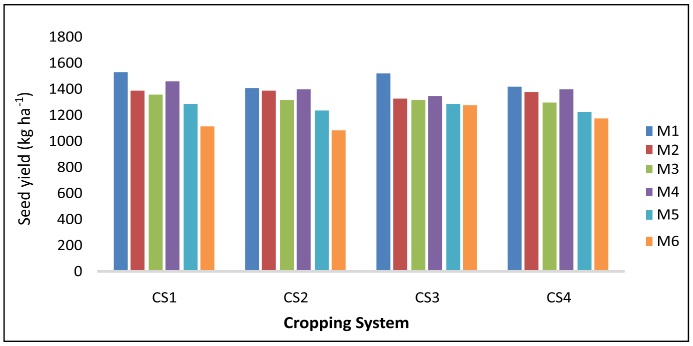


Fig. 2.1.5 Yield of soybean (kg ha^{-1}) under different nutrient management practices (*Kharif 2018*)

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

Management practice: (M1) 100% Organic (Organic manure equivalent to 100% N requirement of the system), (M2) 75% organic (Organic manure equivalent to 75% N requirement of the system) +innovative practices (spray of cow urine and vermi-wash 10% each twice), (M3) 50% Organic + 50% inorganic, (M4) 75% Organic + 25% inorganic, (M5) 100% inorganic package, (M6) State recommendations

2.1.6 Evaluation of response of different varieties of major crops for organic farming

Performance of different varieties of soybean and maize were evaluated for their yield response to screen out promising varieties for organic management practices for central India. Among the 12 varieties of soybean grown under similar organic nutrient source and doses, the cultivar RVS-2002-4 (1363 kg ha^{-1}) out-performed in terms of seed yield followed by RVS-2002-6, JS-20-29, JS -335, JS -20-41 and RVS-2002-7 (Fig. 2.1.6, Plate 2.1.6). Among the maize varieties, yield of Proagro 4212 variety recorded highest yield (3540 kg ha^{-1}) followed by Kanchan, Pratap 5, JM 8, JM 216, Arawali, Pratap 6, CPBG 4202 and lowest yield was recorded in Popcorn.

Plate 2.1.6 Performance of maize and soybean under organic farming

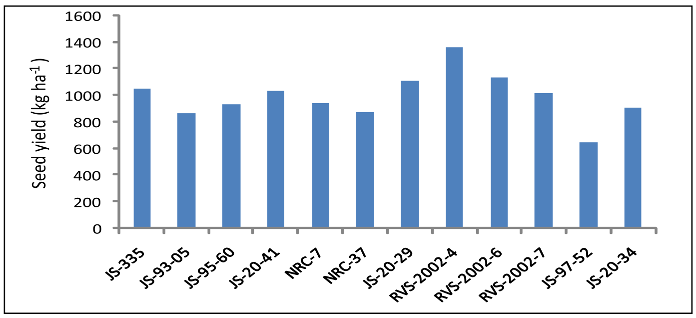


Fig. 2.1.6 Performance evaluation of different varieties of soybean crops under organic practices (*Kharif, 2018*)

2.1.7 Evaluation of weed management practices for maize-mustard production system under organic conditions

Grain yield of maize significantly differed due to different weed management practices under organic production systems in deep black soils. Results revealed that maize grain yield was significantly influenced by non-chemical weed management practices. Incorporation of cotton seed cake + one hand weeding recorded significantly highest grain yield (4313 kg ha^{-1}) followed by intercropping with cowpea treatment, two hand weeding at 25 and 50 DAS, one mechanical weeding at 25 DAS + one hand weeding at 50 DAS as compared to control. However, the weed management practices, weed mulch (water hyacinth 4 t/ha dry biomass one hand pulling at 40 DAS and mulching with dried leaf of mango @ 5t/ha recorded the similar grain yield (Fig. 2.1.7).

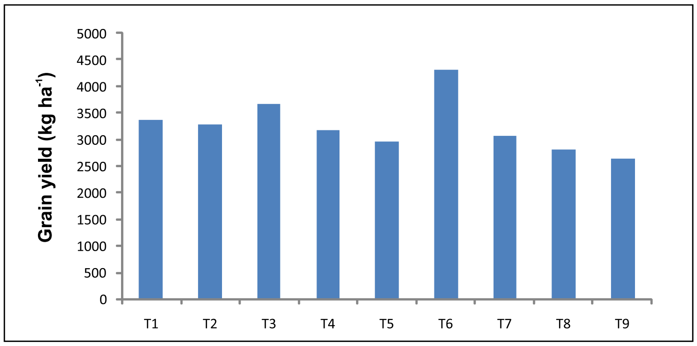


Fig. 2.1.7 Evaluation of weed management practices for maize production under organic conditions (*Kharif, 2018*)

T1: Hand weeding (Two) at 25 and 50 days after sowing,T2: One mechanical weeding at 25 days after sowing + One Hand weeding at 50 days after sowing,T3: Intercropping with Cowpea (1:1), T4: Stale seed bed + reduced spacing (45 × 20 cm) + mulching with mustard straw + one Hand weeding at 40 DAS, T5: Locally available weed mulch (Water hyacinth 4 t/ha dwb) + one hand pulling at 40 DAS,T6: Incorporation of cotton seed cake 15 days before planting/sowing @ 5t/ha + one hand weeding at 40 DAS, T7: Soil solarization with 110 microns polythene mulch during summer + one hand weeding at 40 DAS, T8: ITK treatment on weed control practiced by farmers (mulching with dried leaf of mango @ 5t/ha), T9: Control

2.1.8 Impact Assessment of Neem Coated Urea (NCU) and Soil Health Card (SHC) in Central and Western India

A questionnaire has been prepared to collect primary data comprising the aspects like general information of sampled farmers, socio economic characteristic of sampled farmers, farmer's knowledge about chemical fertilizers/nutrients, advisory aid for purchase of chemical fertilizers, time, place and form of purchase of fertilizers, transportation and storage of fertilizers, application of fertilizers, environmental pollution and fertilizers, subsidies in fertilizers, NCU compared with NU, NCU impact on pest and diseases, farmers income, environment, etc, knowledge about basics of SHC, change in knowledge due to SHC scheme, SHC impact on farmers income and cost of cultivation; before and after SHC and NCU. Also questionnaire to collect information from fertilizer dealers has been formulated.

2.1.9 Effect of slow N release formulations for enhancing productivity and nitrogen use efficiency in cereals

A field experiment was initiated to assess the formulations from M/s Rhodia Speciality Chemical Fertilizer Pvt Ltd.

Table 2.1.9 Effect of different treatments on wheat grain yield, N uptake and N use efficiency

Treatment	N dose (kg ha^{-1}) and source	Grain Yield (kg ha^{-1})	N uptake (kg ha^{-1})	PFP	Agronomic efficiency (kg ha^{-1})
T1	0	2295	37.08	-	-
T2	160 (urea)	4658	94.67	29.1	14.77
T3	160 (NCU)	5216	90.90	32.6	18.26
T4	80 (Urea)	3960	80.40	49.5	20.81
T5	80 (NCU)	4538	85.89	56.7	28.03
T6	80 (urea- 0.2% Ag Rho N protect B)	4523	83.22	56.5	27.85
T7	80 (urea- 0.3% Ag Rho N protect B)	4538	76.69	56.7	28.03
T8	80 (urea- 0.2% Ag Rho NN protect B)	4575	81.37	57.2	28.50
T9	80 (urea- 0.3% Ag Rho NN protect B)	4599	88.67	57.5	28.81
T10	120 (Urea)	5078	92.58	42.3	23.19
T11	120 (NCU)	5160	101.67	43.0	23.87
T12	120 (urea- 0.2% Ag Rho N protect B)	5108	88.58	42.6	23.44
T13	120 (urea- 0.3% Ag Rho N protect B)	5198	101.45	43.3	24.19
T14	120 (urea- 0.2% Ag Rho NN protect B)	5103	87.61	42.5	23.40
T15	120 (urea- 0.3% Ag Rho NN protect B)	5133	108.65	42.8	23.65
	LSD (p=0.05)	*206*	*29.95*		

The experiment consisted of 15 treatment combinations involving two N levels, two formulations and a control. The assessment of the products on wheat crop was carried out. The highest grain yield of wheat @ 120 kg N ha^{-1} was recorded with application of 0.3% Ag Rho NN protect B (Table 2.1.9). The response of Ag Rho N or NN protect B was not significant in wheat productivity as NCU and all other combinations of the Ag Rho were statistically at par with each other. A similar trend was observed with respect to straw yield of wheat which varied between 2773 and 6132 kg ha^{-1} (Plate 2.1.9).

Plate 2.1.9. Performance of wheat with N and NN protect B

The study revealed that the effect of these formulations was clear on maize crop but in wheat crop the increase in grain yield as well as nutrient uptake was not significant. Also, the formulations were found to be almost at par with NCU with respect to grain yield as well as nitrogen uptake. However, such studies need to be conducted for more years to arrive at certain conclusion. Overall, from the one year data, it may be inferred that the formulation assessed may enhance maize crop yield and nutrient use efficiency over normal urea but seems almost at par with that of NCU.

2.1.10 Spatial variability of some soil properties in soybean-wheat belt of Central India.

Soil properties vary across landscapes, regions and even within farm fields, causing spatial variability in crop yields. However, this variation is not adequately considered in traditional soil survey and mapping technique. Therefore, a study was undertaken to quantify the soil spatial variability in soybean- wheat belts of central India to prescribe site-specific requirements of specific soils and crops. A total 280-georeferenced soil samples were collected after harvesting of wheat crop. These soil samples were analysed for various soil physical and chemical properties and mapped for their spatial variability (Fig. 2.1.10). The best-fit models for measured soil properties were exponential for clay and field capacity, spherical for pH and EC, and circular for SOC with lack of spatial dependence to strong spatial dependency. Spatial distribution map indicated that most of soil in study region are non-saline (EC < 4 ds/m), alkaline and falls under the category of clayey soil having clay more than 30%. The field capacity of soil ranged from 30% to 40%, and SOC content was 0.6% to 0.7% in most part of study region. The nugget to sill ratios of semi-variograms for EC and clay were lower than 25%, which indicates strong spatial dependence in the study area. The nugget/sill ratios of semi-variograms for pH and field capacity were between 25% and 75%, which reveals moderate spatial dependence. The SOC content showed the weak spatial dependency with 88% of nugget to sill ratio. The strong spatial dependency primarily results from intrinsic factors, whereas moderate to weak spatial dependence indicates some contribution of anthropogenic factors such as soil tillage, fertilizer application and irrigation on variability of a soil property.

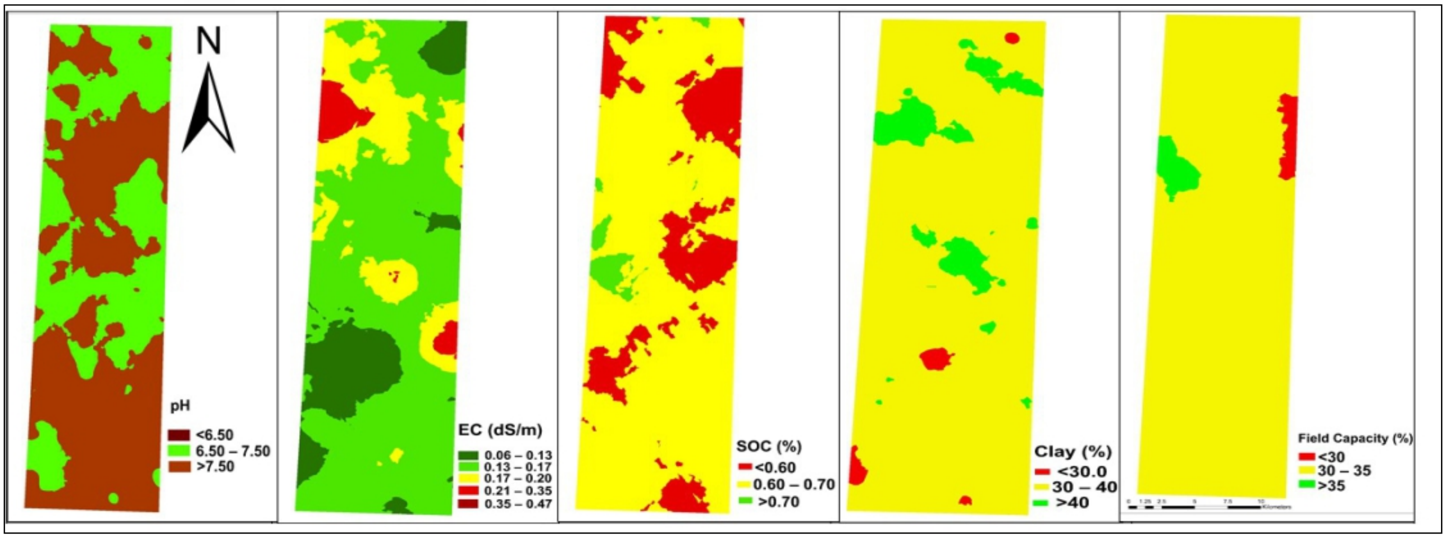


Fig. 2.1.10 Spatial distribution map of SOC, EC, Clay, Field capacity and pH in soybean- wheat belt of central India.

2.1.11 Diagnosing leaf nitrogen content in wheat using hyperspectral remote sensing

Hyperspectral remote sensing is a rapid and non-destructive method for diagnosing nitrogen status in wheat crops. In this study, wheat hyperspectral data at different phonological stages were collected from the long-term fertilizer experiment at Jabalpur. Owing to different nitrogen treatment, leaf chlorophyll content varied greatly among imposed treatments. As spectral reflectance is inversely

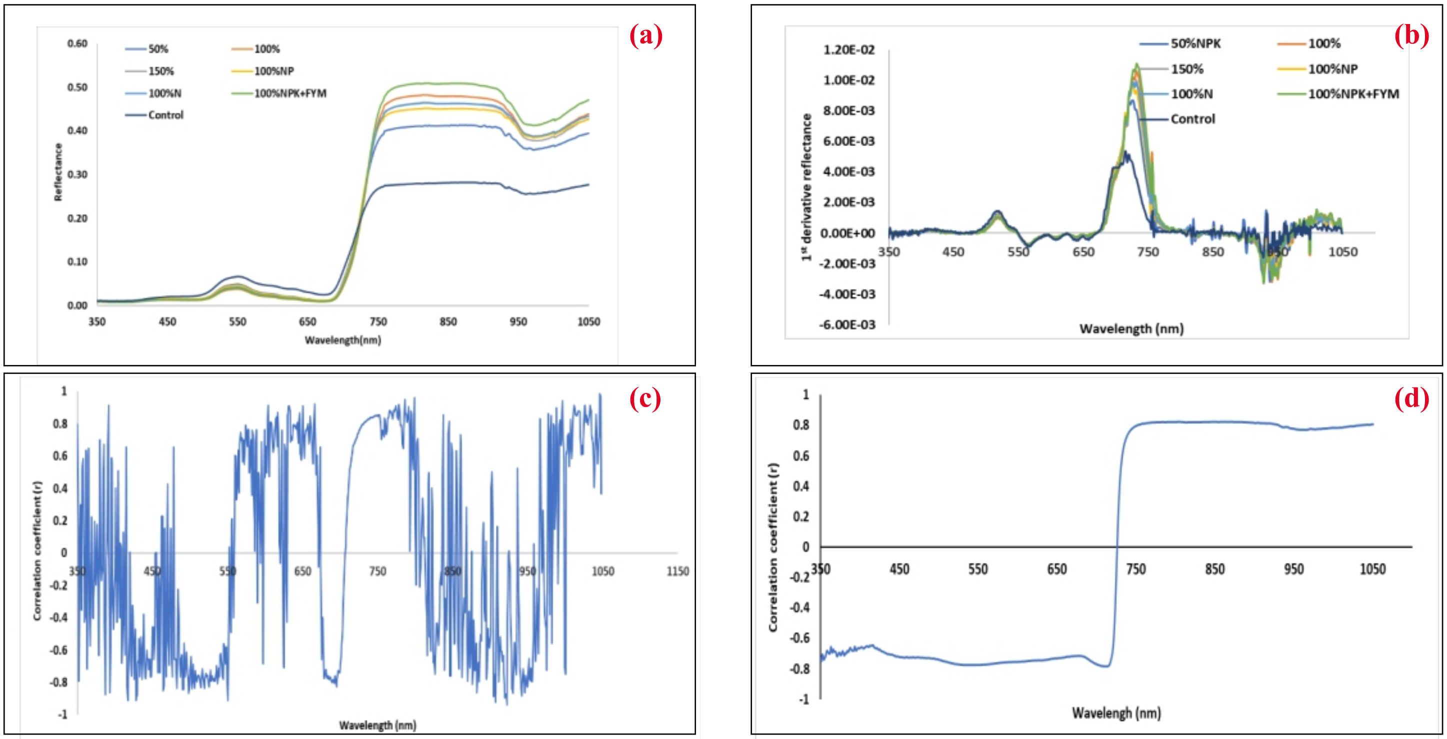
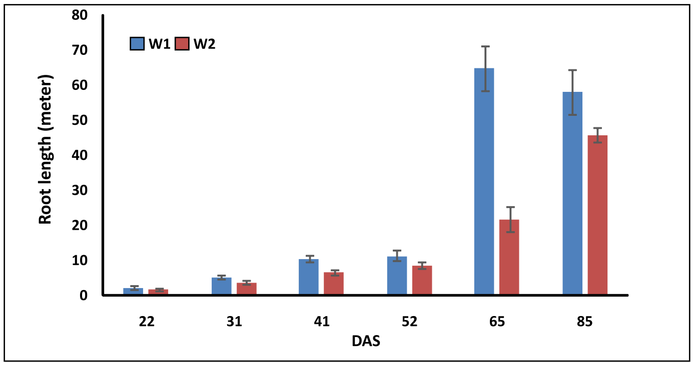


Fig. 2.1.11 (a) Raw hyperspectral (b) first derivative of raw hyperspectral (c) correlation coefficient between raw hyperspectral reflectance and wheat leaf nitrogen treatments (d) correlation coefficient between first-order hyperspectral reflectance and wheat leaf nitrogen treatments

related to leaf chlorophyll content in visible region (400-700 nm), higher and lower reflectance were observed in control and NPK+FYM treatments, respectively and vice versa in near infra-red region (700- 1050 nm). The internal structure of leaf primarily controls the reflectance in the near infrared region. Further, a quantitative correlation with following parameters: wheat leaf nitrogen content, raw hyperspectral reflectance, and first-order differential hyperspectral reflectance was established. In this study, higher correlation coefficient was obtained in near-infra-red region i.e. 750-850 nm, which indicates that these bands are most appropriate to estimate nitrogen content in wheat crop.

2.1.12 Root length and root length density of wheat crop under different water and nitrogen treatments.

Root length density, the length of roots per unit volume of soil, is one of the important parameters required to understand plant performance under different abiotic stresses. A better knowledge of the root distribution within soil profile is necessary to ascertain their effect on water and nutrient uptake by plants. The results of effect of different water and nitrogen treatments on root length and root length density is presented in Fig. 2.1.12 a, b. The results of ANOVA indicated that drought induced significant reduction in total root length over the wheat growth period. Highest reduction in root length under the drought stress was observed at 65 DAS followed by 85 DAS. The reduction in root length was 66% and 21% at 65 DAS and 85 DAS, respectively. Further, root length density was calculated by the total root length observed at particular date of sampling divide by volume of plastic bag used for crop growth. It is observed that water and nitrogen treatment significantly affect root length density throughout the growing period of wheat except 10 DAS. Under the well-watered situation, highest root length density was observed at 65 DAS after that decrease in root length density was observed, whereas in drought situation, maximum root length density was observed at 85 DAS. Overall, highest root length density (1.53 cm/cc) was observed under the W1N1 at 65 DAS.



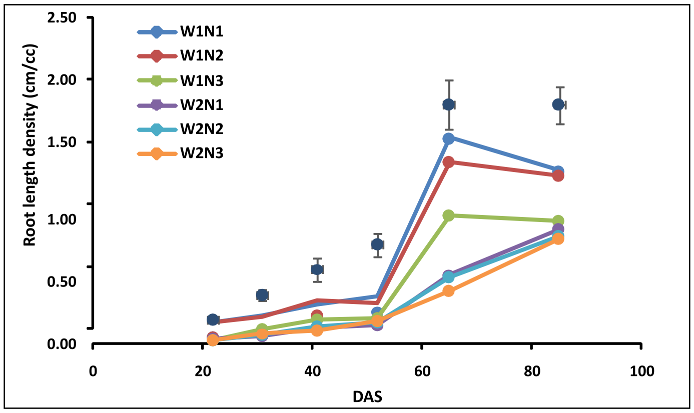
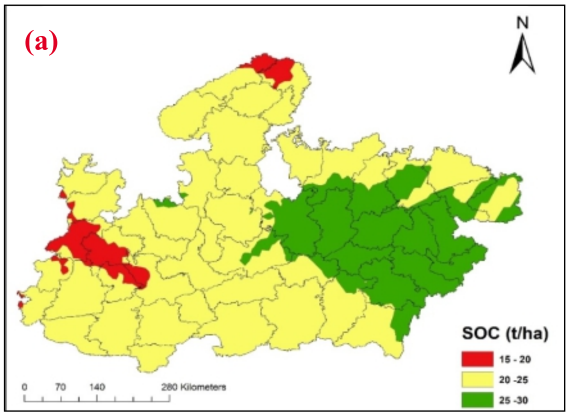


Fig. 2.1.12 The effect of water and nitrogen treatments on (a) Root length (average over nitrogen content), (b) Root length density. W1N1-85% field capacity+100% nitrogen, W1N2-85% field capacity+75% nitrogen, W1N3-85% field capacity+50% nitrogen, W2N1-55% field capacity+100% nitrogen, W2N2-55% field capacity+75% nitrogen, W2N3-55% field capacity+50% nitrogen.

2.1.13 Estimation of equilibrium soil organic carbon content in Vertisols and associated soils of Madhya Pradesh

Soil organic carbon (SOC) is regulated by climate and soil propertie such as clay content. In addition, land use and management practices are important factors influencing SOC contents and turnover within homogenous soil regions. A calibrated and validated APSIM crop model was used to



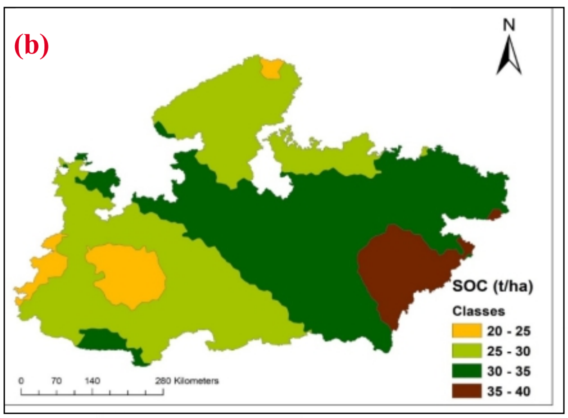


Fig. 2.1.13 Equilibrium soil organic carbon content in Maize–Chickpea cropping system under (a) general recommended dose of NPK and (b) NPK+ FYM @ 5 t/ha

estimate equilibrium soil organic carbon stock in top 30 cm of Vertisols and associated soils of Madhya Pradesh. Results indicated that equilibrium SOC content under the 100% NPK and 100% NPK+5t ha^{-1} FYM ranged from 15-30 t ha^{-1} and 20-40 t ha^{-1}, respectively. Continuous use of 100% NPK + 5 t ha^{-1} FYM over time will boost the SOC stocks over central India. Overall, under the 100% NPK, 0.32, 0.17, 0.058, and 0.048 Pg carbon were sequestrated in deep black soil, mixed red-black soil, alluvial soil, and shallow soils, respectively. Whereas, under the 100% NPK+ 5 t ha^{-1}, 0.44, 0.213, 0.071, and 0.077 Pg carbon were sequestrated in deep black soil, mixed red-black soil, alluvial soil, and shallow soils, respectively.

2.1.14 Development of soil spectral database for Raisen district of Madhya Pradesh:

A better technique is the need of the hour for rapid assessment of soil health and soil classification, one of which is the use of applications of remote sensing techniques. The use of ground-based sensors to obtain soil spectral data has enabled the characterization of these data and the advancement of techniques for the quantification of soil attributes. In order to do this, the creation of a soil spectral database/library is inevitable. A spectral library should be representative of the variability of the soils in a region. To build the soil spectral database, geo-referenced soil samples from 280 locations were collected from Raisen district of Madhya Pradesh. The soil samples were analysed for pH, EC, particle size, SOC, available phosphorous and available potassium. The spectral data were also obtained in the laboratory with the Field Spec Pro: Analytical Spectral Devices, Boulder, Colorado spectroradiometer using 350-2,500 nm wavelengths. For the reflectance data collection, the soil samples were air-dried, ground, processed through a sieve (2 mm mesh) and placed in Petri dishes. The reflectance of each sample was calculated by taking the average of 30 scans performed by the sensor. The spectral reflectance graph along with attached soil attributes of each sample can be seen by selecting the point on the map given below (Figure 5).

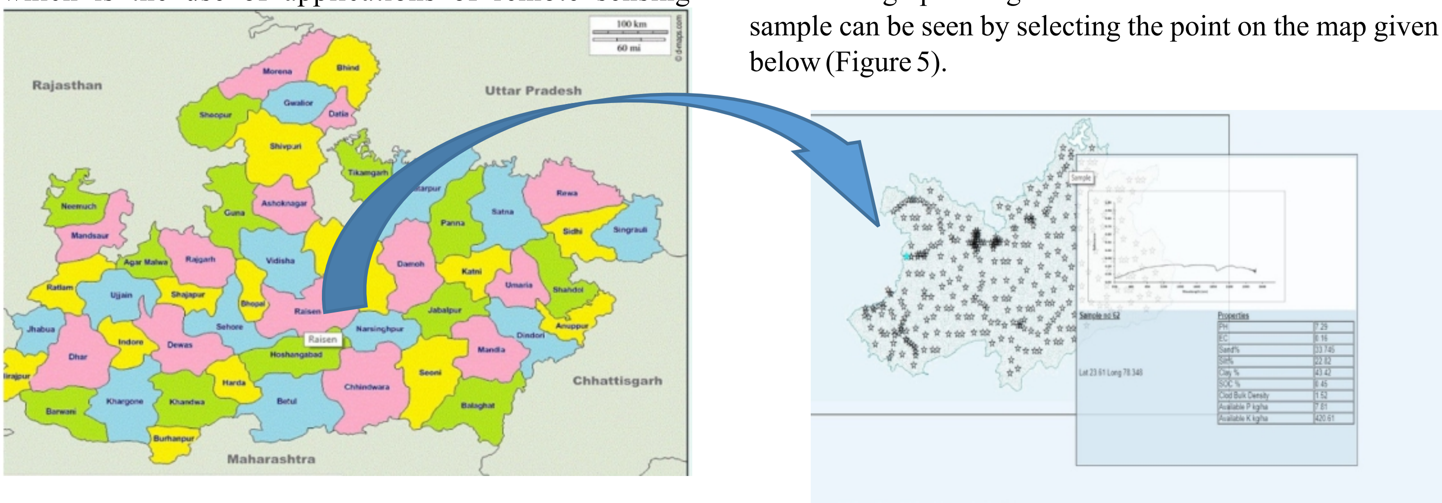


Fig. 2.1.14 Snapshot of spectral database built for Raisen district pf Madhya Pradesh.

2.1.15 Estimation of properties of Alfisols using Mid-Infrared Spectroscopy

Across time, man has used different methods for soil evaluation and quantification of the elements found in soil. This has generally been done through field evaluations and laboratory analysis of soils in order to know and evaluate the quality of the soil, its capability to supply nutrients and water to plants for their potential growth. Diffuse reflectance spectroscopy is a method that can be used to support this conventional methods of soil analysis. Mid infrared reflectance (MIR) spectroscopy has shown great potential for fast, accurate and cheap soil analysis with particular application in the field where high spatial density is needed. However, MIR spectra need calibration and validation with the laboratory analyzed data for development of prediction models for different soil properties which will be applicable for a soil type. An attempt was made to develop chemometric models for prediction of some important properties of Alfisols. Validation of the models was carried out to identify soil properties that can be measured through these techniques with reasonable accuracy. Physical and chemical properties namely, soil organic carbon, available P and K content, EC, pH, sand, silt and clay content of the soil samples collected from Orissa and Jharkhand were estimated through standard laboratory methodology and soil spectra in the mid-infrared region (2500-25000 nm range) of all 360 soil samples were recorded using the alpha-MIR Spectrometer (Fig. 2.1.15a) for development of models. The scattergram depicting range, frequency, mean and median of soil properties are presented in Fig. 2.1.15b. Partial least square regression method was used for development of prediction models for various soil properties. About 80% soil samples were used for model development and 20% samples were used for validation of models. The validation of the model showed that the predictability as expressed through co-efficient of determination (R^2), root mean square error (RMSE), Mean Absolute Errors (MAE) varied markedly among the different soil properties tested. The models developed could predict reasonably well the SOC concentration and pH of the soil. Particle size distribution (Sand, Clay and Silt) also showed good calibrations with small root mean square error (RMSE)/ mean absolute errors (MAE) of below 5% and high r-squared value (R^2>0.7) for the validation set. The MIR spectroscopy techniques showed great potential for estimation of soil organic carbon, soil particle size distribution and pH for the Alfisols.

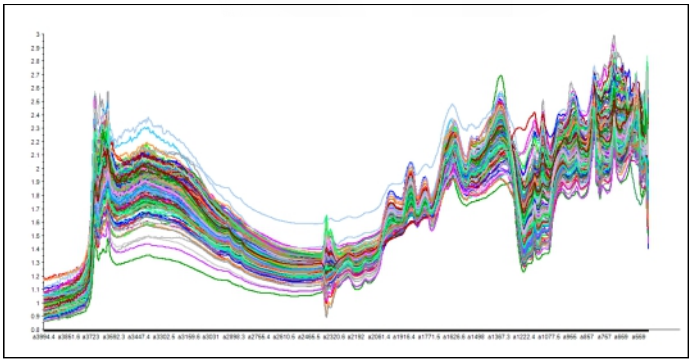


Fig. 2.1.15a MIR Spectra of soil samples from Odisha recorded using alpha-FT-MIR spectrometer

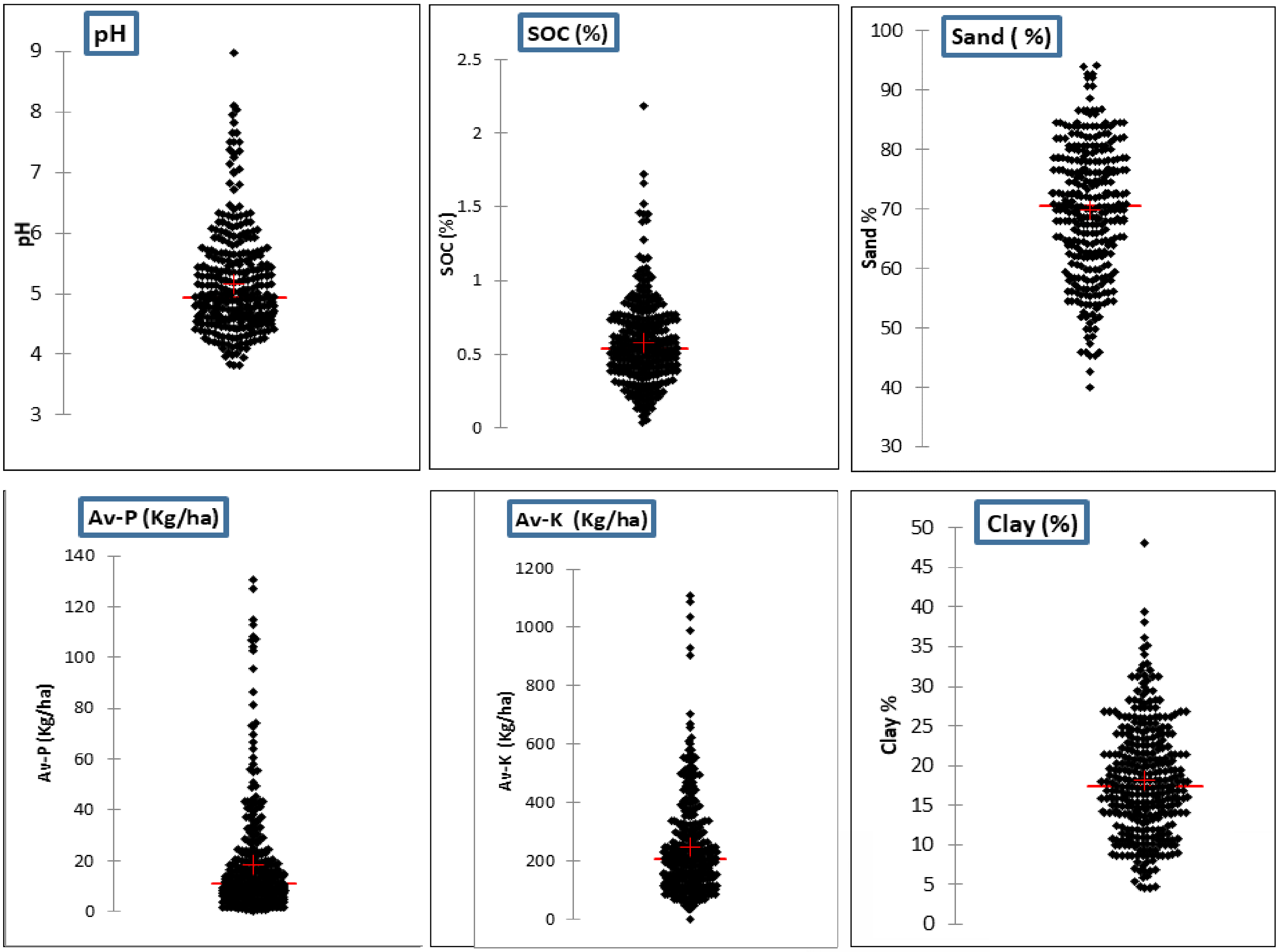


Fig. 2.1.15b Scattergram of soil properties of samples collected from the Alfisols regions of Odisha and Jharkhand.

2.1.16 Enhancing the productivity of major crops through improving the natural resource base of tribal inhabited areas of Madhya Pradesh

A pilot survey was carried out in eight villages of Balaghat district to identify the villages that are predominantly inhabited by tribal population. Three villages, *Kaweli, Kulpa,* and *Sarra* were identified to implement the project activities. These villages located at a distance of 29 km, 32 km and 40 km from Balaghat district head quarter and 10-15 km inside the forest where public or private transportation services are not available. Surveys were carried out in the three villages during the *kharif* and *rabi* seasons of 2018-19 to document the indigenous agricultural practices in soil and water management, use of traditional farm implements for soil and water management in their farmlands. Tribal farmers of these villages are practicing settled agriculture in the land demarcated for agriculture by the forest department inside the forestland. Rice is grown as rainfed crop in their farmlands. Rice-fallow is the dominant cropping system but some farmers have a short duration pulses and oilseed crops utilizing the residual soil moisture after the harvest of the kharif rice. Major indigenous technologies that are in practice among the tribal farmers are; growing crops on raised earthen beds in the homestead gardens, terracing of undulated land for farming (Plate 2.1.16a), fragmentation of farm fields into small units, construction of grassy field bunds with water outflow system, deep summer ploughing using wooden plough, construction of water harvesting ponds in lower hill slopes and lining of sides of the pond with stones to prevent water loss through seepage (Plate 2.1.16b), allowing cattle grazing in farm fields, manuring of farm fields using farmyard manure and wood ash, and application of pond soil in farm fields. Tribal farmers use hybrid seeds and the yield of rice crop in tribal farmlands is ranged between 2.5-3 tonnes per hectare. As a part of agro-ecosystem sustainability analysis soil samples were collected from the three villages from nine locations at first stage for the analysis of physical, chemical and biological properties.

Plate 2.1.16a Terracing of undulated farmland

Plate 2.1.16b Strengthening pond sides with stones

2.2 AICRP on Long Term Fertilizer Experiments (LTFE)

2.2.1 Impact of Nutrient Management on Soil Physical Properties under Long Term Fertilizer Experiments in India

Physical condition of soil plays an important role in water holding capacity, water movement and storage and root growth. These properties also influence the chemical and biological phenomena. Since transformation of nutrient and chemical process are governed by physical condition of soil hence it is more important from soil health point of view. Physical properties of soil do not change in short time through management practices and hence not estimated on regular basis. After doing experiment continuously for a sufficient time for 20-25 years or more, physical properties were estimated and the details are described.

Mollisols - Pantnagar

Data generated on different soil physical properties (Table 2.2.1a & Fig. 2.2.1a,b) after 40 years revealed that application of balanced chemical fertilizer resulted decline in bulk density. Incorporation of FYM further reduced the bulk density (BD) of soil. Data on mean weight diameter (MWD), hydraulic conductivity and water stable aggregate followed the trend reverse to bulk density. These soil physical properties are interdependent. Increase in soil aggregates on fertilizer application increases the proportion of large pore size which increase the pore spaces and flow of water which is responsible decline in bulk density. Increase in bulk density and decline in other associated properties is due to reduction in soil organic carbon from 1.48 to 0.56 per cent in control plot.

Table 2.2.1a Effect of inorganic fertilizer and manure on physical properties of soil

Treatments	Bulk density (Mg m^{-3})	MWD (mm)	Penetration resistance (kg cm^{-2})	Hydraulic conductivity (cm hr^{-1})	Water stable aggregates (%) (> 0.25 mm)	Water holding capacity (%)
Control	1.41	0.55	3.54	0.63	20.84	21.84
100% NPK- Zn	1.36	0.70	3.32	0.78	52.10	45.10
150% NPK	1.32	0.71	3.36	0.75	50.40	46.40
100% NPK+Zn	1.31	0.78	3.16	0.86	54.10	50.10
100% NPK+FYM	1.29	1.07	2.42	0.95	59.24	56.20
LSD (0.05)	0.035	0.042	0.073	0.09	4.53	4.53

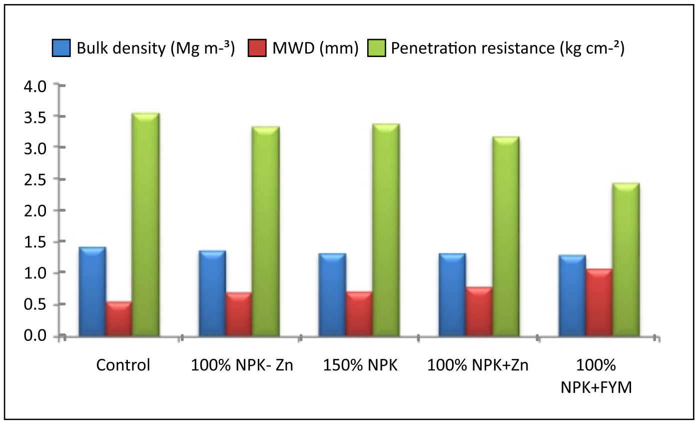


Fig. 2.2.1a Effect of inorganic fertilizer and manure on physical properties of soil (LTFE at Pantnagar)

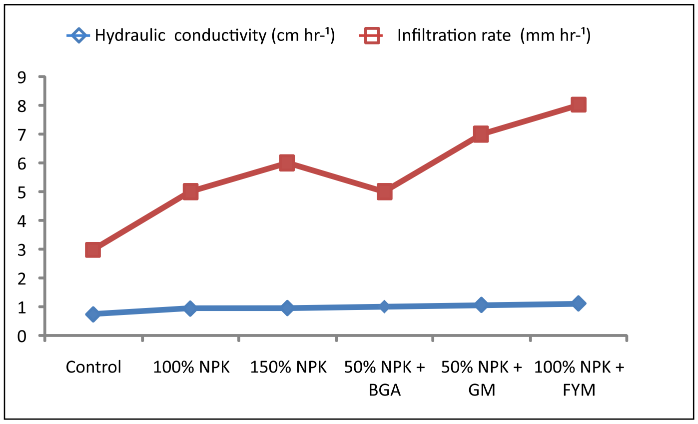


Fig. 2.2.1b Long-term impact of integrated nutrient management on hydraulic properties and infiltration rate of soil (LTFE at Pantnagar)

Vertisols - Raipur

Data (Table 2.2.1b) revealed that application of fertilizer resulted increase in hydraulic conductivity, infiltration rate and reduced crack volume. Addition of FYM and blue green algae (BGA) further made improvement in these properties.

Increase in proportion of bigger size aggregates (Table 2.2.1c & Fig.2.2.1c) on application of balanced nutrient is due to increase in soil organic carbon which is responsible for all water transmission properties. However,

Table 2.2.1b Long- term impact of integrated nutrient management on hydraulic properties and cracking pattern of soil

Treatments	Hydraulic conductivity (cm hr^{-1})	Infiltration rate (mm hr^{-1})	Cumulative infiltration (mm)	Crack volume (cm^3 m^{-2})
Control	0.73	3	443	1407.36
100% NPK	0.93	5	536	847.80
150% NPK	0.95	6	543	918.19
50% NPK + BGA	1.00	5	625	806.80
50% NPK + GM	1.06	7	578	747.53
100% NPK + FYM	1.11	8	694	625.73
LSD ($P < 0.05$)	0.12	0.68	53.99	150.0

incorporation of FYM and BGA had more conspicuous effect on soil aggregates. It means application of nutrients with and without organic matter resulted in improvement of soil physical condition. Increase in porosity and decline in bulk density (Table 2.2.1d) also support the observations recorded.

From the results it is inferred that there is no adverse effect of fertilizer nutrient on physical properties of soil rather there was an improvement in physical condition of soil which is conductive for plant growth, moisture retention and plant available water .

Table 2.2.1c. Percent water stable aggregates and mean weight diameter under different treatments after harvest of rice.

Treatments	>2 mm	2-1 mm	1-0.5 mm	0.5-0.25 mm	<0.25 mm	MWD (mm)
Control	4.70	63.06	19.97	7.68	4.55	1.302
100% NPK	22.03	44.63	22.51	8.57	2.22	1.626
150% NPK	32.10	46.48	11.48	7.51	2.24	1.924
50% NPK+BGA	31.54	51.51	8.71	7.38	0.82	1.963
50% NPK+GM	37.11	49.84	5.33	4.45	3.22	2.093
100% NPK+FYM	48.56	16.05	6.76	16.77	11.77	2.051
LSD (*P*<0.05)	5.72 (S)	7.76 (S)	4.59 (S)	4.86 (S)	3.53 (S)	0.15 (S)

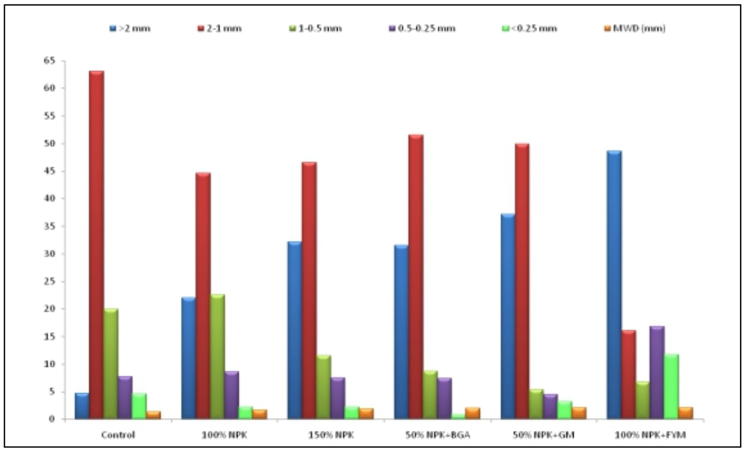


Fig. 2.2.1c. Percent water stable aggregates and mean weight diameter under different treatments after harvest of rice

Table 2.2.1d Effect of long term fertilizer and manure application on physical properties of soil

Treatments	BD ($Mg\ m^{-3}$)	Total porosity (%)	HC ($cm\ hr^{-1}$)	Moisture content (%)	WHC (%)
Control	1.45	46.63	0.79	21.51	37.86
100% N	1.42	46.8	0.8	20.11	40.29
100% NP	1.41	46.84	0.8	22.47	43.36
50% NPK	1.41	48.93	0.91	23.93	45.06
100% NPK	1.4	47.37	0.91	23.49	46.25
150% NPK	1.41	47.47	0.93	25.62	46.66
100% NPK + Zn	1.41	47.29	0.87	25.58	44.63
50% NPK + BGA	1.37	49.11	0.88	23.19	45.93
50% NPK + GM	1.35	49.72	0.94	26.11	48.10
100% NPK+ FYM	1.36	49.67	0.96	30.17	50.59
LSD (*P*<0.05)	0.03	1.28	0.051	3.709	3.939

Vertisols - Parbhani

Data presented in Table 2.2.1e indicated that application of fertilizer resulted decline in BD compared to fallow and control but was statistically at par. However, decline in bulk density on application of FYM continuously for 25 years is statistically significant probably due to addition of more organic carbon through FYM and biomass through higher yield. Perusal of data further revealed increase in infiltration rate and porosity but reverse in case of B.D. This means declines in bulk density led to increase in porosity and water infiltration rate.

Table 2.2.1e Effect of organic manures and inorganic fertilizers on physical properties of soil after harvest of experimentation at Parbhani

Treatments	Bulk density ($Mg\ m^{-3}$)	Porosity (%)	Infiltration rate ($cm\ hr^{-1}$)
Control	1.31	51.80	1.63
100% NP	1.28	56.50	1.68
100% NPK	1.28	56.75	1.73
150% NPK	1.27	60.25	1.89
100% NPK+FYM @ 5 t/ha	1.21	62.00	1.96
LSD ($P<0.05$)	0.03	1.64	0.094
Initial	1.31	51.00	1.68

Vertisols -Akola

Data generated on bulk density and hydraulic conductivity indicated that application of nutrients in balanced and integrated manner resulted decline in bulk density (Table 2.2.1f). But the reverse was noted in respect of hydraulic conductivity. Decline in bulk density on application of nutrient is due to increase in pore space as a results of aggregation and addition of larger residual biomass to soil. This resulted in an increase in hydraulic conductivity on application of nutrients in balance manner.

Table 2.2.1f Soil physical properties after harvest of wheat

Treatments	Bulk density ($Mg\ m^{-3}$)	Hydraulic conductivity ($cm\ hr^{-1}$)
Control	1.55	0.29
100% N	1.54	0.32
100% NP	1.48	0.38
100% NPK	1.41	0.46
150% NPK	1.34	0.60
100% NPK + Zn @ 2.5 kg ha^{-1}	1.36	0.58
100% NPK + FYM @ 5 t ha^{-1}	1.30	0.73
100% NPK + 37.5 kg S ha^{-1}	1.36	0.58
LSD ($P<0.05$)	0.097	0.084

Inceptisols - Bhubaneshwar

Perusal of data on physical attributes of soil as influenced by nutrient management indicated that application of nutrient resulted increase in proportion of larger size aggregates, hydraulic conductivity and water holding capacity (Table 2.2.1g). But the reverse was noted in case of bulk density. Increase in bigger size aggregates is due to incorporation of residual biomass in larger quantity every year which resulted in binding of small aggregates together to form bigger aggregates. The bigger size aggregate led to increase in pore space and water holding capacity and on the contrary, reduced the bulk density. Thus, balance nutrient application improved the physical condition of soil.

Table 2.2.1g Effect of nine years of long term manuring on physical properties

Treatments	Water stable aggregates (%)		Bulk density (Mg m^{-3})	Hydraulic conductivity (cm hr^{-1})	Water holding capacity (%)
	(<53 µm)	(> 253 µm)			
Control	1.45	4.95	1.41	1.44	34.87
100% NPK	1.68	4.97	1.35	1.55	40.67
150% NPK	1.36	5.69	1.34	1.57	42.65
100% NPK + Zn	1.61	5.14	1.37	1.55	39.72
100% NPK + FYM	1.81	5.67	1.28	1.69	52.38
100% NPK + B + Zn	1.53	5.22	1.35	1.58	40.66
100% NPK + S + Zn	1.46	5.10	1.38	1.53	40.12
LSD (0.05)	0.34	0.53	0.03	0.10	3.52
Initial			1.55	1.52	42.2

Inceptisols -Jagtial

Perusal of data (Table 2.2.1h) on physical properties estimated after 23 years of experimentation indicated that application of fertilizer nutrients resulted in increase in available water content, infiltration rate and hydraulic conductivity, gravimetric soil moisture content compared to control. Addition of organic manure (FYM) over and above NPK resulted in further improvement of these properties. Decline in bulk density on application of fertilizer nutrients is due to increase in soil carbon which encourages forming bigger clods and creating more voids in soil for water storage.

The results on aggregates analysis (Table 2.2.1i) clearly demonstrated that application of fertilizer nutrient resulted

Table 2.2.1h. Effect of long term fertilizer and manure application on physical properties of post–harvest soils of rice

Treatments	BD (Mg m^{-3})	Porosity (%)	Available water content	Infiltration rate (mm hr^{-1})	Hydraulic conductivity (cm hr^{-1})	Water holding capacity	Gravimetric moisture content (%)
Control	1.49	44.19	15.87	5.60	0.244	36.74	18.14
100% NP	1.45	45.38	19.42	6.70	0.269	37.13	20.19
100% NPK	1.44	45.64	19.80	6.65	0.277	37.67	20.80
150% NPK	1.42	46.20	19.93	7.35	0.286	38.57	20.56
100% NPK + FYM	1.39	46.65	21.22	9.10	0.316	42.41	23.99
CD (P<0.05)	0.06	NS	3.31	0.67	0.027	1.76	3.87

Table 2.2.1i Effect of long term fertilizer and manure application on percentage water stable aggregates of post-harvest soils of rice at Jagtial

Treatment	> 2000 µm	2000 -1000 µm	1000-500 µm	500-250 µm	250-100 µm	Total	WSA	MWD
Control	8.4	48.9	6.7	4.7	4.43	68.75	73.18	1.34
100% N	12.5	58.8	4.0	3.4	2.42	78.59	81.01	1.45
100% NP	19.1	46.2	5.3	3.6	5.60	74.11	79.71	1.43
100% NPK	18.0	39.2	8.8	7.0	4.02	72.94	76.96	1.36
150% NPK	24.4	40.9	8.6	6.9	3.97	80.89	84.86	1.41
100% NPK + Zn	23.1	43.2	6.8	5.7	3.67	78.70	82.37	1.44
100% NPK + FYM	38.6	30.0	12.2	6.4	2.97	87.12	90.09	1.49
LSD (P<0.05)	3.27	3.51	1.17	0.61	0.80	5.93	6.00	0.09

WSA= water stable aggregates; MWD= mean weight diameter increase in proportion of all size of water stable aggregates compared to control. Increase in proportion of aggregate increased with increase in nutrient dose from 50 to 150% NPK. The values on different aggregate size fertilizer increased on addition of FYM. Increase in aggregate size is due to addition of more carbon through residual biomass. Increase in mean weight diameter (MWD) of the aggregate supports the results obtained on water transmission and storage in soil.

Alfisols - Pattambi

Perusal of data revealed that application of FYM and fertilizer both resulted in reduction of bulk density (BD) of soil but magnitude of reduction was more on incorporation of FYM along with fertilizer (Table 2.2.1j). Data further indicated that there was an increase in porosity and water holding capacity on increase in dose of fertilizer upto 150% NPK. Incorporation of green manure in situ also shown favorable effect on soil physical properties.

Table 2.2.1j. Soil physical properties at Pattambi

Treatments	Bulk density ($Mg\ m^{-3}$)	Water holding capacity (%)	Porosity (%)
Control	1.35	34.75	41.42
100% NP	1.26	34.76	43.55
100% NPK	1.24	34.20	44.95
150% NPK	1.22	35.99	44.79
100% NPK+ lime	1.23	35.17	43.90
100% NPK+ GM	1.20	36.97	45.63
100% NPK+ FYM	1.17	40.89	49.25

Thus, long term fertilizer experiments clearly demonstrated that application of fertilizer in balanced form resulted improvement in soil physical condition of soil which is essential for the growth of soil microorganism, root growth and water storage.

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

2.3.1 Assessment of micronutrient deficiency in different soils of India

Analysis of more than 2.0 lakhs soil samples revealed wide spread micronutrients deficiency in soils. On an average, 36.5, 12.8, 4.2, 7.1 and 23.2% soils are deficient in Zn, Fe, Cu, Mn and B, respectively. The concentration of available Zn, Fe, Mn, Cu and B in different soils of the country varied widely (Table 2.3.1). The available Zn concentration varied from trace to 45.4 mg kg^{-1} in different soil types. The mean values of available Zn concentration varied from 0.40 mg kg-1 (desert soils-lithosolic) to 2.4 mg kg^{-1} (glacier and eternal snow and sub-montane soils). The per cent sample deficient in available Zn was recorded highest in desert soils-lithosolic (86.3%) followed by skeletal soils (63.2%), desert soils-rhegosolic (54.0%), medium black soils (39.4%), mixed red and black soils (36.2%) and so on. The values of available Fe in different soils varied from 0.01 to 964 mg kg^{-1}. The highest mean value of 69.8 mg kg^{-1} was recorded in laterite soils whereas the lowest value of 7.0 mg kg^{-1} was recorded in desert soils-rhegosolic. The per cent sample deficient in available Fe followed the order: desert soils- lithosolic> desert soils-rhegosolic> grey brown soils > old alluvial soils > calcareous sierozemic soils > skeletal soils > medium black soils and so on. The concentration of available Mn in different soils ranged from 0.01 to 445 mg kg^{-1}. The lowest and the highest mean value of available Mn concentration were recorded in desert soils-lithosolic (4.70 mg kg^{-1}) and deltaic alluvium (32.6 mg kg^{-1}) respectively. Like available Zn and Fe, the highest per cent sample deficient in available Mn was obtained in desert soils-lithosolic (37.8%). Different soils had traces to 136 mg kg^{-1} of available Cu concentration. The mean values of available Cu concentration varied from 0.40 to 3.90 mg kg^{-1}. The per cent sample deficient in available Cu was higher in desert soils followed by old alluvial soils, calcareous sierozemic soils and so on. The different soils varied widely with respect to available B concentration. The available B concentration ranged from 0.01 to 170 mg kg^{-1} with mean values spanning from 0.54 mg kg^{-1} (sub-montane soils) to 12.9 mg kg^{-1} (deltaic alluvium). Higher values of per cent sample deficient in available B were recorded in grey brown soils (46.3%), sub-montane soils (33.7%), desert soils-rhegosolic

(24.7%), calcareous alluvial soils (24.4%) and red sandy soils (22.8%). Whereas, skeletal soils, desert soils-lithosolic and old alluvial soils had lower per cent sample deficient values. The wide variation in the available micronutrient concentrations in different soils is owing to variation in soil parent material, prevailing climatic condition and soil management practices.

Table 2.3.1 Available micronutrient (mg kg^{-1}) status and deficiency in different soils

Soil Type	Zinc			Iron			Copper			Manganese			Boron		
	Range	Mean	PSD	Range	Mean	PSD	Range	Mean	PSD	Range	Mean	PSD	Range	Mean	PSD
Alluvial Soils -Recent	0.01-13.2	1.10	29.0	0.20-466	32.3	13.4	0.04-82.0	2.30	2.20	0.10-244	15.9	3.70	0.01-19.1	0.90	11.3
Brown Hills Soils	0.04-44.6	2.00	13.3	0.68-920	19.3	5.3	0.02-9.98	1.40	2.20	0.05-150	13.5	4.10	0.06-11.6	0.70	11.4
Calcareous Alluvial Soils	0.06-13.4	1.40	29.2	0.10-190	19.8	12.4	0.01-20.7	2.30	1.30	0.06-66.6	9.50	3.00	0.02-18.5	1.00	24.4
Calcareous Sierozemic Soils	0.01-35.7	1.90	13.4	0.03-141	15.7	22.8	0.02-17.7	1.30	5.00	0.05-92.6	8.10	9.90	0.08-19.1	1.60	5.80
Deep Black Soils	0.06-6.6	1.20	32.4	1.02-94.9	23.9	12.5	0.09-12.3	2.30	0.50	0.18-97.3	15.6	18.8	0.04-14.0	1.00	20.7
Deltaic Alluvium	0.04-16.0	1.40	28.8	0.33-522	57.7	5.2	0.03-95.7	3.90	0.70	0.11-272	32.6	1.90	0.01-137	12.9	20.1
Desert Soils-Lithosolic	0.01-4.6	0.40	86.3	1.75-81.6	7.90	51.7	0.11-24.0	0.40	18.5	0.01-82.7	4.70	37.8	0.08-1.00	0.90	2.40
Desert Soils-Rhegoslic	0.05-11.3	0.80	54.0	1.32-101	7.00	39.4	0.07-7.21	0.70	7.50	0.09-222	11.8	16.3	0.05-1.50	1.10	24.7
Glaciers and Eternal Snow	0.07-10.7	2.40	8.6	0.82-127	27.0	1.3	0.08-7.86	1.70	0.50	0.33-70.1	14.5	1.10	0.06-1.60	0.80	12.3
Grey Brown Soils	0.04-13.8	1.20	32.7	0.52-95.9	11.5	25.1	0.06-14.1	1.60	0.60	0.98-137	20.9	0.30	0.02-1.75	0.70	46.3
Laterite Soils	0.02-45.4	1.60	24.8	0.01-964	69.8	6.5	0.00-136.4	2.20	4.80	0.05-250	26.1	2.20	0.05-15.8	1.00	19.5
Medium Black Soils	0.01-40.0	1.10	39.4	0.06-297	16.3	22.3	0.04-96.0	3.70	0.30	0.13-233	19.4	1.10	0.01-170	2.10	16.9
Mixed Red and Black Soils	0.04-30.2	1.20	36.2	0.03-420	19.3	17.9	0.03-81.9	1.80	2.20	0.01-383	16.2	3.50	0.03-150	1.50	12.7
Old Alluvial Soils	0.10-44.6	1.40	30.8	0.36-342	26.6	25.0	0.07-87.0	1.40	7.40	0.17-101	12.8	7.70	0.06-11.5	1.40	5.00
Red and Yellow Soils	0.02-15.3	1.20	31.7	0.40-422	40.9	11.9	0.02-17.7	2.40	0.80	0.10-167	21.5	1.50	0.04-1.50	1.10	17.2
Red Loamy Soils	0.02-26.5	1.40	27.3	0.22-803	34.0	11.4	0.03-47.9	2.20	1.60	0.10-445	23.1	9.50	0.08-1.40	1.10	11.5
Red Sandy Soils	0.01-17.5	1.40	20.9	0.03-551	24.8	15.0	0.02-57.1	3.70	0.40	0.02-342	17.8	4.80	0.02-10.3	1.00	22.8
Skeletal Soils	0.07-12.6	0.60	63.2	0.20-67.9	9.70	22.4	0.06-13.3	2.00	0.30	0.20-62.9	13.1	2.10	0.30-1.58	1.80	0.60
Sub- Montane Soils (Podsolic)	0.12-9.40	2.40	9.9	2.43-63.6	22.0	1.0	0.16-5.59	1.60	0.20	2.09-87.8	16.4	0.00	0.05-1.30	0.50	33.7
Tarai Soils	0.07-8.80	1.30	21.1	0.22-718	53.2	10.8	0.01-45.0	2.10	2.10	0.09-205	17.5	1.70	0.03-13.6	1.40	6.60

*PSD per cent sample deficiency

2.3.2 Understanding spatial variability of soil micronutrients in the intensively cultivated Trans-Gangetic Plains of India for site-specific micronutrient management

Soil micronutrient deficiency adversely affects crop production in intensive agriculture. However, information on the spatial variability of key micronutrients in intensively cultivated regions of India is limited. Thus, the present study was carried out in the Trans-Gangetic Plains (TGP) region of India with the hypothesis that spatial variability of micronutrient availability is high due to small farms and varied management. The major objectives of the study were (i) to assess the spatial variability of plant available micronutrients, viz. extractable zinc (Zn), copper (Cu), manganese (Mn) and iron (Fe) at a regional scale through geostatistical methods, (ii) to develop distribution maps for soil micronutrients using ordinary kriging and (iii) to assess the relationships of micronutrient availability with several soil properties.

A total of 5638 soil samples, representative of the surface (0-15 cm) horizon were collected (covering Inceptisols, Entisols, Alfisols and Aridisols) from farms in 21 districts of the TGP. For each micronutrient, semivariograms were calculated and their main parameters (nugget effect, sill and range) were obtained. Moderate spatial dependence for extractable Zn, Cu and Fe and strong spatial dependence for extractable Mn were recorded. The nugget/sill ratio values were 0.60, 0.37, 0.34 and 0.19 for extractable Zn, Fe, Cu and Mn, respectively. Available Fe, Zn, Mn and Cu deficiencies (including acute deficiencies) were observed in 28, 15, 14 and 13% of soil samples, respectively. Soil pH showed significant and negative correlations with the concentrations of extractable Zn, Cu, Mn and Fe; whereas the correlation was significant and positive with soil organic carbon (SOC) concentration. The distribution maps (Fig.2.3.2) generated could be used as a guide for precise and site-specific micronutrient management in the study region.

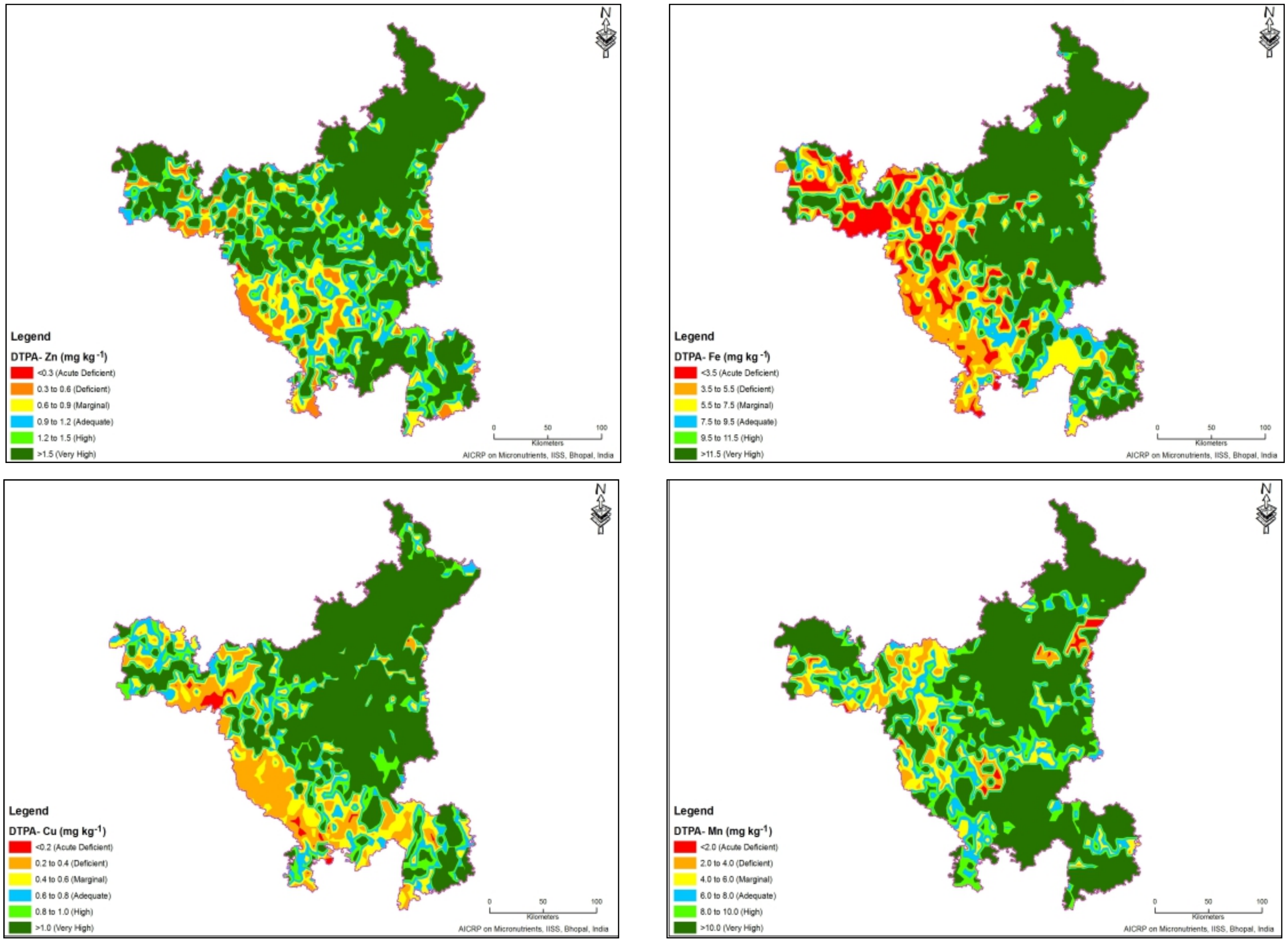
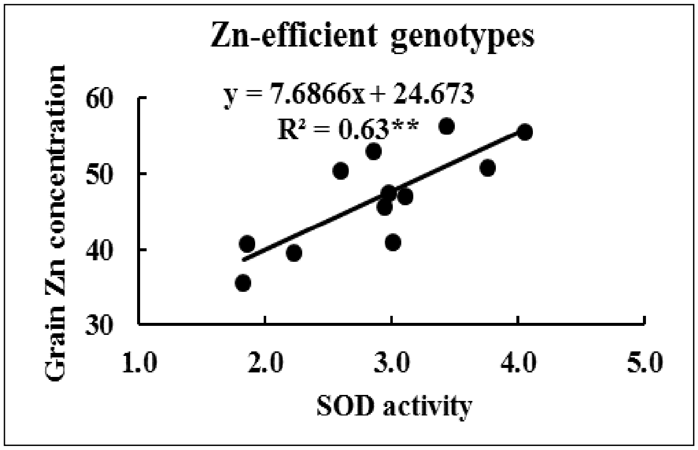


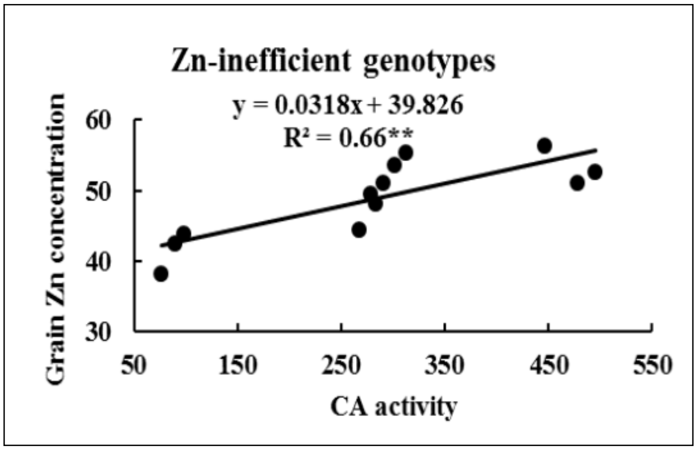
Fig. 2.3.2 Distribution maps of DTPA extractable Zn, Cu, Mn and Fe concentrations in the soil generated by ordinary kriging

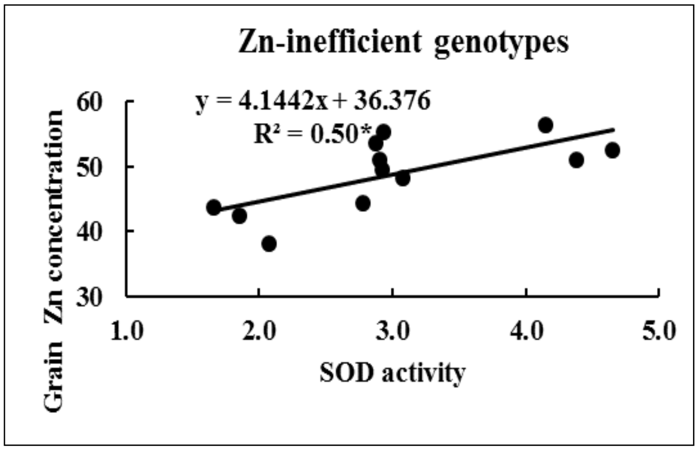
2.3.3 Zinc application enhances super oxide dismutase and carbonic anhydrase activities in zinc efficient and inefficient wheat genotypes

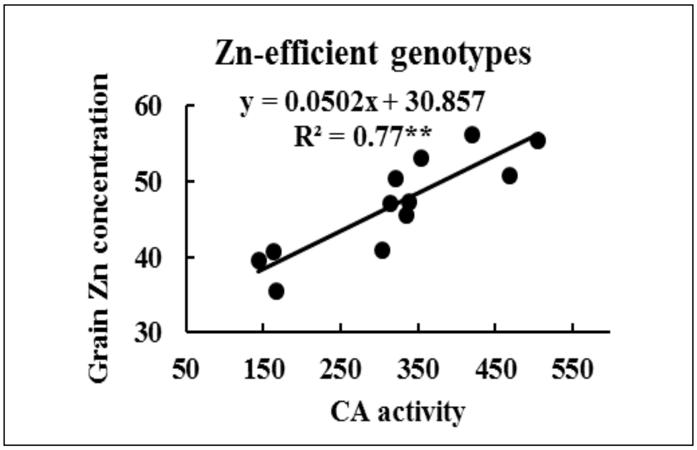
Deficiency of zinc (Zn) in soils and crops of the world is an established fact. There is need for application of Zn application and growing Zn efficient crop genotypes to tide over the situation. However, information pertaining to application of Zn to Zn-efficient and Zn-inefficient crop genotypes grown in field condition on plant enzyme (wherein Zn is a co-factor) activities is limited. To investigate the influence of different Zn regimes on superoxide dismutase (SOD) and carbonic anhydrase (CA) activities of Zn-efficient and Zn-inefficient wheat genotypes, the present study was carried out comprising three each of Zn-efficient and Zn-inefficient genotypes of wheat grown under field experiment under four Zn treatments such as no Zn, soil Zn, foliar Zn, and both soil and foliar Zn. Application of Zn (soil/foliar/both) enhanced SOD and CA activities of both Zn-efficient and Zn-inefficient genotypes at pre- and post-anthesis growth stages of wheat compared to no Zn. Under no Zn, SOD activities were higher in both Zn-efficient and Zn-inefficient genotypes at post-anthesis stage however, reverse was true for CA activities. Application Zn enhanced

Zn concentration in leaves, stem and grain of both Zn-efficient and inefficient genotypes. Grain Zn concentration increased by 25.1, 35.7 and 38.2% with soil, foliar and both soil and foliar application of Zn, respectively in Zn-inefficient genotypes and by 7.2, 21.1 & 30.6% with soil, foliar and both and foliar application of Zn, respectively in Zn-efficient genotypes, compared to no Zn. In Zn-efficient genotypes, SOD and CA activities contributed about 63 and 77% towards grain Zn concentration, respectively (Fig.2.3.3). Whereas, SOD and CA activities contributed about 50 and 66% towards grain Zn concentration, respectively in Zn-inefficient genotypes. The results indicated that both soil and foliar application are needed for enhanced SOD and CA activities and plant Zn concentration in wheat. Physiological utilization of Zn plays an important role in Zn efficiency of wheat genotypes.









2.3.4 Synergistic effect of N and Zn application in biofortifying Zn of Zn-efficient and inefficient group of wheat cultivars

In developing countries, daily diet is largely contributed by cereals, which have low genetic abilities and low concentrations of micronutrients including zinc (Zn) in their grains. Hence, wide spread deficiencies of zinc and other essential nutrients are prevailing in the human. Present study focuses on the biofortification of Zn in wheat grains, taking advantage of synergistic effect of the micronutrient i.e., zinc and macronutrient i.e., nitrogen (N). Nitrogen and Zinc are the two major yield-limiting factors in wheat which interacts and affects the availability of each other. In order to evaluate the interactive effects of N and Zn on yield and quality of wheat, a field study for consecutive two years was conducted at Indian Institute of Soil Science, Bhopal under the aegis of AICRP-MSPE. Six treatments comprised of T1- Low Zn Soil (0 Kg Zn ha^{-1}), T2- 20 kg Zn ha^{-1} soil application, T3- Three foliar sprays of $ZnSO_4$ @ 0.5%, T4- 20 kg Zn ha^{-1} soil application + foliar Zn application, T5- 20 kg Zn ha^{-1} soil application + 25% additional nitrogen application and T6- Foliar Zn application + 25% additional nitrogen application. From the study it was observed that soil application of Zn along with three foliar sprays was equally good, when compared with 25% additional N application along with three foliar sprays of Zn, in terms of grain Zn content, in both Zn-efficient as well as Zn-inefficient group of cultivars. Whereas the grain yield was comparable in efficient cultivars for treatments T4 (Soil Zn combined along with three foliar sprays of Zn) and T6 (25% additional Nitrogen along with three foliar sprays of Zn) but was significantly higher in Zn-inefficient group of cultivars under treatment T4 as compared to T6. Maximum enhancement in protein contents was observed under treatment T4 which was significantly higher than the treatments T1, T2, T3 and T5 but was at par with the treatment T6. The phytate: Zn ratio was also lowest in the treatment T6 followed by treatment T4. So, the soil application of Zn along with three foliar sprays is the best treatment in terms of grain yield whereas additional application of 25% nitrogen along with three foliar sprays of Zn was equally good in terms of grain Zn and protein content of wheat, in both Zn-efficient as well as Zn-inefficient group of cultivars.

2.4 AICRP on Soil Test Crop Response (STCR)

2.4.1 Development of soil testing protocol of nitrogen and phosphorus for organic farming system

To understand the basic concept of nutrition in organic farming system, the nature and magnitude of nutrient stock in soil and the capacity by which soil feed the crop is essential. But no or little attention was so far given to develop methodology to measure the nutrient stock in organic production system. In the present investigation an initiative has been taken to identify the potential contributory N and P pools by developing suitable methods/extractants. To carry out the investigation, a field experiment with French bean was laid out in organically converted field for three consecutive years. Vermicompost, FYM, MOC and poultry manure and their combinations were used as sole nutrient sources. A chemically treated with three replications was also maintained as check. To understand the character and dimension of some potentially available organic N and P pools different extractants were tested as follows (Table 2.4.1 a to f)

Table 2.4.1a. Method used for potentially available N

Extractants	Compositions	Strength and pH	Soil : Extractant	Special treatment	Reference
Phosphate Buffer (PB)	Di-sodium Hydrogen Phosphate + Potassium Hydrogen Phosphate	(1/15) M, pH : 7	1:4	Mechanical shaking	Higuchi (1982)
Calcium Chloride	Calcium Chloride	0.01 M	1:10	Heating, Mechanical shaking followed by centrifugation	Nemeth *et al.* (1988)
Sodium Bicarbonate	Sodium Bicarbonate	0.01 M	1:20	Mechanical shaking	Bradford (1976)
Basic EDTA	Sodium Hydroxide + EDTA	NaOH : 0.1 M EDTA : 0.05 M	1:25	Heating on Hot water bath followed by centrifugation	Bowman and Moir (1993)

Table 2.4.1b. Method used for potentially available P

Extractants	Compositions	Strength and pH	Soil : Extractant	Shaking time	Heating
Basic-EDTA	0.1(M) NaOH+0.5(M) EDTA	-	1:25	Manual shaking for 5 min	2 hrs at 100^0C
K_2CO_3	1% K_2CO_3	-	1:200	Manual shaking for 5 min	1hr at 100^0c
Olsen	0.5(M) $NaHCO_3$	8.5	1:50	30 min	-
Organic acid used					
Citric Acid	2% Citrate Solution	-	1:20	1 hr	-
α Keto-glutaric Acid	0.05(M) Glutarate solution	4.5	1:20	1 hr	-

Mineralized N accumulation was higher in organically managed plots as compared to conventionally managed plots. Between organically managed plots, the highest amount of potentially mineralized N was recorded under FYM (10 t ha^{-1}) + MOC (1.25 t ha^{-1}) for phosphate buffer, VC (5 t/ha) + PM (2.5 t ha^{-1}) for calcium chloride, FYM (10 t/ha) + VC (5 t ha^{-1}) for sodium bicarbonate and VC (5 t ha^{-1}) + MOC (1.25 t ha^{-1}) for basic EDTA. However, fraction extracted by phosphate buffer contributed the highest amount of mineralized N among the 4 extractant driven organic-N.

Table 2.4.1c. Predicted Mineralised N at full growth stage of different extractant driven Organic N

PREDICTED MINERALISED N (FGS) [kg ha^{-1}]				
Treatment	**PB**	**$CaCl_2$**	**$NaHCO_3$**	**NaOH**
T1*	203.71[bc]	94.99[e]	149.86[d]	109.19[ef]
T2*	174.58[d]	97.31[cde]	159.73[c]	119.85[cd]
T3*	216.56[ab]	102.72[bcd]	168.20[b]	125.69[bc]
T4*	179.60[d]	84.58[f]	147.59[d]	107.14[f]
T5*	141.17[e]	65.31[g]	101.94[e]	64.03[g]
T6*	199.06[bc]	88.58[f]	184.61[a]	132.89[ab]
T7*	230.04[a]	103.38[bc]	159.43[c]	131.78[ab]
T8*	188.56[cd]	96.47[de]	160.18[c]	119.96[cd]
T9*	210.81[b]	101.73[bcd]	181.58[a]	138.01[a]
T10*	201.36[bc]	117.58[a]	166.76[b]	136.19[a]
T11*	214.94[ab]	97.67[cde]	150.21[d]	123.15[c]
T12*	198.07[bc]	108.16[b]	171.92[b]	114.99[de]
MEAN	**196.53**	**96.54**	**158.50**	**118.82**

Means followed by common letter/letters are not significantly different at *P = 0.05* by Duncan's Multiple Range Test

Comparison of different Soil Test Methods:

To compare the capacity of different extractants to derive potentially available nitrogen and their relative contribution to plant nutrition and yield, Pearson correlation analysis was performed. Perusal of results of correlation study showed that except the conventional method of nitrogen estimation by $KMnO_4$, other four extractants exhibited very high correlation among themselves (Table 2.4.1d) towards potentially mineralized nitrogen derived from extractable organic-N by each of the extractant at full growth stage of French bean irrespective of organic sources used as nutrients. Phosphate buffer is highly correlated to $CaCl_2$ (r = 0.766, p=0.01), $NaHCO_3$ (r=0.783, p=0.01) and basic EDTA (r=0.782, p=0.01). While, moderate correlation was revealed in between $CaCl_2$ and $NaHCO_3$ (r=0.703, p=0.05) and basic EDTA (r=0.704, p=0.05). However, highest correlation was attained between $NaHOC_3$ and basic EDTA (r=0.860, p=0.05). A strong correlation established by phosphate buffer with rest of three extractants reflects their strength to extract similar nature and dimension of mineralizable nitrogen and capable of estimating N available to plant. It may, thus, be claimed as putatively good extractant. No such significant correlation existed between mineralized nitrogen derived from extracted organic-N by each of four extractants and $KMnO_4$ oxidized-N indicates dissimilar nature and size of potentially mineralized nitrogen estimated by $KMnO_4$. Thus, its strength as good method under organic system is poor.

Table 2.4.1d. Relationship between Mineralized N / Inorganic N extracted by five different extractants through Pearson's Correlation Coefficient

	$KMnO_4$ (INORGANIC N)	PB (MIN. N)	$CaCl_2$ (MIN. N)	$NaHCO_3$ (MIN. N)	NaOH (MIN. N)
PB	0.52(NS)	1			
$CaCl_2$	0.37(NS)	0.766**	1		
$NaHCO_3$	0.53(NS)	0.783**	0.703*	1	
NaOH	0.52(NS)	0.782**	0.704*	0.860**	1

(*) and (**) indicates significance at P = 0.05 and 0.01 respectively and (NS) denotes non-significant relationship

To understand the relationship between extractant driven potentially mineralized nitrogen and N uptake, pod and dry matter yield (DMY) and to find out suitable extractant, correlation analysis was performed. Results demonstrated that $KMnO_4$ failed to maintained significant correlation with N uptake, pod and DMY of French Bean (Table 2.4.1e**)**. This confirms its non-suitability under organic production system. Except $CaCl_2$, all the extractants revealed good correlation with all parameters related to crop studied. Phosphate buffer and basic EDTA exhibited strong correlation with N uptake (r = 0.34 and r = 0.751, respectively, p = 0.01) and pod yield (r = 0.362 and r = 0.685, respectively, p = 0.01) of French bean as well as moderate correlation with DMY (r = 0.299 and r = 0.676, p = 0.05). On the other hand, $NaHCO_3$ established strong correlation with N uptake (r = 0.749, p = 0.01) and moderate correlation with pod (r = 0.685, p = 0.05) and DMY (r = 0.676, p=0.05). But, $CaCl_2$ failed secure significant correlation with N uptake and DMY. Findings, thus, argue that phosphate buffer and basic EDTA derived potentially mineralized nitrogen has higher contribution in plant available N which in turn influenced on plant N uptake, pod and DMY of French Bean.

Table 2.4.1e. Relationship between Mineralised N / Inorganic N extracted by different extractants with Plant biomass, Pod yield and N uptake

Mineralised N / Inorganic N	Plant biomass	Plant yield	Plant uptake
Phosphate buffer (Min. N)	0.299*	0.362**	0.348**
Calcium chloride (Min. N)	0.523(NS)	0.591*	0.536(NS)
Sodium bicarbonate (Min. N)	0.676*	0.685*	0.749**
Sodium hydroxide (Min. N)	0.676*	0.685**	0.751**
Potassium permanganate (Inor g. N)	0.38 (NS)	0.4 (NS)	0.5 (NS)

(*) and (**) indicates significance at P = 0.05 and 0.01 respectively and (NS) denotes non-significant relationship

Overall results showed that phosphate buffer extractable organic N was qualified as potential extractant as measured by predicted mineralized N. This extractant was highly correlated with all the tested extractants [r ($CaCl_2$) = 0.77**, r ($NaHCO_3$) = 0.78**, r (NaOH) = 0.78**] except $KMnO_4$ (r = 0.52) and ranked first on the basis of correlation sum (Scored:**2.85**), and regression factor scoring, in one hand, strongly correlated with N uptake (r = 0.348**), pod (r = 0.362**) and dry matter yield (r=0.299*) of French Bean, on the other hand. Similarly, 1% K_2CO_3 extractable potentially available P + 2% citric acid soluble P (1% K_2CO_3 + 2% citric acid) may be suitable extractant for P estimation

Table 2.4.1f Regression factor scores of extractants evaluation for extraction of Potentially Available N

Extractant	Regression factor scores			Rank			Rank sum
	PC1	**PC2**	**PC3**	**PC1**	**PC2**	**PC3**	
Phosphate buffer	0.307579	0.568781	0.580179	3	1	1	4(*BEST*)
Basic EDTA	0.175646	0.203753	-0.225294	4	4	4	12
$CaCl_2$	0.136981	0.224053	0.439945	5	3	2	10
$NaHCO_3$	0.426716	0.517374	-0.640993	2	2	5	9
$KMnO_4$	0.820788	-0.563113	0.090618	1	5	3	9

under organic farming soil.

Thus, these extractants may putatively be selected as suitable extractant for potentially available-N and P estimation under organic production systems. Before recommendation, the accuracy of the method should be tested under diverse agro-ecosystem with variety of cropping system. Moreover, soil test N/P should be correlated with crop response under certified organic production systems. The outcome of the present exercise will help to develop noble soil tests method for routine N/P estimation to cater the need of organic farmers and certifying agencies.

Theme II. Conservation Agriculture, Carbon Sequestration and Climate Change

2.5 Conservation Agriculture and Climate Change

2.5.1 Soil aggregation as influenced by different tillage and cropping system after 7 crop cycles

Soil aggregation often provides information on structural stability and physical condition of soil. Soil samples were collected after 7 crop cycles and measured mean weight diameter (MWD) under different tillage and cropping system. The MWD was higher in surface soils (0-5cm) and it decreases with increasing soil depth. Tillage, cropping system and soil depth had a significant effect ($P< 0.05$) on MWD. It was observed that MWD was affected significantly by the interaction of tillage × cropping system × soil depth. Across the different tillage, no-tillage (NT) had larger MWD (0.97 mm) than reduced tillage (RT) (0.93 mm) and conventional tillage (CT) (0.77 mm) (Fig. 2.5.1). Among the cropping systems, the largest MWD was recorded under maize-gram (1.04 mm) and the lowest under maize + pigeon pea (0.87 mm) under NT. Soil aggregation improved under NT and RT, coupled with retention of crop residue as compared with CT. Repeated soil disturbances through tillage operations and less residue addition recorded lower MWD under CT. Continuous addition of residue under NT and RT provides a source of C for microbial activity and nucleation centres for aggregation; therefore, increased microbial activity probably induced the gluing of residue and soil particles into macro aggregates which help in physical protection of C. Conservation agriculture management practices had a positive effect on soil aggregation and aggregate stability and also increased soil organic carbon content.

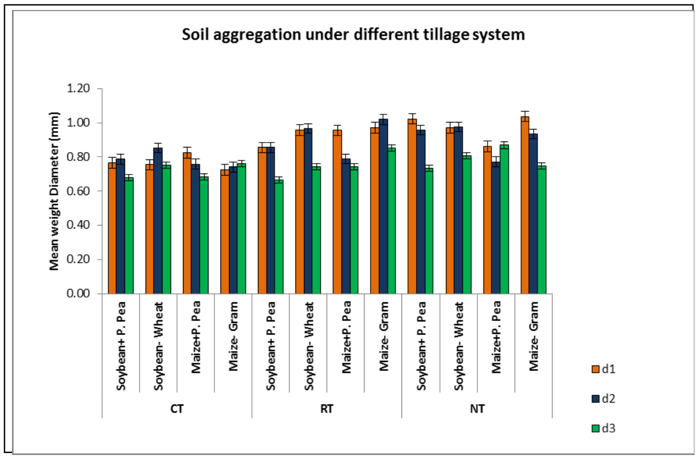


Fig. 2.5.1. Effect of different tillage and cropping system on mean weight diameter (mm) at different soil depths

2.5.2 Aggregate associated carbon under different tillage and cropping systems

Effect of different tillage and cropping system on percent aggregate size distribution (%) at different soil depth after seven crop cycles were presented in Fig 2.5.2a to e. Results indicated that the percentage of microaggregates (Miagg) recorded higher percent, followed by small macroaggregates (SMag), large macroaggregates (LMag) and silt+clay (S+Cag). The percent distribution of microaggregates under different tillage systems of CT, RT and NT were 45.94-49.49; 45.56-48.76; 42.65-47.26, respectively and the corresponding value for small macroaggregates (SMag) were 32.54-35.53; 35.19-36.89; 36.51-38.16, respectively. Large macroaggregate (LMag) per cent under different tillage of CT, RT and NT were 7.61-8.20%; 7.37-9.61%; 8.31-10.74% and the corresponding values for silt + clay were 8.85-10.82%; 7.49-9.31%; 8.34-10.16%, respectively. LMag aggregate was significantly affected by tillage system at 0-5 cm depth. SMag and Miag showed no significant among tillage systems. At 5-15 cm depth, SM and M were significantly affected by tillage system, whereas LM and S+C were not. At 15-30 cm depth, tillage had no significant effect on aggregate size distribution.

Effect of different tillage and cropping system on aggregate associated C at different soil depths were presented in Fig 2.5.2a to d. The results demonstrated that the aggregate-associated C content increased with aggregate size and it was in the following order of large macraggregate (LMag) > small macroaggregate (SMag) > microaggregate (Microag) > silt+clay (S+Cag) in the soil samples. Overall, LMag had highest aggregate C and S+Cag had the lowest aggregate associated C across different tillage and cropping system. Tillage practices and cropping systems had no significant

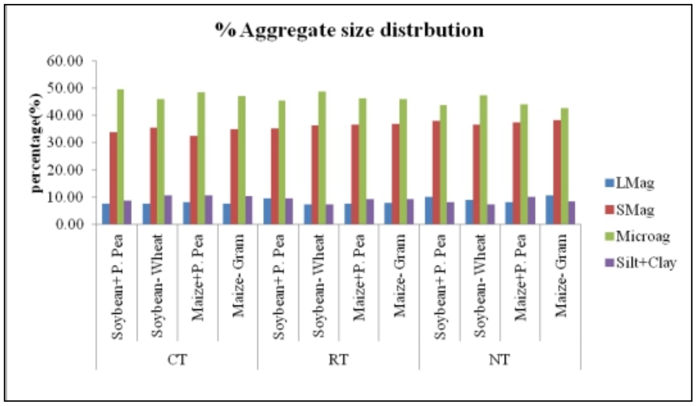


Fig. 2.5.2a Effect of different tillage and cropping system on percent aggregate size distribution (%)

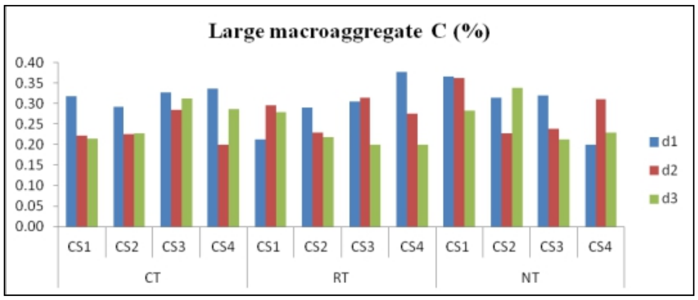


Fig. 2.5.2b Effect of different tillage and cropping system on large macro-aggregate associated C at different soil depth [CS1-Soybean+Pigeonpea (2:1); CS2- Soybean-Wheat; CS3-Maize-Pigeonpea (1:1); CS4- Maize-Gram; d1:0-5 cm; d2:5-15 cm and d3:15-30 cm depth].

effect on aggregate associated-C for all aggregate size fractions, whereas soil depth had a significant effect on all aggregate-associated C. The interaction of cropping system × depth was significant for LM-C. There was relatively higher LM aggregate C under NT (0.57 %) followed by RT (0.53%) and CT (0.51%) at 0-5 cm depth and aggregate C decreased with lower depths i.e. 5-15 cm and 15-30 cm depth. Similar trend was observed in SM aggregate C, micro- aggregate C and S+C aggregate C.

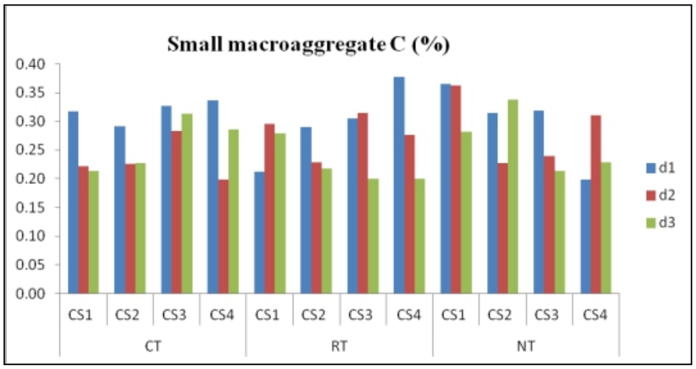


Fig 2.5.2c Effect of different tillage and cropping system on small macro-aggregate associated C at different soil depth [CS1-Soybean+Pigeonpea (2:1); CS2- Soybean-Wheat; CS3-Maize-Pigeonpea (1:1); CS4- Maize-Gram; d1:0-5cm; d2:5-15cm and d3:15-30cm depth].

Tillage and cropping systems effect increased aggregate associated C under LM and SM aggregates. Carbon content increased with the size of aggregates; the larger SOC content in macro-aggregates was because of less SOM decomposable in micro-aggregates protected in the macro-aggregates. Regardless of tillage treatments, LM had more aggregate-C than other size fractions. In contrast to NT, CT had less aggregate-C because of frequent tillage, which breaks down aggregates and also favours decomposition of soil organic carbon. In fact aggregate size decreased under CT, probably due to continuous tillage operations/ mechanical disturbances of macro aggregates, which could have exposed SOM that had been protected against oxidation. Soil aggregation improved under NT compared with RT and CT. Larger SOC contents in macro-aggregates indicated that addition of crop residues and root biomass promotes microbial biomass, especially fungal hyphae within macro-aggregates, which not only enhances C content but also improves physical stabilization of aggregates.

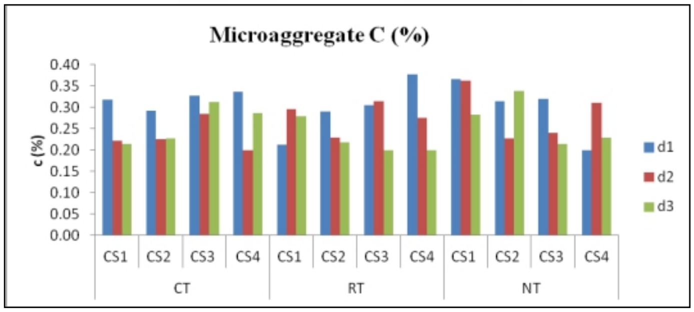


Fig. 2.5.2d Effect of different tillage and cropping system on micro-aggregate associated C at different soil depth

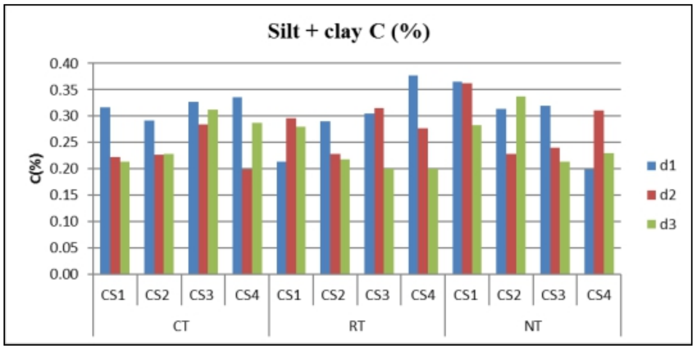


Fig. 2.5.2e Effect of different tillage and cropping system on silt+clay associated C at different soil depth

2.5.3 Long-term Impact of CA practices on Soil Organic Carbon (SOC)

The mean data of SOC during the 9th year of experimentation. In general, concentration of SOC was significantly decreased with increasing depth. The SOC content was significantly affected by different tillage systems and cropping system. Irrespective of soil depths, higher SOC was recorded under NT compared CT practices. The NT recorded significantly higher SOC (0.83%) than CT (0.69%) in surface depth (0-5) cm. Cropping system also showed significant effect on SOC content. Among the cropping systems evaluated, maize-gram and maize-wheat recorded significantly higher SOC (0.84%) followed by soybean-wheat (0.81%) under NT. Whereas, under CT maize-wheat recorded minimum SOC (0.65%) at 0-5 cm depth. Results indicated that interactive effect of tillage × cropping system × soil depth was not significant for SOC (Table 2.5.3). The increased SOC in the surface soil was attributed to a combination of crop residue addition and relatively less soil disturbance by tillage operations under NT.

Table 2.5.3 Effect of different tillage and cropping system on soil organic carbon (SOC, %) during 9th crop cycles

Treatments	Depth			
	0-5 cm	5-15 cm	15-30cm	Mean
CT				
Maize-Gram	0.73	0.47	0.42	0.54
Maize-Wheat	0.65	0.43	0.36	0.48
Soyabean-Wheat	0.68	0.47	0.37	0.50
Mean	**0.69**	**0.46**	**0.38**	**0.51**
NT				
Maize-Gram	0.84	0.60	0.49	0.64
Maize-Wheat	0.84	0.53	0.43	0.60
Soyabean-Wheat	0.81	0.57	0.46	0.61
Mean	**0.83**	**0.57**	**0.46**	**0.62**
	Least Significant Difference (LSD)	Significant		
Tillage system (TS)	0.028	**		
Cropping system (CS)	0.025	**		
Depth (D)	0.017	***		
TS x CS	0.035	NS		
TS X D	0.024	**		
CS x D	0.029	NS		
T x CS X D	0.041	NS		

*Significant at 5% level: **Significant at 1% level: ***Significant at 0.1% level

2.5.4 Impact of conservation agricultural practices on crop yield

Grain yields of different crops were recorded and converted into soybean grain equivalent yield (SGEY) for comparing different cropping systems (Fig. 2.5.4, Plate 2.5.4). Tillage had no significant effect on the soybean grain equivalent yield (SGEY), whereas cropping system had a greater effect on SGE yield. Among various cropping system studied, maize-wheat had significantly higher yield (7401 kg ha^{-1}) followed by soybean-wheat (6432 kg ha^{-1}) under NT. Similarly, trend was observed under CT. SGEY indicated that maize-gram cropping system has recorded higher average yield compared to other cropping systems, regardless of tillage system.

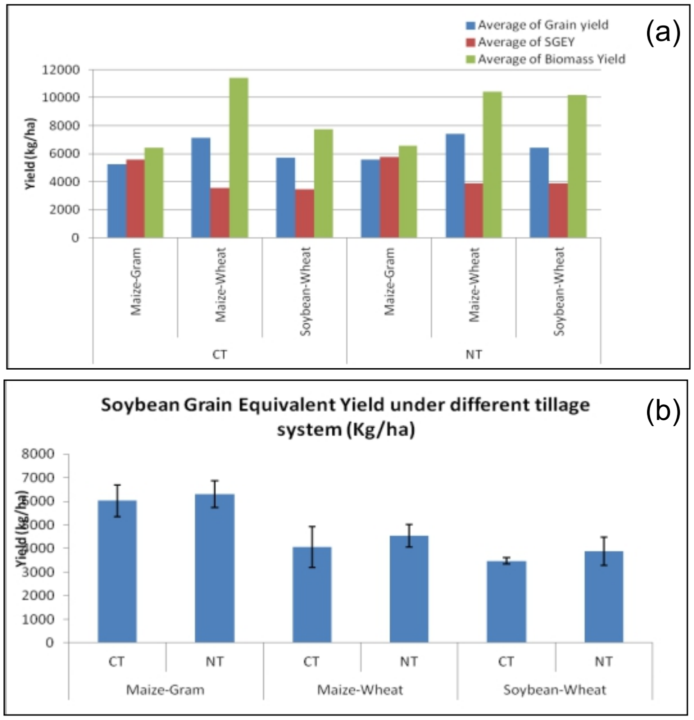


Fig. 2.5.4 Effect of different tillage and cropping system on a) Grain Yield and Biomass Yield b) SGEY (kg ha^{-1})

Plate 2.5.4 Establishment of soybean under no tillage system

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

To assess the effect of conservation agriculture practices on soil health, soil samples from an on-going conservation agriculture experiment (started since 2015) in research farm of the Institute were collected from 0-5, 5-15 and 15-30 cm depth. The samples were analyzed for pH, EC, organic C and available NPK. All together 96 soil samples were analyzed. Slight reduction in soil pH (0.15 units) was recorded under the no till (NT) system in comparison to conventional (CT) plots (7.82). Among the different nutrient treatments, lowest pH was recorded in treatments where N was applied through STCR approach in 0-5 cm of soil depth. No significant effect of crop residue retention (30 and 60 cm) on soil pH was noticed. The reverse trend was recorded in case of soil EC. EC was found higher under NT and reduced tillage (RT) treatments as compared to CT treatments in 0-5 cm soil depth. The highest EC value of 0.28 was recorded in treatments where N was applied through STCR approach. No significant change in soil OC was recorded between different treatments. However, maize-chickpea rotation had higher organic C in surface layer in comparison to soybean-wheat system. No significant difference in labile C was recorded under different treatments. Under maize-chickpea rotation, 22-43% higher available N was recorded under NT and RT treatments in comparison to CT treatment. However, no significant difference in available N content was recorded under different treatments under soybean-wheat crop rotation. In 0- 5 cm of soil depth, available P was higher to the tune of 22-46% under NT and RT in comparison to CT under maize-chickpea crop rotation. Available P was drastically reduced in 5-15 and 15-30 cm soil depth. Available K was higher by 12-21% under NT and RT treatments as compared to CT treatments in 0-5 cm soil depth under maize-chickpea rotation. Maize-chickpea rotation contains 33% higher available K in comparison to soybean-wheat rotation. No significant difference in available K was recorded under different treatments under 5-15 and 15-30 cm of soil depth.

A long term (10 years) resource conservation experiment was evaluated for changes in soil biological properties under rice-wheat cropping system. Soil samples were collected from ongoing long-term experiment on resource conservation technology conducted at ICAR-CSSRI, Karnal. All together 10 treatment combinations comprising of conventional, reduced and no tillage were evaluated with and without residue for changes in measured microbial biomass carbon, soil respiration and metabolic quotient in 0-5 and 5-15 cm soil depths. Also, easily extractable glomalin related soil protein was estimated under the different treatments. Highest concentration of microbial biomass carbon was recorded (256 mg kg^{-1}) in 0-5 cm of soil depth in treatments of zero tilled rice (direct seeded) with wheat residue incorporation and zero tilled wheat plots which retained of 1/3rd residue of the previous crop. The lowest concentration of 72.4 mg kg^{-1} of MBC was recorded in plots of directed seeded rice followed by wheat in reduced tillage with previous crop residue incorporation. Easily extractable glomalin related soil protein was found maximum in plot of direct seeded rice followed by wheat in reduced tillage. This treatment was found to be at par with the treatment of direct seeded rice with wheat residue in reduced tillage followed by zero tilled wheat with entire rice residue retention.

2.5.6 Effect of different level of residue retention on soil properties under soybean-wheat cropping system

In order to study the effect of residue retention on soil properties under no till system in soybean-wheat cropping sequence, soil samples from 0-10 and 10-20 cm of soil depth was collected from research farm of ICAR-IISS, Bhopal. It was observed that five years of 90% of soybean and wheat residue retention had led to the improvement in soil organic carbon by 10% in comparison to nil residue retention. However, the effect was not significant in 10-20 cm of soil depth. Regarding particulate organic carbon (POC), it was also significantly higher (62.5%) in 0-10 cm of soil depth as compared to no residue retention. Moreover, here also the effect was only pronounced in 0-10 cm of soil depth (Fig. 2.5.6a). Regarding, NO_3-N content at harvest in 0-10 cm of soil depth, it was 2.62 times higher in 0% residue retained plot in comparison to 90% of residue retained plot. The effect was also significant in 10-20 cm of soil depth. Here also, NO_3-N content was 1.74 times higher in 0% residue retained plot as compared to 90% of residue retained plot.

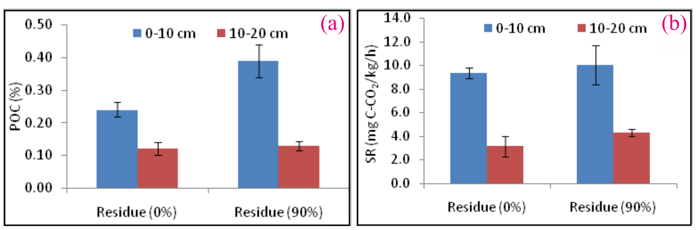


Fig. 2.5.6a Effect of residue retention under no till system on a) % POC and b) basal soil respiration

Soil basal respiration was found to 7.3% higher in 90% residue retained plot as compared to no residue retention. Similar trend was recorded in 10-20 cm of soil depth.

Vesicular Arbuscular Mycorrhiza (VAM) colonization as affected by residue retention was studied during wheat growing season. It was observed the VAM colonization in wheat root was significantly higher in 90% of residue retained plot in comparison to no residue retained plot. It was recorded that in 90% of residue retained plot VAM colonization was 46% whereas it was only 26% in 0% of residue retained plot (Plate 2.5.6).

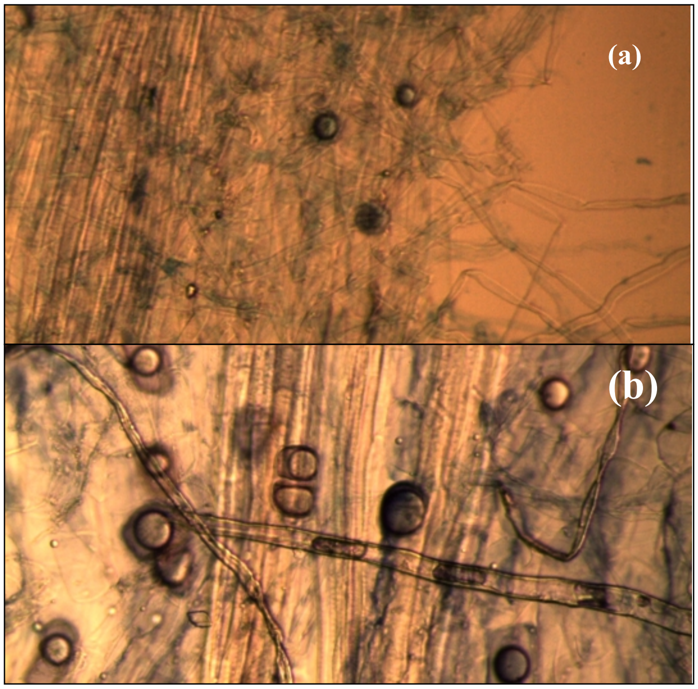
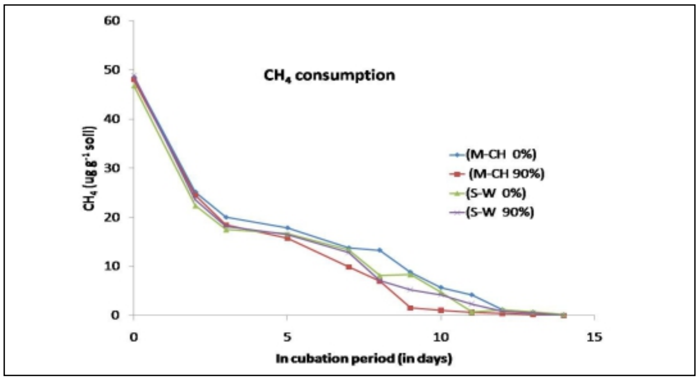


Plate 2.5.6 Effect of residue retention on VAM colonization in (a) 0% and (b) 90% of residue retained wheat plot

The CH_4 oxidation rate of soil under soybean-wheat and maize-wheat cropping system was also measured. It was observed that methane oxidation rate was significantly higher under 90% of residue retained treatment in comparison to no residue retained plot under both the cropping systems. Methane oxidation rate was almost 1.89 times higher in 90% of residue retained plot (Fig 2.5.6b). Moreover, abundance of bacterial genes was measured under soybean-wheat and maize-chickpea rotation under no till system. It was observed that the bacterial population was dominated by *Eubacteria* followed by *Methanotrophs* and *Ammonia oxidizer* under both the cropping systems. There was no significant difference in bacterial abundance due to retention of crop residues (Fig 2.5.6b).



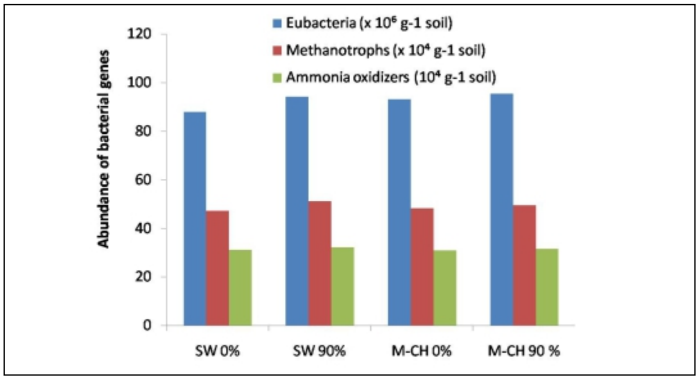


Fig 2.5.6b Effect of residue retention on methane oxidation and abundance of bacterial genes under no till system

2.5.7 Effect of reversal of conservation tillage on soil organic carbon after harvest of soybean in soybean-wheat cropping system

No till and reduced till fields when converted to conventional tillage may have adverse impact on soil carbon storage and nutrient availability. The experiment comprised of four tillage treatments (NT-CT, NT, RT-CT and RT) with three levels of fertilizer (T_1: NPK (RDF), T_2: NPK + 1.0 t FYM-C (ha^{-1}) every year and T_3: NPK + 2.0 t FYM-C (ha^{-1}) every year). After three growing periods of converting 8 years' long-term experiment under conservation tillage in soybean-wheat system, the results revealed that the NT system had the highest SOC content in the surface 0-5 cm layer only. The relative increase in SOC concentration for 5-15 cm soil depth was observed with reversal of no tillage (NT) and reduced tillage (RT) to conventional tillage (CT). This could be attributed to increased mineralization of incorporated crop residue in NT-CT and RT-CT treatments. The soil nutrient content (N and P) was not significantly affected by interactive effect of tillage and fertilizer on surface soil layer (0-5 cm). Interactive effect of tillage and fertilizer was found significant on available P content at 5-15 cm soil depth. In contrast to N, soil available P relatively increased with reversal of tillage in NT and RT. In comparing the tillage systems, tillage reversal (NT-CT, RT-CT) and RT had significantly higher available potassium than NT in 0-5 cm and 5-15 cm soil layers.

2.5.8 Estimating maize water productivity in central India using APSIM model.

This study examines variation in temporal water productivity of maize crop in different district of Madhya Pradesh. A well-calibrated and validated APSIM model was used to predict maize crop yields and consumptive water use with uncertainty analysis for 2000-2015. Simulated yield and consumptive water use were used to calculate the crop water productivity. The results indicated that among the studied districts mean water productivity of maize was the highest (1.83 kg m^{-3}) in Chindwara district and the lowest (1.42 kg m^{-3}) in Gwalior district (Fig. 2.5.8a).

Calibration and validation of APSIM model for pigeon pea

The Agricultural Production System simulator (APSIM) model was used to parameterize and validate pigeon pea cv TJT 501 for India. For this, a well calibrated experiment was conducted at ICAR-IISS research farm with optimum application of nutrients in the year 2018. Due care was taken to control incidence of diseases and pests. The different crop coefficients generated through calibration experiment to match the observed and predicted values of different pheno-phases are presented in Table 2.5.8a.

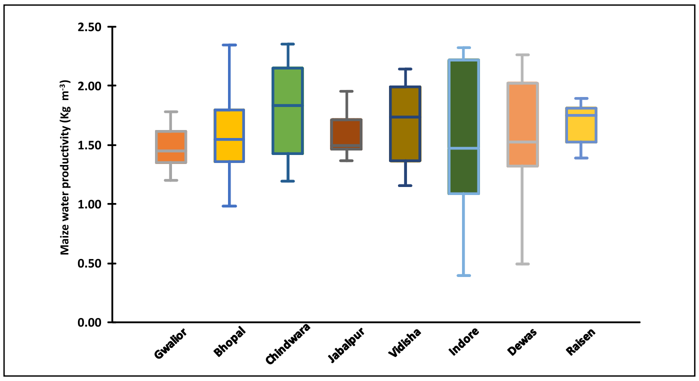


Fig. 2.5.8a Maize water productivity in some districts of central India as estimated by APSIM Model

The observed and predicted phenological stages of the pigeon pea variety TJT 501 presented in Fig. 2.5.8c revealed that there was good agreement between observed and

Table 2.5.8a APSIM pigeon pea (TJT-501) cultivar parameters

Parameter	Description	Units	Value
tt_emerg_to_init	Thermal time from emergence to flora initiation	°C day	1170
tt_endjuv_to_init	Thermal time from end of juvenile to floral initiation	°C day	94
tt_init_to_flower	Thermal time from floral initiation to flowering	°C day	213
tt_flower_to_start_grain	Thermal time from flowering to start grain fill	°C day	156
tt_start_to_end_grain	Thermal time from start grain fill to end grain fill	°C day	311
tt_end_grain_to_maturity	Thermal time from end grain to maturity	°C day	199
tt_maturity_to_ripe	Thermal time from maturity to harvest ripe	°C day	75

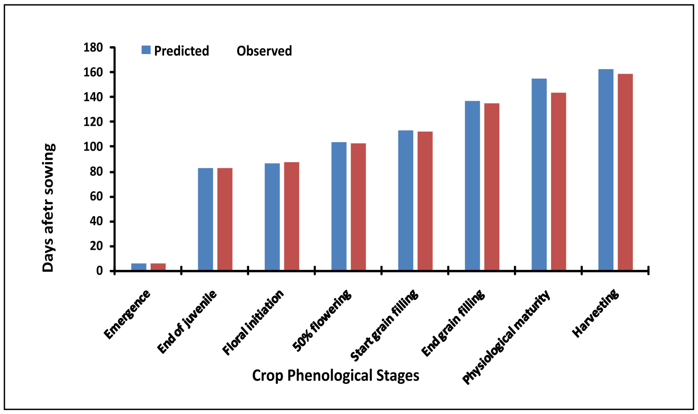


Fig. 2.5.8b Crop coefficients generated through calibration experiment to match the observed and predicted values of different pheno-phases

predicted phenological stages such as days to emergence, end of juvenile, floral initiation, flowering, grain filling, and maturity. There was also a good agreement between observed grain yield of 2.3 t ha^{-1} against the predicted value of 2.2 t ha^{-1}. The model was also validated from multiyear and multi-locational trials from the national level demonstrations obtained from AICRP (Pigeon pea), ICAR-IIPR Kanpur. From the validation results, it was observed

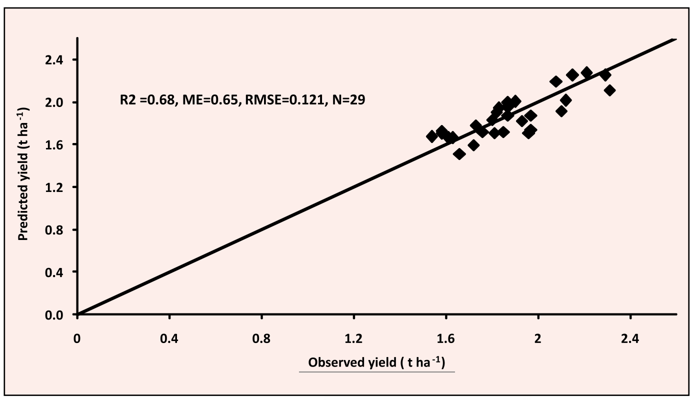


Fig. 2.5.8c Relationship between observed vs predicted grain yield of pigeon pea variety TJT 501 from the validation data set obtained from pigeon pea growing areas of India.

that there was a good correlation between the observed grain yield of variety TJT 501 as evidenced from $R^2 = 0.98$**, ME = 0.65 t ha^{-1}, and RMSE = 0.26 t ha^{-1}. From this observation it is suggested that the APSIM pigeon module can be successfully used for varieties of scenarios analysis in future.

2.5.9 Climate change vulnerability assessment and maps for districts of Madhya Pradesh

Assessing vulnerability to climate change is important for defining the risks posed by climate change and provides information for identifying measures to adapt to climate change impacts. An assessment was done to study the overall implications of climate change on climate vulnerability for 51 districts of Madhya Pradesh to identify the vulnerable districts to climate change in current (1981 to 2010) and projected climate scenarios, viz. RCP 4.5 and RCP 8.5, mid-century (2021-2050) and end of century (2071-2100) by using indicators of precipitation and temperature calculated from Cordex South Asia daily weather datasets of Indian Institute of Tropical Meteorology, Pune and NEX-GDDP data. Using indicator based methodology, vulnerability indices were calculated and districts of Madhya Pradesh were classified into various vulnerability categories. The climate vulnerability Maps for districts of Madhya Pradesh is given in Fig.2.5.9. Overall climate vulnerability of the Madhya Pradesh districts is projected to increase towards mid-and end-century as compared to the current conditions for both emission scenarios of RCP 4.5 and RCP 8.5.Vulnerability of districts under RCP 8.5 scenarios is projected to be higher as compared to RCP 4.5 scenario. The projected increase in vulnerability towards end-century is higher than that of mid-century for RCP 8.5 scenario while the projected increase in vulnerability towards end-century is relatively lower than that of mid-century for RCP 4.5 scenario.

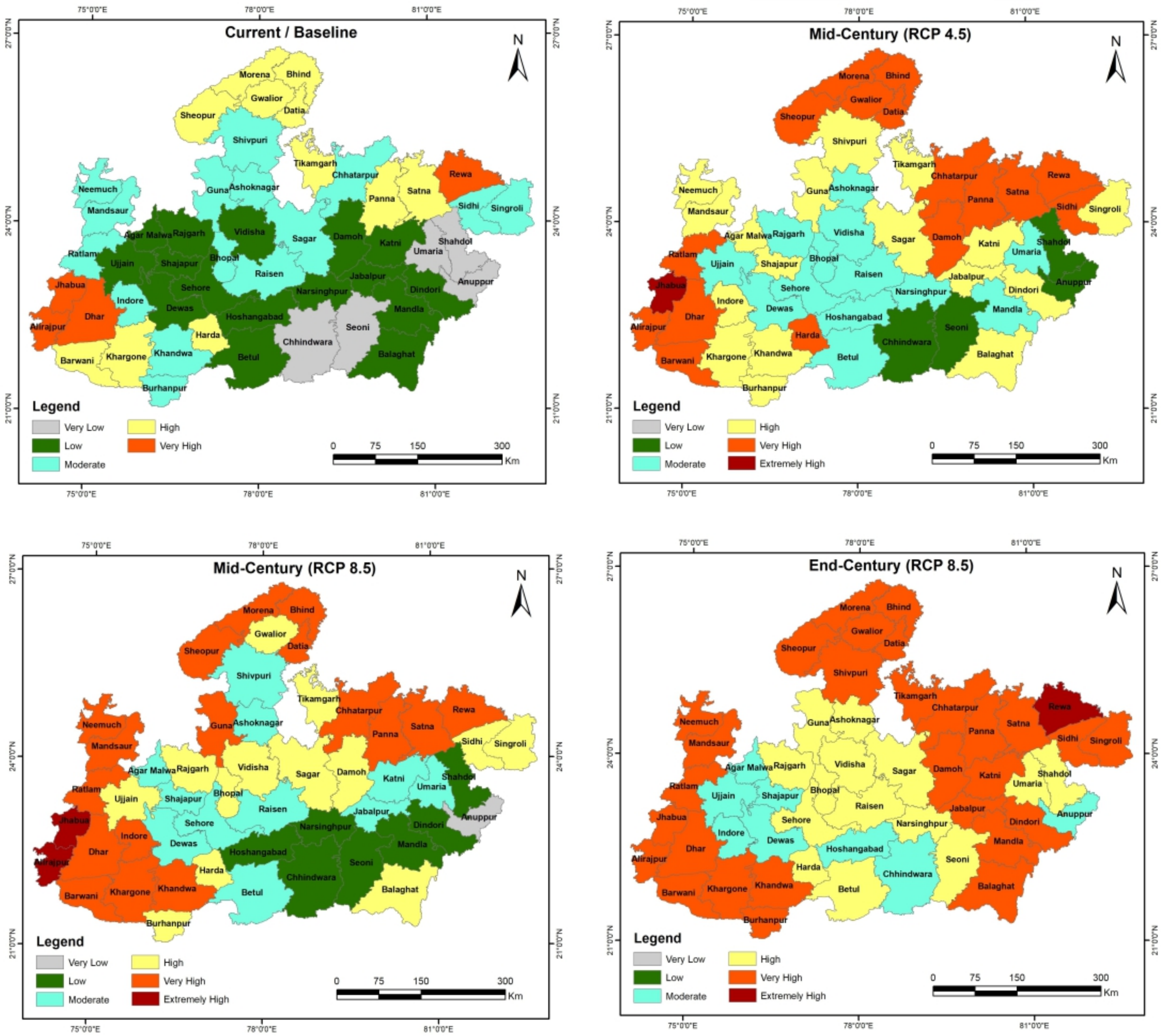


Fig. 2.5.9 Climate change vulnerability maps for districts of Madhya Pradesh for current and projected climate scenarios

Theme -III: Microbial Diversity and Genomics

2.6 Microbial Diversity and Genomics

2.6.1 Effect of elevated CO_2, chlorpyrifos and biochar on nitrification and microbial abundance in rhizosphere of wheat in tropical Vertisol

Wheat (HI 8498) was grown under different concentration of CO_2 (400 and 800 ppm), biochar (0 and 1%), and chlorpyrifos (0 and 10 ppm). Nitrification was estimated regularly by measuring soil NO_3-N over 60 days of wheat growth. Nitrification rate was lowest (0.67±0.15 NO_3-N produced g^{-1} soil d^{-1}) in soil under CO_2 400 ppm biochar 0% chlorpyrifos 10 ppm. Highest nitrification rate (4.53±0.59 NO_3 -N produced g^{-1} soil d^{-1}) was in the treatment of CO_2 800ppm biochar 1% chlorpyrifos 0 ppm. Abundance of 16S rRNA gene copies (× 10^6 cells g^{-1}soil) of eubacteria varied from 25±3.00 to 75±4.04. Abundance of ammonia oxidizing bacteria (amoA) (× 10^5 cells g^{-1} soil) varied from 1.43±0.404 to 8.33±0.577 (Table 2.6.1a). Shoot weight (g) of crop varied

Table 2.6.1a. Nitrification rate, abundance of 16S rRNA gene copies of eubacteria, amoA gene copies of nitrifying bacteria.

CO_2 (PPM)	Biochar (%)	Chlorpyrifos (%)	Nitrification rate (mg NO_3^- N produced g^{-1} soil d^{-1})	16 s r RNA gene (x 10^6 cells g^{-1} soil)	amoA gene of nitrifying bacteria (x10^5 cells g^{-1} soil)
400	0	0	1.808±0276	34 ±4.04	3.33± 0.577
		10	0.665±0.152	25±3.00	1.43±0.404
	1	0	2.368±0.87	39±3.78	3.66±0.577
		10	0.760±.069	30±1.73	3.03±0.058
800	0	0	3.815±0.407	74±2.51	7.83±0.764
		10	1.562±0.293	44±5.29	4.33±0.577
	1	0	4.525±0.585	75±4.04	8.33±0.577
		10	2.157±0.100	54±4.04	6.06±0.902
Tukeys HSD (p 0.05, df error 23)			0.061	1.88	0.076

from 23.0±2.00 to 43.0±3.700. Similarly root weight of wheat varied from 9.6±0.577 to 25.4±2.335 (Table 2.6.1b). Results showed that elevated CO_2 and biochar stimulated nitrification, microbial abundance and plant growth while the chlorpyrifos inhibited those parameters. The impact of elevated CO_2 was highest followed by chlorpyrifos and biochar. Study concluded that the rise in atmospheric CO_2 may severe the negative impact of chlorpyrifos on nitrification and soil microbial abundance. However, the use of biochar may alleviate these negative impacts and aid in retaining soil function.

Table 2.6.1b. Shoot and root weight of wheat (HI 8498) under experimental condition

CO_2 (ppm)	Biochar (%)	Chlorpyrifos (%)	Shoot weight (g)	Root weight (g)
400	0	0	27.6±1.637^{e}	12.6±0.346^{de}
		10	23.0±2.000^{f}	9.6±0.577^{f}
	1	0	30.7±0.755^{d}	17.3±1.429^{c}
		10	23.3±1.155^{f}	10.0±0.001^{e}
800	0	0	41.6±2.887^{b}	21.6±0.577^{b}
		10	29.3±5.038^{d}	14.6±3.055^{d}
	1	0	43.0±3.700^{a}	25.4±2.335^{a}
		10	34.3±0.577^{c}	16.3±2.309^{c}
Tukey's HSD (p 0.05, df error 23)			1.12	1.58

2.6.2 Bio remediation of heavy metal contaminated soil using endophytic fungi

Bhanpur municipal waste dumping site of Bhopal city from central India, was selected as heavy metal contaminated site for the research study. Soil sample was collected from two plants (Vetiver grass and Castor oil plant) that grow well in such harsh condition. Rhizospheric soil was collected in polythene bag and stored at 4°C until further analysis.

Enumeration of total fungal count from collected soil samples: Enumeration of total fungal count was carried using serial dilution agar plate technique. Serial dilution of soil sample was carried out in test tube containing sterile distilled water. 100 µl from 10^{-3} and 10^{-4} dilutions tube was used for spreading on Rose Bengal agar (RBA) for selective

Plate 2.6.2a. Collection of samples

growth of fungal species. Plates were incubated at 25°C in dark for 3 to 5 days. The colony forming Unit (CFU) of rhizospheric soil of vetiver grass was 4.6×10^{6} $CFUg^{-1}$ of soil.

Isolation and identification of fungal species from soil samples:

After enumeration of fungal species, the individual colonies of different morphology were selected for purification in fresh Rose Bengal agar plates. These fungal isolates were identified further by morphological and 18s rRNA sequencing.

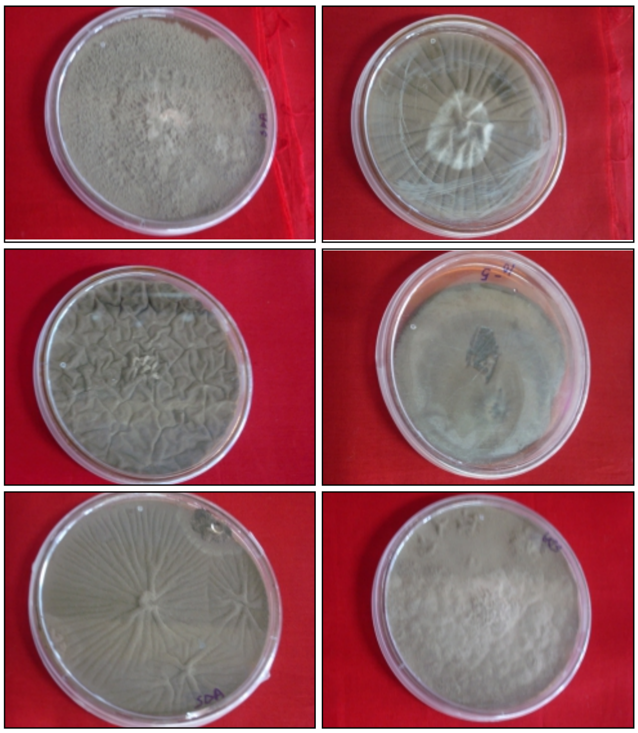


Plate 2.6.2b: Growth of fungi on Rose Bengal agar plate

Isolation and identification of endophytic fungi from plant roots:

Isolation of endophytic fungi from the root of vetiver grass was carried out. Initially, the plant root surface was cleaned with tap water. Surface sterilization was carried with 70% alcohol, followed by 2.5% of sodium hypochlorite solution. Finally, the roots were washed with distilled water for 3 to 5 times in order to remove the surface sterilizing agent. The roots were cut into small pieces and placed over sterilized PDA plate. The plates were then incubated at 25°C in dark for three to five days. The fungal hyphae emerging from the tip of root segment was sub cultured and purified in fresh PDA plates. The purified fungal species was further used for morphological and 18s rRNA gene sequencing in order to identify endophytic fungi.

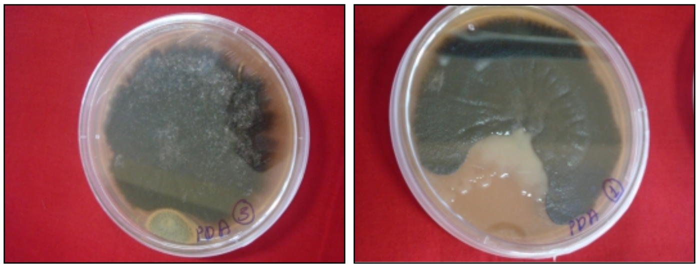


Plate 2.6.2c Growth of endophytic fungi on potato dextrose agar

2.6.3 Accelerated decomposition process using lingo-cellulolytic microbial consortia

Total 8 bacterial cultures and 11 fungal cultures were isolated from Municipal Solid Waste. All the isolates were found to degrade cellulose on CMC (Carboxy Methyl Cellulose) agar plate. The isolates were also tested for their proficiency to degrade lignin. Ability to degrade lignin, involves three different complex enzymes namely: Phenol oxidase (laccase) and heme peroxidases [lignin peroxidase (LiP) and manganese peroxidase (MnP). The isolated cultures were screened for their efficiency to produce Laccase, LiP and MnP individually on respective media. Among all the isolates 7 fungal and 4 bacterial cultures were found to produce lignin degrading enzymes. These isolates were used for developing consortia for decomposition of vegetable waste, horticultural wastes and kitchen wastes.

For rapid decomposition of organics, six fungi, and eight thermophilic (could thrive and work at 50-60 °C temperature) bacteria possessing cellulose and lignin degradation ability were isolated from city waste and fresh cow dung. Using these isolates, bio-waste like city waste

(Kitchen waste), vegetable waste, horticultural waste and farm waste were subjected to decomposition followed by assessment of maturity and stability indices. The loss rate or decomposition kinetics study revealed that the kitchen, vegetable and horticultural waste compost had the higher rate of decomposition (*K*) of about 1.36 to 2 fold as compared to crop residue compost. Further the potential loss percentage was maximum (95.68%) in vegetable waste compost (Table 2.6.3a).

Maturity parameters such as C/N ratio, L/C ratio, CEC/TOC ratio and degree of polymerization reached much earlier in vegetable waste compost (20 days) followed by kitchen waste (25 days), horticultural waste compost (35 days) and farm waste compost (45 days). Point sources of segregation of domestic waste (Kitchen waste), vegetable waste substantially reduce the content of heavy metals and improve the quality of compost (Table 2.6.3b). Thermophilic microbes enhance the decomposition process at 50- to 60 ^{0}C. Microbial community has been studied at different stages of decomposition and it was found that thermophilic bacterial community increased with the temperature. After curing stage of composting the content of heavy metals were relatively low and below the permissible limits (Table 2.6.3c).

Table 2.6.3a. Loss rate kinetics of different compost with and without bio inoculation

Types of compost	Inoculation status	*A (Intercept)* Potential loss (% loss)	*K (Rate constant)* (kg day^{-1})
Kitchen waste compost	Inoculated	50.25	0.1010
	Un-inoculated	41.04	0.0746
Crop residue compost	Inoculated	47.75	0.0530
	Un-inoculated	45.64	0.0544
Vegetable waste compost	Inoculated	95.68	0.0214
	Un-inoculated	37.99	0.012
Horticulture waste compost	Inoculated	44.67	0.0202
	Un-inoculated	30.96	0.0102

Table 2.6.3b. Compost maturity and stability indices of different compost

Compost maturity parameters	Kitchen waste compost		Vegetable waste compost		Horticultural waste compost		Farm waste wheat straw	
	I	U	I	U	I	U	I	U
Ash (%)	67.42	58.00	62.71	62.71	61.14	62.19	57.70	56.08
TOC (%)	18.10	23.33	20.72	20.72	21.59	21.01	23.50	24.4
Loss C (%)	44.2	28.01	35.80	40.13	45.21	46.68	47.78	45.78
TN (%)	1.37	1.05	1.21	0.87	1.01	0.87	1.12	1.08
C/N	13.21	22.22	17.12	23.81	21.38	24.15	20.98	22.59
Lignin	17.33	14.51	15.92	15.92	15.45	15.77	14.40	14.21
Cellulose	15.33	14.23	16.30	15.29	17.90	14.20	17.90	16.70
L/C	1.13	1.02	0.98	1.04	0.86	1.11	0.80	0.85
CEC (c mol (p$^+$) kg^{-1}	113.33	57.00	85.17	59.89	67.35	55.34	68.80	66.50
Water soluble C (%)	0.51	0.76	0.63	0.63	0.68	0.65	0.45	0.55
Water soluble Carbohydrate (%)	0.59	0.91	0.75	0.75	0.80	0.77	0.88	0.67
CEC / TOC	6.26	2.44	4.11	2.89	3.12	2.63	2.93	2.73
HA	13.47	8.50	10.98	9.78	9.75	7.65	7.98	7.34
FA	4.20	3.40	3.80	3.80	3.67	3.76	3.61	3.21
Total Extractable humus fraction	17.7	11.90	14.78	13.58	13.42	11.41	11.59	10.55
H/FA or DP	3.21	2.50	2.89	2.57	2.66	2.04	2.21	2.29

 # I: Inoculation; U: Un-inoculation

Table 2.6.3c. Heavy metals content (ppm) in matured compost and their threshold limits

Parameters	Vegetable waste compost (20 days)	Kitchen waste (25 days)	Horticultural waste (35 Days)	Farm waste using wheat straw (45 days)	Threshold limits
Cd	T	0.7 -1.0	T	T	5.0
Cr	10-12	12.3 -14.2	4.5-5.6	1.5 -2.4	50.0
Ni	5.5-6.7	3.6-4.4	2.9-3.5	1.2-3.1	50.0
Cu	20-23.3	19.8 - 24.2	22.9-23.6	20.1-21.3	300.0
As	T to 1.2	T- 1.1	T-1.5	T-2.1	10.0
Zn	65.8 -56.7	77.1-65.6	76-67.9	75-87.3	500
Pb	107-21.2	12.3-22.3	18.0-21.6	17.7-22.8	100

#Trace: T

2.6.4 Endophytic bacteria of corn root for plant growth promotion

Bacterial endophyte from corn root grown at different doses of nitrogen fertilizers of NICRA experiment field was explored and characterized for plant growth promoting attributes. Out of total 47 bacterial isolates, 29 showed growth on N free media, 16 could solubilize inorganic P, 22 isolates were K solubilizer, 8 possessed biocontrol activity against *Macrophomina phaseolina* and 25 were positive for siderophore production ability. An Isolate FDN2-1 showing highest P and K solubilizing ability (431 ppm from Tri-calcium phosphate and 52ppm from Glauconite respectively), and also possessed multiple PGPR attributes and was characterized using biochemical, microscopic and genetic approaches. This isolate was Gram negative rod and phylogenetically related to *Burkholderia* sp. FDN2-1 was based on partial sequence of 16s rRNA gene.

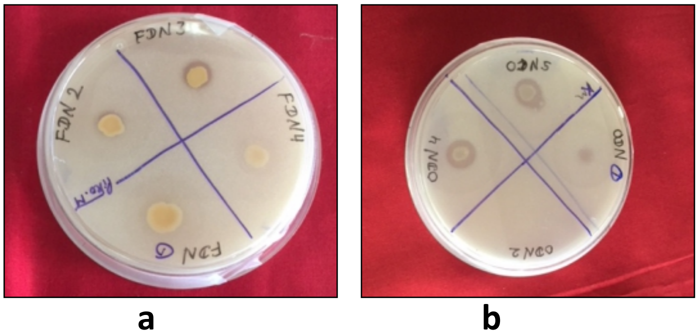


Plate 2.6.4a Corn endophyte showing Phosphorus (a) and Potassium solubilization ability on plate

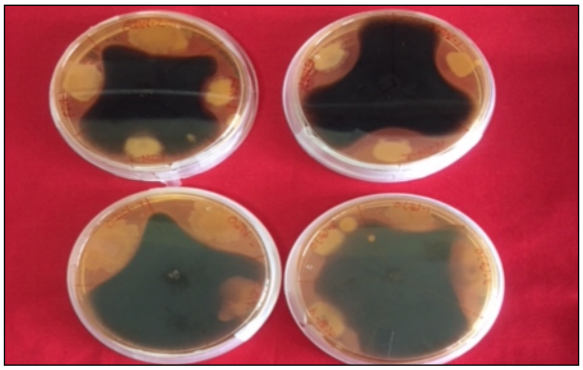


Plate 2.6.4b Biocontrol ability of corn root endophytes against *Macrophomina phaseolina*

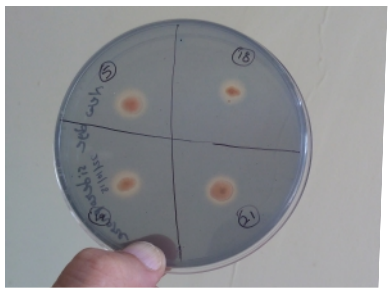


Plate 2.6.4c Siderophore production ability of corn root endophytes

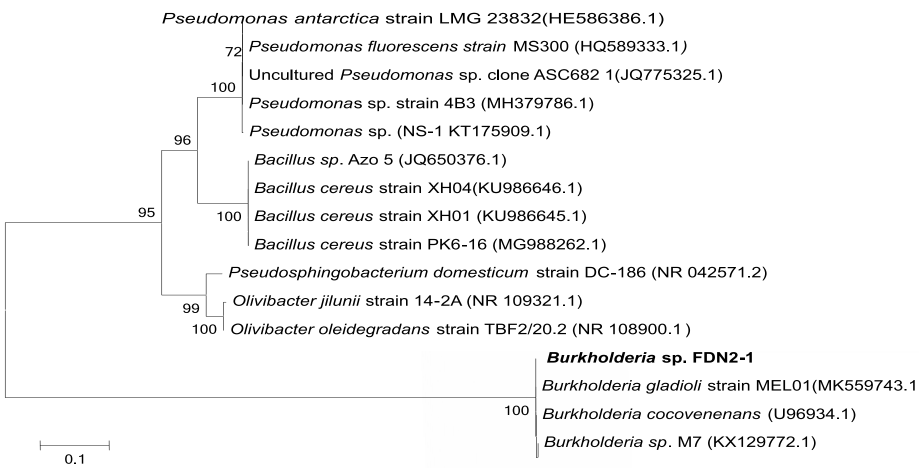


Fig. 2.6.4. Phylogenetic tree of FDN2-1 showing clustering with *Burkholderia* sp.

2.6.5 Soil biological activity under organic farming

Soil enzyme activity is an indirect indication of the activities of microbes and 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 in terms of fluorescien 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 plot which was closely similar to 75% organic + innovative/25% inorganic as compared to 100 % inorganic in wheat. For other crops also FDA hydrolysis was recorded highest in 100% Organic followed by 75% organic + innovative/25% inorganic treatment indicating beneficial effect of addition of organics on soil microorganisms (Fig.2.6.5a). Among the cropping systems, soybean-wheat recorded higher FDA hydrolytic activities followed by soybean-mustard and soybean-chickpea. Organic management had the highest dehydrogenase activity among all the nutrient management system (Fig. 2.6.5b). Similarly, alkaline phosphatase and β Glucosidase enzymes activities were found to be 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. 2.6.5c, 2.6.5d).

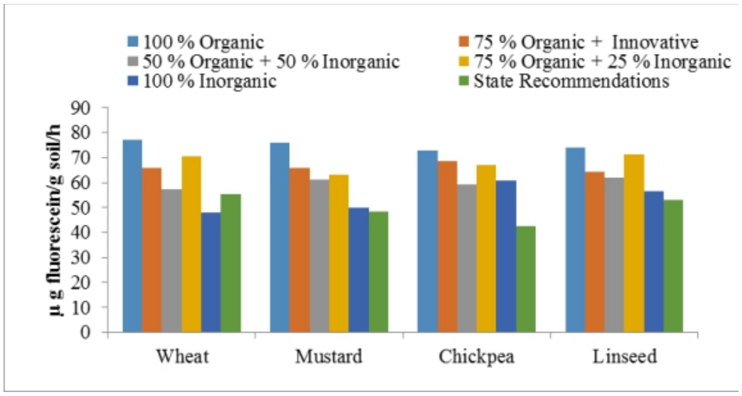


Fig. 2.6.5a. Fluorescein diacetate hydrolysis activity as affected by different nutrient sources in different crops

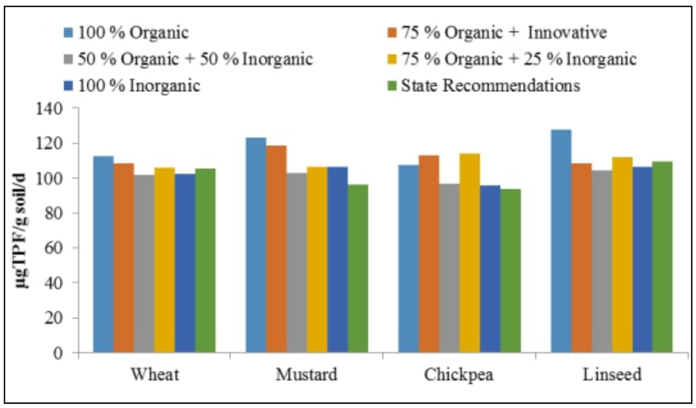


Fig. 2.6.5b. Soil dehydrogenase activity as affected by different nutrient sources under different crops

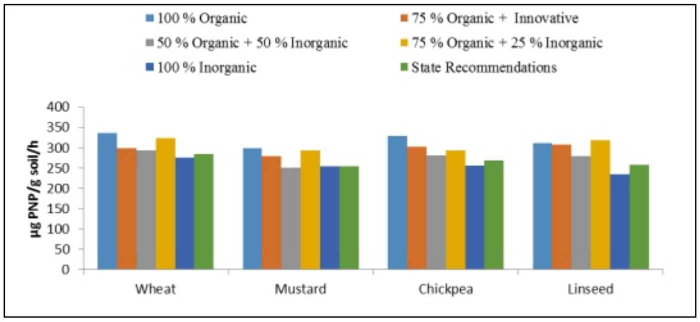


Fig. 2.6.5c. Alkaline phosphatase activity as affected by different nutrient sources under different crops

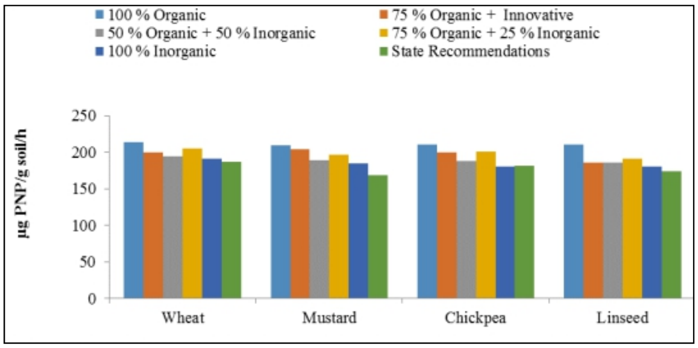


Fig. 2.6.5d. β - Glucosidase activity as affected by different nutrient sources under different crops

2.6.6 Effect of long-term use of FYM and inorganic fertilizer on biological P supply power of soil in LTFE Barrackpore

Biological P supply power of the LTFE soil was determined by incubating soil with Pikovskaya media where the P source was used as tri-calcium phosphate (TCP)/aluminum phosphate (Al-P)/ferric phosphate (Fe-P). Results revealed that 100% NPK+FYM had the highest P supply power from TCP which was statistically similar with the fallow. However, the P supply power from Al-P and Fe-P was highest under fallow, followed by 100% NPK+FYM and 100% NPK. The P supply power of soil followed the trend: TCP>Al-P>Fe-P in all the treatments. However, it is evident that the imbalanced fertilizer application for long term (100% N and 100% NP) had declined the biological P supply power of soil, even from control, though the effect was not significant.

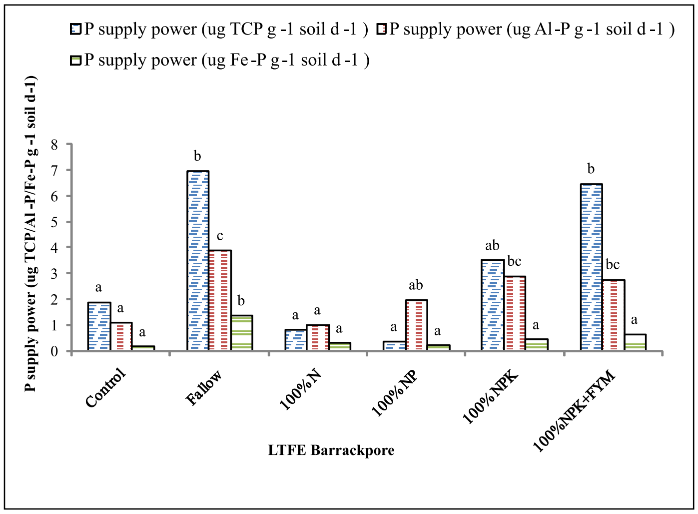


Fig. 2.6.6a. Long term effect of FYM and inorganic fertilizer on biological P supply power of soil in LTFE Barrackpore

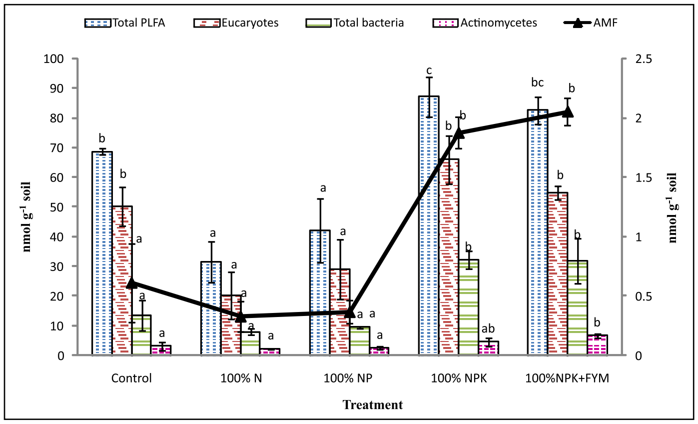


Fig. 2.6.6b Long term effect of FYM and inorganic fertilizer on soil microbial community in LTFE Palampur

Phospholipid fatty acid (PLFA) content showed distinct variation among INM, balanced and imbalanced fertilizer application. Out of the different biomarker PLFA corresponding to different groups of microbial community, only total PLFA, total bacteria, actinomycetes, AMF and eukaryotes had significant variation due to fertilizer and manure application; rest of the groups i.e Gram+ve, Gram-ve, saprophytic fungi and anaerobes did not have any significant variation among the treatments, thus not presented here. Results revealed that imbalanced fertilizer application had significantly ($p<0.05$) reduced the abundance of total PLFA (38.6 -54.3 %) and eukaryotes (42.3 - 59.8 %) as compared to control. Balanced fertilizer application and INM had significantly greater abundance of total PLFA, total bacteria, AMF, actinomyctes and eukaryotes than control and imbalanced fertilizer application.

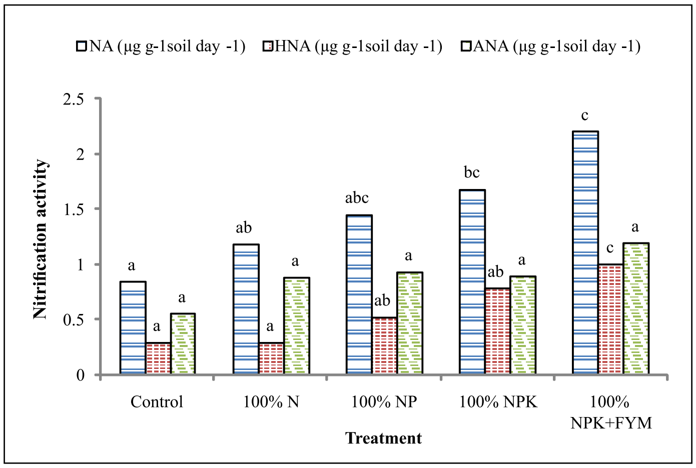


Fig. 2.6.6c. Long term effect of FYM and inorganic fertilizer on potential nitrification in LTFE Palampur

As well perceived the major contributor of soil nitrification was Autotrophic nitrification activity (ANA), however Heterotrophic nitrification activity (HNA) had significant contribution. ANA contributed 53.0 - 74.6 % of total NEA in different treatments whereas, HNA contributed 24.6- 45.5 % of total Nitrification activity (NA). The INM treatment (100% NPK+FYM) significantly increased NEA and HNA as compared to control and 100 % N treatment. Marginal increase of ANA was noticed in INM and balanced fertilization as compared to control and imbalanced fertilization. ANA ranged from 0.55-1.19µg g^{-1} soil day^{-1} whereas the HNA ranged from 0.29-1.00µg g^{-1} soil day^{-1}. The highest HNA was found in 100% NPK+FYM treatment which was statistically similar with 100% NPK and had 48 - 71 % more ($p<0.05$) HNA than imbalanced fertilization and control.

Key regulator of N mineralization and ecological indicator in LTFE Palampur soil

Multiple regression and path analysis have often been chosen to address the dynamics and multiple causality involved in soil biological and ecological process. A stepwise linear multiple regression analysis (R^2 = 0.97, Adjusted R^2 = 0.96) with NMP as dependent variable revealed that TOC and protease enzyme activity are the prime regulators of N mineralization dynamics in sub-humid to humid Alfisol. Similarly, another multiple regression model ($R^2 = 0.99$ Adjusted $R^2 = 0.99$) with respect to geometric mean of enzyme activities (GMea) revealed that NH_4^+-N, MBN, Total PLFA and TOC are the major controlling factors of the soil health indicator reflecting N cycling enzyme dynamics.

PNM = 2.36 +1.68 TOC +0.52 Protease

GMea = 7.17 + 1.18 NH_4^+-N +0.12 MBN+0.04 Total PLFA +0.28 TOC

2.6.7. Specific enzyme activity related to carbon cycling in various land use practices of semi-arid to sub-humid Central India

Specific enzyme activity of phenol oxidase controls carbon sequestration potential in the natural as well as agro-ecosystem. Lower specific enzyme activity of phenol oxidase in integrated nutrient management treatment as compared to imbalanced fertilizer application reflected lower decomposition of lignin or poly phenolic macromolecules in turn indicating higher carbon sequestration potential (Fig. 2.6.7a). Similarly, specific enzyme activity of phenol oxidase indicated that the horticulture and grassland system has the potential of carbon sequestration in upper soil depth whereas agroforestry and Palash based black forest soil has higher carbon sequestration potential in lower depth (Fig. 2.6.7).

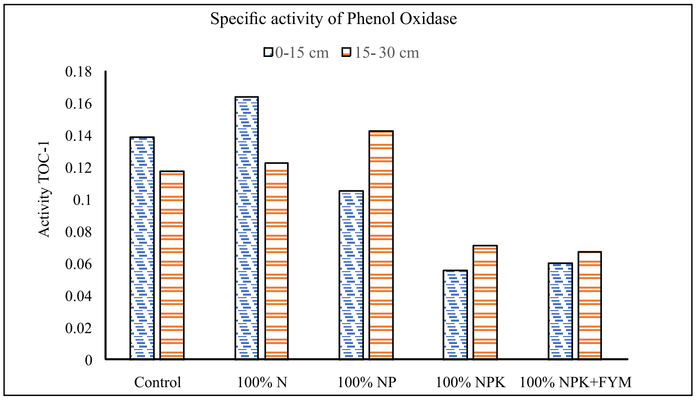


Fig. 2.6.7a. Specific activity of carbon cycling enzyme at 0-15 and 15-30 cm depth in LTFE Raipur

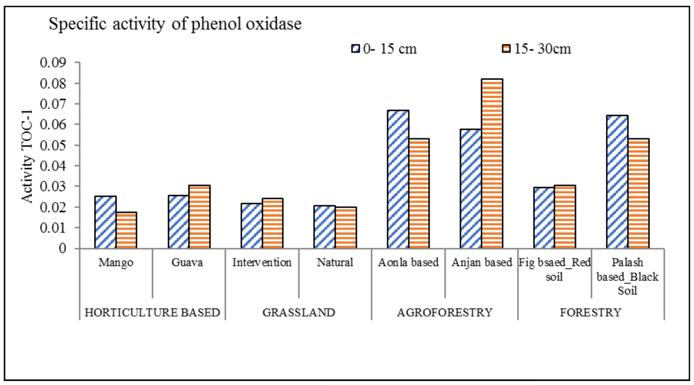


Fig. 2.6.7b. Specific activity of carbon cycling enzyme at 0-15 and 15-30 cm depth under different land use systems

2.7 AINP on SBB

2.7.1 Genetic diversity of Soil Micro flora and fauna in North East Hill Region

Microbial diversity in a rice soil ecosystem in response to different organic fertilizer regimes of NEH was estimated. The fertilizer regimes were constituted of different organic fertilizers as mentioned in the Fig. 2.7.1a. In general, the microbial abundance was dominated by bacteria (57 - 99%) followed by Archaea (0-33%) and Eukarya (0.55-10%). Among the different bacterial phyla, proteobacteria contributed to the highest bacterial diversity (38-68%). The functional microbial diversity was dominated by methane oxidizing bacteria. Highest methanotrophs were observed in the treatments of compost at 5 t ha^{-1}. The endophytic actinobacteria of rice were identified (Fig. 2.7.1b). which were closely homologous to the 16S rRNA gene of *Streptomyces finlayi* and *Streptomyces parvulus* and showed antagonistic effect against four pathogenic fungi *viz. Fusarium oxysporum, Rhizoctonia solani, Curvularia lunata* and *Sclerotinia sclerotiorum. Nocardiopsis sp* and *Streptomyces finlayi* exhibited maximum inhibition against the plant pathogenic bacteria *Xanthomonas oryzae* and *Erwinia sp.*

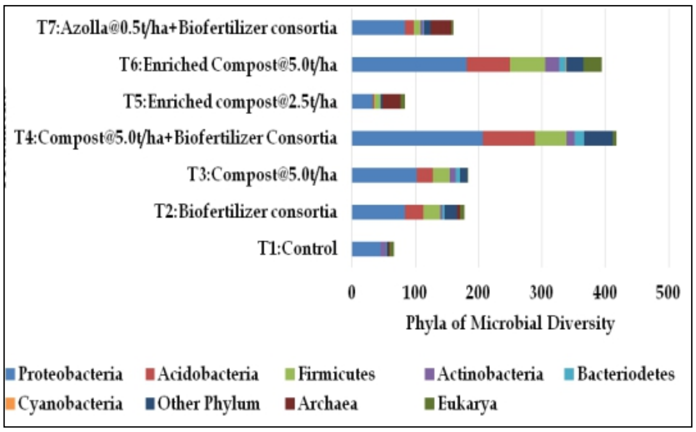
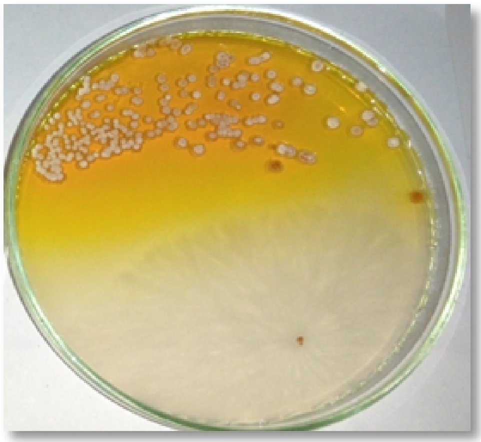
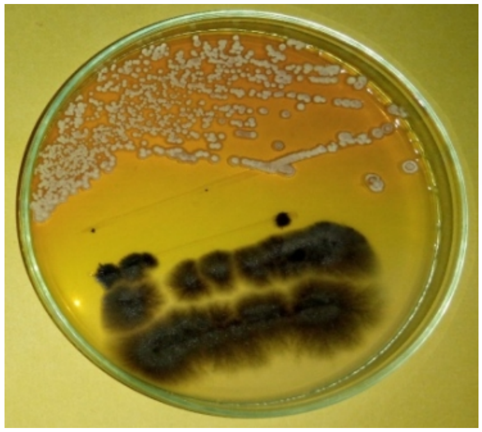


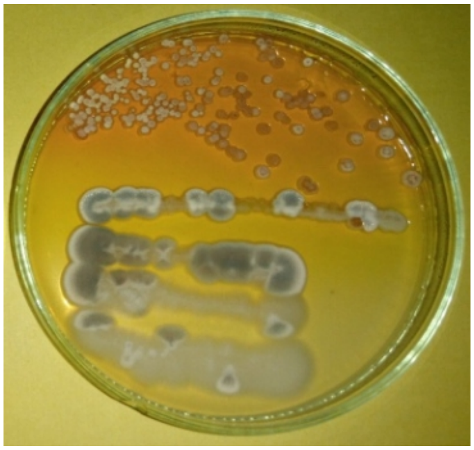
Fig. 2.7.1a. Microbial diversity at phylum level as influenced by organic inputs



Rhizoctonia solani



Curvularia lunata



Fusarium oxysporium

Sclerotinia sclerotiorum

Plate 2.7.1b *In vitro* inhibition of plant pathogenic fungi and bacteria by endophytic Actinobacteria

2.7.2 Development of a bacterial species based probe to assess the fertility status of soil

Soil biological quality index (SBQI) methods were developed at the AINP SBB centre located at TNAU. The indices were developed from different soil biological attributes. The SBQI indices can be based on simple additive (SBQI-1 and SBQI-2), scoring function (SBQI-3), principal component analysis- (SBQI-4) and quadrant-plot based method (SBQI-5). Minimum dataset to represent the total biological activities of the soil and its contribution to the soil quality aimed to develop a unit less soil biological quality index (SBQI) scaled between 0 and 10. Parameters were soil organic carbon, microbial biomass carbon, labile carbon, protein index, dehydrogenase activity and substrate-induced respiration. The SBQI, calculated using the threshold values of each biological attributes ranged between 3.4 - 7.3 for the tested soil samples. All the five methods were further validated for their efficiency in 25 farmers' soils of the location and proved that these methods can be effectively used to scale the biological health of the soil. Among the five SBQIs developed in this study, SBQI-5 was the best. This index relates highly with the variables to scale the biological health of soils.

2.7.3 Long term study and application of biofertilizer in different cropping system

A long term experiment (8 yrs) was conducted to assess the

Table.2.7.3a. System productivity (t ha^{-1}) of maize-cowpea cropping system under the influence of biofertilizers application

Sl. No	Treatment /POP	Maize	Cowpea pod	Maize Equivalent	Relative performance
1	No BF (Control)	6.02	3.06	10.7	-
2	Solid BF basal	7.07	3.52	12.7	100
3	Liquid BF basal	6.97	3.46	12.3	89
4	Solid incubated basal	8.32	3.79	14.2	195
5	Liquid incubated basal	7.06	3.83	13.0	128
6	Seed coating with solid BF	8.55	3.89	14.5	211
7	Seed soaking with liquid BF	8.19	4.01	14.4	206
8	Seed soaking with liquid BF (2 lt.) and top dressing with 8 lts. of liquid BF in Rhizosphere	8.56	4.11	14.9	233
9	LSD (P=0.05)	0.66	0.25	0.83	-
10	CV (%)	7.0	5.1	5.0	-

*Package of Practices (POP)

comparative efficacy of solid and liquid based biofertilizers on Maize-Cowpea and Ragi-Cabbage cropping systems in a sandy loam acidic soil of pH 5.5 (Table 2.7.3a). The soil was characterized as low organic carbon (4.3 g kg^{-1} soil), low available N and K, high P and medium S status. Liquid biofertilizers which were applied through seed soaking and top dressing, were efficient in improving yield of maize-cowpea than solid biofertilizers. Bioinoculation of *Rhizobium* had significant influence on the crop productivity (Table 2.7.3b). The uptake of nutrients (both major and minor) by the crops almost doubled compared to no bio inoculation. *Rhizobium* resulted highest seed yields of 1630 kg ha^{-1} at Bhubaneswar, followed by 1790 kg ha^{-1} at Nuapada and 1640 kg ha^{-1} at Bhawanipatna. However, the yields were 330, 230 and 530 kg ha^{-1}, higher than the local commercial inoculants.

Table.2.7.3b. Nutrients uptake under the influence of integration of biofertilizer use

Sl. No	Treatment	Update of nutrient									
		N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn
		kg ha^{-1}						mg kg^{-1}			
1	No BF (Control)	176	14.7	58.0	53.1	23.8	4.4	828	238	508	208
2	Seed soaking in 2 L and 8 L top dressing *Rhizosphere* ha^{-1}	304	31.3	128.0	102.0	48.0	12.0	1557	513	120	360

Theme - IV: Soil Pollution, Remediation and Environmental Pollution

2.8 Soil Pollution and Remediation

2.8.1 Assessment of cotton for remediation of soils contaminated with heavy metals: Multiple heavy metals

In the earlier studies, cotton (Bt)(RCH-2) plant was assessed for the remediation efficiency in soils contaminated with different heavy metals (Cd, Pb and Cr) by exposing it to different concentrations (0,50,100 & 200 mg kg^{-1} soil of Cd), (0,500,750 and 1000 mg kg^{-1} soil of Pb) and (0,12.5,25 & 50 mg kg^{-1} soil of Cr) individually. Even at the highest level of each heavy metal, no mortality was observed. Further, the tissue concentration of the metals indicated that, cotton was an excluder of Cd, Pb and Cr. With that experience, another experiment was conducted with higher levels of Cd (0, 200, 400, 600, 800 and 1000 mg kg^{-1} soil) and (0, 1000, 1500, 2000, 2500 and 3000 mg Pb kg^{-1} soil) by taking the highest levels of Cd and Pb in the previous study as base levels i.e., 200 mg Cd kg^{-1} soil and 1000 mg Pb kg^{-1} soil to find out the tolerance limit of cotton to Cd and Pb. Results indicated that the plant tolerated up to 1000 mg Cd kg^{-1} soil and 3000 mg Pb kg^{-1} soil. In the current study, the plants were exposed to different combinations of heavy metals (mg kg^{-1} soil) i.e., (T_1) $Cd_0Pb_0Cr_0$, (T_2) $Cd_0Pb_0Cr_{25}$, (T_3) $Cd_0Pb_{750}Cr_0$, (T_4) $Cd_0Pb_{750}Cr_{25}$, (T_5) $Cd_{100}Pb_0Cr_0$, (T_6) $Cd_{100}Pb_0Cr_{25}$, (T_7) $Cd_{100}Pb_{750}Cr_0$ and (T_8) $Cd_{100}Pb_{750}Cr_{25}$. Though, the application of heavy metals (Cd, Pb and Cr) resulted in stunted growth and decreased the yield, the difference was significant only in the case of Cr. However, when the heavy metals were applied in combination, there was a significant reduction in total dry weight, number of bolls pot^{-1} and lint yield pot^{-1}. Chromium when applied separately was more toxic than when it was applied in combination with other heavy metals particularly Pb. The tissue analysis revealed that, when Cr was applied in combination with Pb, there was a significant reduction in the uptake of Pb (Fig.2.8.1) and (Plate 2.8.1, 2.8.1) (Table 2.8.1) .

Table 2.8.1 Effect of multiple heavy metal stress in cotton

Treatment (mg kg soil^{-1})	Dry weight root (g pot^{-1})	Dry weight shoot (g pot^{-1})	Total dry weight (g pot^{-1})	No. of bolls pot^{-1}	Lint yield (g pot^{-1})
$Cd_0Pb_0Cr_0$	13.20^{a}	55.88^{a}	69.08^{a}	10.00^{a}	43.46^{a}
$Cd_0Pb_0Cr_{25}$	5.27^{e}	27.71^{d}	32.98^{d}	2.67^{e}	11.04^{e}
$Cd_0Pb_{750}Cr_0$	10.50^{b}	53.34^{a}	63.84^{ab}	9.00^{ab}	40.79^{a}
$Cd_0Pb_{750}Cr_{25}$	8.57^{bcd}	50.44^{a}	59.01^{ab}	7.33^{bcd}	34.96^{ab}
$Cd_{100}Pb_0Cr_0$	9.90^{b}	54.79^{a}	64.69^{ab}	9.33^{ab}	38.96^{ab}
$Cd_{100}Pb_0Cr_{25}$	6.40^{de}	32.79^{cd}	39.19^{de}	6.33^{cd}	22.61^{cd}
$Cd_{100}Pb_{750}Cr_0$	9.53^{bc}	47.54^{ab}	57.07^{bc}	8.33^{abc}	30.45^{bc}
$Cd_{100}Pb_{750}Cr_{25}$	7.17^{cde}	39.19^{bc}	46.36^{cd}	5.33^{d}	20.92^{d}
CD(0.05)	2.67	11.10	11.94	2.13	8.59

Plate 2.8.1a Effect of multiple heavy metal stress in cotton

Plate 2.8.1b Effect of multiple heavy metal stress in cotton

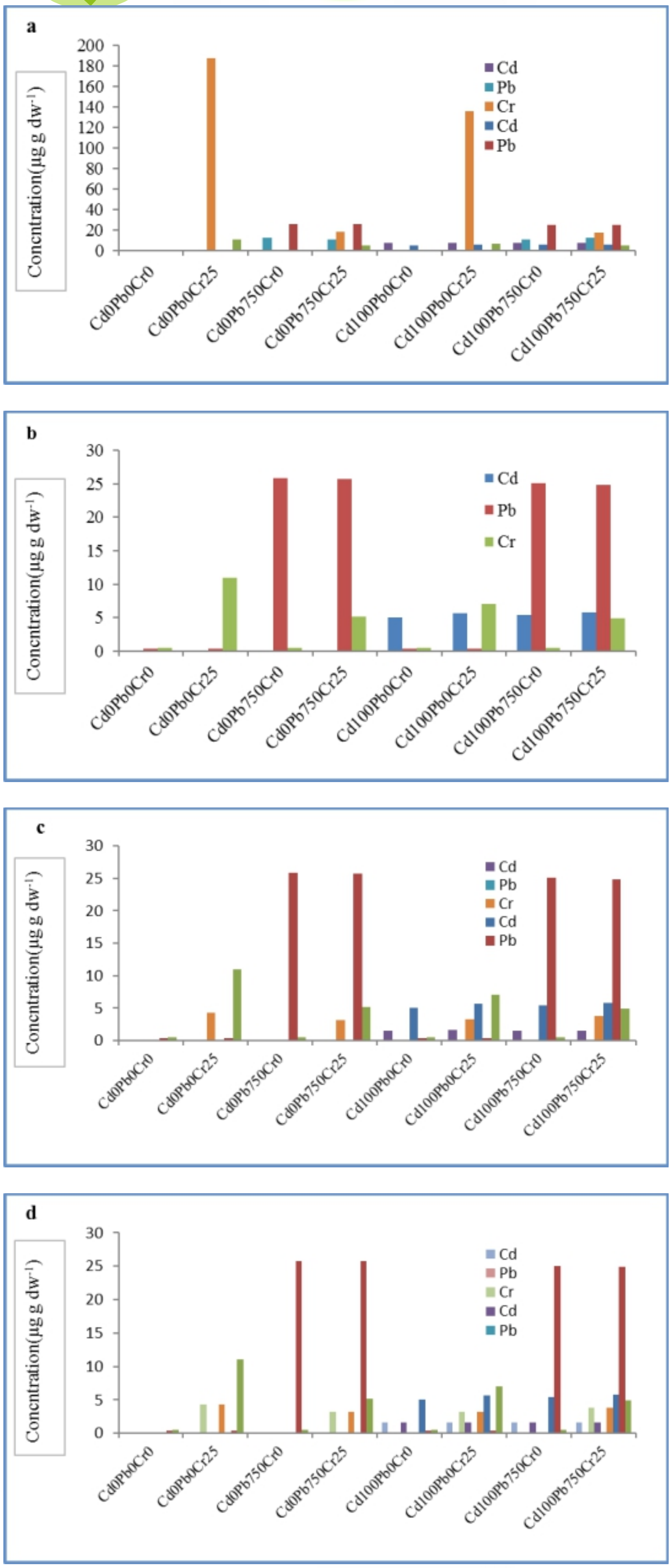


Fig. 2.8.1 Partitioning of heavy metals (Cd, Pb and Cr) in a) roots; b) shoots; c) seeds of cotton; d) cotton

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

Bhanpur landfill receives garbage from the entire city with no recycling facility and has been making life miserable for locals for years. Residents of nearby rural and urban areas are facing hazardous smoke and other impacts. The main problems facing by the surroundings area are leaching from waste dump leads to ground water contamination, surface water contamination due to run-off from the waste dump, bad odour, pests, rodents and wind-blown litter around waste dump, generation of inflammable gas such as methane from the waste dump, frequent fires, spread of epidemics due to stray animals, soil contamination, greenhouse gas emission etc. The composition of MSW of Bhanpur was recorded as plastics 10.71%, leather, rubber 30.25%, clothes 5.23%, soil 8.25%, glass 10.50%, metals 15.26%, bricks, stones16.23% other wastes 3.57%. PLFA analysis of the microbial community was done to know the distribution of different microbes in pristine soil, cultivated soil, polluted soil and plant rhizosphere. It was observed that population of beneficial microorganisms was reduced in polluted soil. The solid waste consists of heterogeneous mixture of undesirable mass or materials coming from the industrial, agricultural, institutional, domestic and animal waste. The toxic components of the waste such as heavy metals, organic pollutants cause degradation of soil health, ground water quality, affects plant growth, livestock and human health after entering the food chain or drinking water supply. There is need to identify economically viable technique to minimize toxicity from various kinds of pollutants and to protect the soil health by the transformation of toxic compounds/heavy metals to a harmless state. Development of best package of practices for growing of plants in the contaminated sites and phyto-remediation of heavy metal contaminated sites of MSW dumping areas with plants like Vetiver (*Chrysopogon zizanioides*) has great effect on soil microbiological properties. This study observed that, rhizosphere of the established plants has positive influence on the improvement in microbiological activities. The microbial populations such as total heterotrophs, fungi and actinomycetes population was found more in the rhizosphere of vetiver plants as compared to control or unpolluted soil. The microbial activities in terms of soil respiration and soil enzyme activities such as soil dehydrogenase activities, fluorescein di-acetate hydrolysis was also found higher in the rhizosphere soil of the contaminated waste site as compared to control.

Table 2.8.2 Microbial population in MSW contaminated Bhanpur soil

Samples	Total Heterotroph (cfu g^{-1} soil)	Fungi (cfu g^{-1} soil)	Actinomycetes (cfu g^{-1} soil)	Soil respiration (mg CO_2-C kg^{-1} soil 10 d^{-1})	Soil dehydrogenase activity (µg TPF g^{-1} soil h^{-1})	Fluorescein diacetate hydrolysis (g fluorescein g^{-1} soil h^{-1})
Rhizosphere soil from the vetivar , Bhanpur	5.5-8.5 $x10^8$	4.6-5.8$x10^6$	5.0-6.2 $x10^8$	94 ± 10.5	34 ±4.2	25 ± 2.0
Control soil (Unpolluted soil)	4.8 -5.4 $x10^7$	3.0-4.2 $x10^5$	3.0-4.5x 10^6	46 ± 7.4	18± 2.5	14 ± 1.2

Plate 2.8.2 Development of green belt at Bhanpur dump area

2.8.3 Ageing effect of spiked cadmium on its bioavailability in soil and phytotoxicity to spinach crop

The cadmium was spiked with graded levels ranging from 0 to 40 mg kg^{-1} soil (0,2,5,10,15, 20,30,40 mg kg^{-1} soil) in alluvial soil (Rarha series; Sub-order: Udic Ustochrept); black soil (Jindakheri series; Sub-order: Typic Haplustert) and lateritic soil (Ranchi series; Sub-order: Typic Haplustalf) during April 2016. Three consecutive spinach crops were raised till 2018 and at the end of each harvest stage, plant and soil samples were analyzed for cadmium content. The bioavailable Cd content and toxicity over a period of time (3 years) remains almost similar in case of Alfisol, whereas the plant phytotoxicity and bioavailability was reduced significantly in Vertisol at the end of third year as compared to first year of spiking. In case of Alluvial soil (Kanpur), there was slight decrease in bioavailable Cd content and phtotoxicity at the end of third year as compared to 1st year of spiking.

The study was also aimed to assess the suitability of extractant (0.01M $CaCl_2$, 1M$CaCl_2$, DTPA and 0.43M HNO_3) in predicting bioavailable cadmium content in soil as influenced by major soil properties and its relationship with plant cadmium content in spinach leaf. Significant linear relationship was observed between the different extractable content (0.01M $CaCl_2$, 1M$CaCl_2$, DTPA and 0.43M HNO_2) and spinach leaf Cd content with relatively low R^2 of 0.846 for 0.01M $CaCl_2$ (Fig. 2.8.3a). Pot culture experiments were conducted for the third consecutive year to derive phytotoxicity limits of Cd for major soil Orders (Alfisol, Vertisol and Inceptisol) of India. The results showed that the average percent reduction in dry biomass of spinach leaf at the highest level of cadmium contamination (40 mg kg^{-1}) over control after three crop cycles was 43.67, 39.19 and 26.31 % in Alfisol, Inceptisol and Vertisol, respectively (Fig. 2.8.3b). Even after the three consecutive spinach growth (3 years of experiment) the 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. Similarly, the trend was similar over the period of three years that at their corresponding levels, cadmium accumulation in spinach biomass leaf was more in lateritic soil followed by alluvial and black soil. The results also indicate that the phytotoxicity of cadmium for spinach crop was lower in Vertisol due to high pH and clay content.

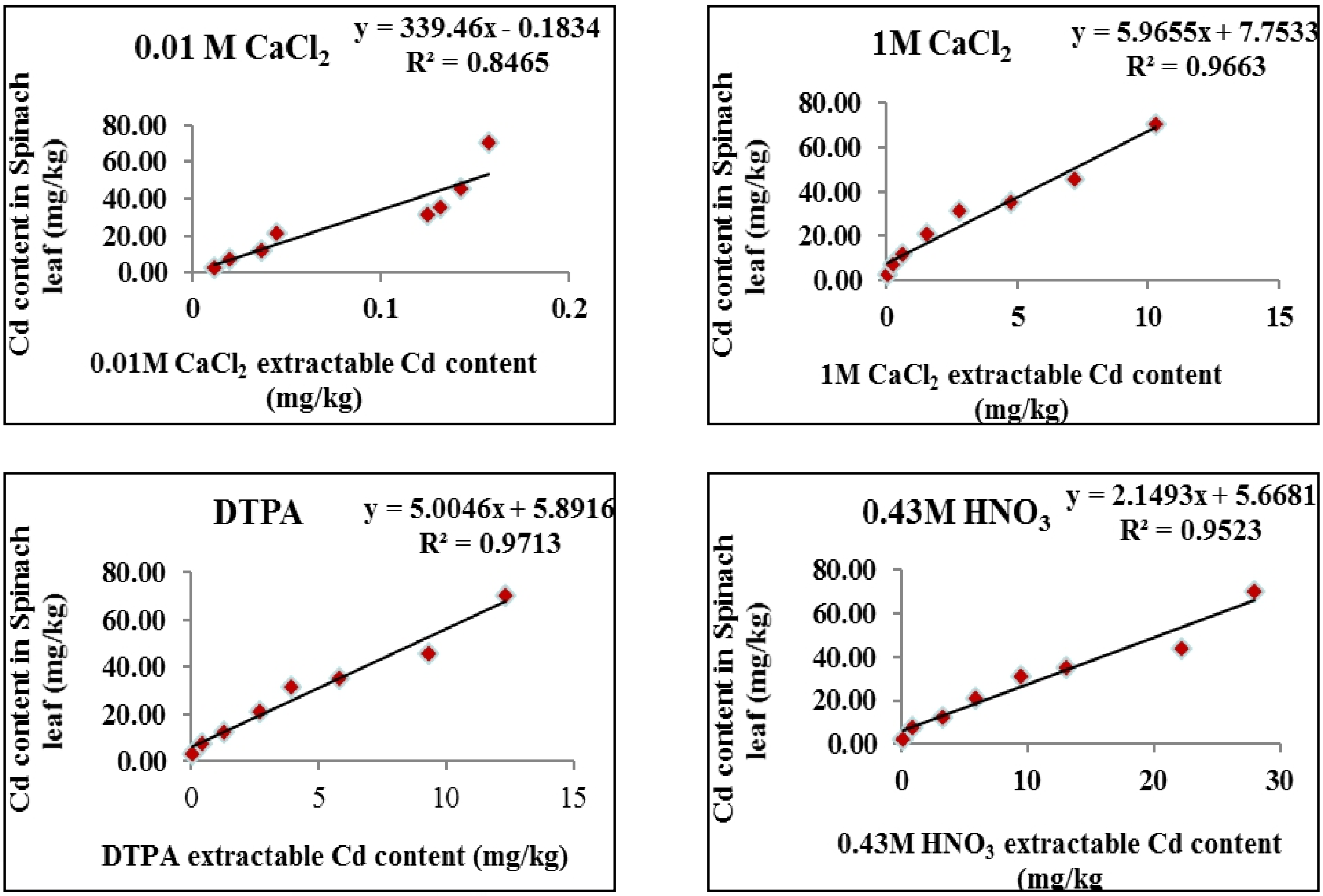
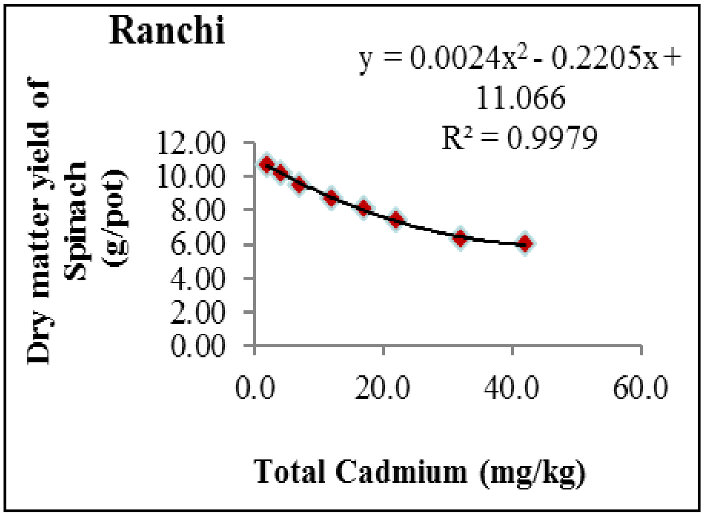
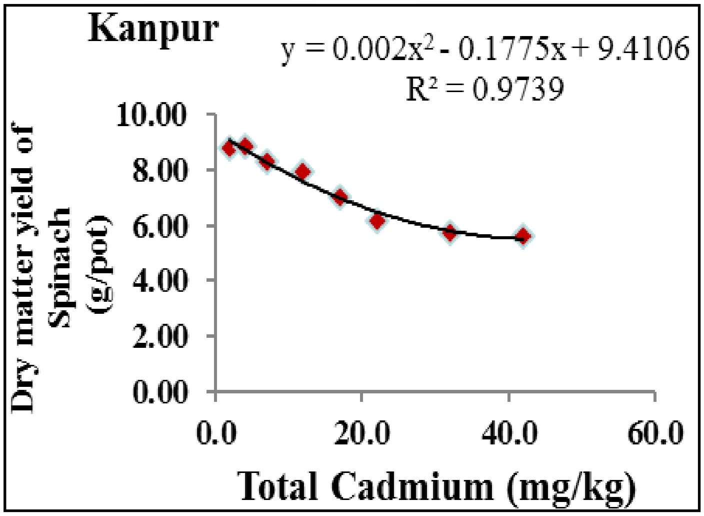


Fig. 2.8.3a Relationship between bioavailable Cd content in black soil and Cd content in spinach leaf





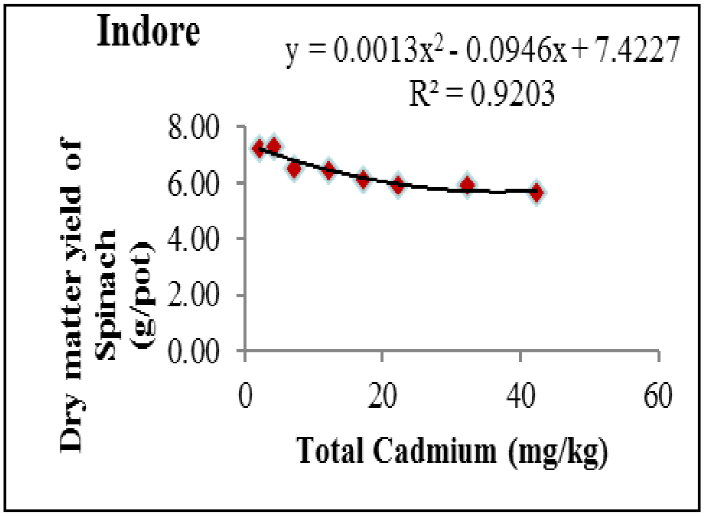


Fig. 2.8.3b Effect of Cadmium levels on dry matter yield of spinach leaf

2.8.4 Reclamation and rehabilitation of copper mining affected land in Malanjkhand, Madhya Pradesh

The soil and tail samples (rejects from ore process) have been collected from copper mining affected land in Malanjkhand. The maximum and minimum pH values of the soil were found to be 5.93 and 3.57 with an average value of 4.69. The acidic pH of the soil is due to the impact of mine drainage. Similarly, the maximum value of EC was 876 µS cm^{-1} while the least EC was 951.67 µS m^{-1} with an average of 83.40 µS cm^{-1}. Maximum organic carbon percentage was 0.511 while the least value was 0.189 with average of 0.33. The pH and EC of water samples varied from 3.21 to 6.95 and 3.08 to 472 µS cm^{-1} respectively. The results showed no beneficial effect of vetiver plantation on heavy metal uptake in tail dam in the initial stages. The heavy metal (HM) content in plants part showed differential uptake of HM. Even rhizospheric soil showed tremendous concentration of HM of vetiver (Table 2.8.4a, b, c, d).

Table 2.8.4a Heavy metal content of Tail/Experiment sand

Soil Sample (mg kg^{-1})	Cd	Co	Cu	Fe	Pb	Zn
Tail site + Vetiver	0.63	20.10	372.48	1481.50	8.75	13.03
Expt site	1.00	16.83	117.88	1231.75	19.28	22.23
Tail 1 - Vetiver	0.50	18.78	404.00	1244.50	8.63	9.35
Tail Tank	0.75	1.23	221.98	1019.95	4.73	6.40
Expt site (blank)	0.50	3.00	751.00	874.00	1.75	6.45
Cyprus Soil	0.50	15.05	144.20	1258.00	7.90	18.05
Vetiver Expt	0.50	12.25	108.10	1274.00	8.15	37.00
Vetiver wild	0.25	3.45	1400.00	1222.50	3.90	8.30

Table 2.8.4b Different plants with different metal uptake capacity

Plant Sample (mg Kg^{-1})	Cd	Co	Cu	Fe	Pb	Zn
Vetiver wild Shoot	0.50	4.00	4.23	39.70	0.24	3.98
Vetiver Shoot	0.15	12.00	0.68	10.92	0.94	0.74
Cyprus Shoot	0.00	0.00	5.44	528.80	1.04	1.32
Cassia tora Shoot	0.00	0.00	0.42	10.46	0.06	1.30
Vetiver Expt Shoot	0.20	16.00	0.65	45.32	0.12	2.22
Vetiver wild Root	0.10	8.00	4.73	24.45	0.29	0.94
Vetiver Root	0.05	4.00	1.11	43.28	0.12	1.33
Cyprus Root	0.15	12.00	0.76	57.88	0.17	2.09
Cassia tora Root	0.05	4.00	0.44	19.08	0.15	0.79
Vetiver Expt Root	0.20	16.00	1.35	49.80	0.14	1.29

The water samples show no heterotrophs, however, the soil attached to vegetation (Vetiver) showed the microbial as well as DHA activity. It shows that development of microbial activity due to development of vegetation.

Table 2.8.4c Some of the biological parameters from the representative samples

Vegetation	Heterotrophs (Dilutionx10^5)	DHA (µg TPF g^{-1} soil day^{-1})
Vetiver tail 1	2	33.1
Vetiver tail 2	5	128.1
Natural Tail 1	1	16.3
Natural Tail 2	38	75.0
Experiment	4	10.6
Vetiver tail soil	28	17.5
Vetiver wild soil	9	63.8
Experiment soil	3	109.4
Tail 3 km	2	33.1

The most tailings disposal sites are devoid of vegetation and have a stressed heterotrophic microbial community. In the study, Vetiver (Chrysopogon zizanioides) planted at Tailing Dam Embankment to see the effect of established plants on rhizopshereic microorganisms and microbial activity. The results showed higher population of bacteria, fungi and actinomycetes in the rhizospheres soils of Vetiver than the tailing sand. The soil enzymatic activities such as dehydrogenase activity and fluorescein di-acetate activity were found higher in case of rizhosphere of Vetiver vegetation as compared to tailing sand.

Table 2.8.4d Effect of vetiver plantation on soil microbiological properties in Cu mining tailings embankment

Samples	Bacteria (cfu g^{-1} soil)	Fungi (cfu g^{-1} soil)	Actino-mycetes (cfu g^{-1} soil)	Dehydrogenase activity (µg TPF g^{-1} soil h^{-1})	Fluorescein di-acetate hydrolysis (µg TPF g^{-1} soil h^{-1})
Rhizosphere soil from the vetiver/grass	3.6-4.2 x10^7	5.1-5.5x 10^6	3.2-3.5 x10^7	5.6± 1.2	12± 1.2
Tailing sand	3.4-5.1x 10^5	2.1-3.2x 10^3	7.8-12.0x 10^5	1.2 ± 0.4	6.5 ± 0.8

Plate 2.8.4 Vetiver Plantation on tail dam slope at Malanjkhand copper mining area

2.8.5 Impact of polluted irrigation water on soil health and crop production surrounding Nagda, M.P.

Most of the agricultural land of more than 14 villages at both sides of the chambal river at downstream side is irrigated with effluent from textile and ancillary industries loaded river water during post rainy season for growing crops.

Soil and effluent samples were collected from different sites surrounding Nagda town. Soil samples in particular collected from adjoining effluent irrigated fields as well as tube-well irrigated fields. Physico-chemical properties of the effluent and bore-well water were estimated including heavy metals by different standard methods. The results revealed that EC in soil (maximum 5.75 dS m^{-1}) is a critical problem for crop cultivation. As the EC in irrigation water was also recorded high (7.28 dS m^{-1}), more number of irrigation will convert the land barren after few years. Heavy metal (Cd, Ni, Co, Pb, Cr) content was below the permissible limit (FAO, 1985) in water samples. The colour of bore well and river water has turned to red (Plate 2.8.5a). The field experiments with different doses of FYM (0, 5, 10, 20 t/ha) were conducted at Atlawda, Nenawatkheda, Banbana, BCI Farm and Bhatisuda. Soybean (*Glycine max*) was taken as a test crop. In case of BCI Farm, due to bird and cattle menace soybean crop was not grown. Green manuring through Dhaincha and Sunhemp was practiced in BCI Farm. The highest yield of soybean crop (2.5 t ha^{-1}) was recorded in Grasim Banbana Farm (Normal Soil). Due to salinity effect poor yield was recorded at Atlawda (1.5 t ha^{-1}) and particularly in Nenawatkheda village (1.0 t ha^{-1}) and soybean seeds were shrunken and small in size whereas bold size seeds were found in normal soil (Plate 2.8.5b and c) and (Table 2.8.5a and b).

Plate 2.8.5a Contaminated river water

Table 2.8.5a Physico-chemical properties of water sample

Sl. No.	Sample ID	pH	EC dS m^{-1}	Potassium (mg l^{-1})	Sodium (mg l^{-1})
1	ETP	7.65	9.91	12.10	2600
2	Upstream Bhilsuda	7.91	1.046	33.10	32.70
3	Down Stream Nenawatkheda	7.63	5.86	5.70	93.00
4	Down Stream Atlawda	7.51	7.28	1.60	63.00
5	Grasim Banbana	7.87	0.783	28.50	108.00

Table 2.8.6b Heavy metal content (mg l^{-1}) in water samples

Location	Cd	Pb	Ni	Cr	Co
ETP	-TR-	0.134	0.016	0.047	0.001
Down Stream					
Nenawatkheda	0.002	0.011	0.008	0.002	0.001
Parmerkhedi	-TR-	0.013	0.012	0.042	0.002
Bhagatpuri	0.002	0.016	0.019	0.005	0.001
Gidgarh	0.001	0.021	0.016	0.025	0.001
Killodiya	0.001	0.024	0.004	0.002	-TR-
Atlawda	0.001	0.028	0.015	0.031	0.003
Upstream					
Bhilsuda	-TR-	0.020	0.003	0.005	0.001
Bhatisuda	0.001	0.022	0.006	0.003	-TR-
Nayan	0.001	0.022	0.007	0.008	-TR-
Tumni	0.002	0.026	0.008	0.004	-TR-
Pardhi	0.001	0.026	0.005	0.004	0.001

River water treated field

ETP water treated field

Plate 2.8.5b Impact of ETP water application on growth of Sunhemp in BCI farm, Nagda

BANBANA NENAWATKHEDA

BANBANA ATLAWDA

Plate 2.8.5c Normal and defected soybean seed of Nenawatkheda

3. Transfer of Technology

3.1 TOT by ICAR-IISS

3.1.1 Ensuring food security, sustainability and soil health through resource conservation based farmer first approach in Central India

(a) Training and demonstration

S.No.	Date	Name of Programme	No. of villages covered	No. of Participants
1.	15/10/2018	Women Farmers' Day	4	52
2.	15/02/2019	One day training on Conservation agriculture, Soil health and composting	4	58
3.	20/02/2019	One day skill development programme for rural women through post-harvest food processing at KVK CIAE, Bhopal	4	55
4.	01/03/2019	Demonstration of conservation agriculture machinery and practical training of Farmers at ICAR-CIAE, Bhopal	4	100
5.	08/03/2019	One day training programme for women on farm waste management.	4	91
6.	14/03/2019	One day skill development programme on Resource Conservation technologies for sustainable agriculture	4	52

Training programme for farm women on the occasion of Women Farmers' Day on 15th October, 2018

Training on conservation agriculture, composting technique, soil health management and balanced nutrient application on 15th February, 2019

One day training cum workshop on "Post harvest skill development of rural women" on 20th February, 2019

One day training program on waste management on 8th March, 2019

(b) Extension activities

S.No.	Date	Name of Programme	No. of villages covered	No. of Participants
1.	05/12/2018	World Soil Day	15	15
2.	31/12/2018	Organised Farmer Field Visit to institute	4	60
3.	25/01/2019	Meeting on water conservation (village Khamkheda)	2	25
4.	26/03/2019	Farmers field day programme at Khamkheda village	2	104
5.	27/03/2019	Farmers field day programme at Bhairopur village	2	101

Awareness and celebration of world soil day on 05th December, 2018

Awareness programme under Swachh Bharat Abhiyan

Stakeholders meeting on water conservation at Khamkheda village on 25th January, 2019

Farmers field day programme at Khamkheda village 26th March, 2019

Farmers field day programme at Bhairopur on 27th March, 2019

Direct seeded Basmati rice (PB-1)

Technology Assemblage, Application and Feedback

A. Crop based module

92 demonstrations were conducted during *kharif* 2018-19 (42 soybean and 50 rice) Introduction of new soybean variety (RVS 2001-4) has recorded better yield to the extent of 50% as compared to soybean variety JS 95-60.

Performance Indicators: Rice

a.	Technical observation **Yield** (q/ha)	Farmers practice transplanted	DSR
i	Grain	50	36.08
ii	Straw	70	65.50
b.	**Economic indicators**		
i.	Cost of cultivation (Rs./ha)	71687	39360
ii.	Net income (Rs./ha)	58313	54448
iii.	B:C ratio	1.81	2.38

Performance indicators: Soybean

a.	Technical observation	Farmers practice	CA Based intervention
	Yield (q/ha)		
i	Grain	15.00	16.30
ii	Straw	22.50	25.00
b.	**Economic indicators**		
i.	Cost of cultivation (Rs./ha)	25300	21500
ii.	Net income (Rs./ha)	20000	28000
iii.	B:C ratio	1.79	2.30

Performance indicators: Wheat

a.	Technical observation **Yield** (q ha^{-1})	Farmers practice	CA Based intervention
i	Grain	**47.50**	**50.61**
ii	Straw	70.00	75.00
b.	**Economic indicators**		
i.	Cost of cultivation (Rs. ha^{-1})	40000	36000
ii.	Net income (Rs. ha^{-1})	60000	75000
iii.	B:C ratio	2.5	3.08

Performance indicators: Chickpea

a.	Technical Observation	Farmers practice	Intervention
	Yield (q ha^{-1})		
i	Grain	13.50	14.40
ii	Straw	21.00	23.00
b.	Economic indicators		
i.	Cost of cultivation (Rs. ha^{-1})	20000	18000
ii.	Net income (Rs. ha^{-1})	34000	39600
iii.	B:C ratio	2.70	3.20

Zero tillage in wheat

Zero tillage in Gram

B. Horticulture based module

2. Vegetable cultivation in summer/ *kharif*

Demonstrations on vegetable production technology with balanced nutrient application and need based pest management were conducted in the cluster.

Performance indicators: Sponge gourd

a.	Technical observation	Farmers practice	Intervention
	Yield (q ha^{-1})	120	150
b.	**Economic indicators**		
i.	Cost of cultivation (Rs. ha^{-1})	55000	60000
ii.	Net income (Rs. ha^{-1})	125000	165000
iii.	B:C ratio	3.27	3.75

Performance indicators: Bottle gourd

a.	Technical observation	Farmers practice	Intervention
	Yield (q ha^{-1})	140	180
b.	Economic indicators		
i.	Cost of cultivation (Rs. ha^{-1})	65000	70000
ii.	Net income (Rs. ha^{-1})	145000	200000
iii.	B:C ratio	3.23	3.85

Sponge gourd demonstrations field visit by scientists from NAARM

Bottle gourd demonstrations field

Performance indicators: Okra

a.	Technical observation	Farmers practice	Intervention
	Yield (q ha^{-1})	75	82
b.	Economic indicators		
i.	Cost of cultivation (Rs. ha^{-1})	65000	60000
ii.	Net income (Rs. ha^{-1})	85000	104000
iii.	B:C ratio	2.30	2.73
c.	Farmers reaction	Farmers were satisfied with the demonstrations and adopting balanced nutrient application.	

Okra demonstrations field visit by scientists from ICAR-NAARM

New plantation/ Orchards

A total of 3500 plants were planted in the cluster. The data on status of plantation is presented in table below

Table: Growth parameters of fruit plants

Plant Type (Fruit)	Age	Nos. Planted	Survival	Average plant height (cm)	Average girth in cm (circumference)	Status
Guava	22 month	1000	658	150 cm	22.5 cm	Vegetative growth stage
Mango	22 month	500	359	135 cm	12.5 cm	Vegetative growth stage
Drumstick	18 month	1000	755	425 cm	75 cm	Flowering
Papaya	10 month	1000	780	285 cm	55 cm	Fruiting

Plantations of Mango and Guava

Demonstration of *in-situ* decomposition technology

Demonstrated in-situ decomposition technology using consortia of thermophilic ligno-cellulolytic microbes in the farmers field of Khamkheda village.

Details of bacteria/actinomycetes species identified for rapid decomposition of organic waste

IISS Isolates	Species	Gram staining	Phylum	GenBank Accession Number
A3	Streptomyces tendae	+Ve	Actinobacteria	MK680814
A9	Streptomyces parvus	+Ve	Actinobacteria	MK680815
A11	Bacillus subtilis	+Ve	Firmicutes	MK680816
A14	Streptomyces badius	+Ve	Actinobacteria	MK680817
A15	Streptomyces thermocarboxydus	+Ve	Actinobacteria	MK680818
A18	Achromobacter denitrificans	-Ve	Proteobacteria	MK680819

Low cost vermicomposting units in 50 farmer fields were demonstrated under FFP.

Performance indicators

a.	Technical observation	Before	After
	Yield	-	700- 1000 kg per cycle
b.	Economic indicators		
i.	Cost of cultivation (Rs. ha^{-1})	-	2000
ii.	Net income (Rs. ha^{-1})	-	5000
iii.	B:C ratio	-	3.5
c.	Farmers reaction		

Vermicomposting activities as enterprise activity

3.1.2 Farmer Field Visits and Farmer-Scientist Interface Meeting at Balaghat

In connection with the project on "Enhancing the Productivity of Major Crops through Improving the Natural Resource Base of Tribal Inhabited Areas of Madhya Pradesh" scientist from the institute visited farmer fields of few villages in Balaghat district to understand about their crops, cropping pattern and management practices (Plate 3.1.2a). Farmer-scientist interface meetings were also conducted in the Khursodi and Kaweli villages (Fig. 3.1.2b) on 18th and 19th August in order to understand the problems and prospects of agriculture in the villages. Scientists from ICAR-Indian Institute of Soil Science, Bhopal and Krishi Vigyan Kendra, Badgaon, Balaghat were interacted with a group of 15 farmers in Khursodi village and a group of 60 farmers in Kaweli village along with the sarpanch and village secretary of the respective villages during the programmes (Plate 3.1.2a and b)

Plate 3.1.2a Farmer Field Visits

Plate 3.1.2b Farmer –Scientist Interface Meeting

3.1.3 Farmer field school at Balaghat

A farmer field school on "soil sampling for soil testing" was organized for the farmers of Kaweli, Kulpa, and Sarra villages during January 09-10, 2019 in their village premises (Plate 3.1.3a). Scientists from ICAR- Indian Institute of Soil Science, Bhopal explained them the importance of soil testing and what is the soil test result indicates. The farmers were also taken to the nearby field where the scientists demonstrated them how to collect and prepare a good composite soil samples and trained them to take soil samples and prepare an ideal sample for soil testing (Plate 3.1.3b).

Plate 3.1.3a Farmer Field School at Kulpa Village, Balaghat

Plate 3.1.3b Sample collection

3.2 AICRP-MSPE (FLDs)

3.2.1 Response of grapes to micro and secondary nutrient application in Tamil Nadu

Field experiment conducted to assess the effect of soil and foliar application of secondary and micronutrients on yield of Panneer variety of grape revealed that, foliar spraying of secondary nutrients (Ca and Mg) and micronutrients (Zn, Fe and B) along with recommended NPK doses increased the yield and yield attributes of grapes. Application of 100% RDF (500:400: 1300 g of NPK/vine in three splits) + 25 kg $ZnSO_4$+50 kg $FeSO_4$+10 kg borax along with foliar spraying of either 0.5% $CaNO_3$+0.5% $MgSO_4$+0.5% K_2SO_4 or 0.1 % Boric acid + 0.2% $ZnSO_4$+ 0.5% $FeSO_4$ registered higher fruit yield and bunch weight of 16.4 t ha^{-1} and 407 g bunch^{-1} respectively, in Panneer variety during summer season. Soil application of NPK + micronutrients sustained the soil available micronutrients compared to foliar spraying of secondary or micronutrients (Plate 3.2.1).

Plate 3.2.1 Field view of Grape trial at farmer's field in Theethipalayam village, Coimbatore, Tamil Nadu

3.3 AICRP on STCR

3.3.1 Transfer of Technology at AICRP on STCR:

Fertilizer prescription equations developed by different centres for facilitating users for profitable use of fertilizers based on soil test values and yield target have been demonstrated through 46 verification trials/FLDs as well as 607 front line demonstrations under STC (erstwhile TSP). Also 28 capacity building programmes were undertaken for creating awareness about soil health and STCR based fertilizer application which benefitted 2225 farmers including 695 women farmers are given below:

Table 3.3.1 Verification trials/FLDs

Crop/variety	Block/village	Name of districts	No. of FLDs	Yield (q ha^{-1}) Farmers practices	Yield (q ha^{-1}) Yield of STCR based dose	Increased yield (%)
Haryana						
Irrigated						
Raya (RH 0749)	Bhadawar I, Bhadawar II, Gyanpura	Hisar	3	17.77	25.24	42.04
Dryland						
Raya (RH 0406)	BiyanaKhera I, BiyanaKhera II	Hisar	2	10.98	19.53	77.87
Himachal Pradesh						
Soybean (cv. PK 472)	Dadh, Ghughar, Biara and Garla	Kangra	9	11.90	24.00	101.68
Toria (cv. Bhawani)	Charatgarh, Biara, and Sasan	Una	10	7.80	14.90	91.03
Madhya Pradesh						
Paddy (IR-36)	Simariya	Seoni	1	12.21	34.43	181.98
Paddy (Sahbhagi)	Partapur	Seoni	1	15.91	37.37	134.88
Paddy(Kranti)	Tikariya	Jabalpur	1	17.42	36.13	107.41
Paddy (Kranti)	Simariya	Seoni	1	15.22	35.58	133.77
Paddy (MTU 1010)	Bhinjawada	Seoni	1	16.85	34.57	105.16
Paddy (MTU 1010)	Khajri	Jabalpur	1	15.54	37.23	139.58
Wheat(GW-322)	Temerbita	Jabalpur	1	23.15	51.18	121.08
Wheat (GW-322)	Simariya	Seoni	1	25.21	52.78	109.36
Wheat (GW-322)	Bhinjawada	Seoni	1	25.53	48.89	91.5
Wheat (GW-273)	Khajri	Jabalpur	1	27.81	50.69	82.27
Wheat(GW-3211)	Tikariya	Jabalpur	1	26.65	50.88	90.92
Gram(JG-311)	Bhinjawada	Seoni	1	5.14	14.51	182.3

Crop/variety	Block/village	Name of districts	No. of FLDs	Yield (q ha^{-1}) Farmers practices	Yield of STCR based dose	Increased yield (%)
			Assam			
Scented Rice var. (Keteki Joha)	Birina Gaon, Danichapari, Komolia Chapari, Dubi Gaon, Kasha Goral, JRT and Khanamukh, JRT	Golaghat	10	62.20	74.50	19.77

3.4 Scheduled Tribe Component (STC) Program

3.4.1 STC under ICAR-IISS

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, Budiyagaon, 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 3.4.1a,b,c). 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.

Enhancement of soil health and improvement of livelihood of tribals of Rajnandgaon district, Chhatisgarh

Tribal villages of Ambagarh Chowki block/tehsil were selected and constraints related to agriculture were discussed with the farmers in groups. Rice is the major crop. It is raised as transplanted (irrigated) as well as direct sown (unirrigated). Area under rainfed cultivation is much more than irrigated area. Apart from rice, sorghum, maize, pigeon pea, mung etc are also cultivated by the tribal farmers during the *kharif* season. During *rabi* season, wheat, chickpea, mustard and lathyrus crops are grown only by those farmers who have irrigation facilities and resource poor farmers kept their fields as fallow and these are used for grazing the cattle. To address the problems in agriculture, an exposure visit and workshop in the form of Farmers- Scientists

Plate 3.4.1a Farmers-Scientist interaction session on soil health management at KVK, Rajnandgaon (Chhatisgarh)

Plate 3.4.1b Farmers participants during interaction session

Plate 3.4.1c Un-irrigated fallow agriculture fields used for grazing at Mangatola village, Ambagarh Chowki, Chhatishgarh

interactions were organised at KVK, Rajnandgaon (Chhatisgarh) as well as at Mangatola village of Ambagarh Chowki block on March 8-9, 2019. An on-farm method demonstration of soil sampling was conducted. Water and soil samples for analysis were collected from farmers field (Plate 3.6.1a, b and c).

3.4.2 STC under AICRP - STCR

Table 3.4.2a FLD under STCR

Crop/variety	Block/village	Name of tribal districts	No. of FLDs	Yield (q ha^{-1}) Farmers practices	Yield (q ha^{-1}) Yield of STCR based dose	Increased yield (%)
Chhattisgarh						
Soybean (JS-97-52)	Gangpur (Lohara)	Kabirdham	25	7.69	8.32	8.19
Maize (PAC-3396)	Dumali, (Kanker)	Kanker	5	50.48	67.10	32.92
Wheat (LOK-1)	Puswada (Kanker)	Kanker	5	23.9	30.76	28.7
Maize (Pioneer 3501)	Madhota (Bastar)	Bastar	10	48.97	70.06	43.07
Wheat (GW-322)	Barbaspur (Manendragarh)	Korea	10	24.69	30.34	22.88
Wheat (GW 366)	Kunvarpur (Lakhanpur)	Sarguja	10	20.77	25.6	23.25
Maize (Hycell),	Bhagdeva	Kanker	15	59.73	65.73	10.05
Wheat (Kanchan)	Badebendri	Kanker	10	16.45	21.80	32.52
Chickpea (JG-11)	Mahoda, Bindranavagarh	Gariyaband	25	11.01	14.02	27.34
Rice (Balmleshwari)	Telawat	Kanker	20	49.24	59.26	20.35
Rice (MTU-1010)	Pandonagar/Pahadgaon	Ambikapur	20	35.01	47.68	36.19
Rice (Chnadrahasini)	Ghutra	Korea	20	39.88	50.15	25.75
Maize (DKC 9114)	Tekameta	Jagdalpur	20	55.19	65.84	19.3
Wheat (HI-1544)	Barbaspur	Koriya	20	16.21	25.37	56.51
Potato (Kufri Bahar)	Khada	Korea	5	1.71	2.10	22.81
Mustard (Bharat Sarson- 2)	Dakaipa	Korea	2	8.65	12.50	44.51
Wheat (HI-1544)	Amgaon, Gangapur	Ambikapur	25	23.98	31.61	31.82
Odisha						
Lady's finger (JKOH-7315)	Rukunapur	Keonjhar	10	96.40	138.80	43.98
Green gram (IPM-0214)	Kailash	Deogarh	10	8.25	12.81	55.27
Brinjal (Fitto crown)	Nirgundipali	Deogarh	19	160.63	229.84	43.09
Lady's finger (Shakti)	Upardiha	Keonjhar	13	95.62	137.23	43.52
Cowpea (YB-07)	Sendkap Jantari	Keonjhar	13	42.08	62.00	47.34
Madhya Pradesh						
Paddy (MTU 1010)	Shiwari	Dindori	20	26.48	36.03	36.06
Lentil (JL 3) (Rhizobium)	Shiwari	Dindori	10	3.72	6.25	68.01
Chick pea (JG-63) (Rhizobium)	Shiwari	Dindori	10	8.25	11.95	44.85
Chick pea (JG-16)	Orai	Mandla	10	8.11	12.61	55.49
Chick pea (TJT-501)	Shiwari	Dindori	10	8.30	12.10	45.78
Wheat (JW 3211, HI 1500)	Orai	Mandla	10	22.98	32.50	41.43

Crop/variety	Block/village	Name of tribal districts	No. of FLDs	Yield (q ha^{-1}) Farmers practices	Yield of STCR based dose	Increased yield (%)
		Telengana				
Rice (KNR 118)	Burjugaddathand	Burjugaddatha nd	10	46.98	53.60	14.09
Rice (KNR 118)	Koyagutta	Kamma Reddy Dist	6	48.31	53.95	11.67
Castor (PCH 111)	Peddathanda	Nagarkurnooldt	10	17.94	22.57	25.81
Rice (MTU1010)	Borlam, Mandal and Banswada	Kammareddydt Telangana	6	57.80	62.10	7.44
Maize (Sugar-75-sweet corn)	Suryanagarm, Mandal and Kurupam	Vijayanagaram dt, A.P.	1	145.00	170.00	17.24
Maize (Sugar-75-sweet corn)	Durballi Mandal and Kurupam	Vijayanagaram dt, A.P.	1	185.00	205.00	10.81
Groundnut (K-6)	Sivannapet Mandalan d Kurupam	Vijayanagaram dt, A.P.	1	20.48	22.78	11.23
Groundnut (K-6)	Kollikota Mandal and Kurupam	Vijayanagaram dt, A.P.	1	21.53	22.58	4.88
Groundnut (K-6)	Paderu Mandal and Paderu	Visakhapatna m dt, A.P.	2	19.95	21.51	7.82
		Maharashtra				
Paddy(Indrayani)	Chirapali	Ahmednagar	26	24.62	31.69	28.72
Finger millet (PhuleNachani)	Chakore-Beje	Nasik	22	15.05	20.73	37.74
		Uttar Pradesh				
Rice (Var. HUR 3022)	Naugarh/Majhgawan & Persiya	Chandauli	10	26.00	50.00	92.31
Maize (Var.GS-802)	Naugarh/Pathraur	Chandauli	5	20.00	35.00	75.00
Mustared (Var. Ashirbad)	Naugarh/persiya/Jhar igawan	Chandauli	10	13.00	20.00	53.85
		Tamil Nadu				
Bhendi	Panapalli, PN Playam Block	Coimbatore	2	105.60	146.80	39.02
Chilli	Samakuttapatti , Panamarathupatti Block	Salem Dist	1	143.00	199.00	39.16
Finger millet	Ponnurukki, Sirumalai, Dindugul Block	Dindugul Dist	4	24.80	39.20	58.06
	Panapalli, PN Playam Block	Coimbatore Dist	3	25.00	38.50	54.00
Groundnut	Adimalaipatti, Panamarathupatti Block	Salem Dist.	12	15.90	24.60	54.72
Maize	Ponnurukki, Sirumalai, Dindugul Block Adimalaipatti,	Dindugul Dist	9	30.30	49.10	62.05

Crop/variety	Block/village	Name of tribal districts	No. of FLDs	Yield (q ha^{-1}) Farmers practices	Yield (q ha^{-1}) Yield of STCR based dose	Increased yield (%)
Maize	Panamarathupatti Block	Salem Dist	3	45.40	70.90	56.17
Maize	Panapalli, PN Playam Block	Coimbatore Dist	3	43.00	65.25	51.74
Maize	Ukkaiyanur, Karamadai Block	Coimbatore Dist	3	46.20	69.15	49.68
Onion	Neelampathy, Karamadai Block	Coimbatore Dist	1	134.00	202.00	50.75
Onion	Panapalli, PN Playam Block	Coimbatore Dist	3	135.00	205.00	51.85
Radish	Neelampathy, Karamadai Block	Coimbatore Dist	1	304.00	499.00	64.14
	Panapalli, PN Playam Block	Coimbatore Dist	5	301.00	490.00	62.79
	Ukkaiyanur, Karamadai Block	Coimbatore Dist	3	303.00	493.00	62.71
Tomato	Ukkaiyanur, Karamadai Block	Coimbatore Dist	1	495.00	795.00	60.61
		West Bengal				
Cabbage (var. Green Express)	Village:- Ghetugachi Block:-Chakdah	Nadia	5	516.00	558.00	8.14
Cauliflower (var. Snow ball)	Village:- Banamalipara Block:-Chakdah	Nadia	3	362.00	418.00	15.47
Broccoli (var. CSH-1)	Village:- Ghetugachi Block:-Chakdah	Nadia	2	357.00	392.00	9.8
Onion (var. Sukhsagar)	Village:- Banamalipara Block:-Chakdah	Nadia	7	132.00	148.50	12.5
Pointed gourd (var. Haibathkali)	Village:- Gotra Block:-Chakdah	Nadia	3	230.00	246.00	6.96
Tomato (var. Amlik)	Village:- Ghetugachi Block:-Chakdah	Nadia	3	481.00	524.00	8.94
Mustard (var. B9)	Village:- Gotra Block:-Chakdah	Nadia	4	9.40	10.00	6.38
Kharif Rice (Var. Satabdi)	Village:- Banamalipara Block:-Chakdah	Nadia	3	44.80	49.50	10.49
		Assam				
Rapeseed, Var- S-38	Maharipara village	Baksa	5	5.60	10.90	94.64
Hybrid Rice var.- US-382	Birina Gaon	Golaghat	3	44.50	70.80	59.10
	Danichapari	Golaghat	3	46.60	68.90	47.85
	Komolia Chapari	Golaghat	3	45.20	71.20	57.52
	Dubi Gaon	Golaghat	3	47.60	68.90	44.75
	Kasha Goral,	Jorhat	2	48.20	72.40	50.21
	Khanamukh,	Jorhat	1	48.50	71.50	47.42

Crop/variety	Block/village	Name of tribal districts	No. of FLDs	Yield ($q\ ha^{-1}$) Farmers practices	Yield of STCR based dose	Increased yield (%)
Scented Rice (Joha Rice) var. Keteki Joha	Birina Gaon	Golaghat	1	12.60	27.80	120.63
	Danichapari	Golaghat	3	10.50	26.70	154.29
	Komolia Chapari	Golaghat	2	10.70	27.60	157.94
	Dubi Gaon	Golaghat	2	11.80	26.50	124.58
	Kasha Goral,	Jorhat	1	12.70	28.90	127.56
	Khanamukh,	Jorhat	1	13.20	28.40	115.15

Table 3.4.2b List of capacity building programmes cum field days

Training date	Village	District	Total no. of participant	No. of women farmers
		Uttar Pradesh		
24.12.2018	Persiya	Chandauli	25	25
27.12.2018	Persiya	Chandauli	25	25
28.12.2018	Persiya	Chandauli	50	26
		Manipur		
10-11-2018	Wainem	Kangpokpi	40	32
27-02-2019	Yaiphakol	Churachndpur	29	20
01-03-2019	Leishokching	Chandel (Aspirational District)	38	25
04-03-2019	Purum Lainingkhul	Chandel (Aspirational District)	33	21
18-03-2019	Lamphoupasna	Chandel (Aspirational District)	122	98
26-03-2019	Kharam Pallen	Kangpokpi	32	17
31_03_2019	Nambol, Makha	Bishnupur	20	8
		Telengana		
22-10-2018	Gudivenakathanda	Rangareddy	43	16
16-03-2019	Markaguda	Adilabad	56	4
16-03-2019	Borlam	Kammareddy	66	10
8-01-2019	Suryanagaram	Vijayanagaram	64	8
		Tamin Nadu		
24.10.2018	Panapalli, Aanaikatti Hills	Coimbatore	45	29
		Chhattisgarh		
10.10.2018	Ujiyarpur	Korea (C.G.)	40	09
15.03.2019	Village- Deo Kongera	Kanker (C.G.)	30	15
		Jabalpur		
10.11.2018	Orai	Mandla	22	07
18.11.2018	Shivri	Dindori	19	04
18.11.2018	Shivri	Dindori	24	08

Training date	Village	District	Total no. of participant	No. of women farmers
		Assam		
30.11.2018	Maharipara village	Baksa, Assam	80	60
25.12.2018	Barbalishiha village, Tamulpur	Baksa, Assam	45	0
		Maharashtra		
04.06.2018	Village:- Ghetugachi	Nadia	72	33
20.8.2018	Village:- Gotra	Nadia	80	38
02.10.2018	Village:- Banamalipara	Nadia	70	32
05.12.2018 (World Soil Day Celebration)	Village:- Binnagar	Nadia	300	100
		Odisha		
03.11.2018	Sendkap village of Keonjhar Sadar Block of Keonjhar district	Keonjhar	30	7
04.11.2018	Ghiabandha village of Reamal block in Deogarh district	Deogarh	30	18

3.4.3 STC under AINP on SBB

Training at different locations of Attappady under TSP activities

A consortium of NPK biofertilizers (PGPR Mix- I) developed by Kerala Agricultural University was mass multiplied and distributed to selected farmers of Attappady area. During 2018-19, a total quantity of 650 kg of PGPR Mix -I and 10 kg of AMF was distributed to 650 tribal farmers engaged in the cultivation of vegetables, pulses, banana, sorghum, groundnut, ragi etc. One kg each of PGPR Mix- I was distributed uniformly to the selected farmers. In order to create awareness on Biofertilizers, training programmes were conducted in three different locations of Attappady area. During 2018-19, as envisaged 100 tribal farmers were selected from each location comprising of Neelikuzhi, Kulukkoor & Cheerakkadavu of Attappady hill tract. As scheduled in the programme, 3 trainings were conducted on biofertilizers at above three locations of Attappady for the tribal farmers, Agricultural Extension officers and officials of Attappady. A total of 325 tribal farmers and 25 extension officers participated in the training programme.

Name of location	Beneficiaries Number of Farmers	Number of Extension officers
Neelikuzhi	111	8
Kulukkoor	112	9
Cheerakkadavu	102	8
Total	325	25

3.4.4 STC under AICRP on MSPE (FLD)

About 45 FLDs were conducted in the tribal farmers' fields at Kondanur Pudur, Panapalli and Sadivayal villages of Coimbatore district and Thiruchikadi village at the Nilgiris district to demonstrate the effect of various micronutrients and sulphur application individually and in combination in increasing the yield of crops such as rice, ragi, sorghum, red gram, horse gram, lablab, avarai, garlic, carrot and beetroot. The results showed that application of respective deficient micronutrients and sulphur individually or in combination increased the yield of crops by 8 to 26 per cent over recommended NPK. Further, basal soil application of micronutrients significantly improved the available micronutrient status in soils and micronutrient uptake by crops (Plate 3.4.4a, b and c).


Plate 3.4.4a Interaction meeting with tribal farmers at Thiruchikadi, Nilgiris district


Plate 3.4.4b Discussions with tribal farmers of Panapalli village, Coimbatore District


Plate 3.4.4c Interaction meeting with tribal farmers at KondanurPudur, Coimbatore

3.5 MGMG activities undertaken during the year 2018-19

Mera Gaon Mera Gaurav Programme has been undertaken to promote the direct interface of scientists with the farmers to hasten the lab to land process. The institute scientists organised various activities such as trainings, demonstrations, interface meetings or gosthies with the farmers in their adopted villages. Apart from these mobile based advisories and literature support on various aspect have been provided. The farm inputs like certified seeds, fertilizers, insecticides, weedicides *etc.* were distributed to the beneficiaries. "White ear head" was noticed as very common problem with rice fields and concerned farmers have been educated for its proper control. At farmer's field, demonstrations were conducted on soybean, rice and wheat crop. Some improved practices like potassium response in Vertisol, integrated nutrient management, rapo-composting were advocated to the farmers. Productivity was celebrated with participation of farmers. In action, various days such as Rashtriya mahila kishan diwas (15/10/2018), kisan diwas (23/12/2018) and world soil day (5/12/2018) were celebrated with the adopted farmers under MGMG programme. Live webcast of the prime minister's address was also arranged for MGMG farmers at Institute's hall.

Plate 3.5a Rashtriya Mahila Kisan Diwas was celebrated on October 15, 2018 at Farmer's field in MGMG adopted village

Plate 3.5c Demonstration at Farmer's field in *kharif* crop

Plate 3.5b Celebration of Kisan Diwas on December 23, 2018 at ICAR-IISS, Bhopal

Plate 3.5d Farmer- Scientist discussion at Farmer's Field

Table 3.5 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	Dobra, Khejra, Perwalia Sadak, Badarkha Sadak, Mubarakpur
2	Dr. M.C. Manna, HOD, SBD Dr. Prabhat Kumar Tripathi, PS, & Co-nodal officer Dr. N.K. Sinha, Scientist, SPD Dr Dolamani Amat Scientist, SBD	Acharpura, Parewakheda, Arwali, Hazampura and Parewaliasahani

S.No.	Group	Name of five villages adopted by Group Leader
3	Dr. Muneshwar Singh PC, LTFE Dr. R.H. Wanjari, PS, LTFE Dr. K. Bharati, PS, SBD Mrs. Seema Bhardwaj, Scientist, SPD	Choupdakala, Ghat Kheri, Sayyaid Semara, Emaliya Chopra and Amoni
4	Dr. J.K. Saha, HOD, ESS Dr. Hiranmoy Das, Scientist (STCR) Dr. Vasudev Meena, Scientist, ESS Dr. Madhumounti Saha, Scientist, ESS	Islam Nagar, Dewalkhedi, Bharonpura, Kalyanpura, Puraman Bhavan
5	Dr. K M Hati, PS, SPD Dr. Sanjay Srivastava, PS, SC&F Dr. K.C. Shinogi, Scientist, SC&F 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. 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 Prakash Meena, Scientist, SC&F	Golkhedi, Binapur, Kanchbavli, Khamkheda and Raslakhedi
8	Dr. R.S. Choudhary, HOD, SPD Dr. Pramod Jha, PS, SC&F Dr. A.K. Vishwakarma, PS, SPD Dr. Abhijit Sarkar, Scientist, ESS	Raipur, Kanera, Momanpur, Kadhaiya and KarodKhurd
9	Dr. Pradip Dey, PC, STCR Dr. N.K. Lenka, PS, SC&F Dr. M. Mohanty, SS, SPD Dr. M. Vassanda Coumar, SS, ESS	Ratibad, Rasuliya Pathar, Mugaliahat, Ratanpur Sadak, Chandukhedi
10	Dr. A.K. Tripathi, PS, SBD Dr. S. Ramana, PS, SBD Dr. J. Somasundaram, PS, SPD Dr. Asit Mandal, Scientist, SBD	Dobra Jagir, KoluaKhurd, Sagoni Kalan, Chor Sagoni, Adampur Chhawni
11	Dr. Ajay, PS, ESS Dr. Tapan Adhikari, PS, ESS Dr. Sangeeta Lenka, Scientist, ESS Dr. Ankush Lala Kamble, Scientist, SC&F	Shahpur, Devpur, Kasi Barkeda, Sagoni, and Barkedi Hajam

S.No.	Group	Name of five villages adopted by Group Leader
12	Dr. S.R. Mohanty, PS & I/c AINP on SBB Dr. Sanjib Kumar Behera, Sr. Scientist, MSPE Dr. Utkarsh Tiwari, Scientist, ESS Ms. Alka Rani, Scientist, SPD	Pipaliya Bajkhan, Dewalkhedi and Malikhedi

4. Training and Capacity Building

4.1. Training Attended by Staff

a. Participation in Training (Category-wise)

S. No.	Category	No. of employees undergone training during April 2018-March 2019
1	Scientist	13
2	Technical	9
3	Administrative & Finance	3
4	Skilled Supporting Staff	2
	Total	**27**

b. HRD fund allocation and utilization (Rs. in Lakhs)

S. No.	RE for HRD 2018-19	Actual Expenditure 2018-19 for HRD
1.	1.00	0.97

c. Training attended during 2018-19

C1 Category: Scientific staff

S.No	Name of employee	Title	Organizer	Duration
1	Dr. K.M. Hati	Post-doctoral research and training for five months	The University of Queensland St. Lucia, Australia	May 1, 2018-October 2, 2018
2	Dr. Pramod Jha	Post-doctoral research and training for Six months	The University of Queensland St. Lucia, Australia	May 8, 2018-November 2, 2018
3	Dr. R.H. Wanjari and Dr. N.K. Lenka	National Dialogue AI and loT Applications in Agriculture	ICAR-NAARM, Hyderabad	June 1-2, 2018
4	Mrs. Seema Bhardwaj, Dr. Asit Mandal, Dr. B.P. Meena and Dr. M.V. Coumar	SAARC Regional Program on Integrated Nutrient Management for Improving Soil Health and Crop Productivity	SAC, Dhaka	September 5-10,2018
5	Dr. A.L. Kamble and Dr. Hiranmoy Das	Innovative Practices in Extension Research and Evaluation	ICAR- NAARM, Hyderabad	September 24-29, 2018
6	Dr. Vasudev Meena, Mr. Abhijit Sarkar, Mrs. Madhumanti Saha and Dr. Seema Bhardwaj	Linking geo-spatial technologies and agricultural system models to assess impact of climate change on natural resource management	ICAR-IISS, Bhopal	October 24 - November 2, 2018
7	Mrs. Madhumonti Saha	Physiological approach to phytoremediation: advances, impacts and prospects	ICAR-IISS, Bhopal	December10-19, 2018

S.No	Name of employee	Title	Organizer	Duration
8	Mr. Utkarsh Tiwari	Natural Resource and Environmental Management	IIFM, Bhopal	December17-21, 2018
9	Dr. R.Elanchezhian	MDP on PME	ICAR-NAARM Hyderabad	December 17-22, 2018
10	Mr. Abhijit Sarkar	Recent advances in micro-irrigation and fertigation systems for improved input use efficiency of open and covered cultivation through engineering interventions	ICAR-CIAE, Bhopal	January 3-23, 2019
11	Dr. Priya Gaurav	Integrated Scientific Project Management for Women	Centre for Organization Development, Hyderabad.	January 7-11, 2019
12	Dr. K.C. Shinogi	Winter school on farmers' empowerment through entrepreneurial ventures	Directorate of Extension, Punjab Agricultural University, Ludhiana, Punjab	February 1-21, 2019
13	Dr. A.K. Tripathi	दो दिवसीय राष्ट्रीय वैज्ञानिक राजभाषा परिसंवाद	ICAR-CIFE, Mumbai	February 25-26, 2019

C2 Category: Technical staff

S.No	Name of employee	Title	Organizer	Duration
1	Mr. Deepak Kaul	Motivation, positive thinking and communication skills for technical officer	ICAR-NAARM, Hyderabad	June 21-27, 2018
2	Mr. Hukum Singh and Mr. Vinod Chaudhary	Motivation, Positive Thinking and Communication Skills	ICAR-CIAE, Bhopal	August 1-7, 2018
3	Mr. Hukum Singh	Farm Management	ICAR-IIFSR, Modipuram, Meerut	September 14-20, 2018

S.No	Name of employee	Title	Organizer	Duration
4	Mr. DR Darwai	Farm Management	ICAR-IIFSR, Modipuram, Meerut	Februaruy 13-19, 2019
5	Mr. Sukhram Sen	Automobile Maintenance, Road Safety and Behavioural Skills	ICAR-CIAE, Bhopal	February 19-25, 2019

C3 Category: Administrative Staff

S.No.	Name of employee	Title	Organizer	Duration
1	Mr. PS Sunil Kumar	Orientation Course in Record Management for Records Officers	ICAR-IASRI, New Delhi	June 4-6, 2018
2	Mr. PS Sunil Kumar and Mr. Hira Lal Gupta	ERP training	ICAR-IASRI, New Delhi	October 8-12, 2018
3	Smt. Babita Tiwari	दो दिवसीय राष्ट्रीय वैज्ञानिक राजभाषा परिसंवाद	ICAR- CIFE, Mumbai	February 25-26, 2019

C4 Category: Skilled Supporting Staff (SSS)

S.No.	Name of employee	Title	Organizer	Duration
1	Mr. Bhagwat Prasad and Mr. Lala Ram Sahu	Selection, Adjustment, Operation and Maintenance of Agricultural Implements for Field and Horticultural Crops	ICAR-CIAE, Bhopal	March 12-25, 2019

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 Scientist/Mentor
1	Mr. Avijit Ghosh	ICAR-IGFRI, Jhansi	3 Months	Dr. M.C. Manna
2	Mr. Asik Datta	ICAR-IIPR, Kanpur	3 Months	Dr. N.K. Lenka
3	Mr. Amresh Chaudhary	ICAR-NIASM, Baramati	3 Months	Dr. M. Mohanty

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	Miss Swarnima Shrivastava	RVSKVV. Gwalior	Ph.D.	Dr. A.K. Patra
2	Miss Pooja Verma	IIFM, Bhopal	Ph.D.	Dr. J.K. Saha
3	Ms. Vinu Jacob	IIFM, Bhopal	Ph.D.	Dr. M. Vassanda Coumar
4	Mr. Jitendra Kumar Sharma	RVSKVV, Gwalior	M.Sc.	Dr. Sangeeta Lenka
5	Mr. Jitendra Porwal	RVSKVV, Gwalior	M.Sc.	Dr. M. Vassanda Coumar
6	Mr. Vikas Baghel	RVSKVV Gwalior	M.Sc.	Dr. J. K. Thakur
7	Miss Payal Giri	IGKV, Raipur	M.Sc.	Dr. M. Mohanty
8	Mr. Nagender	RVSKVV, Gwalior	M.Sc.	Dr. N.K. Sinha

4.4 Training Imparted to the Farmers/Extension Officers/Students/Visits

Name of the programme/Training	Number of participants	Duration	Sponsors
Visit to IISS	30 Progressive farmers	March 24, 2018	Farmer Welfare and Agriculture Development Betul, Madhya Pradesh under Mukhyamantri Kheti Teerth Yojana
Visit	80 SC farmers	March 28, 2019	ICAR-IISS Bhopal under SCSP Programme
Visit	87 farmers	April 19, 2018	Farmer Welfare and Agriculture Development, Raisen district, Madhya Pradesh.
Visit	40 Extension Officers	May 23, 2018	State Agriculture Management Institute, Rehmankheda Lucknow Uttar Pradesh under Exposure visit programme
Different Organic & Inorganic Source of Nutrients and Different practices of INM and Balance use of Fertilizers	Extension Officer/ Agriculture Officers	May 25, 2018	State Institute of Agriculture Extension & Training, Bhopal.
Visit	35 students	May 31, 2018	Indo-European Chamber of Commerce and Industry
Organic farming and Soil Health	30 extension officers	July 28, 2018	State Institute of Agriculture Extension & Training, Bhopal
Visit	40 students	July 30, 2018	Farmer Welfare and Agriculture Development, District Rajgarh, Madhya Pradesh
Organic Farming System Approach	35 candidates of Agri-Clinic and Agri- Business	August 1, 2018	Centre for Advanced Research & Development, Bhopal, Madhya Pradesh
Visit	15 farmers	September 19, 2018	Project Director ATMA, Sagar, Madhya Pradesh
Visit	50 farmers	September 20, 2018	Deputy Director Agriculture and Project Director ATMA, Jaipur
Visit	30 Progressive farmers	September 27, 2018	Office of Senior Agriculture Development, Officer Betul, Madhya Pradesh under Mukhyamantri Kheti Teerth Yojana
Organic farming What, Why and How? Different Components of Organic Farming	Krishak Mitra/Didi 30 participants	October 8, 2018	State Extension & Training Centre Obedullaganj, Distt. Raisen.
Organic Farming & Soil health management	Diploma in Agricultural Extension Services for Input Dealers (DAESI) programme 35 participants	October 16, 2018	Indo-Europen Chamber of Commerce & Industry, Bhopal (Madhya Pradesh)

Name of the programme/Training	Number of participants	Duration	Sponsors
Organic Farming and Composting techniques	Farmers of Department of Agriculture (ATMA), Coimbatore, Tamil Nadu	October 29-31, 2018	ICAR-IISS, Bhopal
Importance of soil health/ Role of soils in landscape planning	40 Post graduate students	November 16, 2018	School of Planning and Architecture (SPA), Bhopal
Vermicomposting technique	Green House Operator under Prime Minister Skill Development Programme	November 20, 2018	KVK, ICAR-CIAE, Bhopal
Organic Farming System Approach	62 students of Agri-Clinic and Agri- Business Centre Scheme	December 6, 2018	Indo-Europen Chamber of Commerce & Industry, Bhopal, Madhya Pradesh
Organic Farming	20 candidates of Agri-Clinic and Agri- Business	December 18, 2018	Centre for Entrepreneurship Development, Madhya Pradesh (CEDMAP)
Organic Farming	35 candidates of Agri-Clinic and Agri-Business	December 20, 2018	Centre for Advanced Research & Development, Bhopal, Madhya Pradesh (CEDMAP)
Organic Farming, demonstration along with techniques of soil testing	20 candidates of Agri-Clinic and Agri- Business	December 22, 2018	Centre for Entrepreneurship Development, Madhya Pradesh (CEDMAP)
Importance of organic farming	Farmers under capacity building programme under ATMA scheme	January 4, 2019	Tarawali village, Berasia Block, Distt. Bhopal
Organic Farming	25 candidates of Agri-Clinic and Agri- Business	January 10, 2019	Centre for Entrepreneurship Development, Madhya Pradesh (CEDMAP).
Visit	72 farmers	January 23, 2019	Farmer Welfare and Agriculture Development Distt. Rewa, Madhya Pradesh under Sub Mission On Agriculture Extension
Visit	40 Extension Officers	February 25, 2019	State Agriculture Management Institute, Rehmankheda Lucknow Uttar Pradesh under Exposure visit programme
Visit	40 students	February 27, 2019	Centre for Advanced Research and Development
Special training on Soil Testing : Entrepreneurship Development	31 Students	March 6, 2019	Mahatma Phule Krishi Vidypeeth College of Agriculture, Pune, Biocare India Pvt. Ltd. Nagpur and Pelican Equipments Chennai.
Visit	30 Students	March 6, 2019	Mahatma Phule Krishi Vidyapeeth College of Agriculture Pune
Visit	32 farmers	March 7, 2019	Farmer Welfare an d Agriculture Development Betul, Madhya Pradesh under Mukhyamantri Kheti Teerth Yojana

Name of the programme/Training	Number of participants	Duration	Sponsors
Special training on Soil and Water Clinic	37 Students and 03 staffs	March 12, 2019	Sadguru College of Agriculture Mirajgaon, Ahmednagar Affiliated to Mahatma Phule Krishi Vidypeeth, Rahuri
Organic farming and soil health to farmers in Kisan Sangosthi	100 Farmers	March 12, 2019	Farmer Training Block Berasia Project Director, ATMA, Bhopal
Farmers Scientist interaction meet on Jaivik Khad, Mrida Swathya Evam Santuleet Poshan Prabandhan under SC&ST programme at Khamkheda and Bhairopura village	52 SC farmers	March 14, 2019	ICAR-IISS, Bhopal
Farmers field day organized under Farmer FIRST Project at Khamkheda and Bhairopur villages	104 and 101 farmers participated	March 26-27, 2019	ICAR-IISS, Bhopal

About 120 students from Navodaya Vidyalaya Samiti visited our Institute (November 22, 2018)


4.5 Farmers training organized under SCSP

Date	Name of the programme	No. of participants
March 14, 2019	Skill development programme to scheduled caste farmers (village Khamkheda) on “Resource conservation technologies for sustainable crop production”.	50
March 28, 2019	Skill development programme to scheduled caste farmers (village Bhairupura) on ″स्थायी सतत कृषि के लिस संसाधन संरक्षण प्रौद्योगिकियाँ″	50
March 28, 2019	Skill development programme to scheduled caste farmers (village Parwalia Sadak) on″समन्वित पोषक तत्व प्रबंधन″	30

5. Awards, Honours and Recognitions

Awards

1. Dr. A.K. Patra awarded Fellow of West Bengal Academy of Science & Technology (FWAST) for 2018 by West Bengal Academy of Science & Technology.
2. Dr. A.K. Patra awarded International Plant Nutrition Institute (IPNI)-FAI Award for 2018 by IPNI-FAI, India.
3. Dr. A.K. Patra, awarded Dr. N.S. Randhawa Memorial Lecture Award for 2018 by Indian Society of Soil Science, New Delhi.
4. Dr. K.M. Hati was awarded Endeavor Research Fellowship-2018 of Government of Australia for Post Doctoral Research at University of Queensland, St Lucia, Queensland, Australia during May 01, 2018 to October 02, 2018.

5. Dr. Pramod Jha was awarded Endeavor Research Fellowship-2018 of Government of Australia for Post Doctoral Research at University of Queensland, St Lucia, Queensland, Australia during May 08, 2018 to November 02, 2018.

6. Dr. R. Elanchezhain was awarded as Fellow of National Academy of Biological Sciences for the Agriculture/Forestry Science section.
7. Dr. N.K Lenka selected as Fellow of the Indian Association of Soil & Water Conservationists, Dehradun for the year 2018.

8. Dr. Pradip Dey selected as Fellow (2018), Indian Horticulture Society, New Delhi.
9. Dr. Pradip Dey selected as Fellow (2018), West Bengal Academy of Science and Technology, Kolkata
10. Drs. MC Manna, RH Wanjari, Muneshwar Singh, AK Patra and SK Chaudhari (2018) received IPNI-FAI Award for Best Research on 'Management and Balanced Use of Inputs in Achieving the Maximum Yield'.

11. Dr. Sanjib Kumar Behera received XII International Congress Commemoration Award 2018 by Indian Society of Soil Science, at Anand Agricultural University, Anand on November 27, 2018.

12. Dr. Sanjib Kumar Behera received Mosaic Company Foundation Young Scientist Award-2018-19 by Mosaic India Private Limited, Gurgaon, India on March 12, 2019.
13. Dr. Vasudev Meena received "Scientist of the Year Award-2018" by Society for Scientific Development in Agriculture and Technology (SSDAT) in GRISAAS-2018, at Rajasthan Agricultural Research Institute, Durgapura, Jaipur on October 28-30, 2018.
14. Dr. M. Vassanda Coumar received "Scientist of the Year Award-2018" by Society for Scientific Development in Agriculture and Technology (SSDAT) in GRISAAS-2018, at Rajasthan Agricultural Research Institute, Durgapura, Jaipur on October 28-30, 2018.
15. Drs. D.H. Phalke, M.C. Manna and S.R. Patil received "K.S. Kale memoral award-2018" for best research article entitled "Effect of in-situ decomposition of sugarcane crop residue and sugar industrial wastes on soil carbon dynamics under sugarcane land use system in Vertisols".

Honours and Recognitions

1. Dr. A.K. Patra, acted as Member, Intergovernmental Technical Panel on Soils (FAO, Rome) for 2018-2021 by FAO of UN, Rome (One from India among 21 of the world).
2. Dr. A.K. Patra, acted as external examiner to Conduct viva-voce examination of Ph.D scholar at ICAR-CIFE, Mumbai on June 21, 2018.
3. Dr. A.K. Patra, attend 21st CMSI Annual Convention 2018 and Chair a Session of the National Conference entitled "Advances in Clay Science towards Agriculture, Environment and Industry" at ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata during September 14-15, 2018.
4. Dr. A.K. Patra, acted as Expert Member of the 9th Working session of Intergovernmental Technical Panel on Soils (ITPS) during October 10-12, 2018 at Rome, Italy.
5. Dr. A.K. Patra, acted as President, Indian Society of Soil Science, NASC, New Delhi during 2019-contd.
6. Dr. A.K. Patra, acted as Member, Working Group, South East Asian Laboratory Network (SEALNET) under Global Soil Partnership (GSP), FAO, Rome for 2018-2020 and organised the 2nd Lab Managers Meeting (22 countries) of SEALNET at IISS, Bhopal during November 19-25, 2018.
7. Dr. A.K. Patra, acted as Speaker, Plenary Session, 106th Session of Indian Science Congress during January 3-7, 2019 at LPU, Punjab.
8. Dr. A.K. Patra, acted as Session Co-ordinator of Technical session on Soil Health (Soil and Fertilizer) during XIV Agricultural Science Congress, New Delhi during February 20-23, 2019.
9. Dr. A.K. Patra acted as Co-chairman of session and lead speaker on "Saline agro-ecosystem: impact and management of water and environment" in Golden Jubilee International Salinity Conference (GJISC-2019) during February 7-9, 2019 at ICAR-CSSRI, Karnal.
10. Dr. A.K. Patra, acted as Member in Panel Discussion on "Bridging Research, Extension and Policy Gaps to Promote use of Potassium" on July l0, 2019 in: FAI-IPI Roundtable conference "Potassium in Balanced Fertilization - Emerging Issues" at FAI House, New Delhi 2019.
11. Dr. A.K. Patra, acted as an external examiner to conduct viva-voce examination of a Ph.D. scholar at ICAR-CIFE, Mumbai on May 21, 2018.
12. Dr. A.K. Patra, acted as resource person in the Launching workshop for a Conservation Agriculture project BCKVV, Kalyani during July 6-8, 2018.
13. Dr. A.K. Patra, visited ICAR-IISR, Indore, regarding collaborative research between ICAR-IISS, Bhopal & ICAR-IISR, Indore and delivered Dr. NS Randhawa Memorial lecture at ICAR-IISR, Indore during September 22-23, 2018.

14. Dr. A.K. Patra, co-chaired the Technical Session "Assessment and evolution of system productivity, income and resource use of different IFS modals" and also deliver a keynote address in the National Symposium on "Integrated Farming Systems for 3Es" at UAS, Bengaluru, during December 23-24, 2018 being organized at IIFSE, Modipuram during December 22-25, 2018.
15. Dr. A.K. Patra, participated in the 106th Session of Indian Science Congress as a nominee of DG, ICAR, and deliver a speech in the plenary session, during January 3-7, 2019.
16. Dr. A.K. Patra, acted as Convener, Plenary Session, 106th Session of Indian Science Congress, LPU, Jalandhar during January 3-7, 2019.
17. Dr. A.K. Patra, acted as an External Expert in the CSIR Assessment Committee meeting scheduled at the CSIR-National Geophysical Research Institute, Hyderabad on January 28, 2019.
18. Dr. A.K. Patra, acted as External examiner for viva-voce of Ph.D. student at Division of Soil Science and Agricultural Chemistry at MPKV, Rahuri during January 11-13, 2019.
19. Dr. A.K. Patra, acted as Jury Panelist in the National Jury Convention - (Stage 4) for Mahindra Samriddhi India Agri Awards (MSIAA) at New Delhi during February 11-12, 2019.
20. Dr. A.K. Patra, Co-Chaired a session as Chairman and lead Speaker on “Saline agro-ecosystem: impact and management of water and environment” during February 7-9, 2019.
21. Dr. A.K. Patra, acted as Advisor for Powarkheda Centre of ICAR-CIFE, Mumbai for taking of Research/Training and Development activities for two year (2017-19).
22. Dr. A.K. Patra, participated in a selection committee meeting for appointment to the post of Senior Scientist & Head (under KVK) as DG, ICAR's nominee at JNKVV, Jabalpur.
23. Dr. A.K. Biswas has been appointed as Adjunct Professor of Uttar Banga Krishi Viswavidyalaya, Cooch Behar by the Academic Council of the University.
24. Dr. Brij Lal Lakaria was selected as a member of Editorial Board of the Indian Journal of Soil Conservation by the Indian Association of Soil and Water Conservationists, Uttranchal, Dehradun w.e.f. March 2018.
25. Dr. Sangeeta Lenka was invited as Delegate and Rapporteur in SAARC nations Regional Consultation meeting on “Climate Resilient Agricultural Policies Strategies and Programmes” held at NAARM, Hyderabad, from April 17-19, 2018.
26. Dr. M. Vassanda Coumar was elected as Councillor (2019-2020) for the Clay Minerals Society of India for Central Zone.
27. Dr. Sanjib Kumar Behera elected as Councillor of Indian Society of Soil Science, New Delhi for the biennium 2019 and 2020.
28. Dr. Sangeeta Lenka received Best Athlete (Female) Award in ICAR-Central Zonal Sports Tournament at Bhopal on November 12-15, 2018.
29. Dr. Pramod Jha was nominated as editor of Journal of Indian Society of Soil Science, New Delhi.
30. Dr. Pramod Jha was invited for key lecture on Carbon Sequestration in Agricultural Soils: Issues and Strategies during National Conference on “Strategies for Soil Health Management: Achievements & Researchable Issues” (March 2-3, 2019) at RVSKV, Gwalior.
31. Dr. R. Elanchezhain was selected as Expert for Development of Course materials for Diploma in Vocational Education and Training in Agriculture and Horticulture for NCERT, MHRD GOI at PSS Central Institute of Vocational Education Shyamala Hills, Bhopal.
32. Dr. R. Elanchezhain was selected as editor of Indian Journal of Plant Physiology of Indian Society for Plant Physiology since June 2018.
33. Dr. R. Elanchezhain was elected as Zonal Secretary for Central zone of Indian Society for Plant Physiology comprising Madhya Pradesh, Rajasthan, Chhattisgarh and Jharkhand for three years 2019-2021.
34. Dr. R. Elanchezhain acted as Reviewer/Referee for the journal Photosynthetica and Indian Journal of Plant Physiology.
35. Dr. Pramod Jha was invited as an expert in an inception workshop for kick starting the process of SAPCC revision on February 5-6, 2019 at State Knowledge Management Centre on Climate Change (SKMCCC) established in Environmental Planning & Coordination Organization (EPCO), Govt. of MP.
36. Dr. Pradip Dey was awarded Best Poster Award in

Golden Jubilee International Salinity Conference 2019 on Resilient Agriculture in Saline Environments under Changing Climate: Challenges & Opportunities, held during February 7-9, 2019 at ICAR-CSSRI, Karnal, Haryana.

37. Dr. Pradip Dey served as expert of the Working Group for development of Module on Soil Health and Testing for NCERT, Ministry of Human Resource Development, Govt. of India 2018.
38. Dr. Pradip Dey delivered 7th Dr. B. Ramanoorthy Memorial Lecture, Instituted by Tamil Nadu Agricultural University on October 24, 2018 at TNAU, Coimbatore
39. Dr. Pradip Dey was selected member IMC, ICAR-Central Coastal Agricultural Research Institute, Goa.
40. Dr. Pradip Dey Co-Chaired, Technical Session-I of IFPRI Dialogue on Innovations for Promoting Balanced Application of Macro and Micro Nutrient Fertilisers in Indian Agriculture, held at Vivanta by Taj Ambassador, New Delhi, organised by CSISA, Bill and Millanda Gates Foundation, IFPRI and IPNI on December 12, 2018.
41. Dr. Pradip Dey was invited as guest of Honour of Valedictory function of DST sponsored Training Progrmme on Integrated Nutrient Management and Nutrient Budgeting through advanced models to improve crop productivity at ICAR-Indian Institute of Soil and Water Conservation, Regional Centre, Udhagamandalam (Ooty), The Milgiris, Tamail Nadu on October 26, 2018.
42. Dr. Asit Mandal acted as Editorial Board member for the following Journals viz. International Journal of Bio-resource and stress Management (Editor in Editorial Committee), Indian Journal of Waste Management (National Editorial Board Member), Journal of Environmental Biology (Consulting Editor) and Popular Kheti (Associate Editor)
43. Dr. Asit Mandal received reviewer recognition certificate from the Journal of Hazardous Materials
44. Dr. Sudeshna Bhattacharjya received reviewer recognition certificate from the "Journal of the Saudi Society of Agricultural Sciences"
45. Dr. Sudeshna Bhattacharjya received reviewer recognition letter from the "PLOS ONE" and Proceedings of the National Academy of Sciences, India Section B: Biological Sciences (Springer)
46. Dr. N.K. Lenka attended a DPC Meeting held at ICAR-CISH, Lucknow on March 25, 2019 as a nominee of the Director General, ICAR, New Delhi for assessment of ARS Scientist under CAS.
47. Dr. K.M. Hati attended a DPC Meeting held at ICAR-IIWM, Bhubaneshwar on March 23, 2019 as the nominee of the Director General, ICAR, New Delhi for promotion of ARS Scientist under CAS.
48. Dr. K.M. Hati attended a DPC Meeting held at ICAR-CICR, Nagpur on March 28, 2019 as a nominee of the Director General, ICAR, New Delhi for promotion of ARS Scientist under CAS.
49. Dr. M. Mohanty, served as Jury member/expert in 34th MP Young Scientist Congress at Rajiv Gandhi Proudyogiki Vishwavidyalaya (RGPV), Bhopal (M.P.) during February 28-March 01, 2019.
50. Dr. M. Mohanty, acted as Rapporteur in the 4th Annual Review Workshop of NICRA in NASC complex New Delhi under the category of "Virtual Modelling Group".
51. Dr. M. Mohanty was invited as a key note speaker on the topic "Application of spectroscopy for soil quality assessment with special reference to salt affected soils" in the Golden Jubilee International Salinity Conference (GJISC-2019) at ICAR-Central Soil Salinity Research Institute, Karnal during February 7-9, 2019
52. Dr. M. Mohanty acted as an Expert/Scientist to discuss on Application of AI in Agriculture with NITI Aayog team at ICAR headquarter, New Delhi on March 11, 2019.
53. Dr. Hiranmoy Das, Scientist acted as Rapporteur in the 72nd Annual Conference of ISAS held at CIAE Bhopal during December 15-18, 2018 under the category of "Statistical Genetics and Bio-informatics".
54. Dr. Hiranmoy Das was invited for key lecture on "New series of OCDs in BIBD setup" in the session of Design of Experiments at the 72nd Annual Conference of ISAS held at ICAR-CIAE, Bhopal during December 15-18, 2018.
55. Dr. R. Elanchezhian attended a DPC Meeting held at ICAR-CIAE, Bhopal on March 15, 2019 as a nominee of the Director General, ICAR, New Delhi for promotion of ARS Scientist under CAS.
56. Dr. Priya Gurav acted as editorial board member of Earth Science (EARTH), Science Publishing Group, New York, U.S.A.

6. Linkages and Collaboration

The Institute has linkages with several ICAR institutes and SAUs located throughout the country. The three AICRPs (LTFE, STCR & 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, M/s Grasim Industries Limited, Nagda, Ujjain, M.P., NTPC Govt. of India and UPL Pvt. Ltd, Mumbai are collaborating with the Institute on various R&D activities.

List of Co-operating Centres under AICRPs/AINP

AICRPs/AINP	No. of cooperating centres		
	ICAR	SAUs/ SGUs	Total
AICRP on LTFE: UAS GKVK, Bangalore; OUAT, Bhubaneswar; TNAU, Coimbatore; PJTSAU, Hyderabad; JNKVV, Jabalpur; PAU, Ludhiana; CSKHPKV, Palampur; BAU, Ranchi; GBPUAT, Pantnagar; KAU, Pattambi; JAU, Junagarh; MPUAT, Udaipur; VNMAU, Parbhani; PDKV, Akola; IGKVV, Raipur; ICAR-IARI, New Delhi; ICAR-CRIJAF, Barrackpore; ICAR-IASRI, New Delhi	**3**	**15**	**18**
AICRP on STCR: PJTSAU, Hyderabad; RAU, Pusa; IGKV, Raipur; ICAR-IARI, New Delhi; HAU, Hisar; HPKV, Palampur, GKVK, Bangaluru; KAU, Vellanikara; JNKVV, Jabalpur; MPKV, Rahuri; OUAT, Bhubaneswar; PAU, Ludhiana; SKRAU, Bikaner; TNAU, Coimbatore; GPUAT, Pantnagar; BCKVV, Kalyani; ICAR-CRIJAF, Barrockpore; PAJANCOA, Puduchery; BHU, Varanasi; AAU, Jorhat; JAU, Gujarat; SKUAT, Srinagar; BAU, Ranchi; IISR, Lucknow; ICAR-Complex, Manipur	**4**	**21**	**25**
AICRP on MSPE: PJTSAU, Hyderabad; RAU, Pusa; AAU, Anand;HAU, Hisar; JNKVV, Jabalpur; PDKV, Akola; OUAT, Bhubaneshwar; PAU, Ludhiana; TNAU, Coimbatore;GBPUAT, Pantnagar; AAU, Jorhat; BCKV, Kalyani; RAU, Ranchi; CSKHPKV, Palampur; CSAUAT, Kanpur; KAU Kerala; UAS Bengaluru; CAU, Manipur; NIANP Bengaluru;ICAR-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

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, R. S. Chaudhary
2. Evaluating rock phosphates for their suitability for direct application
Sanjay Srivastava, A.K. Tripathi, P Dey, Prabhat Tripathi and Gurav Priya Panduranga
3. 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.
4. Evaluation of glauconite as source of potassium for crops
A.O. Shirale, Gurav Priya Pandurang, Sanjay Srivastava, BP Meena and A.K. Biswas
5. 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, Hiranmoy Das, R.L. Raut (KVK, Balaghat), Rameshwar Ahirwar (KVK, Balaghat), Aparna Jaiswal (COA, Balaghat)
6. Mineralogy of Vertisols in relation to K availability in central and western India
Gurav Priya Pandurang, A.O. Shirale, B.P. Meena, B.L. Lakaria, Sanjay Srivastava, P. Chandran

Externally Funded Projects

7. Network Project on Organic Farming
A.B. Singh, B.P. Meena, Brij Lal Lakaria, S. Ramana and J.K. Thakur
8. Simulating the effect of elevated CO_2 and temperature on water productivity and nutrient use in soybean-wheat cropping system (NASF funded)
N.K. Lenka, Sangeeta Lenka, A.K. Shukla, R. Elanchezhian, J.K. Thakur, Pradip Dey, P. Chandra, K.K. Singh
9. 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, AL Kamble, Asha Sahu, Shinogi K.C., A.O. Shirale, Hiranmoy Das
10. Assessing the impact of imbalanced use of chemical fertilizer on soil health using a soil function based quantitative approach funded by DST, New Delhi
N.K. Lenka, B.P. Meena, Sangeeta Lenka, AO Shirale, R.H. Wanjari

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

Institute Projects

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

External funded projects

12. CRP-Conservation Agriculture
LCPC: *A.K. Biswas and DLCPC: 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, R.K. Singh, Pramod Jha
b. Demonstration of best-bet conservation agriculture practices on farmers' fields in Vertisols of central India
AK Vishwakarma, RH Wanjari, KC Shinogi, AK Tripathi
c. Fine-tuning of conservation agricultural practices for Vertisols of central India
J Somasundaram, S. Ramana, BP Meena and Abhay Shirale
d. Development of water and nutrient management practices in conservation agriculture for Vertisols of central India
R.K. Singh, Sanjay Srivastava and NK 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, JK Thakur and K. Bharati
13. 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 B.B. Gaikwad
14. 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

15. Cropping systems and soil management effects on soil organic carbon sequestration and greenhouse gas emission in Vertisols of central India under change climate scenarios funded by NICRA, ICAR.
    M. Mohanty, Pramod Jha, Sangeeta Lenka, J. Somasundaram, N.K. Sinha, A.K. Vishwakarma, R.S. Chaudhary and Muneshwar Singh
16. Assessing the potential impact of climate smart technologies on soil health and nutrient accounting in selected vulnerable districts of MP funded by EPCO, Bhopal
    Sangeeta Lenka, N.K. Lenka, MV Coumar, M. Mohanty, S. Bhattacharjya, J.K. Saha, A.K. Patra
17. Assessing the potential impact of climate change and management on soil carbon and nitrogen storage in selected ecosystems of India funded by NASF
    Sangeeta Lenka, N.K. Lenka, Vasudev Meena, Asit Mandal, Biswapati Mandal, BCKV, West Bengal
18. Sustainable adaptive management of water resources to variable climates of Madhya Pradesh fundey by ICARDA
    M. Mohanty, N.K. Sinha, A.K. Patra

Programme III – Soil Microbial Diversity and Biotechnology

Inter-Institute Project (ICAR-IISS, Bhopal and ICAR-IISR, Indore)

19. "Effects of long term use of fertilizer and manure on soil functional diversity and nutrient supplying capacity under different soils and cropping systems".
    Sudeshna Bhattacharjya, Asha Sahu, M.C. Manna, Muneshwar Singh, R.H. Wanjari, M.P. Sharma and A.K. Patra

Externally Funded Projects

20. Indo-UK Nitrogen Fixation Centre (IUNFC), sponsored by BBSSRC, DBT, New Delhi
    S.R. Mohanty, D.L.N. Rao
21. Metagenomic mapping of microbial diversity in rhizosphere of major crops of India and Argentina offsetting production potential funded by DST.
    S.R. Mohanty, A.K. Patra, K. Bharati, Muneshwar Singh, J.K. Thakur
22. Exploring soil microbial community and mechanism in soil carbon sequestration under long term land uses in semi-arid sub-humid Central India funded by SERB, DST.
    S. Bhattacharjya
23. Ecogenomics of soil microbes involved in global climate mitigation and nitrogen use efficiency in rice-wheat agroecosystem of central India under elevated CO_2 and temperature funded by DST
    S R Mohanty, K Bharati, S Gangil (CIAE)
24. Evaluation of soybean-rhizobia interaction under elevated CO_2 and temperature to develop climate ready microbial inoculants for central India funded by AMAAS
    S R Mohanty, A Mandal, K Bharati
25. Enhancing decomposition rate and quality of biowaste through microbial consortia for improving soil health funded by NASF, ICAR
    M.C. Manna, Asha Sahu, Sudeshna Bhattacharjya, A.B. Singh, A. K. Tripathi, J.K. Thakur, Dolamani Amat
26. Exploring endophytic fungi for the phytoremediation of heavy metal contaminated soils funded by SERB, DST
    Asit Mandal, JK Thakur, MC Manna, AK Patra, M. Vassanda Coumar

Programme IV: Soil Pollution, Remediation and Environmental Security

Institute Project

27. Determination of baseline concentration for delineating contaminated areas in black soils of central India
    M. L. Dotaniya, Rajendiran S., J.K. Saha, S. Kundu, Hironmoy Das
28. Assessment of Cotton for the remediation of soils contaminated with heavy metals
    S. Ramana, A.K. Tripathi, K. Bharati and Asha Sahu

Externally Funded Projects

29. Management of Municipal Solid Waste (MSW) contaminated landfill area of Bhanpur, Bhopal sponsored by Municipal Corporation of Bhopal
    Ajay, Tapan Adhiakari, K. Bharati, Asit Mandal and J.K. Saha
30. Reclamation and rehabilitation of copper mining affected land in malanjkhand area of madhya pradesh, sponsored by Hindustan Copper Ltd. Malanjkhand
    Ajay, Tapan Adhikari, Asit Mandal and J. K. Saha
31. Management of municpal solid waste contaminated dumping area of Bhanpur, Bhopal funded by MPCST
    Ajay, Tapan Adhikari, K. Bharati and Asit Mandal

Collaborative projects in other institutes where IISS scientists are associated in

32. 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. Consultancies, Contractual 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 , 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, B.P. Meena
3	Response of crop to applied Potassium in Vertisols of India.	PRII, Gurgoan	Muneshwar Singh, R.H. Wanjari, B.L. Lakaria, Abhay Shirale
4	Effect of aquasorb on water and nutrient use efficiency & crop productivity of soybean & 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 sponsored	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 Srivastrava, 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
8	Evaluation of effect of Zeba fertilizer product on nitrate-N leaching	M/s UPL Limited, UPL House, 610Bl2, Bandra Village, Off Western Express Highway, Bandra-East, Mumbai- 400051	A.K. Biswas, R. Elanchezhian, N.K. Lenka, A.O. Shirale, A.K. Patra

9. Publications

A. Papers in Research Journal

International/ National (NAAS rating more than 6)

International

Biswas AK, Jha P, Sharma P, Hati KM, Ramana S, Singh AB, Patra AK (2018). Impact of distillery effluent on soil carbon and nitrogen dynamics in a vertisol of central India. *Communications in Soil Science Plant Analysis,* 47 (10): 1252-1262.

Dhaliwal SS, Ram H, Shukla AK, Mavi GS (2019). Zinc biofortification of bread wheat, triticale, and durum wheat cultivars by foliar zinc fertilization. *Journal of Plant Nutrition*, DOI: 10.1080/ 01904167.2019. 1584218.

Dotaniya ML, Rajendiran S, Meena VD, Coumar MV, Saha JK, Kundu S, Patra AK (2018). Impact of long-term application of sewage on soil and crop quality in Vertisols of Central India. *Bulletin of Environmental Contamination and Toxicology,* DOI: 10.1007/ s00128-018-2458-6.

Jadon P, Rajendiran S, Yadav SS, Coumar MV, Dotaniya ML, Singh AK, Bhadouriya J, Kundu S (2018). Volatilization and leaching losses of nitrogen from different coated urea fertilizers. *Journal of Soil Science and Plant Nutrition*, 18 (4): 1036-1047.

Jat RL, Jha P, Dotaniya ML, Lakaria BL, Rashmi I, Meena BP, Shirale AO, Meena AL (2018). Carbon and nitrogen mineralization in Vertisol as mediated by type and placement method of residue. *Environment Monitoring and Assessment* 190: 439

Kanthle AK, Lenka NK, Tedia K (2018). Land use and biochar effect on nitrate leaching in a typic haplustert of central India. *Catena*, 167:422-428.

Laik R, Singh SK, Kumar V, Singh SP, Shukla AK, Nidhi, Yadav RC (2019). Zinc fertilization in rice-wheat cropping system under upland calcareous soil. *Journal of Plant Nutrition*, DOI: 10.1080/ 01904167.2018.1482916.

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Manna MC, Rahman MM, Naidu R, Sahu A, Bhattacharjya S, Wanjari RH, Patra AK, Chaudhari SK, Majumdar K, Khanna SS (2018). Bio-waste management in subtropical soils of India: future challenges and opportunities in agriculture. *Advances in Agronomy*, 152:89-148.

Meena BP, Biswas AK, Singh M, Chaudhary RS, Singh AB, Das H, Patra AK (2019). Long-term sustaining crop productivity and soil health in maize–chickpea system through integrated nutrient management practices in Vertisols of central India. *Field Crops Research*, 232:62-76.

Meena BP, Ashok K, Lal B, Meena RL, Shirale AO, Dotaniya ML, Kuldeep K, Sinha NK, Meena SN, Ram A, Gautam P (2019). Sustainability of popcorn-potato cropping system improves due to organic manure application and its effect on soil health. Potato Research, 1-27. 10.1007/s11540-018-9410-3.

Mohanty SR, Yadav R, Dubey G, Ahirwar U, Ahirwar N, Aparna K, Rao DLN, 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.

Gurav PP, Datta SC, Ray SK, Choudhari PL, Ahmed N (2018). Assessment of potassium release threshold levels in Vertisols (shrink-swell soils) of different agro-ecological regions of India. *Applied Clay Science*, 165, pp. 155-163.

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Behera SK, Shukla AK, Suresh K, Mathur RK (2018). Evaluation of nutritional status and yield limiting nutrients in oil palm plantations of Cauvery delta zone of Tamil Nadu. *Journal of the Indian Society of Soil Science*, 66(1): 89-95.

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B. Technical/Popular Articles/Review Articles/Leaflets

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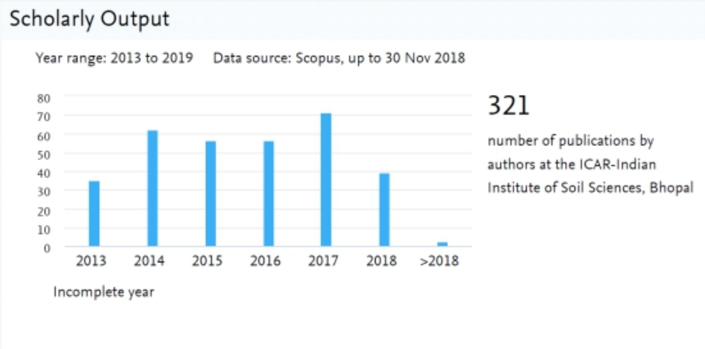

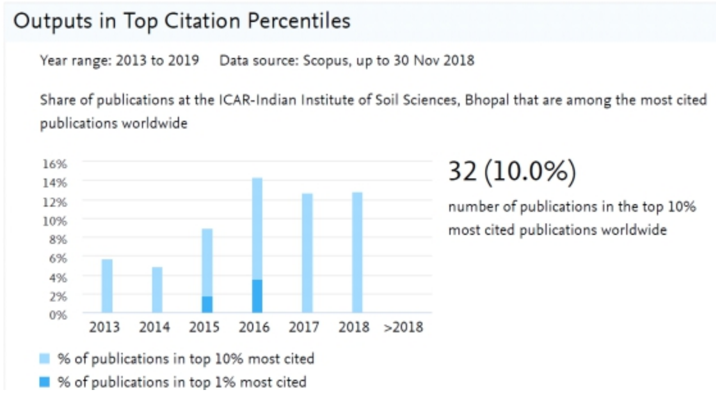

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Year range: 2013 to 2019 Data source: Scopus, up to 30 Nov 2018

Scholarly Output	Authors	Field-Weighted Citation Impact
321▲	165▲	1.11
Citation Count	**Citations per Publication**	***h*5-index**
1,684	5.2	14

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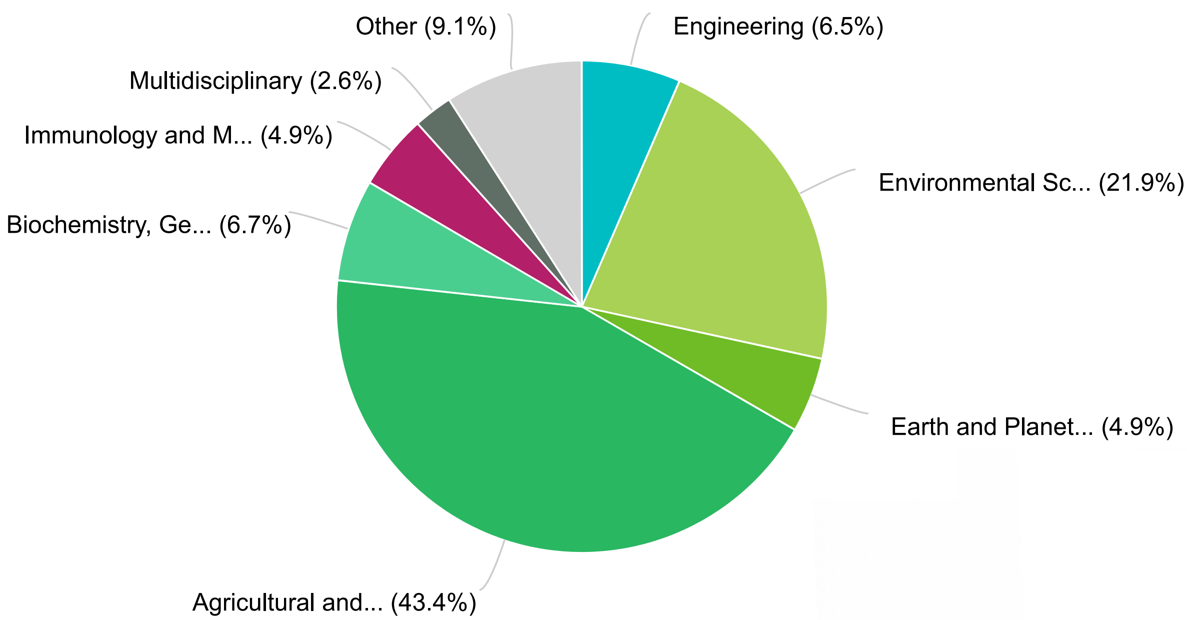

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1	Dr. Pradip Dey, I/c PC (STCR)	Chairman
2	Dr. M.C. Manna, HoD (SB)	Member
3	Dr. K.M. Hati, Pr. Scientist	Member
4	SAO	Member

Mridaparikshak Technology Management Committee		
1	Dr. Pradip Dey, I/c PC (STCR)	Chairman
2	Dr. A.K. Biswas, I/c HoD (SC&F)	Co-Chairman
3	Dr. Tapan Adhikari, Pr. Scientist	Member
4	Dr. Monoranjan Mohanty, Pr. Scientist	Member
5	Dr. Sanjay Srivastava, Pr. Scientist & PI (Mridaparikshak)	Member Secretary
Consultancy Processing Cell		
1	Dr. Pradip Dey, 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	F&AO 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, Personal Assistant	Member
Library Committee		
1	Dr. M.C. Manna, HOD (SB)	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	F&AO 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	F&AO	Member
6	SAO	Member
7	Librarian	Member
8	I/c Library	Member Secretary

Campus Security Committee		
1	Dr. B.P. Meena, Scientist	Chairman
2	SAO	Member
3	Mr. Anurag, Security Supervisor	Member-Secretary
Academic Cell		
1	Dr. S. Kundu, Pr. Scientist & Ex-HOD (ESS)	Incharge
2	Dr. R. Elanchezhian, Pr. Scientist	Member
3	Dr. (Mrs.) Kollah Bharati, Pr. Scientist	Member
4	Dr. M. Mohanty, 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. Kollah Bharati, Pr. Scientist	Chairperson
2	Dr. Asha Sahu, Scientist	Member
3	Dr. Priya Gurav, Scientist	Member
4	Mrs. Geeta Yadav, Private Secretary	Member
5	Mrs. Kirti Bais, Personal Assistant	Member
6	Mrs. Raksha Dixit, LDC	Member
7	Mrs. Nirmala Mahajan, T-6	Member
8	Mrs. Kavita Bai, SSS	Member
Committee for Prevention of Sexual Harassment of Women Employees		
1	Dr. Sangeeta Lenka, Scientist	Chairperson
2	Dr. Shalini Chakraborty, Scientist, Fruit Research Station, Itkhedi	Member-External
3	Dr. 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. 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

3	Dr. A. K. Vishwakarma, Pr. Scientist	Member
4	SAO	Member
5	Dr. Panna Lal Singh, Pr. Scientist, ICAR-CIAE, Bhopal	Member (External Expert)
6	Mr. C.T. Wankhede, Electrician	Member
Condemnation of Permanent Articles Committee		
1	Dr. M.C. Manna, I/c HOD (SB) Dr. A.B. Singh, Pr. Scientist (Alternate)	Chairman
2	Dr. N.K. Sinha, Scientist	Member
3	AAO	Member
4	AF&AO	Member
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. Kollah Bharati, Pr. Scientist	Member
5	Dr. Pramod Jha, Pr. Scientist	Member
6	SAO	Member
Estate Committee (Including quarter allotment)		
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. Sangeeta Lenka, Scientist	Member
3	Dr. Bharat Prakash Meena, Scientist	Member
Sports Promotion Committee		
1	Dr. Brij Lal Lakaria, Pr. Scientist	Chairman
2	Mr. Thomas Joseph, Private Secretary	Member
3	Mrs. Babita Tiwari, Assistant	Member
4	Mr. Anurag, Security Supervisor	Member
5	Mr. Sanjay Katenga, LDC	Member
Monitoring/Utilization of Plant/Machinery/Equipments/Instruments		
1	Dr. A.B. Singh, Pr. Scientist	In charge
Remote Sensing and GIS Laboratory		
1	Dr. Monoranjan Mohanty, Pr. Scientist	In charge
2	Dr. N.K. Sinha, Scientist	Member
3	Dr. B.P. Meena, Scientist	Member

Central Lab		
1	Dr. S.R. Mohanty, Pr. Scientist	In charge
2	Dr. J.K. Thakur, Scientist	Member
Training Hostel		
1	Dr. Monoranjan Mohanty, Pr. Scientist	Controlling Officer
2	Dr. B.P. Meena, Scientist	In charge
	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, HOD (SPD)	Nodal Officer
2	Dr. N.K. Sinha, Scientist	Member
AKMU		
1	Dr. J. Somasundaram, Pr. Scientist	In charge
	Dr. N.K. Sinha, Scientist (Alternate)	Member
Vehicle Operation Committee		
1	Dr. Asit Mandal, Scientist	In charge
2	Mr. Vinod Babu Pal, T-6	Member
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, Personal Assistant	Office staff
Screen House		
1	Dr. S. Ramana, Pr. Scientist	In charge
2	Dr. Asha Sahu, Scientist (Alternate)	Member
Library		
1	Dr. S. Ramana, Pr. Scientist	In charge
2	Dr. Shinogi K.C., Scientist (Alternate)	Member
HRD (Training)		
1	Dr. K.M. Hati, Pr. Scientist	Nodal Officer
Mera Gaon Mera Gaurav		
1	Dr. A. B. Singh, Pr. Scientist	Nodal Officer
2	Dr. Prabhat Tripathi, Pr. Scientist	Co-Nodal Officer
Weed Management		
1	Dr. A.K. Vishwakarma, Pr. Scientist	Nodal Officer
STC Programme Implementation Committee		
1.	Dr. J.K. Saha, I/c HOD (ESS)	Chairman
2.	Dr. M.L. Dotaniya, Scientist	Member
3.	Dr. A.O. Shirale, Scientist	Member
4	Dr. R.H. Wanjari, Pr. Scientist	Member Secretary & Nodal Officer

11. Important Meetings/Activities

Institute Research Council Meeting

The Institute Research Council (IRC) meeting of the institute was held during June 18-19, 2018 in the committee room of the institute. 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. At the outset, 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. Elanchezhian (I/c PME Cell) requested all the scientists to present the salient research findings followed by discussion. Thereafter, the ongoing (12 Nos.) and concluded projects (10 Nos.) were presented and reviewed by the IRC.

Foundation day 16 April 2018

The ICAR-Indian Institute of Soil Science, Nabibagh, Bhopal celebrated its 31st Foundation Day on April 16, 2018 at the Institute campus with great enthusiasm. Chief Guest of the program, Dr.Tejinder Singh, IFS, Additional Principal Chief Conservator of Forests of the Western Zone emphasized the role of natural resources for the survival of the mankind. He stressed upon finding out the root cause of problems of soil pollution and degradation, rather than relying more on preventive measures. Dr. S. K. Singh, Director, National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur; Dr. V. P. Singh, Director, National Institute for High Security Animal Diseases Laboratory, Bhopal and Dr. A. Subba Rao, Former Director of the IISS, Bhopal attended the event as Guests of Honour. At the outset, Dr. JK Saha, I/c Director welcomed the guests and dignitaries and briefed about the achievement of the Institute. Progressive farmers from villages adopted under Mera Gaon Mera Gaurav (MGMG) scheme and the National and State level award winning farmers were felicitated on the occasion. A farmer-scientist interaction was also held in which farmers put forth problems being faced related to crop residue management and conservation agriculture, which were elaborately discussed among the participants. Later, in the afternoon, the Foundation Day lecture was delivered by Dr. S. K. Singh, Director, NBSS & LUP, Nagpur. In the foundation day lecture, he briefed upon the growing menace of soil degradation and stressed upon using high resolution soil resources data for optimum land use planning. The program was coordinated by Dr. R. Elanchezhian, Principal Scientist and Member Secretary.

Yoga Day

ICAR-Indian Institute of Soil Science had celebrated Yoga Day on June 21, 2018 at the institute campus

Independence Day

The 72[th] Independence Day′ was celebrated on August15, 2018 in the Institute premises with great gaiety and fervor. Different cultural 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

ICAR-Indian Institute of Soil Science, Bhopal celebrated World Soil Day with the theme “Be the Solution to Soil Pollution” with an aim to raise awareness among people to reduce soil pollution. World Soil Day is celebrated annually on the 5[th] of December with goal to create awareness on the importance of soil quality for food and nutritional security, human well-being and healthy ecosystems. About 200 farmers participated in the world soil day organized at famers' field at Parwalia Sadak Village, Bhopal. Dr N.N.

Goswami, Former Dean, (IARI) & Ex-Vice Chancellor (CSAUAT), Kanpur, Dr A. Subba Rao, Ex-Director (IISS), and Prof. D.K. Das, Ex-Head, Division of Agricultural Physics, IARI, New Delhi, graced the occasion. Officials from Govt of M.P. and State of Bank of India also participated in this event.

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 September14-28, 2018. 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

Organised various activities such as cleaning of streets, drain, and back alleys, waste collection drive, village/school level rallies and mobilize community to build compost, during “Swacchta hi Seva” program during September 15-October 02, 2018. Dr. R.S. Choudhary, Nodal Officer, SBM co-ordinated various activities during this period.

Staff also participated in 'Swachh Bharat Abhiyaan' programme at nearby area schools on September 26, 2018 and December 17, 2018 to promote hygiene and cleanliness.

Organized awareness programme among school students on cleanliness and hygiene under 'Swachhata hi seva' programme in Sardar Patel higher secondary school on September 26, 2018

Vigilance Awareness Week

Vigilance Awareness Week 2018 was organized at ICAR-IISS, Bhopal during October 29 to November 3, 2018. All staff were administered the Integrity Pledge on this occasion.

Sports activities

Central Zone Sports Tournament 2018 was organized by the Institute at sports complex of BHEL, Bhopal for the first time during November12-15, 2018. More than 500 participants from 15 ICAR Institutes attended this Central Zone Sports Tournament. The programme was concluded on November 15, 2018 by Dr. Navin Chandra, Director General, Madhya Pradesh Council of Science and

Technology and Dr. A. Subba Rao, former Director, ICAR-IISS. Dr. Brij Lal Lakaria, the Organizing Secretary, managed the event marvelously with whole hearted support by all the committees under the guidance and Chairmanship of Dr. Ashok K. Patra, Director, Indian Institute of Soil Science, Bhopal.

New Year Day

The Staff Recreation Club (SRC) organized the 'New Year Day' celebration on January 1, 2019 in which various cultural and sports programs were organized for the staff of the institute.

Republic Day

The 70th Republic Day was celebrated on January 26, 2019 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 with great zeal and enthusiasm during February 12-18, 2019. The inaugural function of National Productivity Week under the theme of 'Circular economy for productivity and sustainability" was conducted on February 12, 2019 at 11:00 AM in the institute premises. Dr. R. Elanchezhian, Organizing Secretary, briefed about the importance of National Productivity Week and various activities during the weeklong celebration. Dr. M.C. Manna, I/c Director ICAR-IISS, addressed the gathering and emphasized the need for productivity enhancement and sustainability in agriculture with special reference to crop residues and agricultural waste management. Dr. A.B. Singh, Principal Scientist

discussed about farmers-scientist interaction meet to be organized at ICAR-IISS during the week. All the staff of ICAR-IISS participated in the function. An Essay competition on the theme "Circular economy for productivity and sustainability" was conducted on February 13, 2019. In addition, a painting competition was conducted on the same theme on February 14, 2019 followed by slogan and quiz competition was also conducted on February 16, 2019. A farmers-scientists interaction meet was organized at ICAR-IISS Bhopal on February 15, 2019 and on February 18, 2019. More than 50 farmers from different villages of Bhopal district which were adopted by ICAR-IISS Bhopal under Mera Gaon Mera Gaurav and Farmer FIRST projects at Bhairopura, Kanch Bavli, Kamkheda, Parwalia Sadak, Gol Khedi, Karond Khurd, Diwaniya, Pipaliya Bajkhan and Intkhedi participated in the interaction on February 15, 2019 at 11:00 AM in the forenoon session. The valedictory function of National Productivity Week was held on February 18, 2019 after farmers-scientist Interaction Meet. Dr. R. Elanchezhian, Organizing Secretary briefed various programs organized during National Productivity Week.

Women's Day

ICAR-IISS, Bhopal celebrated International Women's Day with great zeal and enthusiasm on March 08, 2019. On this occasion, inaugural program was started with address to women farmers on the occasion, Institute had also organized the Live Telecast of Hon'ble Prime Minister's address for the entire staff of the Institute with enthusiastic participation of almost 300 people, including both women and men. Women farmers from different cluster of villages were given one day training program on waste management under the farmers first project. The campaign theme for 2019 International Women's Day was "*Balance for better*" to think equal, build smart, innovate for change for women. This year theme depicts the innovative ways in which we can advance in gender equality and the empowerment of women especially in the social protection systems, access to public services and sustainable infrastructure. The program commenced with the ICAR song and lamp lightening. Dr. K Bharati, Chairperson of Women's Cell ICAR-IISS, Bhopal

welcomed the gathering and guests and outlined the history of observance of International Women's Day and its relevance to Indian women. On this day, Mrs Reena Patra, Guest of Honor's expressed her tributes to the women who have immensely contributed and sacrificed to shape the society. It was followed by Dr. Parul Rishi, Professor of Psychology, IIFM, Bhopal and Chief Guest of the function delivered a special talk on *"I love my stress to live a life I love"*. Finally, Dr. Ashok K Patra, Director, ICAR-IISS, Bhopal made a brief remarks emphasizing the importance of female literacy with low infant mortality, their contribution to the society in general, and agriculture sector in particular, with rural women constituting the backbone of their family and community. The program was smoothly conducted and coordinated by all the women staff members and research scholars of the Institute. The program was moderated by Dr. Asha Sahu, Scientist and ended with the vote of thanks proposed by Dr. Priya Gurav, Scientist, ICAR-IISS, Bhopal.

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

Name	Programme	Venue	Period
Dr. P. Dey	National Round Table on "Minimum Support Price for Farmers and National Consultation on "Agri Export Policy" organized by Indian Council of Food and Agriculture	Habitat Centre, New Delhi	April 3, 2018
Dr. P. Dey	TIFAC (Department of Science and Technology, Govt. of India): Global Technology Watch Group (GTWG) Sustainable Agriculture 5th meeting	TIFAC Board Room, New Delhi	April 4, 2018
Dr. K.M. Hati	Meeting of the Council of the Indian Society of Soil Science	ICAR-IARI, New Delhi	April 7, 2018
Dr. Sangeeta Lenka	SAARC nations Regional Consultation meeting on"Climate Resilient Agricultural Policies Strategies and Programmes"	NAARM, Hyderabad	April 17-19, 2018
Dr. A. K. Shukla	National Crop Nutrition Summit 2018	India Habitat Centre, New Delhi	April 20, 2018
Dr. R. Elanchezhian	Workshop on "Development of course materials for diploma in vocational education and training"	PSSCIVE (NCERT), Bhopal	April 24-26, 2018
Dr. J. K. Saha	Attended meetings on Environmental Impact Assessment on the industrial activities in and around Kanpur	Kanpur	May 7-8, 2018
Drs. A.K. Patra and A.K. Vishwakarma	International Conference on Nutrition Sensitive Agriculture	Bhopal	May 15, 2018
Director, All PCs and HoDs	Senior officers' meeting of State and ICAR officials with Union Minister of Agriculture and Farmer's Welfare, Govt. of India, Shri Radha Mohan Singh	ICAR-CIAE, Bhopal	May 17, 2018
Dr. A.K. Patra	Presentation of a lead paper in the seminar on Doubling Farmers' Income: Technological and Management Interventions	DBS, Dehradun	May 18, 2018
Dr. A.K. Shukla	National Conference on Intensification and Diversification in Agriculture for Livelihood and Rural Development	RPCAU, Pusa, Samastipur, Bihar	May 27-28, 2018

Name	Programme	Venue	Period
Drs. A.K. Patra, A.K. Shukla, A.K. Biswas, S. Kundu and N.K. Lenka	Annual General Meeting of NAAS	New Delhi	June 4-5, 2018
Dr. Sangeeta Lenka	Expert Committee meeting of EPCO project	EPCO, Bhopal	June 18, 2018
Dr. Sangeeta Lenka	Cost Committee meeting for the NASF project	KAB-I, New Delhi	June 19, 2018
Drs. A.K. Patra, Muneshwar Singh, A.K. Shukla, Pradip Dey, M.C. Manna, A.K. Biswas and Sanjay Srivastava	Brainstorming session on "Holistic strategy for assessment of Soil Health"	NASC Delhi	June 25-27, 2018
Drs. A.K. Shukla and S.K. Behera	Concluding workshop of contractual network research projects entitled "Evaluation of efficacy of sulphur and zinc containing complex fertilizers for enhancing yield through balanced nutrition in different crops in India" and "Evaluation of efficacy of zinc metalosate and boron metalosate foliar supplements for enhancing yield through balanced nutrition of important crops grown in India"	CSKHPKV, Palampur, H.P.	June 28-29, 2018
Dr. A. B. Singh	Workshop on Strategies to improve Agricultural Extension in Madhya Pradesh	SIEAT, Bhopal	July 4, 2018
Dr. A.K. Patra	Resource person in the Launching workshop for a Conservation Agriculture project	BCKVV, Kalyani	July 7-8, 2018.
Dr. A.K. Patra	Cadre Strenght Review meeting of the institute at NASC Complex, Pusa and meeting on methodology to be adopted for assessment of fertilizers as per Soil Health Card	ICAR, Krishi Bhawan, New Delhi	July 17-18, 2018.
Drs. A.K. Patra, A.K. Biswas and A.K. Vishwakarma	ICAR-CIMMYT Joint Workshop on "Conservation Agriculture in India: Key Learning's, Research Gaps and Way Forward for Impact	NASC Complex, Pusa New Delhi	July 9-10, 2018

Name	Programme	Venue	Period
Dr. A.K. Patra	Cadre Strength Review meeting of the institute at NASC Complex, Pusa and meeting on methodology to be adopted for assessment of fertilizers as per Soil Health Card	ICAR, Krishi Bhawan, New Delhi	July 17-18, 2018.
Dr. P. Dey	Valedictory programme as Chief Guest of Skill development programme on "Soil Health Management" organized by Sasya Shyamala KVK, RKMVERI	Sonarpur, Village Dongaria, Uttar Raipur, Budgebudge II, South 24 Parganas	July 27, 2018
Dr. A.K. Patra	Harmonization of soil data, Soil fertilizer maps and collaborative studies between ICAR -IISS Bhopal & ICAR-NBSS&LUP, Nagpur	ICAR-NBSS&LUP, Nagpur	July 30 to August 1, 2018
Dr. M. Mohanty	6th Annual Review Workshop of NICRA project	NASC complex, New Delhi	August 6-9, 2018
Dr. J.K. Saha	Attended the meetings of Site Selection Committee for establishing KVK for district Sukma, Chattisgarh	Sukma, Chattisgarh	August 21-22, 2018
Dr. A.K. Biswas	Workshop on Zero Budget Natural Farming (ZBNF) organized by RySS, Govt. of A.P.	Vijayawada	August 30-31, 2018
Dr. J.K. Saha	Assessment committee meeting of the CAS	ASRB, KAB -I, Pusa, New Delhi	September 4-5, 2018
Dr. A.K. Biswas	DPC meeting for promotion of ARS Scientists under Career Advancement Scheme as member of the Selection committee	Umiam, Meghalaya	September 4-5, 2018
Dr. N.K. Sinha	Participated and presented progress of project entitled "Hyperspectral Remote Sensing Approaches to Evaluate Soil Quality and Crop Productivity of Central India"	ICAR-CRIDA Hyderabad	September 4, 2018
Drs. M. Vassanda Coumar, B.P. Meena, Asit Mandal and Seema Bhardwaj	SAARC Regional Training Programme on “Integrated Nutrient Management for Improving Soil Health and Crop Productivity”	ICAR-IISS, Bhopal	September 5-10, 2018
Dr. J. Somasundaram	25th Zonal Workshop of KVKs of Zone IX comprising of Madhya Pradesh and Chhattisgarh	JNKVV, Jabalpur	September 5-7, 2018
Dr. A.K. Patra	Participated and delivered a presentation in the National Workshop on "Sustainability of Indian Agriculture : Natural Resource Perspective with special reference to Soil"	ICAR, NASC Complex, New Delhi.	September 6-10, 2018

Name	Programme	Venue	Period
Dr. R. S. Chaudhary	National Workshop organized by NIAP, New Delhi on Finalizing "Soil Health Indicators	NASC, New Delhi	September 7-8, 2018
Drs. A.K. Patra and A.K. Biswas	Workshop on Sustainability of Indian Agriculture	NASC Complex, New Delhi	September 8, 2018
Drs. A.K. Biswas, R. S. Chaudhary and J. Somasundaram	Meeting on 'Weed management in Conservation Agriculture	ICAR-DWR, Jabalpur	September 11-12, 2018
Drs. A.K. Patra A.K. Biswas and A.K. Vishwakarma	Review meeting on weed management of CRP on CA	ICAR-DWR, Jabalpur, MP	September 11-12, 2018
Dr. A.K. Patra	Meeting with Hon'ble DG, ICAR and ICAR-IISS QRT Chairman	New Delhi	September 12-13, 2018
Dr. A.K. Patra	Acted as guest of hounored in the 21st CMSI Annual Convention 2018 and Chaired a Session of the National Conference entitled "Advances in Clay Science towards Agriculture, Environment and Industry"	ICAR- NBSS & LUP, Regional Centre, Block-DK, Sector -II, Salt Lake, Kolkata -700091	September 13-16, 2018
Dr. P. Dey	Panel discussion on Soil mineralogy and potassium inputs; the interrelations" organized by International Plant Nutrition Institute (IPNI) - South Asia Programme	Kolkata	September 14, 2018
Dr. Priya Gurav	Attended and presented a West Zone "ISSS Best Doctoral Research Award-2018" of ISSS	College of agriculture Udaipur, Rajasthan	September 24, 2018
Dr. M. Mohanty	Annual Review workshop (Monsoon Mission II)	IITM, Pune	September 24-27, 2018
Dr. A.K. Patra	National level awareness/ workshop for the Academic Institutions on National Academic Depository at All India Council for Technical Education.	AICTE, New Delhi	September 28, 2018
Dr. A. K. Patra	Strategy workshop on "Development and Adoption of Novel Fertilizer Materials"	NASC, New Delhi	October 4-5, 2018
Drs. A.K. Patra and A.K. Biswas	Strategy workshop on Development and Adoption of Novel Fertilizer Materials	New Delhi	October 5, 2018
Dr. P. Dey	IMC	ICAR-CCARI, Goa	October 6, 2018
Dr. N.K. Sinha	Training Workshop on Climate Change over the High Mountains of Asia (HMA)	IITM Pune, India	October 8-12, 2018

Name	Programme	Venue	Period
Dr A.B. Singh	Second Meeting of QRT-ICAR IIFSR in relation to Organic farming	Rajasthan Agricultural Research Institute	October10-11, 2018
Dr. A. K. Patra	9th working session of the Intergovernmental Technical Panel on Soils (ITPS)	FAO Hqrs. in Rome, Italy	October 10-12, 2018
Dr. A. K. Patra	Agri. Start-up & Entrepreneurship conclave and ICAR Award Ceremony	New Delhi	October 16-20, 2018
Drs. A.B. Singh, R. Elanchezhian and Dolamani Amat	Global Clean Up Congress-2018	TNAU, Coimbatore	October 22-24, 2018
Dr. A.O. Shirale	Training on Linking geo-spatial technologies and agricultural system models to assess impact of climate change on natural resource management	ICAR-IISS, Bhopal	October 24-November 2, 2018
Dr. R.H. Wanjari	XXI Biennial National Symposium of Indian Society of Agronomy on “Doubling Farmers’ Income Through Agronomic Interventions Under Changing Scenario”	Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan	October 24-26, 2018
Dr. A. K. Patra	Participated in the Global Agri Prize Ceremony of ICFA and meeting with NTPC officials regarding fly ash project	NRM Division/ICAR Hqr New Delhi	October 25-27, 2018
Dr. Vasudev Meena	International Conference on “Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2018)	RARI, Durgapura, Jaipur	October 28-30, 2018
Drs. R. S. Chaudhary, K.M. Hati, M. Mohanty, J Somasundaram and M.V. Coumar	2nd SEALNet workshop cum-training	ICAR-IISS, Bhopal	November 19 -23, 2018
Dr. A . K. Patra	Annual Convention of the India Society of Soil & National Seminar on "Developments in Soil Science - 2018" and Special Session on "Recent Technologies of Soil Health Assessment"	Anand Agricultural University, Anand , Gujrat	November 25, 2018
Dr. R.H. Wanjari and Vasudev Meena	International Conference on “Weeds and Society: Challenges and Opportunities”	ICAR-DWR, Jabalpur	November 21-24, 2018
Dr. Priya Gurav	Attended and presented in final round of “ISSS Best Doctoral Research Award -2018” of ISSS	Anand Agriculture University, Gujarat	November 26-28, 2018

Name	Programme	Venue	Period
Drs. Muneshwar Singh, A. B. Singh, A. K. Shukla, S. K. Behera, R.S. Chaudhary, Sangeeta Lenka and K.M. Hati	Annual Convention of Indian Society of Soil Science	Anand Agriculture University	November 27-30, 2018
Dr A. B. Singh,	13th Annual Group Meeting of NPOF	TNAU, Coimbatore	November 27-29, 2018
Dr. R. Elanchezhian	4th International Plant Physiology Congress	NBRI, Lucknow	December 2-5, 2018
Dr. A.K. Shukla	FAI Workshop	New Delhi	December 4-7, 2018
Dr. M. Mohanty	Workshop on "Prioritisation of Rainfed areas in India" organized by NRRA, New Delhi and ICAR-CRIDA, Hyderabad	NASC, New Delhi	December 11-12, 2018
Drs. K.M. Hati, M. Mohanty and Hiranmoy Das	72nd Annual Convention of Indian Society of Agricultural Statistics	ICAR-CIAE, Bhopal	December 13-15, 2018
Dr. A. K. Patra	Preparatory meeting of 5th Asian Partnership Meeting with FAO to be organizing by the ICAR	New Delhi	February 26 to March 01, 2019
Dr. J. K. Saha	4th meeting of the Technical Expert Committee (TEC) for Development of Soil Standards under World Bank aided "Capacity Building for Industrial Pollution Management Project (CBIPMP)	Indira Paryavaran Bhawan, New Delhi	December 14, 2018
Dr. R.H. Wanjari	XVII Vasantrao Naik Memorial National Seminar 2018	Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola	December 15-16, 2018
Dr. R. Elanchezhian	Management Development Program on PME	ICAR-NAARM, Hyderabad	December 17-22, 2018
Dr. A.K. Patra	83rd Annual Convention of the Indian Society of Soil Science & National Seminar on "Developments in Soil Science-2018" and Special Session on "Recent Technologies of Soil Health Assessment",	Anand Agricultural University, Anand, Gujarat	December 25, 2018
Drs. A.K. Biswas and K.M. Hati	Review Meeting of CRPs on CA	Krishi Bhawan, New Delhi	December 28, 2018
Dr. R. S. Chaudhary	Multi-stakeholder Consultation Workshop on Kolar River Revival of Upper Lake	EPCO, Bhopal	December 28, 2018
Dr. A.K. Patra	Selection committee meeting for appointment of Senior Scientist & Head (under KVK) as DG, ICAR's nomine at JNKVV, Jabalpur during and visited to ATARI centre, Jabalpur	JNKVV, Jabalpur and ATARI Centre, Jabalpur	January 7-9, 2019

Name	Programme	Venue	Period
Dr. R.H. Wanjari	Workshop on 'Indigenous Seeds and Seed Systems'	Vidarbha Development Board, Nagpur	January 9-10, 2019
Dr. A.B. Singh	Janparishad's 6th International Conference on "Science and Environmental Sustainability for a Peaceful Society	Jan Parishad, State Museum, Bhopal	January 19-21, 2019
Drs. K.M. Hati and M. Mohanty	Meeting for Monitoring and Reviewing the Progress of Foreign Aided Projects	NASC Complex, Pusa, New Delhi	Janauary 24, 2019
Dr. K.M. Hati	Meeting with CGIARs Centres called by the DG, ICAR to Review on-going activities of CGIAR centers with India	NASC Complex, Pusa, New Delhi	Janauary 25, 2019
Dr. Sangeeta Lenka	Annual Review meeting of NASF project	NASC Complex, Pusa, New Delhi	January 30, 2019
Drs. A.K. Patra, Pradip Dey, A.K. Shukla	Annual Conference of Vice-Chancellors of Agricultural Universities & Directors of ICAR Institutes	NASC Complex, New Delhi	January 31 to February 01, 2019
Dr. Sangeeta Lenka	Inception workshop on Revision of State Action Plan on Climate Change	EPCO, Department of Environment, GoMP, Paryavaryan Parisar, E-5, Arera Colony, M.P.	February 5-6, 2019
Dr. Pramod Jha	Workshop for kick starting the process of SAPCC revision	State Knowledge Management Centre on Climate Change (SKMCCC), EPCO, Govt. of MP	February 5-6, 2019
Drs. A.K. Patra, P. Dey and M. Mohanty	ICAR-CSSRI Golden Jubilee International Salinity Conference, 2019 at CSSRI, Karnal during February 7-9, 2019	ICAR-CSSRI, Karnal	February 7-10, 2019
Dr. Tapan Adhikari	Golden Jubilee International Salinity Conference on "Resilient Agriculture in Saline Environments under Changing Climate: Challenges & Opportunities (RAISE-II)	ICAR-CSSRI, Karnal	February 7-9, 2019
Dr. A. B. Singh	International Symposium on Edible Alliums: Challenges and Opportunities	Yashwantrao Chavan Academy of Development Administration, Pune	February 9-12, 2019
Drs. M. Mohanty and N.K. Sinha	Review workshop of ICAR-IISS-ICARDA project	ICARDA India Centre, Amlah, MP	February 15, 2019
Dr. N.K. Lenka	Research planning workshop under SAFBIN programme	Kathmandu, Nepal	February 18-20, 2019

Name	Programme	Venue	Period
Dr. A.K. Patra	Technical session on "Soil Health (Soil & Fertilizer)" in the XIV Agricultural Science Congress on "Innovations for Agricultural Transformation	NAAS & ICAR-IARI, New Delhi	February 19-23, 2019
Dr. A.K. Bisw as	Workshop on Underpinning Science Behind ZBNF (Zero Budget Natural Farming) organized by RySS, Govt. of A.P.	Vijayawada	February 21-23, 2019
Dr. Tapan Adhikari	International Workshop "Indo-German workshop on waste to wealth"	CSIR-AMPRI, Bhopal	February 25-26, 2019
Drs. A.K. Patra and P. Dey	5th Meeting of Asian Soil Partnership (ASP) of Food and Agricultural Organization (FAO), including Steering Committee Meeting of Centre of Excellence of Soil Research in Asia (CESRA)	NASC, New Delhi	February 26 - March 1, 2019
Dr. P. Dey	Group discussion meeting on "Current practices of nutrient recommendations of scope of revising it in India"	International Maize and Wheat Improvement (CIMMYT), New Delhi	February 26, 2019
Dr. A.K. Patra	Acted as guest of honor and presented a key lecture in the National Conference on "Strategies Soil Health Management: Achievement & Researchable Issues" being organized	RVSKVV, Gwalior	March 01-03, 2019
Dr. Pramod Jha	National Conference on Strategies for Soil Health Management: Achievements & Researchable Issues	RVSKV, Gwalior	March 2-3, 2019
Dr. P. Dey	Zonal Monitoring Committee meeting formed by ICAR of Morena and Guna KVKs	Morena and Guna KVKs, MP	March 13-14, 2019
Dr. P. Dey	DPC meeting	ICAR-IISS, Lucknow	March 25, 2019

Training, Capacity Building and Skill development programme on soil health

The objective of the programme was to imbibe scientific knowledge among the farmers prior to the *kharif* season on the importance of soil testing and the practical demonstration gave hands on training to the farmers. Dr A. Madhavi, Centre-in-Charge of STCR at Prof. Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, stressed on the importance of soil testing and with a view to popularize the importance of soil test based balanced fertilizer application with STCR approach among the farmers, a skill development programme was organized under the aegis of ICAR sponsored AICRP-STCR at Pedda golkonda village of Rangareddy district, Telangana state on 16th May, 2018.

STCR based nutrient management: They also explained the soil health card scheme and targeted yield approach for improving crop productivity and maintaining soil health. The programme was attended by progressive farmers wherein the importance of soil testing for maintaining soil health for future generation was also explained in details.

A scientist farmer interaction was the major highlight of the day and the scientists explained the queries raised by the farmers. During feedback session the farmers expressed their satisfaction and felt that such training programmers are beneficial to the farming community and should continue in the future too.

Farmer-Scientist Interaction Meet

ICAR-AICRP (STCR) organised a Farmer-Scientist Interaction Meet in collaboration with AICRP (DA) with an objective to imbibe scientific knowledge among the farmers during the *kharif* season regarding the importance of soil test based nutrient management, use of soil health card as well as enhancing the preparedness for agricultural Contingencies

at Sadalpur village, Hisar district, Haryana on June 29, 2018.

Dr. Pradip Dey, Project Coordinator (STCR), stressed the need for adopting targeted yield approach for plant nutrient management, importance of soil health card for improving crop productivity and maintaining soil health in India. Further role of potassium for maintaining sustainable production during deficit monsoon was discussed. He emphasized the need for preparing action plans for minimizing the effect of mid-season and terminal droughts particularly in south west Haryana which is more drought prone. He also highlighted the significance of crop insurance scheme.

Dr. V. Goyal, Centre-in-Charge (STCR) of CCSHAU, Hisar gave detailed account of STCR demonstrations conducted in Haryana.

Dr. S.K. Sharma, Centre-in-Charge (AICRPDA) elaborated about dryland farming systems and the action plans relating to contingent measures like seed availability of alternate crops and cropping system, soil water conservation measures, availability of various inputs.

Farmers also shared experiences about beneficial effect of STCR technology demonstrated in their field.

Capacity building programme organised under the aegis of ICAR-AICRP (STCR) at Gudivenaka Thanda, the home of Lambadi tribe

To popularize the importance of soil test based fertilizer application for improved crop productivity among tribal farmers, a capacity building programme under the theme of "Soil test and target yield approach for increased crop productivity" was organized on October 22, 2018 under Tribal Sub-Plan of ICAR-AICRP on Soil Test Crop Response. The programme was organized at Gudivenaka

Thanda, a small tribal hamlet of Ranga Reddy district, Telangana and the home of Lambadi tribe. Sixty tribal farmers including twenty women farmers from Gudivenaka Thanda, Ranga Reddy district were participated in the event. Besides, different facets of soil testing and soil health, the farmers were provided hands on training on collection of soil samples.

The welcome address was delivered by Dr. A. Madhavi, Centre-in-Charge of STCR at Prof. Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad who stressed on the importance of soil testing and STCR based nutrient management. Dr. Pradip Dey, Project Coordinator (STCR) explained the soil health card scheme and targeted yield approach for improving crop productivity and maintaining soil health. He also distributed the seed to the farmers under TSP programme to the tribal farmers.

Dr. T. Srijaya, Senior Scientist (STCR), PJTSAU gave a practical demonstration on collection of soil samples. The motive of the programme was to imbibe scientific knowledge among the farmers and the practical demonstration gave hands on training to the farmers. The application of manures and fertilisers as well as sowing methods was also explained to the farmers. A scientist farmer interaction was the major highlight of the programme and the scientists explained the queries raised by the farmers. Every one enthusiastically participated in the programme and showed interest. During feedback session the farmers expressed their satisfaction and felt that such training programmers are beneficial to the farming community and should continue in the future too.

Skill Development Programme on Soil Health Card organised at Panapalli village, the home of Irula Tribe

With an aim to emphasize and creating the awareness about the soil health, a Skill Development Programme themed "Soil test and yield target based balanced fertilization" under the aegis of ICAR-AICRP on Soil Test Crop Response was organized on October 24, 2018 at the Panapalli tribal village, the home of Irula tribe, situated in Anaikatti Hills of Western Ghats Coimbatore district of Tamil Nadu.

Dr. Pradip Dey, Project Coordinator (STCR), discussed and explained the participants about the importance of soil health and its maintenance through the STCR-based approach and distributed the soil health card to around thirty farmers under the STC (erstwhile TSP) Programme.

Dr. R. Santhi, Professor and Head AICRP-STCR Scheme Incharge at TNAU, Coimbatore highlighted the importance and need of soil testing and balanced fertilization. The main aim of organizing such a programme was to imbibe the skill in soil sampling for soil testing and to infuse the knowledge on balanced fertilization for harvesting better yield, profitability, sustaining the soil health and earning a good livelihood for the tribal farmers.

The participatory *Rabi Crop Planning* proved to be one of the major attractions of the Programme. The interaction session between the scientists and the farmers discussed about the soil health card, manure, fertilizer application, interaction of these factors on yield and the quality of the produce in particular.

Around forty-five tribal farmers including 29 women farmers, participated in the Programme.

13. Workshops, Seminars and Trainings Organized
Training/short Courses Conducted

International Workshop cum-training

Programme	Organizers	Duration	Sponsored by
SAARC Regional Program on Integrated Nutrient Management for Improving Soil Health and Crop Productivity	Drs. A.K. Patra, Pradip Dey, Sanjay Srivastava and N.K. Lenka	September 5-10, 2018	SAC, Dhaka
2nd Lab Managers Meeting -cum-Workshop of the South-East Asia Laboratory NETwork (SEALNET)	Drs. A.K. Patra Pradip Dey, A.K. Biswas and Sanjay Srivastava	November 19-23, 2018	Food and Agricultural Organization (FAO) and Indian Council of Agricultural Research (ICAR)

Short course/Winter school/Summer school/MTC

Programme	Course Directors/Coordinators	Duration	Sponsored by
ICAR sponsored winter school training on "Advance Microbial Technologies to enhance Nutrient Use Efficiency and Mitigation of Greenhouse Gas Emission from Agriculture"	Drs. S.R Mohanty, Kollah Bharati and J K Thakur	September 4-24, 2018.	ICAR, New Delhi
Model Training Course on "Rapid Bio-Waste Management Technologies: Options for Recycling, Reuse and Recovery"	Drs. Asha Sahu, Sudeshna Bhattacharjya, A.B. Singh, M.C. Manna and A.K. Patra	November 24 - December 1, 2018	DAC, New Delhi
Short course entitled "Physiological approaches to phytoremediation: Advances, impact and prospects"	Drs. Ajay, R. Elanchezhian, S. Ramana	December 10-19, 2018	ICAR-New Delhi

Other training

Programme	Course Directors/Coordinators	Duration	Sponsored by
Training programme on "Soil Analytical Techniques" for the BSc (Agri) students of Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, UP	Drs. S. Kundu and M. Vassanda Coumar	June 7-14, 2018	ICAR-IISS, Bhopal
Training programme on Leaf and soil analysis techniques: Interpretation and recommendation	Drs. B.L. Lakaria R. Elanchezhian and Gurav Priya	August 28 - September 3, 2018	Directorate of Horticulture, Shimla, Himachal Pradesh
Training programme on "Soil Health Assessment and Management" at ICAR -Indian Institute of Soil Science, Bhopal	Drs. Sanjay Srivastava, B.P. Meena and K.C. Shinogi	October 8-12, 2018	Department of Farmers' Welfare & agriculture, Govt. of M.P.

Farmers' training/Student training

Programme	Course Directors/Coordinators	Duration	Sponsored by
Training Program on Linking Geo-Spatial Technologies and Agricultural System Models to Assess Impact of Climate Change on Natural Resource Management	Drs. M. Mohanty, N.K. Sinha, J. Somasundaram and A.K. Patra	October 24-November 2, 2018	NICRA- ICAR
Visit of Grass Root Field exposure visit of 30 international participants of India-UK Water Centre, IISER Bhopal at Perwalia Sadak Bhopal	Drs. R.S. Chaudhary and A.B. Singh	February 25, 2019	ICAR-IISS, Bhopal
Training programme for the farmers (20) of Annur Block, Coimbatore, Tamil Nadu on " Soil Fertility Management"	Drs. J. Somasundaram, A.K. Vishwakarma, M. Vassanda Coumar and N.K. Sinha	October 29-31, 2018	ICAR-IISS, Bhopal
Kisan Sangosthi on "Integrated Nutrient Management Practices for Doubling Farm Income" at Dewalkhedi village under MGMG	Drs. J.K. Saha, M.L . Dotaniya, Hiranmoy Das, Sonalika Sahoo	June 21, 2018	ICAR-IISS, Bhopal
Field visit and Farmer Scientist Interaction Meet at Perwalia Sadak village under SAARC Regional Training on Integrated Nutrient Management for Improving Soil Health and Crop Productivity.	Dr. A.B. Singh	September 9, 2018	IISS, Bhopal
Kisan Diwas	Drs. A.B. Singh, A.O. Shirale, Sudeshna Bhattacharjya	December 23, 2018	ICAR-IISS, Bhopal
One day farmers Scientist interaction meet on "Jaivik Khad, Mridhya Swathya Evam Santuleet Podhan Prabandhan" for 50 farmers under CA, Farmer FIRST and MGMG programme	Dr. A.B. Singh	January15, 2019	ICAR-IISS, Bhopal
One day farmers Scientist interaction meet at Badharkha village Bhopal under NICRA project and MGMG programme	Drs. A.B. Singh, A.K. Viswakarma, R.H. Wanjari and B.L. Lakaria	January 24, 2019	ICAR-IISS, Bhopal
National Productivity Week	Drs. R Elanchezhian, AB Signh, AK Vishwakrma, P Tripathi, AK Tripathi, J Somasundram, AL Kamble,FAO	February 12 - 18, 2019	ICAR-IISS, Bhopal
Farmers' training programme on Resource Conservation Technologies for Sustainable Agriculture for Skill Development under Schedule Castes Sub Plan (SCSP) at ICAR-IISS Bhopal	Drs. A. K. Vishwakarma, B.P. Meena and A.B. Singh	March 14, 2019	Skill Development under Schedule Castes Sub Plan (SCSP)

Programme	Course Directors/Coordinators	Duration	Sponsored by
One-day field day activity on farmer's field under Farmer First project.	Drs. A.B. Singh, R.K. Singh, A.K. Viswakarma, R.H. Wanjari and B.L. Lakaria	March 26, 019	ICAR-IISS, Bhopal
One day farmers training on "Jaivik Khad, Mridhya Swathya Evam Santuleet Poshan Prabandhan" under MGMG, Farmer FIRST and SCSP programme at Karond Khurd, Golkhedi, Khamkheda Perwalia Sadak, Mugalia Hat and Bhairopura village	Drs. A.B. Singh A.K.Viswakarma, B.L. Lakaria and R.H. Wanjari	March 27, 2019	ICAR-IISS, Bhopal
Skill development programme to scheduled caste farmers (village - Bhairupura) on "स्थायी सतत कृषि के लिए संसाधन संरक्षण प्रौद्योगिकियाँ"	Drs. Vasudev Meena, A.B. Singh, B.P. Meena, Nishant Singh, A.K. Viswakarma	March 28, 2019	ICAR-IISS, Bhopal
Skill development programme to scheduled caste farmers (village - Parwalia Sadak) on "समन्वित पोषक तत्व प्रबंधन"	Drs. Nishant Singh, A.B. Singh, B.P. Meena, Vasudev Meena, A.K. Viswakarma	March 28, 2019	ICAR-IISS, Bhopal
One day training programme for forest personnel	Dr. J.Somasundaram	October 6, 2018	ICAR-IISS, Bhopal

Workshop/Seminar/Conference

Programme	Course Directors/Coordinators	Duration	Sponsored by
Concluding workshop of contractual network research projects entitled "Evaluation of efficacy of sulphur and zinc containing complex fertilizers for enhancing yield through balanced nutrition in different crops in India" and "Evaluation of efficacy of zinc metalosate and boron metalosate foliar supplements for enhancing yield through balanced nutrition of important crops grown in India" at CSKHPKV, Palampur	Drs. A.K. Shukla and Sanjib Kumar Behera	June 28-29, 2018	AICRP-MSPE, Bhopal
Workshop on Conservation Agriculture in India: Key Learning, Research Gaps and Way Forward for Impact at Scale Jointly by ICAR and CIMMYT	Dr. A.K. Biswas	July 09-10, 2018	NASC Complex, New Delhi
Workshop cum group meeting on NASF project launch	Drs. S. Lenka, A. Mandal, Vasudev Meena, N.K. Lenka and B. Mandal	October 25-26, 2018	NASF

Programme	Course Directors/Coordinators	Duration	Sponsored by
Workshop on Soil Health Management for improved crop productivity	Drs. R Elanchezhian, P. Tripathi and U. Tiwari	March 8-9, 2019	ICAR-IISS Bhopal and KVK, Rajnandgaon

Leaf and Soil Analysis Techniques: Interpretation and Recommendations organized by Brij Lal Lakaria, R. Elanchezhian, Priya Gurav during August 28 to September 03, 2018 sponsored by Directorate of Horticulture, Govt. of Himachal Pradesh, Shimla participated by DHO, HDOs, AHOs and laboratory personnels (15 nos.)

Kisan Mela/ Exhibition/ Kisan Sammelan

- Organized Farmers' visit and Training programmes on 'Soil Health Management' for the tribals in Barwani district under TSP project at KVK Barwani on March 18, 2019 for 100 farmers.

Training Programme at KVK Barwani under TSP Project (18.03.2019)

- Farmers' Field Day under Farmers' FIRST Project (FFP) at Khamkheda on March 26, 2019; at Bhaironpura and Karod Khurd on March 27, 2019. Scientist-farmer interaction was held at these cluster villages.

Attended the meetings of Site Selection Committee for establishing KVK for district Sukma, Chattisgarh during August 21-22, 2018

Concluding Workshop of Contractual Network research projects at CSKHPKV, Palampur

Model Training Course on "Rapid Bio-Waste Management Technologies: Options for Recycling, Reuse and Recovery"

Manna, M.C. (2018) Organized a District level training programme on "Municipal solid and liquid waste management" at D M office of Ethawah, U.P. for 120 officials during 17-21 December,2018 " sponsored by NITS- BIS, New Delhi.

ICAR sponsored winter school training on "Advance Microbial Technologies to enhance Nutrient Use Efficiency and Mitigation of Greenhouse Gas Emission from Agriculture".

ICAR sponsored short course on "Physiological Approaches to Phytoremediation: Advances, Impacts and Prospects"

Training Cum Workshop on "Post Harvest Skill Development of Rural Women" was conducted under Farmers FIRST project in collaboration with Women Cell, ICAR-IISS, Bhopal on February 20, 2019 at KVK, ICAR-CIAE, Bhopal.

Rashtriya Mahila Kisan Diwas was celebrated on October 15, 2018 at Khamkheda Village.

International Collaboration and coordination

FAO and ICAR-IISS jointly organized Lab Managers Meeting Cum Workshop of South-East Asia Laboratory NETwork (SEALNET) at ICAR-IISS, Bhopal

Food and Agricultural Organization (FAO) and Indian Council of Agricultural Research (ICAR) jointly organized 2nd Lab Managers Meeting-cum-Workshop of South-East Asia Laboratory NETwork (SEALNET) during 19-23 November 2018 at ICAR-Indian Institute of Soil Science, Bhopal. The theme of the workshop was "Quality improvement in Asian soil laboratories: towards

standardization and harmonization of soil analyses and their interpretation". Representatives/ Lab-Managers from FAO, Rome, FAO, India, France and 16 Asian countries viz., China, Japan, Mongolia, Nepal, Laos, Bangladesh, Thailand, Myanmar, Philippines, Vietnam, Bhutan, Sri Lanka, Cambodia, Malaysia, Indonesia and India attended the meeting. The meeting was conducted by Dr. A.K. Patra, as Chairman, Dr. Pradip Dey & Dr. A.K. Biswas Co-Chairman and Sanjay Srivastava as Organizing Secretary .

Regional training on Integrated Plant Nutrient Management System in SAARC countries at ICAR-IISS, Bhopal

For increased awareness and greater scientific cooperation among member countries of South Asian Association for Regional Cooperation (SAARC), the SAARC Agricultural Centre (SAC), Dhaka, Bangladesh and the Indian Council of Agricultural Research (ICAR) took initiatives for Regional Training Program on various important issues affecting agriculture sector of the region. As a part of this initiative, the ICAR-Indian Institute of Soil Science, Bhopal in collaboration with SAC, Dhaka and International Rice Research Institute (IRRI) organized a training program at ICAR-IISS, Bhopal during 5-10 September, 2018 on the theme "Integrated Plant Nutrient Management System in SAARC countries". The training was organized by Dr. A.K. Patra (Chairman), Dr. P. Dey (Organizing Secretary), Dr. Sanjay Srivatava (Co-organizing Secretary) and Dr. N.K. Lenka (Co-organizing Secretary).

Exposure visit cum workshop for tribal farmers

An Exposure visit cum Workshop on Soil Health Management for improved crop productivity for tribal farmers was organized at KVK Rajnandgaon, Chhattisgarh during March 8-9, 2019. On 8th March 2019, about 400 tribal farmers participated in an interactive workshop programme at KVK Rajnandgaon. A large number of women farmers were also participated in this programme as 8th March 2019 have been also celebrated as women's day. A series of lectures were delivered by Scientists of ICAR-IISS, Bhopal viz. Dr R. Elanchezhian, Dr Prabhat Tripathi and Dr. U. Tiwari. Besides, scientists form AICRP on MULLaRP, Raipur, KVK, Rajnandgaon, IGKV, Raipur and Officers of Fisheries, Horticulture, Agriculture from State departments of Rajnandgaon district also participated in the workshop to upgrade the knowledge of farmers and creating awareness among farmers about modern agricultural practices. In the post lunch session, discussions were held with farmers on soil health assessment and management for improving crop productivity. The literature on agricultural practices including Soil sampling techniques, vermicomposting, Krishi darshika, crop calendar wasdistributed to the farmers. On March 9, 2019 team of ICAR-IISS, Bhopal along with team of KVK, Rajnandgaon visited fields of tribal farmers at village Kekti Tola, Sonsai Tola and Manga Tola in Ambagarh chowki tehsil/block of Rajnandgaon. In an interactive session at Manga Tola village, soil related issues of farmers were discussed with their soil health cards and corrective measures were suggested by ICAR-IISS, Bhopal and KVK Rajnandgaon team. Methods of soil sampling were demonstrated and soil samples were drawn from the

farmer's fields in a participatory mode. ICAR-IISS, Bhopal team also collected irrigation water samples from farmers bore wells for further analysis.

Other training programme/meeting

One Day Special Trainning on 'Soil Testing: Entrepreneurship Development' for the B Sc (Ag) students from Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune organized at ICAR-IISS, Bhopal on March 6, 2019.

NICRA- Sponsored 10 days Training Program on Linking Geo-Spatial Technologies and Agricultural System Models to Assess Impact of Climate Change on Natural Resource Management during October 24 to November 2, 2018 at ICAR-IISS, Bhopal.

Organized Inter-state farmers training for 3 days (October 29-31, 2018) sponsored by Department of Agriculture, Coimbatore district for Farmers' from Annur, Coimbatore, Tamil Nadu

One-day Training Programme for the Forest Deptt. personnel on Importance of Soil Health in Nursery Raising/Plantation on October 6, 2018.

ICAR- Indian Institute of Soil Science in association with Bhopal chapter of Indian Society of Soil Science organised 25th Dr. D. P. Motiramani memorial lecture on December 17, 2018. The lecture was delivered by Dr. K. P. Vaidya, Professor, Soil Science & Agriculture Chemistry, BSKVV, Dapoli, Maharashtra on "Integrated Nutrient Management of Sustainable Agriculture".

Organised Swachhta Pakhwada during December 16-31, 2018 with great enthusiasm and activities. During this period both on campus and off campus cleanliness activities were performed involving institute scientist/ staff/ students/ farmers/common citizens.

14. Distinguished Visitors

- Dr. Tejinder Singh, IFS, Additional Principal Chief Conservator of Forests of the Western Zone, Bhopal, Dr. Surendra Kumar Singh, Director, ICAR-NBSS&LUP, Nagpur, Dr. V. P. Singh, Director, ICAR-NIHSAD, Bhopal and Dr. A. Subba Rao, Ex-Director, ICAR-IISS, Bhopal visited on April 16, 2018 for Foundation Day.
- Shri Radha Mohan Singh, Hon'ble Minister of Agriculture and Farmers' Welfare, Govt. of India and President, ICAR visited ICAR-IISS, Bhopal on May 18, 2018. The Hon'ble Minister took note of the progress and achievements of the institute and informed the Scientists and other staff of future challenges and priorities, keeping in view the goal of doubling farmer's income. Dr Ashok K. Patra, Director of the institute apprised the Hon'ble Minister about the achievements and on-going activities of the institute.

- Dr. S. S. Khanna during Inaugural Function of Model Training Course on "Rapid Bio-Waste Management Technologies: Options for Recycling, Reuse and Recovery" onNovember 24, 2018

- Dr. P.N. Takkar (Ex-Director, ICAR-IISS), Dr. A. Subba Rao (Ex-Director, ICAR-IISS) and Dr. D.K. Solanki (IFFCO) during Valedictory Function of Model Training Course on "Rapid Bio-Waste Management Technologies: Options for Recycling, Reuse and Recovery" on December 01, 2018

- Dr. Trilochan Mohapatra, Hon'ble Secretary (DARE) & Director General (ICAR) visited ICAR-Indian Institute of Soil Science, Bhopal on the afternoon of December 13, 2018. Dr. Ashok K. Patra, Director (ICAR-IISS) accompanied DG (ICAR), Bhopal, along with Dr. V.P.Singh, Director (ICAR-NISHAD), Bhopal and Dr N.P.Singh, Director, (ICAR-IIPR), Kanpur on the occasion.

- ICAR-Indian Institute of Soil Science, Bhopal celebrated World Soil Day with the theme “Be the Solution to Soil Pollution” with an aim to raise awareness and call people to Stop Soil Pollution. World Soil Day is celebrated annually on the December 5, 2018 with goal to create awareness on the importance of soil quality for food and nutritional security, human well-being and healthy ecosystems. About 200 farmers participated in the world soil day organized at famers' field at Parwalia Sadak Village, Bhopal. Dr N.N. Goswami, Former Dean, (IARI) & Ex-Vice Chancellor (CSAUAT), Kanpur, Dr A. Subba Rao, Ex-Director (IISS), and Prof. D.K. Das, Ex-Head, Division of Agricultural Physics, IARI, New Delhi, graced the occasion. Officials from Govt of M.P. and State of Bank of India also participated in this event.

- Mr. Suresh Chandel, Ex-Member of Parliament and Member of Governing Body of Indian Council of Agricultural Research visited Indian Institute of Soil Science, Bhopal on September 29, 2018.

15. Infrastructure Development

Instrument/Equipment Purchased

UV-Visible Spectrometer (01 no.), Printers Canon MF241D (02 nos.), LED TV (01 no.), Water Purification System (01 no.), Glass Distillation Unit (02 nos.), Laboratory Hot Plate (01 no.), Almirah. (01 no.), Water Bath (02 nos.), Ice Flacking Machine (01 no.), Refrigerator (01 no.), Bead Beater (01 no.), Chairs, Air Conditioner, Gradient Thermal Cycler, Software, Digital EC Meter, Auto Pipette, Desktops Computer (02 Nos.), Magnetic Stirrer with Hot Plate, Argon Gas Cylinder, FTIR Spectrometer, BOD Incubator, BOD Incubator, pH Meter with Redox Electrode, CHN Analyser, Deep Freezer, Water Tanker, Plant Canopy Analyser, Real Time PCR Machine, Hatching Machine, Gas Chromatograph, Split Slit Drill, Happy Seeder, Ion Selective Field Transistors, Farm Equipment.

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 2018-19	Total
Books	Nil	2591
Bound Journals	Nil	3064
Annual Reports	91	2526
Foreign and Indian Journals	Nil	Nil

Farm Activities

1. Revenue of Rs. 9.69 lakhs were generated through sale of farm produce.
2. Resource conservation based farming activities were promoted in general research farm& promosing result were obtained in teams of productive & resource use.
3. One borewell has been installed in the farm.
4. One happy seeder was procured under FFP.

16. Scientific, Technical, Administrative Personnel

DETAILS OF MANPOWER

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. Bhoi Lal Uikey	Lab Attendant	Skilled Supporting Staff	13.11.1995	13.11.1995
Mr. Darashram	Lab attendant	Skilled Supporting Staff	15.03.1990	15.03.1990
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. PrabhatTripathi	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
Dr. Seema Bhardwaj	Scientist	Soil Science/Pedology	07.01.2008	07.07.2018
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	17.2.2012
Dr. Narendra K. Lenka	Pr. Scientist	Soil Physics/Soil & Water Conservation	30.11.2000	09.10.2009

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
Dr. TapanAdhikari	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. 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. V.D. Meena	Scientist	Agronomy	15.09.2011	23.12.2011
Dr. Utkarsh Tiwari	Scientist	Agricultural Economics	05.07.2017	12.10.2017
Dr. Abhijit Sarkar	Scientist	Soil Science	05.07.2016	29.06.2018
Dr. Madhumonti Saha	Scientist	Soil Science	05.07.2017	29.06.2018
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

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
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. Shinogi, K.C.	Scientist	Agricultural Extension	27.04.2011	05.09.2011
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. 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	22.05.1990	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. 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. Asha Sahu	Scientist	Soil Chemistry/Fertility	03.05.2010	03.05.2010
Dr. Sudeshna Bhattacharjya	Scientist	Soil Chemistry/Fertility	01.01.2015	10.04.2015
Dr. Dolamani Amat	Scientist	Agriculture 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 & I/c 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

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
AINP-SBB				
Dr. S.R. Mohanty	Pr. Scientist & I/c AINP on SBB	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
PME CELL				
Dr. R. Elanchezhian	Pr. Scientist& I/c PME Cell	Plant Physiology	09.11.1998	17.2.2012
Mr. Sanjay Kumar Kori	Personal Assistant	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
Remot Sensing & GIS Laboratory				
Dr. M. Mohanty	Pr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1999	10.11.1999
Mr. L.N. Chouksey	Messenger	Skilled Supporting Staff	17.12.1988	17.12.1988
LIBRARY SECTION				
Mrs. Nirmala Mahajan	T-7-8	Asstt. Chief Tech. Officer	15.03.1993	15.03.1993
CENTRAL LAB				
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 LAB				
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 (Electrucian)	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

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
ADMINISTRATION SECTION				
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. Hira Lal Gupta	Assistant	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
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	Lab attendant	Skilled Supporting Staff	01.09.1993	10.06.1999

*on deputation

Promotion

1. Dr. M. Mohanty promoted to Principal Scientist w.e.f February 13, 2018th rough CAS.
2. Mr. Hira Lal Gupta got MACP w.e.f. August 23, 2018.
3. Mr. Anurag got MACP w.e.f. August 13, 2018.
4. Mr. Thomas Joseph got MACP w.e.f. November 1, 2018.
5. Mrs. Babita Tiwari got MACP w.e.f. May 15, 2018.
6. Mr. O.P. Yadav got MACP w.e.f. December 19, 2018.
7. Mr. Bhanwar Singh Yadav got MACP w.e.f. January 23, 2019.
8. Mrs. Kavita Bai got MACP w.e.f.December 20, 2018.
9. Mr. Sanjay Kumar Kori promoted to Personal Assistant w.e.f. December 29, 2018.

Superannuation

1. Dr. S. Kundu, Principal Scientist, ESS superannuated on January 31, 2019.

Transfer

1. Dr. Sonalika Sahu, Scientist transferred to ICAR-NBSS&LUP, Nagpur on June 27,2018.
2. Dr. M.L. Dotaniya, Scientist transferred to ICAR-DRMR, Bharatpur on June 26,2018.

Decease

1. Mr. Naresh Singh Yadav, Technical Officer (Driver) departed to heavenly abode on October 28, 2018.

Joining

1. Mrs. Seema Bhardwaj, Scientist joined on July 7,2018
2. Mr. Abhijit Sarkar, Scientist joined on June 29, 2018
3. Mrs. Dr. Modhumonti Saha, Scientist joined on June 29,2018

NOTE