वार्षिक प्रतिवेदन
Annual Report | 2023

भा.कृ.अनु.प. - भारतीय मृदा विज्ञान संस्थान
ICAR - Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal – 462038 (M.P.)
Website: www.iiss.icar.gov.in
(ISO 9001 : 2015 Certified)
Sardar Patel Outstanding ICAR Institution
King Bhumibol World Soil Day Awardee

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ANNUAL REPORT
2023

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

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Editors

Dr. S.P. Datta

Dr. R. Elanchezhian

Dr. Prabhat Tripathi

Dr. Pramod Jha

Dr. M.Vassanda Coumar

Dr. Nisha Sahu

Dr. Alka Rani

Dr. M. Homeshwari Devi

Dr. Rahul Mishra

Typing & Computer Assistance

Mr. Sanjay Kumar Kori

Mr. Sanjay Kumar Parihar

Published by

Director

ICAR-Indian Institute of Soil Science

Nabibagh, Berasia Road

Bhopal – 462 038 Madhya Pradesh

Ph.: 0755-2730970, 2730946, Fax No. 0755- 2733310

Email- director.iiss@icar.gov.in

Website: www.iiss.icar.gov.in

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Preface

Healthy soils are the predicament for several ecosystem services which are necessary to sustain food production, nutrient cycling, biodiversity conservation and healthy life on the planet earth. The maintenance of these ecosystem services which contribute to Sustainable Development Goals (SDGs) of UN requires concerted efforts of inter-disciplinary research approaches. Though the intensive cultivation or farming practices has ensured food security and nutritional security, however, such practices coupled with urbanization and industrialization have led to deterioration of soil health and adversely affected the various soil processes, which posed a great threat to soil and other biodiversity. Under such scenario, to avoid further decline in soil health and improve agricultural productivity, a comprehensive knowledge of soils and its processes are very much indispensable. The shrinking agricultural land resources coupled with soil degradation in India and elsewhere poses a greater risk to food production system, which adversely affects crop yields and leads to malnourishment in many parts of the globe including India. Under such scenario, the scientists working in soil science and allied specializations have a greater sense of responsibility towards thorough research on the sustainable management of soil resources. Therefore, it is acknowledged in recent times that the sustainable management of soil health is indispensable for sustaining agricultural productivity. This demands regular assessment of our soil resources and provides appropriate technological interventions for enhancing soil health and crop productivity. Also, it is imperative on the part of the institute to create awareness among farmer and other stakeholders on the roles and functions of soil for the sustenance of humanity through national / international campaigns.

ICAR-Indian Institute of Soil Science (ICAR-IISS), Bhopal is engaged in research and developmental activities with mandate "to provide scientific basis for enhancing and sustaining productivity of soil resource with minimal environmental degradation". The institute has developed many potential and feasible technologies with laboratory cum field-level validation for the improvement of soil health to address the emerging issues and challenges. This annual report vividly illustrates the multi-scale approaches and work done in the area of soil health and input use efficiency, conservation agriculture and carbon sequestration, soil microbial diversity and genomics, soil pollution, remediation and environmental security. The report also describes the work done on farmers' participatory research and demonstration of the technologies at farmers' fields as well as across the length and breadth of the country through various AICRPs, AINP, CRP centres of the institute and SCSP and TSP programs.

During the period under report, some new technologies and methodologies were developed and refined by the institute, *viz*. STCR Based IPNS-Technology for maize-wheat cropping system in Central India, nutrient use efficient genotypes of wheat grown on Vertisols, CA practices for maize-chickpea cropping systems, phosphate solubilizing bacterial liquid biofertilizer (PSB 1), rhizobium biofertilizer for pigeon pea (Rhizo-1) etc. It is thus, a great pleasure for me to bring out the Annual Report 2023 of the ICAR-Indian Institute of Soil Science.

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

I place on record, my sincere appreciation to Drs R Elanchezhian, Prabhat Tripathi, Pramod Jha, MV Coumar, Nisha Sahu, Alka Rani, M Homeshwari Devi and Rahul Mishra for their dedicated efforts in compiling and editing the report. The service rendered by Mr Sanjay Kumar Kori and Mr Sanjay Kumar Parihar in collecting information and typesetting the manuscript is appreciated.

I acknowledge, with gratefulness and respect, Hon'ble Dr. Himanshu Pathak, Secretary, DARE and Director General, ICAR for his consistent guidance, inspiration and encouragement as well as providing necessary financial support for the overall growth and development of the institute. I am highly thankful to Dr. S.K. Chaudhari, Deputy Director General (NRM) and Dr. A. Velmurugan, Assistant Director General (SWM) for their guidance, active involvement and constructive suggestions in carrying out various research and development activities for the overall progress of the institute.

Bhopal
April 2024

(S.P. Datta)
Director

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कार्यकारी सारांश

विषय वस्तु–I: मृदा स्वास्थ्य एवं पोषक तत्व उपयोग दक्षता

आदान उपयोग दक्षता और मृदा स्वास्थ्य में सुधार

- रबी 2022–23 के दौरा न गेहूँ की 24 प्रजातियों के भौतिक और पोषक तत्व उपयोग दक्षता गुणों का मूल्यांकन किया गया। इनमें 10 प्रजातियों की एग्रोनामी दक्षता 40 प्रतिशत से अधिक तथा आन्तरिक जल उपयोग दक्षता 100 माइक्रोमोल प्रति मोल से अधिक पायी गयी।

- एकीकृत पोषक तत्व प्रबंधन ने फसल की उपज और मृदा स्वास्थ्य को बढ़ाने में श्रेष्ठता दिखाई। गोबर की खाद आधारित एकीकृत पोषक तत्व प्रबंधन मॉड्यूल जैसे एस टी सी आर आधारित 75 प्रतिशत एन पी के + गोबर की खाद 5 टन प्रति हेक्टेयर (वार्षिक दर) में सर्वाधिक मक्का की उपज में वृद्धि हुई। इसके बाद एस टी सी आर 75 प्रतिशत एन पी के + 20 टन प्रति हेक्टेयर गोबर की खाद (प्रत्येक चार साल में) और 75 प्रतिशत एन पी के + वर्मी कम्पोस्ट द्वारा उपज में वृद्धि प्राप्त हुई।

- मृदा के दोनों स्तरों 0–15 और 15–30 सेमी. में जैविक और एकीकृत पोषक तत्व प्रबंधन क्रियाओं के प्रयोग से 18 साल के फसल चक्रो के बाद मृदा में आक्सीकरण उन्मुख कार्बन और इसके संग्रह में महत्वपूर्ण सुधार देखा गया। फसल अवशेषों के विभिन्न स्तरों के प्रतिधारण का मक्का – चना और सोयाबीन –गेहूँ फसल प्रणाली की उपज पर महत्वपूर्ण प्रभाव पड़ा। दोनों फसल प्रणालियों में 90 प्रतिशत अवशेष प्रतिधारण के साथ अधिकतम उपज पायी गयी।

- प्रमुख अवयव विश्लेषण और फजी सी–मीन्स क्लसटरिंग की तकनीकों का उपयोग करके 18930 मृदा नमूनों के विश्लेषण के आधार पर पाँच मृदा पोषक तत्व प्रबंधन क्षेत्र पहचाने गये।

- लुधियाना, पंजाब में गेहूँ के 14 जीनोटाइप्स का पोषक तत्व उपयोग दक्षता, विशेष रूप से जिंक और मैगनीज के लिए मूल्यांकन किया गया। अध्ययन में जीनोटाइप्स PBW-824, BWL-8855, PBW-872, PBW-869 और PBW Zn 1 को फसल उपज के मामले में कुशल पहचाना गया। इसके अलावा PBW- 824 और PBW-869 गुणवत्ता मनाकों में उच्च स्थान पर पाये गये।

- चावल और गेहूँ की फसलों के लिए फास्फोरस और सिलिका के संयुक्त प्रयोग (प्राइमिंग और पर्णीय प्रयोगों के माध्यम से) ने सबसे अधिक उपज वृद्धि दिखाई। सिलिका या फास्फोरस के एकल प्रयोग के प्रभाव को, इन पोषक तत्वों के संयुक्त प्रयोग ने पीछे छोड़ा।

- एस टी सी आर के अखिल भारतीय अनुसंधान परियोजना के केन्द्रों ने उर्वरक अनुशंसा लिए कई निर्धारण समीकरण विकसित किए।

- एल टी एफ ई के तहत प्रमुख फसलों में दीर्घकालिक उर्वरक और खाद अनुप्रयोग ने पोषक तत्व असंतुलन के कारण मृदा सूक्ष्म जीव बायोमास कार्बन और नाइट्रोजन और डी एच ए गतिविधि में गिरावट दिखाई। सबसे अधिक गतिविधि 100 प्रतिशत एन पी के + गोबर की खाद के साथ पायी गयी। जबकि विभिन्न मृदाओं में 150 प्रतिशत एन पी के का प्रदर्शन इसके बराबर देखा गया।

विषय वस्तु–II: संरक्षण कृषि, कार्बन पृथक्करण और जलवायु परिवर्तन

- खुले शीर्ष कक्षों में प्रयोगात्मक स्थिति के तहत, गेहूँ की फसल (प्रजाति, एच आई 1544) में जल और नत्रजन तनाव के बीच परस्पर क्रिया का अध्ययन किया गया। जिसमें जल और नत्रजन तनाव के कारण क्रमशः 3–15 प्रतिशत और 7–14 प्रतिशत की उपज में कमी आई। यह प्रभाव परिवेश CO_2 स्तरों की तुलना में उन्नत CO_2 स्तरों पर अधिक स्पष्ट था।

- स्थान विशेष और पत्तियों के रंग चार्ट आधारित पोषक तत्व प्रबंधन के साथ गेहूँ और भूसे की उपज पारम्परिक खुराको की तुलना में महत्वपूर्ण रूप से बढ़ी। टपक सिचाई ने सबसे अधिक जल उपयोग दक्षता प्रदर्शित की। संरक्षण क्रियाओं ने टपक सिचाई के तहत नो–टिलेज भूखंड में उपज, मृदा स्वास्थ्य और उपलब्ध पोटेशियम को बनाए रखा।

- एपसिम फसल मॉडल का उपयोग उन्नत गेहूँ की उपज के लिए अनुकूली जल प्रबंधन रणनीतियों का प्रस्ताव करने के लिए किया गया। परिणामों से यह ज्ञात हुआ कि 50 मिमी गहराई और 70 प्रतिशत दक्षता दर के साथ चार सिंचाई करने से विभिन्न कृषि संसाधन स्थितियों में औसतन 3800 किग्रा./हे. गेहूँ की उपज प्राप्त हुई।

- एपसिम फसल मॉडल का उपयोग भारत में 24 वर्षो के दौरान विभिन्न नत्रजन और गोबर की खाद प्रबंधन क्रियाओं के तहत चावल–गेहूँ फसल प्रणाली में मृदा जैविक कार्बन गतिशीलता का विश्लेषण करने के लिए किया गया। मॉडल ने अनाज की उपज और मृदा जैविक कार्बन संग्रह गतिशीलता का सटीक पूर्वानुमान लगाया, जिसमें R^2 0.87 और मॉडल दक्षता 0.89 प्राप्त हुई।

- उपोष्ण कटिबंधीय मध्य भारत वर्टिसोल्स में सोयाबीन–गेहूँ प्रणाली पर एपसिम मॉडल का उपयोग करके किए गये एक अध्ययन में मृदा जैविक कार्बन के रखरखाव के लिए अवशेष प्रतिधारण की विभिन्न सीमाऐं पायी गई, पर्याप्त रूप से उर्वरक प्रयोग की गयी फसलों के लिए 10 प्रतिशत और सीमित नत्रजन स्थितियों के लिए 30 प्रतिशत अवशेष प्रतिधारण निर्धारित किया गया।

- एक 10 साल के दीर्घकालिक अध्ययन में नत्रजन प्रबंधन स्तरों की परवाह किए बिना नो–टिलेज में उच्च सक्रिय मृदा जैविक कार्बन संग्रह दर्ज किया गया। सक्रिय मृदा जैविक कार्बन संग्रह में नत्रजन प्रयोग में वृद्धि के साथ बढ़ोत्तरी पायी गई। यह 100 प्रतिशत नत्रजन पर सर्वाधिक थी। टिलेज प्रणाली ने निष्क्रिय मृदा जैविक कार्बन संग्रह पर 150 प्रतिशत नत्रजन स्तर को छोड़कर कोई महत्वपूर्ण प्रभाव नहीं दिखाया।

- फेस (एफ ए सी ई) प्रणाली के तहत मध्य भारत की वर्टिसोल्स में किए गये एक अध्ययन में यह पाया गया कि कार्बन डाई आक्साइड और तापमान के उच्च स्तर ने सूक्ष्म पोषक तत्वों की उपलब्धता (जल में घुलनशील और विनमय योग्य) को सकारात्मक रूप से प्रभावित किया लेकिन यह प्रभाव सांख्यिकीय रूप से सार्थक नही था। संभवतः उच्च कार्बन डाई आक्साइड स्तरों के कारण मृदा अम्लीकरण के कारण जैविक रूप से बंधी धातुओं का खनिजीकरण हुआ।

- स्वाप (SWAP) मॉडल को मृदा जल मात्रा और तापमान पर क्षेत्रीय आंकड़ो के साथ सत्यापित व जॉचने पर ज्ञात हुआ कि पारम्परिक जुताई की तुलना में बिना जुताई के तहत मृदा नमी उल्लेखनीय रूप से उच्च थी। जिससे जल प्रतिधारण और जलवायु परिवर्तन प्रभावों को कम करने के लिए कृषि जल प्रबंधन रणनीतियों के संभावित लाभों के सुझाव दिए गये।

- 1979 से 2021 तक भारत के विभिन्न पारिस्थितिक क्षेत्रों में ई एस ए–सीसीआई सतह मृदा नमी आंकड़ो का एक व्यापक विश्लेषण से पता चला कि अधिकांश (94.09 प्रतिशत) क्षेत्रों में मृदा जल मात्रा में कोई सार्थक अस्थायी प्रवृृत्ति नही दिखी। 2.75 प्रतिशत क्षेत्रों में घटती प्रवृत्ति प्रदर्शित हुई। जबकि 3.16 प्रतिशत क्षेत्रों में मुख्यतः उत्तरी मध्य भारत में जलोढ़, लाल और काली मिट्टी में विशेष रूप से अगस्त और दिसंबर में बढ़ती प्रवृत्ति पायी गयी।

विषय वस्तु–III: सूक्ष्मजीवी विविधता और जैव प्रौद्योगिकी

- थर्मोफिलिक जीवाणु में गेहूँ और धान के भूसे को अपघटित करने की उच्च क्षमता होती है। अतः इनके द्वारा निर्मित कम्पोस्ट में पोषक तत्वों (एन.पी.के) की मात्रा अन्य दूसरे जैव अपघटक की तुलना में अधिक पायी गयी।

- गेहूँ, सरसों, चना एवं अलसी में 50 प्रतिशत जैविक 50 प्रतिशत अकार्बनिक स्रोत से पोषक तत्वों के संयोजन से बीज की अधिक उपज प्राप्त हुई। मृदा विश्लेषण ने यह इंगित किया कि 100 प्रतिशत जैविक उपचार द्वारा पोषक तत्व प्रबंधन का मृदा स्वास्थ्य एवं उर्वरता पर सार्थक प्रभाव पड़ता है जिससे जैविक कार्बन, उपलब्ध पोषक तत्वों एवं एन्जाइम की उच्चतम सक्रियता पाई गयी।

- सरसों की 12 विभिन्न प्रजातियों में अरावली का उपज प्रदर्शन 1223 किग्रा/हे. के साथ सर्वश्रेष्ठ पाया गया। इसके बाद C5–52% प्रजाति 1140 किग्रा./हे. की उपज जैविक खेती हेतु एक सक्षम विकल्प के रूप में चिह्नित की गई।

- प्राकृतिक खेती के अवयवों के साथ–साथ रासायनिक कीटनाशकों के प्रयोग से गेहूँ और अंतः फसल सरसों की समन्वित फसल प्रबंधन में उपज सर्वाधिक पायी गयी। केवल जैविक खाद के प्रयोग के उपचारों में मृदा सूक्ष्म जीवों एवं एन्जाइम की सक्रियता सर्वाधिक पायी गयी, जिसके कि परिणाम जैविक एवं अकार्बनिक उर्वरक के संयुक्त उपचारों से तुलना करने योग्य पाये गए।

- विभिन्न पोषक तत्वों के प्रबंधन प्रक्रियाओं के अंतर्गत जल में घुलनशील पोटेशियम के स्तर पर कोई प्रभाव नहीं पड़ा था। जबकि विनिमयशील पोटेशियम का स्तर भिन्नता के साथ पाया गया। 50 प्रतिशत जैविक + 50 प्रतिशत कार्बनिक उपचार ने गैर विनिमयशील पोटेशियम का स्तर कम किया तथा मृदा संरचना के पोटेशियम की फसल में उपलब्धता बढ़ाई।

- जैविक और समन्वित खेती विधियों में मुख्यतः 50 प्रतिशत जैविक + 50 प्रतिशत अकार्बनिक का संयुक्त उपचार ने सार्थक रूप से मृदा की सतह में मृदा जैव कार्बन का प्रतिशत एवं संग्रह में वृद्धि की, यह इंगित करता है कि सूक्ष्मजीवों की सक्रियता और मृदा के पोषक तत्वों के स्तर में बढ़ोत्तरी करके मृदा स्वास्थ्य व फसल उत्पादन क्षमता को अच्छा किया।

- एंडोफाइटिक कवक जैसे फ्यूजेरियम, कर्ववुलेरिया को नगर के ठोस अपशिष्ट संग्रह स्थल से पृथक कर यह पाया गया कि इनमें भारी धातुओं को सहन करने की क्षमता है। ये कवक पौधों में संतुलन बहाल करने के उपायों और फॉस्फोरस की घुलनशीलता, इंडोल एंसिटिक एसिड तथा सिडरोफोर की उत्पत्ति के लिए उपयुक्त पाये गये।

- मध्य भारत के विभिन्न भूमि उपयोग में रूबिस्कों एन्जाइम की सक्रियता से स्वपोषी कार्बन की स्थिरीकरण की दर पर सार्थक प्रभाव पाया गया। 100 प्रतिशत अकार्बनिक आदानों से उपचारित क्षेत्रों में (एन पी ओ एफ व एल टी एफ ई के अध्ययनों में) कार्बन स्थिरीकरण क्षमता सर्वाधिक पायी गयी।

- लीनियर रिग्रेशन विश्लेषण में कुल नत्रजन, मृदा के रूबिस्को एन्जाइम की सक्रियता को प्रभावित करने वाला प्राथमिक कारक पाया गया। इसके बाद मृदा पी.एच., नाइट्रेट नत्रजन और ग्लोमालिन कारक पाए गये। समायोजित R^2 मान 0.99 विश्लेषण के आधार पर कुल ग्लोमालिन से संबंधित मृदा प्रोटीन, प्रोटिएज और यूरिएज, फिनोल, आक्सीडेज सक्रियता के लिए क्रांतिक पाया गया। जैविक कार्बन सिक्येशट्रेशन, मृदा नत्रजन और एन्जाइम के परस्पर प्रभाव से प्रभावित पाया गया।

- अनुसंधान ज्ञात हुआ कि पौधे के अजैविक तनाव से सुरक्षा के लिए महत्वपूर्ण मिथाइलोट्राफ बैक्टीरिया, गेहूँ की पत्तियों से लेकर बीजों तक में प्रचुर मात्रा में पाए जाते है। अध्ययनों से पता चला कि जड़ क्षेत्रों में उल्लेखनीय नाइट्रोजन स्थिरीकरण और फास्फोरस घुलनशील क्षमताओं के बावजूद एल्कलाइड पेगनाइन जैसे योगिक जड़ों के ऊपर की शाखाओं में बैक्टीरिया के संचरण को नियंत्रित किया।

- पैराबुर्क होल्डेरिया (आई जी के वी1) ने सोयाबीन, चना और अरहर में अकेले या ब्रेडीराइजोबियम (BRP2) के साथ नोड्यूलेशन को बढ़ाया है। आई जी के वी1, के द्वारा सीडरोफोर का उत्पादन न केवल फास्फेट को घुलनशील बनाता है बल्कि नोड्येलेशल को बढाता है। जिससे फलीदार फसलों में जैविक नाइट्रोजन स्थिरीकरण को बढ़ाने के लिए राइजोबियम के साथ सह क्रियात्मक जैव उर्वरक के उपयोग का सुझाव मिलता है।

- ए आई एन पी एस बी बी केन्द्र वाई एस पी यू एच एफ, सोलन, हिमाचल प्रदेश में 44 गुलदाऊदी जीवाणु एंडोफाइट्स को अनुक्रमित किया गया जिससे 91 से 99.77 प्रतिशत न्यूक्लियोटाइड होमोलाजी के साथ 14 वंश का पता चला। विश्लेषण ने जीवाणु रूप से उपचारित पौधों में उच्च एंडोफाइटिक जीवाणु विविधता का संकेत दिया, जिससे बैसिलस स्टेनोटोफोमानास विशेष रूप से प्रमुख थे। जो जैविक संसाधनों के लाभ पर प्रकाश डालते है।

- ए आई एन पी एस बी बी केन्द्र वाई एस पी यू एच एफ, कोयम्बटूर मे पोषण की कमी जागरूकता शिविर के दौरान 450 आदिवासी परिवारों को मोटे अनाज के लिए जैव उर्वरक विकसित और वितरित किए गये तथा एजोस्पिरिलम और फास्फो बैक्टीरिया पाउच दिए गये तथा इन जैव उर्वरको को प्रयोग करने के प्रदर्शन कराए गये।

- टी एन ए यू कोयमबटूर में विकसित मृदा जैविक स्वास्थ्य किट व एस आर आइ जैल प्रोब से श्वसन दर के माध्यम से मिट्टी की जैविक गतिविधि की जॉच की गई। 130 किसनों के सामने प्रदर्शित किट ने लगभग 600 मिट्टी के नमूनों का परीक्षा किया जिससे मिट्टी के कार्बनिक कार्बन, माइक्रोबियल, बायोमास कार्बन और अन्य संकेतकों का मूल्यांकन सरल हो गया और सकारात्मक प्रक्रिया प्राप्त हुई।

विषय वस्तु–IV: मृदा प्रदूषण, पुनःस्थापन और पर्यावरण सुरक्षा

- फ्लाई ऐश के प्रयोग से सोयाबीन के बीज और पुआल की उपज में महत्वपूर्ण वृद्धि हुई। विशेष रूप से 200 टन प्रति हेक्टेयर (13 प्रतिशत और 15 प्रतिशत वृद्धि) और 400 टन प्रति हेक्टेयर (17 प्रतिशत और 15 प्रतिशत वृद्धि) की दरों पर। उच्च दरों (>200 टन प्रति हेक्टेयर) पर ऐश के प्रयोग से मृदा में उपलब्ध फॉस्फोरस की मात्रा में महत्वपूर्ण वृद्धि हुई।

- प्रतिवर्ष 20 टन प्रति हेक्टेयर ऐश के साथ अनुशंसित उर्वरक की मात्रा और 5 टन प्रति हेक्टेयर गोबर की खाद के प्रयोग से केवल अनुशंसित उर्वरक की मात्रा के साथ ऐश के प्रयोग की तुलना में सोयाबीन बीज की उपज में महत्वपूर्ण वृद्धि हुई, जो ऐश–उपचारित मृदा में गोबर की खाद के सकारात्मक प्रभाव को दर्शाती है।

- गेहूँ के उच्च अवशेष अनुप्रयोग दर (10 और 15 टन/हे.) के साथ शून्य/कम पोषक तत्व अनुप्रयोग दर ने सतही फसल अवशेष की तुलना में मृदा में मिलाए गए फसल अवशेष में नाइट्रस ऑक्साइड उत्सर्जन को 49 प्रतिशत से 88 प्रतिशत तक बढ़ा दिया।
- भोज वेटलैंड (आद्रभूमि) की ऊपरी झील में जल गुणवत्ता के मूल्यांकन में अधिकांश जल गुणवत्ता मानदण्ड विश्व स्वास्थ्य संगठन के स्वीकार्य सीमा ओं के भीतर पाए गए, सिवाय नाइट्रेट, फॉस्फोरस और बीओडी के। नाइट्रेट (0.5 मिग्रा प्रति लीटर) और फॉस्फेट (0.1 मिग्रा प्रति लीटर) यूट्रोफिक सीमा से अधिक थे।
- क्रोमियम सांद्रता (ppm), का तेजी से अनुमान लगाने के लिए आर स्टूडियो सॉफ्टवेयर का उपयोग करके एक आंशिक न्यूनतम वर्ग प्रतिगमन (PLSR) मॉडल विकसित किया गया। कैलिब्रेशन और वैलिडेशन के लिए R^2 मान क्रमशः 0.92 और RMSE 0.4 थे और मान क्रमशः 198.64 और 520.98 थे, जो यह इंगित करते हैं कि दृश्य निकट अवरक्त (वीएनआईआर) स्पेक्ट्रोस्कोपी का उपयोग करके क्रोमियम को उचित सटीकता के साथ पूर्वानुमानित किया जा सकता है।
- झिंगुरदा कोयला खदान स्थल के नमूनों में जिंक, कॉपर, कैडमियम और निकिल की औसत सांद्रता विश्व स्वास्थ्य संगठन (1996) द्वारा प्रदूषणयुक्त मृदा के लिए निर्धारित अधिकतम स्तरों (क्रमशः 50, 36, 0.8 और 35 पीपीएम) से अधिक पाई गई।
- पालक में धातुओं का उपभोग स्वीकार्य सीमाओं के भीतर रहा और हेजर्ड कोशेंट (HQ) की गणना ने यह दर्शाया कि पालक उत्पादन के लिए 40 टन प्रति हेक्टेयर नगर पालिका कीचड़ और 10 प्रति हेक्टेयर बायोचार के साथ इसके उपयोग से पर्यावरणीय स्थिरता या मानव खाद्य श्रृंखला पर प्रतिकूल प्रभाव नहीं पड़ता।
- विभिन्न संशोधनों (गोबर की खाद, बायोचार, तालाब की गाद और बायोगैस स्लरी) के साथ 5 प्रतिशत और 10 प्रतिशत अनुप्रयोग दर पर फ्लाई ऐश में सुधार से पालक फसल के शुष्क पदार्थ की उपज में महत्वपूर्ण सुधार हुआ। सिवाय बायोचार–उपचारित फ्लाई ऐश माध्यम के।

Executive Summary

Theme I : Soil Health and Nutrient Use Efficiency

Improving input use efficiency and soil Health

- Evaluated physiological and nutrient use efficiency attributes of 24 selected varieties of wheat during rabi 2022-2023. Ten of them showed more than 40% agronomic use efficiency and intrinsic water use efficiency was more than 100 μmol mol^{-1}.

- Integrated nutrient management (INM) proved superior in enhancing crop yield and soil health. Maize yield notably increased using FYM-based INM modules, such as STCR-based 75% NPK + FYM @ 5t/ha annually, followed by STCR-based 75% NPK + FYM @ 20t/ha every four years, and 75% NPK + vermicompost (VC).

- Soil oxidizable carbon and its pools showed significant improvement after 18 years of crop cycles with the application of various nutrient sources, including organic and integrated nutrient management practices, in both soil layers (0-15 cm and 15-30 cm).

- Retention of different levels of residue significantly affected grain yield of maize-chickpea and soybean-wheat cropping systems. The maximum yield was recorded with 90% residue retention treatment in both the cropping systems.

- Based on analysis of 18930 soil sample, five soil nutrient management zones (MZs) were identified (using fuzzy performance index and normalized classification entropy values) by employing the techniques of principal component analysis and fuzzy c-means clustering.

- In Ludhiana, Punjab, 14 wheat genotypes were evaluated for nutrient use efficiency, particularly Zn and Mn. The study identified genotypes PBW-824, BWL-8855, PBW-872, PBW-869, and PBW Zn1 as efficient in terms of crop yield. Additionally, PBW-824 and PBW-869 ranked highest for quality parameters among the genotypes studied.

- The combine application of P and Si (through priming and foliar applications) resulted in the highest yield increases for both rice and wheat crops, demonstrating that the synergistic use of these nutrients surpasses the effects of using Si or P alone.

- AICRP centres of STCR developed several prescription equations for fertilizer recommendation.

- Long-term fertilizer and manure applications in major crops under LTFEs showed a decline in soil microbial biomass carbon and nitrogen, and DHA activity due to nutrient imbalance. The highest activity were observed with 100% NPK + FYM (INM), while 150% NPK also performed comparably to 100% NPK + FYM across soil types.

Theme II : Conservation Agriculture, Carbon Sequestration and Climate Change

- Under open-top chambers experimental condition, interaction between water and nitrogen stress in wheat crop (var. HI 1544) studies indicates water and nitrogen stress resulted in yield reductions to a tune of 3-15 and 7-14%, respectively. This impact was more pronounced under ambient CO_2 levels compared to elevated CO_2 levels.

- Wheat grain and straw yields significantly increased with site-specific and leaf colour chart-based nutrient management compared to traditional doses. Drip irrigation exhibited the highest water use efficiency, followed by sprinkler irrigation, attributed to improved water distribution. Conservation practices sustained yields, enhanced soil health, and available potassium in no-tillage plots under drip irrigation.

- APSIM crop model was used to propose adaptive water management strategies for enhanced wheat yield. Results suggest that implementing four irrigations with a 50 mm depth and 70% efficiency rate could achieve an average wheat yield of 3800 kg ha^{-1} across diverse farm resource conditions.

- The APSIM crop model was used to analyze soil organic carbon (SOC) dynamics in a rice-wheat cropping system under different nitrogen and farmyard manure management practices in India over 24 years. The model accurately predicted grain yield and SOC stock dynamics, with an R^2 of 0.87 and model efficiency of 0.89.
- In a study on a soybean-wheat system in subtropical central Indian Vertisols using the APSIM model, indicated that varying residue retention thresholds for SOC maintenance is 10% for adequately fertilized crops and 30% for nitrogen-limited conditions. Additionally, higher initial SOC levels necessitated 60% retention under nitrogen limitation, decreasing to 30% and 20% under medium and high nitrogen management levels, respectively.
- In a 10 years long term study, higher active soil organic carbon (SOC) pools was recorded in NT regardless of N management levels. Active SOC pools rose with increased N application, reaching a peak at N100%. However, tillage systems showed no significant impact on passive SOC pools except under 150% N application.
- A study conducted in Vertisols of Central India under the FACE system demonstrated that elevated levels of carbon dioxide (CO_2) and temperature positively influenced micronutrient availability (water soluble and exchangeable), but the effect was not statistically significant, potentially due to soil acidification caused by elevated CO_2 levels leading to the mineralization of organically bound metals.
- The calibrated and validated SWAP model with field data on soil water content and temperature, reveals that soil moisture profiles were notably higher under NT compared to CT, suggesting potential benefits for water retention and agricultural water management strategies in mitigating climate change impacts.
- A comprehensive analysis of ESA CCI surface soil moisture data spanning from 1979 to 2021 across various agroecological regions of India revealed that the majority (94.09%) exhibited no significant temporal trend in soil water content. However, 2.75% of the areas showed a declining trend, while 3.16% displayed an increasing trend, primarily observed in northern and central India with alluvial, red, and black soils, notably in August and December, respectively.

Theme III : Microbial Diversity and Biotechnology

- Thermophilic bacteria significantly enhance the potential of decomposition in both rice and wheat straw, thereby increasing the nutrient content (N, P and K) in the compost as compare to other decomposers.
- The combination of 50% organic and 50% inorganic nutrients yielded the highest seed output for wheat, mustard, chickpea, and linseed. Soil analysis indicated that 100% organic treatments had the highest organic carbon and available nutrients (NPK) and enzyme activities indicating a notable impact of nutrient management practices on soil health and fertility.
- Among the 12 different varieties of mustard, Aravali led the yield performance with 1223 kg ha^{-1}, followed by CS-52 at 1140 kg ha^{-1}, indicating their potential as promising options for organic cultivation.
- Wheat and intercrop mustard yields peaked under integrated crop management involving natural farming components with chemical pesticides. Soil microbial count and enzyme activities peaked in treatments utilizing solely organic manure, with comparable results in treatments combining organic and inorganic fertilizers.
- Water-soluble potassium levels were unaffected under different nutrient management practices while exchangeable potassium levels varied significantly, with the 50% organic + 50% inorganic treatment showing the highest levels. Interestingly, organic methods lowered non-exchangeable potassium, enhancing soil structure and potassium availability to crops.
- Organic and integrated farming methods, especially the treatment combining 50% organic with 50% inorganic sources, significantly enhanced SOC percentage and stock at the surface level, indicating improved soil health and potential for increased crop yields through enhanced microbial activity and soil nutrient status.

- Endophytic fungi like *Fusarium* and *Curvularia*, isolated from municipal solid waste dumping site, demonstrate the capabilities in tolerating heavy metals. These fungi hold promise for phytoremediation efforts and exhibit potential for phosphorus solubilization, production of Indole actetic acid and siderophore generation.

- BioSoilz enhanced soil chemical properties, microbial activities, and crop performance, especially with RDF, boosting soil organic carbon and dehydrogenase activity. Both wheat and maize yields increased with BioSoilz, showing its beneficial impact on crop growth and soil management practices.

- Research reveals RuBisCO enzyme activity in various Central India land uses show significant autotrophic carbon fixation rates. In both the NPOF and LTFE studies, the highest carbon fixation potential was observed in plots treated with 100% inorganic inputs.

- An automatic linear regression analysis identified total nitrogen as the primary factor influencing soil RuBisCO enzyme activity, followed by soil pH, nitrate nitrogen, and glomalin, with an adjusted R^2 value of 0.99. Analysis found total glomalin related soil protein, protease, and urease crucial for phenol oxidase activity and carbon sequestration, influenced by soil nitrogen and enzyme interactions.

- Research shows methylotroph bacteria, crucial for plant abiotic stress protection, abound on wheat leaves, varying to seeds. Studies suggest compounds like alkaloid peganine regulate bacterial transmission to shoots over roots, despite their notable nitrogen fixing and phosphorus solubilizing abilities in root regions.

- Paraburkholderia sp. igkv1 enhances nodulation in soybean, chickpea, and pigeonpea alone or with Bradyrhizobium sp. BRP2. The production of siderophores by igkv1 not only solubilizes phosphate but also boost nodulation, suggesting synergistic biofertilizer use with Rhizobium sp. to enhance biological nitrogen fixation in leguminous crops.

- At AINP SBB centre, YSPUHF, Solan, Himachal Pradesh, 44 chrysanthemum bacterial endophytes were sequenced, revealing 14 genera with 91 to 99.77% nucleotide homology. The analysis indicated a higher endophytic bacterial diversity in organically treated plants, with Bacillus, Stenotrophomonas, notably predominant, highlighting organic amendment's benefits.

- At AINP SBB, TNAU Coimbatore, millets biofertilizers were developed and distributed to 450 tribal families during a nutrition deficiency awareness camp. The tribal farmers received Azospirillum and Phosphobacteria sachets with millet seeds, and demonstrations on applying these biofertilizers were provided.

- The Soil Biological Health Kit, or SRI gel probe, developed at TNAU Coimbatore, estimate soil biological activity via respiration rate. Demonstrated to 130 farmers, the kits tested approximately 600 soil samples, simplifying evaluation of soil organic carbon, microbial biomass carbon, and other indicators, receiving positive feedback.

Theme IV : Soil Pollution, Remediation and Environmental Security

- Fly ash application resulted in significant increase in seed and straw yields of soybean, particularly at rates of 200 t ha^{-1} (13% and 15% increase) and 400 t ha^{-1} (17% and 15% increase) respectively. Higher rates of ash application (>200 t ha^{-1}) significantly increased the available phosphorus content in the soil.

- Application of 20 t ha^{-1} of ash annually along with RDF and FYM at 5 t ha^{-1} resulted in significantly higher soybean seed yield compared to ash application with RDF alone, indicating the positive impact of FYM on soybean yield in ash-treated soil.

- Fly ash application, especially at higher levels (>200 t ha^{-1}), led to a significant decrease (18%) in bulk density of surface soil layers (0-7.5 cm and 7.5-15 cm), along with an increasing trend in infiltration rate, although no significant change in soil penetration resistance was observed.

- Surface return of crop residue resulted in decreased N_2O emissions by 171% (N0), 101% (NL), and 90% (NH) in R5, and 49% (N0), 81% (NL), and 90% (NH) in R15, respectively.

- Higher residue application rates combined with no/low nutrient application rates increased N_2O emissions by 49% to 88% in surface return residue compared to incorporation.
- Assessment of water quality in the upper lake of Bhoj wetland indicated that most water quality parameters were within WHO acceptable limits, except for nitrate, phosphate, and BOD. Nitrate (0.5 mg L^{-1}) and phosphate (0.1 mg L^{-1}) exceeded eutrophic threshold limits.
- A Partial Least Square Regression (PLSR) model was developed using R studio software to estimate Chromium content (ppm) in soil rapidly. The R^2 values for calibration and validation were 0.92 and 0.4 respectively, with RMSE values of 198.64 and 520.98, indicating that chromium could be predicted with reasonable accuracy using Visible Near Infrared (VNIR) Spectroscopy.
- Average concentrations of Zn, Cu, Cd, and Ni in Jhingurda coal mine site samples exceed the desirable maximum levels outlined for unpolluted soils (WHO, 1996), which are 50, 36, 0.8, and 35 ppm, respectively.
- Spinach uptake of metals remained below permissible limits, and hazard quotient (HQ) calculations indicated the safe utilization of municipal sludge, particularly at 40 t ha^{-1} with 10 t ha^{-1} biochar, for spinach production without adverse effects on environmental sustainability or the human food chain.
- Addition of various amendments (FYM, biochar, pond silt, and biogas slurry) to fly ash at both application rates (5% and 10%) significantly improved dry matter yield of spinach crops, except in the case of biochar-treated fly ash medium.

1 Introduction

Soil science research contributes significantly to soil health, food and nutritional security, human wellbeing, ecosystem services and global development. Sustainable soil management is a predicament for achieving Sustainable Development SDG Goals (SDGs) of SDG United Nations SDG1 (End Poverty), SDG2 (Zero Hunger), SDG3 (Good Health Wellbeing), SDG11 (Sustainable Cities and Communities), SDG12 (Responsible Consumption and Production), SDG13 (Climate Action) and SDG15 (Life on Land) and thereby sustaining agricultural production. Hence, it is essential to understand the properties and processes of soil at regional, national and global scales to realize these SDGs. Accordingly, Govt. of India has initiated a several measures nationwide under National Mission of Sustainable Agriculture and Soil Health Card Mission to improve the soil productivity. Though, intensive agricultural production system with over exploitation of scarce soil resources worldwide has produced more food grain, yet soil health has declined at faster rate with higher rates of erosion, declining factor productivity and reduced nutrient use efficiency NUE, loss of soil biota and degradation of land due to environmental pollution. Therefore, increasing food-grain production from shrinking land resources requires prioritization of research pursuits, addressing the emerging issues like enhancing inputs (nutrient and water) use efficiency; sustaining soil and produce quality; conservation agriculture to adapt to climate change and carbon sequestration; exploitation of soil biodiversity and genomics; 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 rigorous efforts to attain its mission and received national and international recognitions. Presently, the institute activity has been strengthened further by the scientific and managerial activities of three All India Coordinated Research Projects, one All India Network Project and one Consortia Research Platform project. These five 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, thereby providing access to the diverse soils, agro-ecosystems across the agro-ecological zones of the country for effective implementation of the various programs of the Institute at national level. During the year under report the institute has made significant scientific contributions in the frontier areas of soil science such as input use efficiency, carbon sequestration and climate change, integrated plant nutrient supply system (IPNS), 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
- Fertilizer fortification
- Resilience of degraded soils
- Developing a workable index of soil quality
- Organic farming and produce quality

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

- Conservation agriculture and carbon sequestration sustainable management of land and soil resources
- Tillage and nutrient interactions
- Crop simulation modeling and adaption to climate change
- Remote sensing and GIS

Programme 3: Microbial Diversity and Genomics

- Characterization and prospecting of soil bio-diversity
- Testing of mixed bio-fertilizer formulations
- Quality compost production and quality standards
- Exploring microbial diversity for improvement of contaminated soil and water
- Exploring C-sequestration potential mediated microbes under different agro-eco-systems

Programme 4: Soil Pollution, Remediation and Environmental Security

- Soil pollution impact assessment and toxicity amelioration
- Phytoremediation and bioremediation of contaminated soils
- Developing technology for efficient reuse/ disposal of city and industrial waste
- Developing soil management practices for minimizing emission of greenhouse gases
- Environmental impact risk assessment of nanoparticles on soil health and plant nutrition

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) Prioritization, Monitoring and Evaluation Cell (PME)

v) Agriculture Knowledge Management Unit (AKMU)

vi) Institute Technology Management Unit (ITMU)

vii) Library, Information and Documentation Unit

viii) Right to Information (RTI) Cell

ix) Consultancy Processing Cell (CPC)

x) Official Language Cell (Hindi Cell)

xi) Vehicle

xii) Training Hostel

xiii) Referral Lab

xiv) Women Cell

All India Co-ordinated Research Projects (AICRPs/ AINP/ CRP)

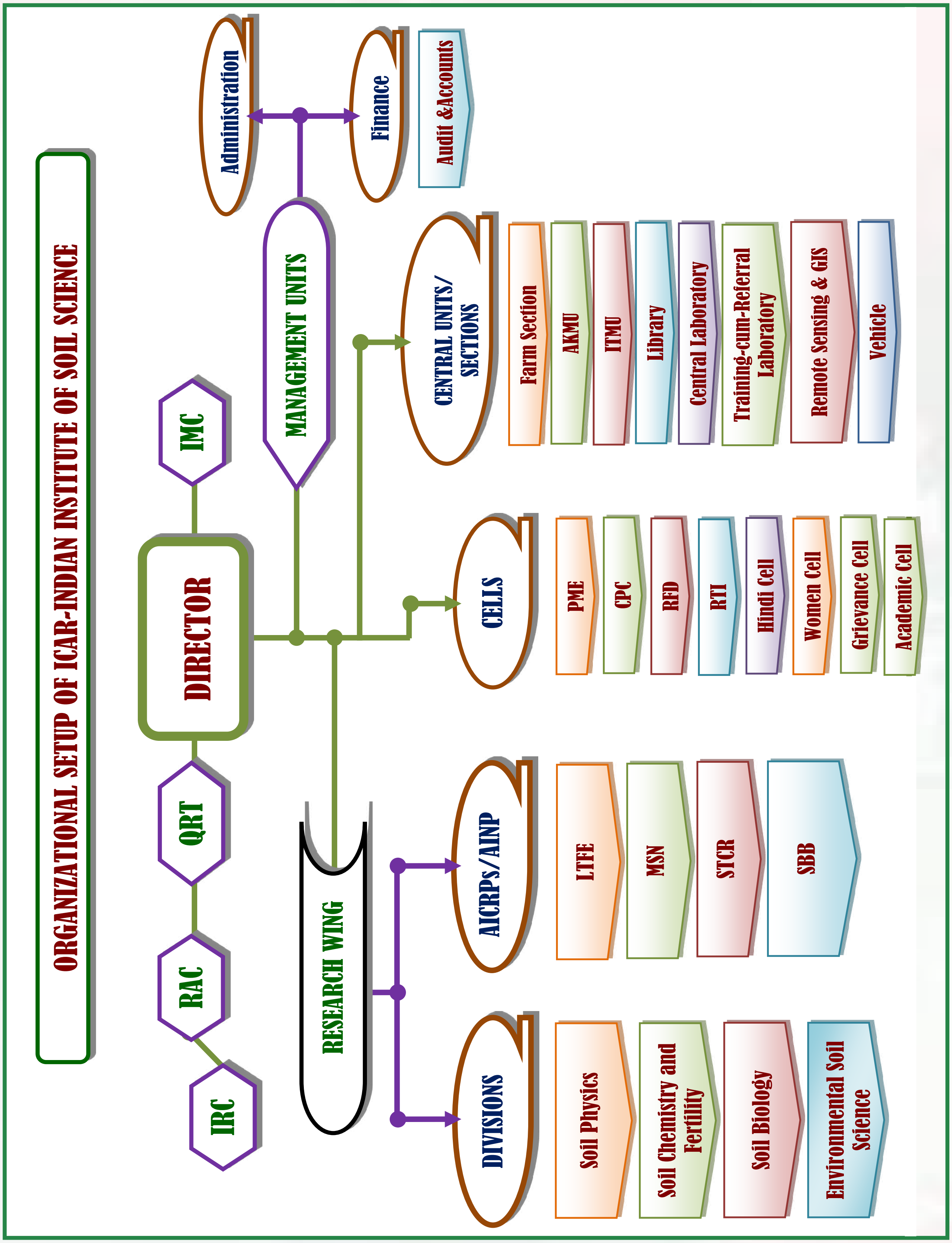
i) AICRP on Long -Term Fertilizer Experimentsto Study Changes in Soil Quality, Crop Productivity and Sustainability (LTFE)

ii) AICRP on Soil Test and Crop Response (STCR)

iii) AICRP on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (MSPE)

iv) AINP on Soil Biodiversity and Biofertilizers (SBB)

v) CRP on Conservation Agriculture (CRP-CA)


ORGANIZATIONAL SETUP OF ICAR-INDIAN INSTITUTE OF SOIL SCIENCE
DIRECTOR
IMC
QRT
RAC
IRC
MANAGEMENT UNITS
Administration
Finance
Audit &Accounts
CENTRAL UNITS/ SECTIONS
Farm Section
AKMU
ITMU
Library
Central Laboratory
Training-cum-Referral Laboratory
Remote Sensing & GIS
Vehicle
CELLS
PME
CPC
RFD
RTI
Hindi Cell
Women Cell
Grievance Cell
Academic Cell
RESEARCH WING
AICRPS/AINP
LTFE
MSN
STCR
SBB
DIVISIONS
Soil Physics
Soil Chemistry and Fertility
Soil Biology
Environmental Soil Science

Manpower

a) Scientific

S. No.	Discipline	Sanctioned				In Position			
		PS	SS	S	Total	PS	SS	S	Total
1	Agricultural Chemicals	0	0	1	1	0	0	1	1
2	Agricultural Economics	0	0	2	2	0	0	0	0
3	Agricultural Extension	0	0	1	1	0	0	1	1
4	Agricultural Microbiology	0	1	2	3	0	1	1	2
5	Agricultural Physics	0	1	0	1	0	0	1	1
6	Agricultural Statistics	0	0	1	1	0	0	0	0
7	Agronomy	0	1	4	5	0	0	3	3
8	Electronics & Instrumentation	0	1	0	1	0	0	0	0
9	Fruit Science	0	0	1	1	0	0	1	1
10	Plant Biochemistry	0	1	0	1	0	0	0	0
11	Plant Physiology	1	1	1	3	1	1	0	2
12	Soil Science	0	4	27	31	1	4	21	26
	Total	**1**	**10**	**40**	**51**	**2**	**06**	**28**	**36**
13	HODs	4	0	0	4	4	0	0	4
14	Project Coordinators	0	0	0	0	0	0	0	0
15	RMP	1	0	0	1	1	0	0	1
	Grand Total	**6**	**10**	**40**	**56**	**7**	**06**	**28**	**41**

b) Technical

S. No.	Posts	Sanctioned	In Position
1	T-1	11	10
2	T-2	-	-
3	T-3	7	4
4	T-4	-	-
5	T-5	-	-
6	T-6	1	0
7	T-7-8	-	-
8	T-9	-	-
	Total	**19**	**14**

c) Administrative

S. No.	Designation	Sanctioned	In Position
1	Assistant Director (OL)	1	0
2	Sr. Administrative Officer	1	0
3	Sr. Finance & Accounts Officer	1	1

S. No.	Designation	Sanctioned	In Position
4	Administrative Officer	1	0
5	Assistant Administrative Officer	2	2
6	Private Secretary	3	3
7	Assistant	8	3
8	Personal Assistant	4	2
9	Upper Division Clerk	3	2
10	Lower Division Clerk	4	4
	Total	**28**	**17**

d) Supporting Staff

S. No.	Designation	Sanctioned	In Position
1	Skilled Supporting Staff	17	10
	Total	**17**	**10**

Finance: Budget statement (Lakhs) 2023-24 is as follows

S. No.	Institute/AICRPs	Budget	Expenditure
1	Main ICAR-IISS Institute	2748.26	2748.26
2	AICRP on MSN	775.41	775.41
3	AICRP on STCR	1274.12	1274.12
4	AICRP on LTFE	695.65	695.65
5	AINP on SBB	319.00	319.00
6	CRP on CA	335.29	335.29
	Total	**6147.73**	**6147.73**

Resource Generation

S.No	Head of Account	Rs. In lakh
1	Sale of Farms Produce	15.67
2	Income from royalty, sale of publication and advertisement	0.16
3	Licence Fee	10.24
4	Interest earned on loans and Advance	17.98
5	Analytical and Testing Fees	0.34
6	Interest earned on short Term Deposits	7.25
7	Recoveries of Loans & Advances	40.78
8	Leave salary and Pension Contribution	9.12
9	Miscellaneous Receipts	11.81
10	Unspent balance of grants of previous year	54.29
11	Recipt from schemes	26.70
	Total	**194.34**

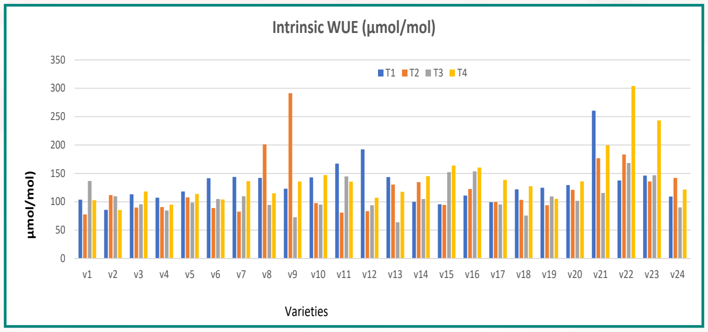
2 Research Achievements

Theme I: Soil Health and Nutrient Use Efficiency

2.1 Improving Input Use Efficiency

2.1.1 Assessment of nutrient (N & P) use efficiency in wheat genotypes for improved crop productivity

An experiment was conducted at ICAR IISS research farm during the rabi season of 2022-2023, to evaluate physiological and nutrient use efficiency attributes of 24 selected varieties of wheat. These genotypes were chosen from a pool of approximately 120 wheat genotypes assessed over the past three years in crop growth and yield trials. These selected genotypes were evaluated under different nutrient gradient with low nitrogen (50% N), low Phosphorus (50%P) and general recommended dose (100%NPK) of fertilizer nutrient (120-60-40 kg ha^{-1} of NPK) under field conditions. Among all the genotypes grown under low nitrogen conditions (50%N), higher grain yield >4 t ha^{-1} was observed in genotypes HI 8737, HI 1563, HI 1605, HI 1531, HI 8498, and Narmada 14, which make them suitable for such low N supply ecosystem. Among all the 24 genotypes, ten showed more than 30% and 40% agronomic use efficiency for applied N under recommended N and low N dose conditions, respectively. All the genotypes exhibited higher agronomic N use efficiency under lower dose of N and notably varieties HI 1605, HI 1531, HI 8498 and DBW 88 exhibited more than 50 Kg kg^{-1} of applied N. Intrinsic water use efficiency was analyzed among the genotypes and several of them exhibited more than 100 μmol mol^{-1} Intrinsic WUE under lower doses of nutrient application (Fig. 2.1.1). However, few genotypes grown under recommended dose also exhibited higher Intrinsic WUE than those grown under lower doses of nutrient. In addition, the remaining 96 genotypes were maintained separately for germplasm conservation.



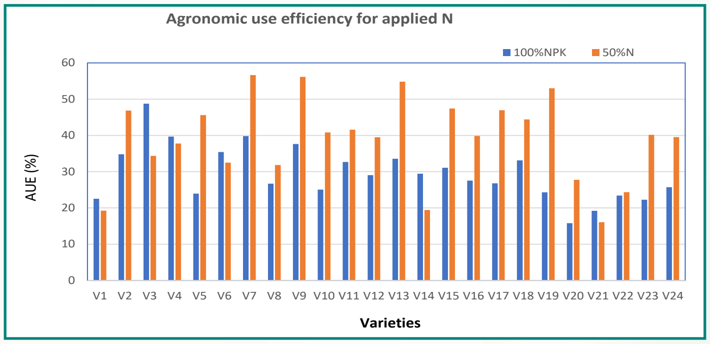


Fig: 2.1.1 Intrinsic WUE and Agronomic use efficiency of wheat genotypes

2.1.2 Long-term evaluation of integrated plant nutrient supply modules for sustainable productivity

A long-term study was conducted to evaluate the integrated plant nutrient supply (IPNS) system in maize-wheat cropping sequence. The study investigated twelve IPNS modules, including Soil Test Crop Response (STCR) based fertilizers, general recommended dose (GRD), farmyard manure (FYM), vermicompost (VC), urban compost (UC), maize residue (MR) and *Glyricidia* loppings (Gly) (Table 2.1.2). The results indicated that crop yield was significantly improved with application of IPNS modules as compared to organic and inorganic modules. Maize yield was significantly higher with FYM based INM modules i.e. STCR based 75% NPK +FYM @ 5t ha^{-1} every year and followed by STCR based 75% NPK along with FYM at 20 t ha^{-1} (once in 4 years) and 75% NPK + vermicompost (VC) as compared to general recommended dose (GRD). Similarly, balanced use of nutrients through STCR based INM modules (75% NPK +5 t FYM) increased grain yield of wheat as compared to GRD and others nutrient management modules (Fig. 2.1.1) .

Table 2.1.1 Treatment details

Sl. No.	Maize	Wheat
T1	No Fertilizer/ Manure	No Fertilizer/ Manure
T2	100% NPK (GRD)	100% NPK (GRD)
T3	100% NPK (STCR based)	100% NPK (STCR based)
T4	75% NPK of T3	75% NPK of T3
T5	75% NPK of T3 +5 t FYM	75% NPK of T3 +5 t FYM
T6	75% NPK of T3+ 1.5 t VC	75% NPK of T3+ 1.5 t VC
T7	75% NPK of T3 + 5 t UC	75% NPK of T3 + 5 t UC
T8	75% NPK of T3 +WR	75% NPK of T3 +MR
T9	WR 5 t ha^{-1} +1.5 t VC+Gly 2 t ha^{-1}	MR 5 t ha^{-1} +1.5 t VC +Gly 2 t ha^{-1}
T10	WR 5t ha^{-1} + 5t FYM+Gly 2 t ha^{-1}	MR 5t ha^{-1} + 5t FYM+Gly 2 t ha $^{-1}$
T11	20 t FYM (every season)	20 t FYM (every season)
T12	75% NPK of T3 +20 t FYM (once in 4 years)	75% NPK of T3 +20 t FYM (once in 4 years)

Adoption of STCR based NPK along with vermicompost also significantly increase the wheat yield over the control and GRD and organic manures alone. However, integration of different organic sources of nutrients (WR 5 t ha^{-1} +1.5 t VC+Gly 2 t ha^{-1} and WR 5t ha^{-1} + 5 t FYM+Gly 2 t ha^{-1}) had no significant effect on maize and wheat yields. System productivity also improved with adoption of STCR based INM Modules as compared chemical and organic fertilization alone. Application of organic modules (the integration of urban compost, crop residue and *Glyricidia* loppings did not influence the system productivity as good as FYM based INM module. Thus, STCR based fertilizers (75% NPK) along with 25% nutrients through organic manures sustained the crop yield.

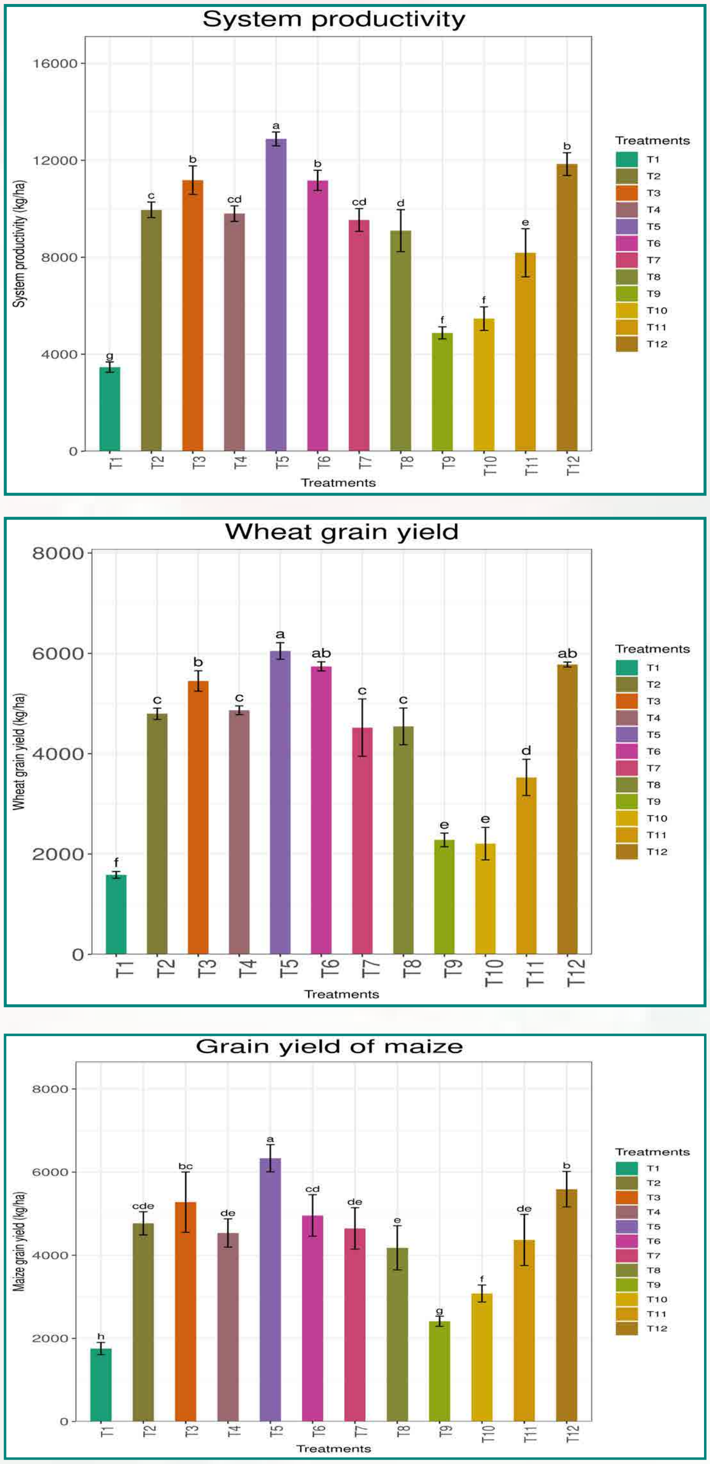


Fig. 2.1.2a Grain yields, system productivity of maize-wheat system influenced by different IPNS modules 2022-23

Plate 2.1.2 Maize- Wheat grown in IPNS module

The data on the soil carbon pools viz. very labile (Cfrac I), labile (Cfrac II), less labile (Cfrac III) and non-labile (Cfrac IV) as outlined by Chan et al. (2001) is presented in Fig. 2.1.2 b and Fig. 2.1.2 c. The results illustrate significant influences on oxidizable organic carbon and its pools resulting from the application of various nutrient sources (organic, inorganic, and integrated nutrient management (INM) practices) across both soil layers (0-15 cm and 15-30 cm) over an 18-year crop cycle. In general, the results revealed that the accumulation of oxidizable organic carbon and its fractions were greater in surface soil (0-15 cm) as compared to subsurface soil layer (15-30 cm) under the different nutrient management practices.

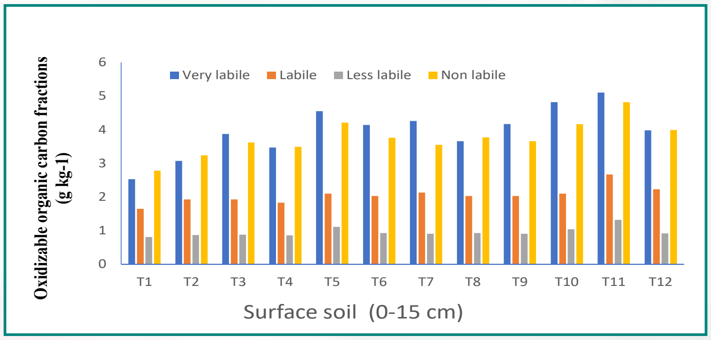


Fig. 2.1.2b Oxidizable organic carbon fractions (g kg^{-1}) at surface soil under integrated nutrient management practices

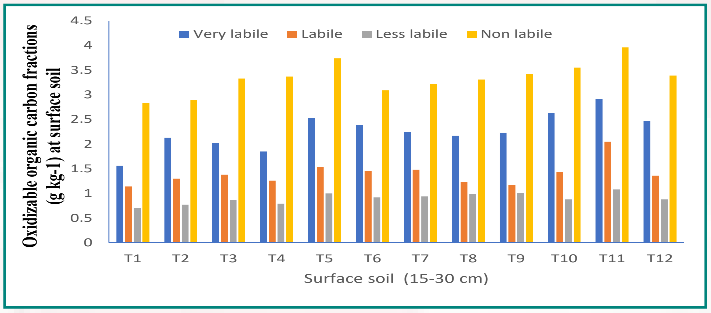


Fig. 2.1.2c Oxidizable organic carbon fractions (g kg^{-1}) at surface soil under INM in Vertisols

2.1.3 Impact of crop residue and nutrient levels on crop productivity and soil health in maize-chickpea cropping system under conservation agriculture.

A factorial randomized design experiment was conducted to investigate the effect of different levels of crop residue retention and optimized doses of nutrient application in maize-chickpea cropping system. The treatments comprised of four levels of residue retention and optimized doses of nitrogen, phosphorus and potassium application, compared to 100% nutrient application.

Response of different residue and nutrient levels on grain yield of maize crop

The result revealed that significant differences in maize crop grain yield were observed across various levels of crop residue retention. The maximum yield of 7483 kg ha^{-1} was recorded in 90 % residue retention treatment, which was significantly superior to 60%, 30% and no residue retention with the mean value 7288, 6852, 6388 kg ha^{-1}, respectively and the lowest grain yield (6388 kg ha^{-1}) was recorded in without residue retention. Conversely, different levels of nutrient applications did not yield significant effects on grain yield, with yields ranging from 6793 kg ha^{-1} to 7191 kg ha^{-1}. The interaction effect between residue levels and nutrient doses did not show any significant effect on grain yield (Fig. 2.1. 3 a). The highest grain yield (7732 kg ha^{-1}) was obtained from 90% crop residue and treatment along with 100% RDF, which was statistically at par with other residue levels. The lowest grain yield (6228 kg ha^{-1}) was observed in without residue retention with 75% N, 100% P, K doses (Plate 2.1.3 a).

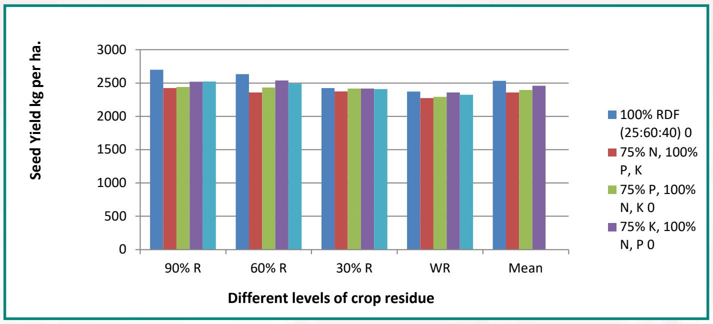


Fig. 2.1.3 a Response of different residue and nutrient levels on grain yield of maize crop

Straw yield

The straw yield of maize crop showed significant differences as a result of different levels of crop residue retention. The maximum straw yield (16260 kg ha^{-1}) was recorded in 90 % residue retention treatment which was significantly superior to 60%, 30% and without residue retention with the mean value 15524, 14807, 14198 kg ha^{-1}, respectively and the lowest straw yield (14198 kg ha^{-1}) was recorded in without residue retention treatment Conversely, various levels of nutrient applications did not yield significant effects on maize straw yield, with yields ranging from 15515 kg ha^{-1} to 14815 kg ha^{-1}. The interaction effect between residue levels and nutrient doses did not show any significant effect on straw yield. The highest straw yield (16426. kg ha^{-1}) was recorded with 90% of crop residue retention and treatment with 100% RDF, which was statistically at par with other residue levels. The lowest straw yield (13450 kg ha^{-1}) was recorded in without residue treatment with 75% N, 100% P, K doses (Fig. 2.1.3 b).

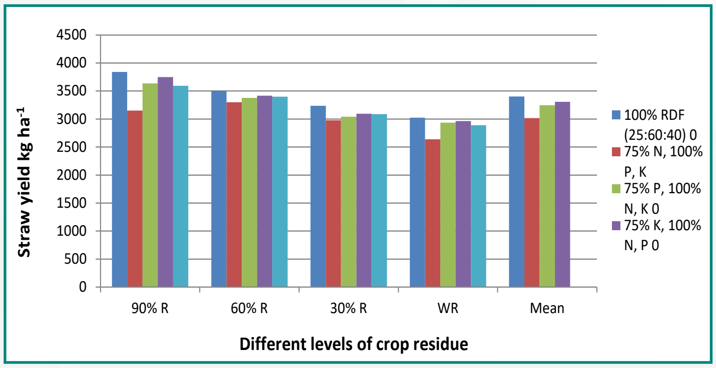


Fig. 2.1.3 b Response of different residue and nutrient levels on straw yield of maize crop

Response of different residue and nutrient levels on seed yield of chickpea crop

The retention of different levels of residue significantly affected grain yield of chickpea. The

Plate 2.1.3 a Response of different residue and nutrient levels on maize crop

maximum yield (2521 kg ha^{-1}) was recorded with 90 % residue retention treatment which was significantly superior to 60%, 30% and without residue retention treatments with the mean value 2490, 2408, 2324 kg ha^{-1}, respectively and the lowest grain yield (2324.46 kg ha^{-1}) was recorded in without residue retention treatment. On the other hand, different levels of nutrient applications did not exhibit a significant effect on chickpea grain yield, with yields ranging from 2358 kg ha^{-1} to 2532 kg ha^{-1}. The interaction effect between residue levels and nutrient doses did not show any significant effect on grain yield. The highest grain yield (2700 kg ha^{-1}) was obtained from 90% crop residue retention and treatment with 100% RDF, which was statistically at par with other residue levels. The lowest grain yield (2275 kg ha^{-1}) was recorded in without residue treatment with 75% N, 100% P, K doses (Fig. 2.1.3 c).

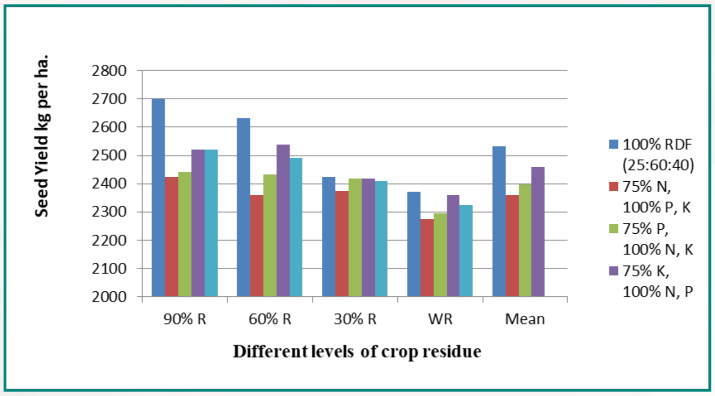


Fig. 2.1.3 c Response of different residue and nutrient levels on seed yield of chickpea crop

Plate 2.1.3 b Response of different residue and nutrient levels on chickpea crop

Straw yield

The data emanating from straw yield of chickpea crop shows no significant effect of different levels of crop residue retention on straw yield . The maximum straw yield (3594kg ha^{-1}) was recorded in 90 % residue retention treatment, which was at par with rest of the residue levels, and the lowest straw yield (2890 kg ha^{-1}) was observed in without residue retention treatment. Similarly, various levels of nutrient applications did not yield a significant effect on chickpea straw yield, with yields ranging from 3016 kg ha^{-1} to 3401 kg ha^{-1}.The interaction effect between residue levels and nutrient doses did not show any significant effect on straw yield (Fig. 2.1.3 d). The highest straw yield (3841 kg ha^{-1}) recorded from 90% crop residue retention treatment. The treatment with 100% RDF was statistically at par with other residue levels. The lowest straw yield of 2637 kg ha^{-1} was recorded in without crop residue retention with 75% N, 100% P, K doses.

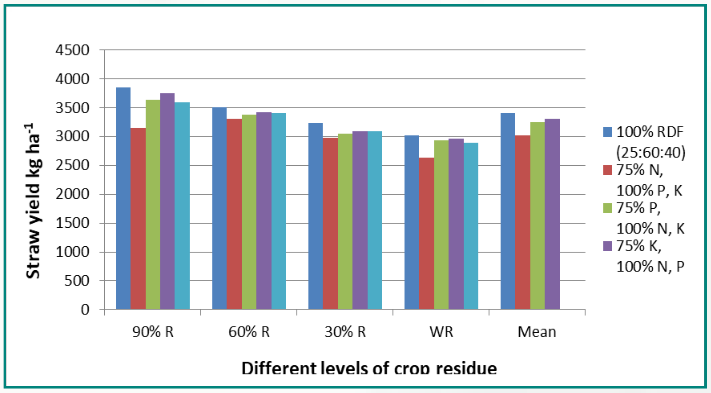


Fig.2.1.3 d Response of different residue and nutrient levels on straw yield of chickpea crop

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

Participatory farmers field experiments were conducted in adopted villages *viz.,* Khamkheda, Raslakhedi, Raipur and Karodkhurd, with soybean (*kharif* season), wheat and chickpea (*rabi* season) crop as test crops. Yield data was recorded for each crop and seasons under no-till, reduced tillage and as conventional tillage/ farmers practices (Plate 2.1.4).

Soybean

During the *kharif* season of 2023, twenty field demonstrations were conducted across farms to assess zero tillage, reduced tillage, and conventional tillage methods for soybean cultivation under the

Conservation Agriculture (CA) program.The data revealed that zero tillage recorded higher grain yield of soybean at most of farmers field as compared to reduced tillage and conventional tillage. However, reduced and conventional tillage also improved the grain yield of soybean at some farmers field as compared to zero till farming (Fig. 2.1.4 a).

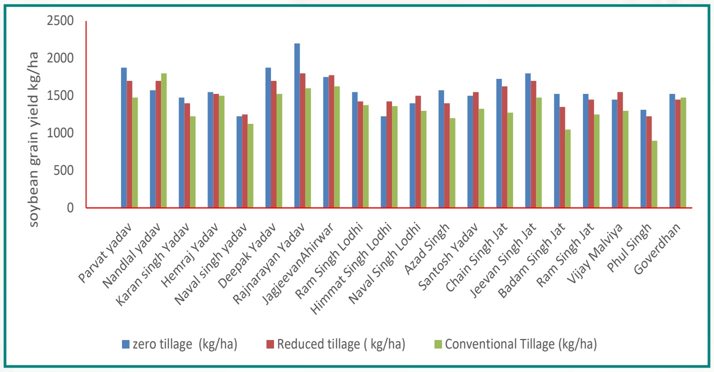


Fig. 2.1.4 a Soybean grain yield in Best-Bet Conservation Agriculture Practices

Plate 2.1.4 Demo of Best-Bet Conservation Agriculture Practices

Grain yield of wheat

In the *rabi* season of 2023, twelve demonstrations were carried out using wheat crops. A perusal of the data revealed that zero tillage recorded higher seed yield of wheat as compared to reduce tillage and conventional tillage, however the differences in grain yield could not attain the level of significance (Fig. 2.1.4 b).

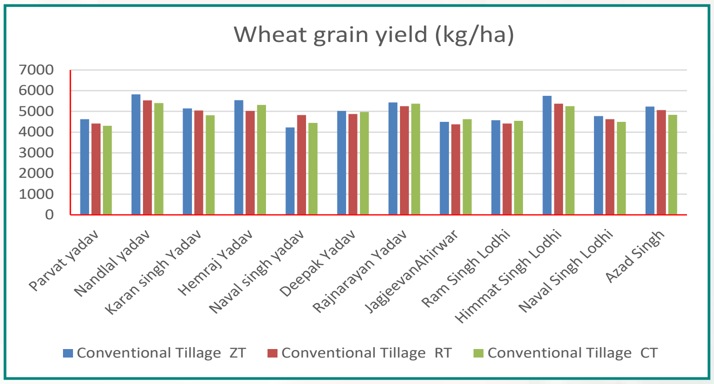


Fig. 2.1.4 b Wheat grain yield in Best-Bet Conservation Agriculture Practices

Chickpea

During the *Rabi* season of 2023, eight demonstrations were conducted using wheat crops. A perusal of the data revealed that zero tillage recorded higher seed yield of chickpea (1367 kg ha^{-1}) as compared to reduced tillage (1277.37 kg ha^{-1}) and conventional tillage (1079.37 kg ha^{-1}), however the differences in grain yield could not attain the level of significance (Fig. 2.1.4 c).

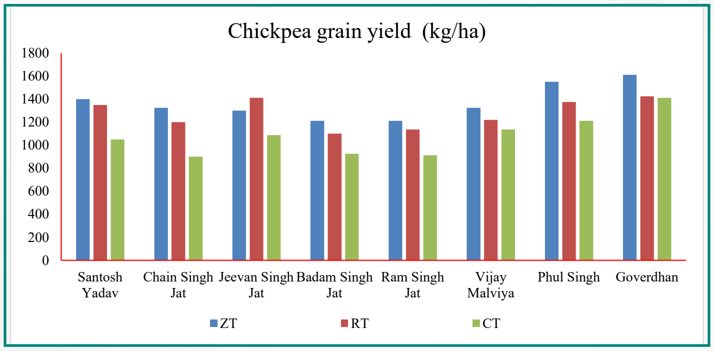


Fig. 2.1.4 c Chickpea grain yield in Best-Bet Conservation Agriculture Practices

2.1.5 Farm field survey in the tribal settlement of Balaghat in Madhya Pradesh

Under the project "Assessment of traditional knowledge systems of tribal farmers for managing

Pilot Survey in the tribal villages

Planting of Gliricidia stem cuttings

Plate 2.1.5 Activities carried out in the tribal settlement in Balaghat district

land resources" a pilot survey was conducted encompassing 400 households across fifteen villages (Plate 2.1.5). The tribal population of the settlement was categorized based on their primary occupation, revealing that 92.1% were farmers, 4.5% were livestock farmers, 2.2% were artisans, and 1.25% were agricultural laborers. Survey results showed that 21% of the tribal farmers adopted chemical fertilizers but at a low rate of 10-15 kg ha^{-1}. Only 4% of the farmers cultivated traditional varieties of the locality like Kalimooch, Jeerashankar etc. as these were found to be low yielding and prone to lodging when the crop matures. High yielding varieties grown in the area include varieties like MTU-1010 and IR-64 that generate an average grain yield of more than 5 t ha^{-1} however, the crop cutting survey in 17 farm fields of eight village (random sampling) recorded the average rice grain yield of the area as 3.2 t ha^{-1}. Analysis of plant samples (straw and grain) collected from 14 farmer fields of three villages showed the average nitrogen, phosphorus and potassium contents in the grain samples as 1.05%, 0.21% and 0.17% respectively and that of straw samples as 0.62%, 0.14% and 1.49% respectively. In order to improve the on-farm resource potential of tribal farmlands perennial green manure crop like *Gliricidia* and biofertilizer like Azolla were introduced to the project area.

2.1.6 Evaluation-cum-demonstration of bio formulations in tribal farm fields of Betul in Madhya Pradesh

Under the STC/TSP project 'Enhancement of soil health and livelihood of tribals in Central India', frontline demonstrations (FLDs) were conducted on nutrient management intervention integrating liquid bio-fertilizers (*Rhizobium, PSB, KSB, ZSB, Azotobacter &Acetobacter)* and bio- formulations (*Trichoderma* and *Pseudomonas)* in 200 tribal farm fields of Betul District, Madhya Pradesh covering 160 hectares during the third *Kharif* season in 2023.The integration of bio-formulations with existing farming practices, which included the application of farmyard manure at a rate of 5 tonnes per hectare and chemical fertilizers including DAP at 100 kg per hectare (for all three crops) and Urea at 125 kg per hectare (for maize and paddy), was implemented. Crops covered under the FLD were soybean (38 fields), maize (129 fields) and paddy (33 fields). Results indicated that the average crop yields achieved under the nutrient management intervention were 13.2 q ha^{-1} for soybean crop, 41.7 q ha^{-1} for maize crop and 42.7 q ha^{-1} for paddy crop, respectively. In contrast, the average yield under farmers practice were 7.8 q $^{ha-1}$ for soybean crop, 34.9 q ha^{-1} for maize crop and 37.3 q ha^{-1} for paddy crop, respectively. The yield increase

Soybean crop

Paddy crop

Plate 2.1.6 Field demonstration of nutrient management intervention in the tribal fields of Betul

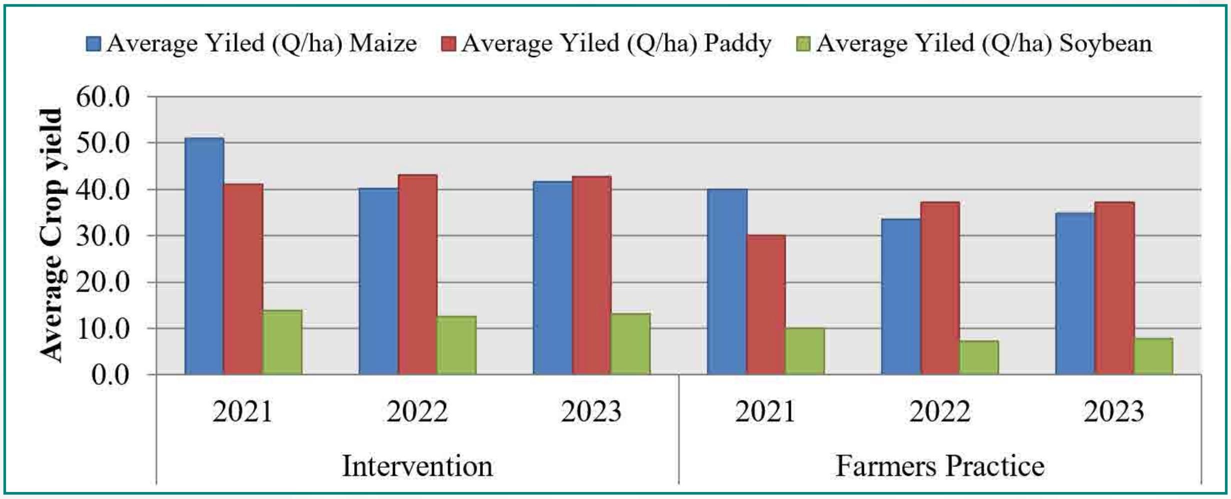


Fig. 2.1.6 Average crop yields of maize, paddy and soybean crops

observed in the three year FLD period (2021-2023) for the three crops compared to farmers practice are 57.4% in soybean, 21.2% in paddy and 22.5% in maize (Plate 2.1.6 & Fig. 2.1.5).

2.1.7 Development of agri-horticultural system for central India and its impacts on soil health, productivity and produce quality

During rainy season, practiced cropping of soybean and cowpea was practices in the orchards, with the soybean yieldling the most in lime orchard (134.65 g m^{-2}) and lowest in aonla orchard (26.90 g m^{-2}). Similarly, highest yield of cowpea was observed in mango orchard (612 g m^{-2}). Phenolic content, a significant constituent in fruit crops closely associated with stress, was notably affected by mulching treatments (Table 2.1.7). Black polythene mulch resulted in lowest whereas control (without mulch) resulted in highest phenolics as well as thickness of leaf. The leaf chlorophyll content was highest under black polythene mulch whereas, lowest under white polythene treatment followed by control. Black polythene mulch was found very effective for yield attributing characters and relative water content in leave. Among the organic mulching, 20 kg wheat residue and 40 kg arhar residue exhibited higher yield as compared to other organic mulches (Fig. 2.1.7a).

Table 2.1.7 Effect of mulching in leaf characteristics in mango

Treatments	Total phenolics (mg GAE 100 g)	Chl_A (mg 100g)	Chl_B (mg/100g)	Total_Ch (mg/100g)	Leaf thickness (mm)
10 kg Wheat residue	1175.71	7.91	2.65	10.56	0.25
10 kg gram residue	1085.23	8.21	2.34	10.55	0.30
10 kg dry grass	787.61	6.63	2.07	8.70	0.22
Black polythene	332.85	12.28	3.56	15.83	0.25
White Polythene	997.14	6.19	1.82	8.00	0.22
Control	1268.57	6.63	2.03	8.65	0.32
CD (0.05)	54.89	0.422	0.151	0.421	0.019
CV	3.165	2.873	3.401	2.200	3.943

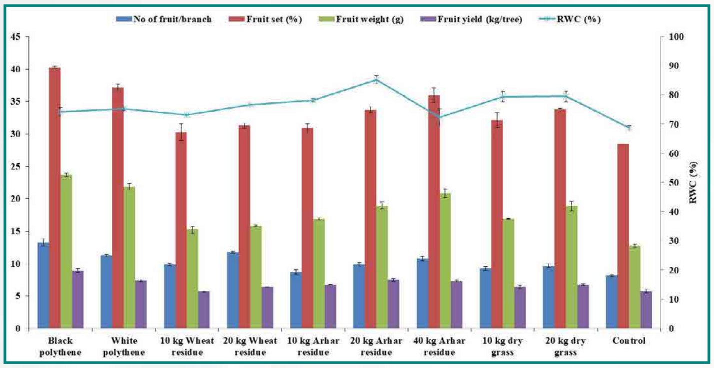


Fig. 2.1.7a Effect on mulching on fruit parameters

Crop regulation in guava through urea

In central India, guava flowering occurs three time and ambe bahar crop experiencing flowering-March-April and harvesting-July-August) is heavily infested by fruit flies which is avoided by spraying urea because these fruits cannot be used for consumption. Thus, various concentrations of urea have been sprayed during flowering (March-April) for flower drop. A single spray of urea at different concentration did not drop flower but repetition of the urea spray at 7th day after first spray @ 25 % and 30 % resulted in higher flower drops (Fig. 2.1.7b).

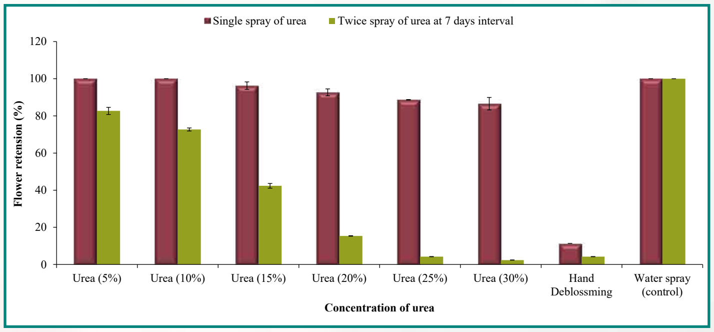


Fig. 2.1.7b Effect of urea spray on guava flowering

2.1.8 Impact of silicon on rice and wheat productivity in *Vertisols* of Central India

An experiment was carried out under the activities of Silicate solubilizing bacteria for enhancing nutrient use efficiency of rice-wheat cropping systems in Vertisols of Central India. The primary aim was to assess the combined effectiveness of phosphorus (P) and Silicon (Si) on the growth and yield of this cropping system. The experiments included seven treatments: a control, phosphorus, silicon and their combination applications with three replications were carried out under this study. In the 2023 PB-1 rice crop, the treatment combining P+ Si priming + Si foliar (T6) yielded highest, while the control had the lowest yield among all treatments.The yield increased over the control was observed as follows:T6, P+ Si priming + Si foliar (48%) > T4, P+ Si priming (46%) > T5, P+ Si foliar (42%)> T1, P (39%)> T2, Si priming (21%)> T3, Si foliar (9%). For the wheat crop in 2023 (HI 1605), the yield increased over the control was observed as follows: T4, P+ Si priming (74%) > T6, P+ Si priming + Si foliar (63%)> T5, P+ Si foliar (54%) > T1, P (52%)> T2, Si priming (5%) ≥ T3, Si foliar (5%).This study suggests that the combine application of Si and P fertilizers significantly benefits the rice-wheat cropping system in Central India's *Vertisols*. However, using Si alone, whether seed priming or foliar application, showed a less positive response compared to the recommended dose of fertilizers (RDF) (Plate 2.1.8a & b).

Plate 2.1.8a PB-1 rice crop at grain filling

Plate 2.1.8b wheat (HI 1605) at Harvesting stage

2.2 AICRP on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (MSPE)

2.2.1 Effect of land use and soil depth on distribution of phyto-available nutrients and SOC pools of Vertisols in central India

Proper understanding of soil parameters under different production systems is necessary for efficient soil management. A study was carried out to assess the status of some selected soil properties (soil pH and electrical conductivity (EC), phyto-available nutrients (available nitrogen (AN), available potassium (AK), exchangeable calcium (Ex. Ca), exchangeable magnesium (Ex. Mg) and available sulphur (AS) and soil organic carbon (SOC) pools (SOC, total organic carbon (TOC), very labile C, labile C, less labile C and non-labile C), to establish relationships among the measured soil parameters at different depths under various land uses of Vertisols of central India. A total of 150 composite soil samples (from 25 plots including nine from agricultural land, nine from horticultural land, three from forest land and four from grassland) were collected from 6 soil depths *viz.*, 0-10, 10-20, 20-40, 40-60, 60-80, and 80-100 cm under agriculture, horticulture, forest and grassland land uses present in central India and analysed. The values of soil pH, EC, AN, AK, Ex. Ca, Ex. Mg, and AS in various soil depths under different land uses varied widely (Fig. 2.2.1). The values of SOC (0.19 to 1.00%), TOC (0.58 to 2.42%), very labile C (0.14 to 0.83%), labile C (0.05 to 0.25%), less labile C (0.05 to 0.26%) and non-labile C (0.23 to 1.42%) in various soil depths under different land uses also varied significantly. Forest and grassland land uses had higher levels of SOC, TOC, very labile and non-labile C content in all the soil depths in comparison to SOC, TOC, very labile and non-labile C content in different soil depths under agriculture and horticulture land use. The levels of SOC, TOC, very labile and non-labile C content under all the land uses decreased with increasing soil depths. SOC was positively and significantly correlated with AN, AK, AS and estimated SOC pools in surface soil layers. Principal component analysis (PCA) of soil parameters in different soil depths resulted in 5 principal components (PCs) with >1 eigenvalue and accounting for >75% variability. This information could be used for managing SOC status and phyto-available nutrients in Vertisols under different land uses.

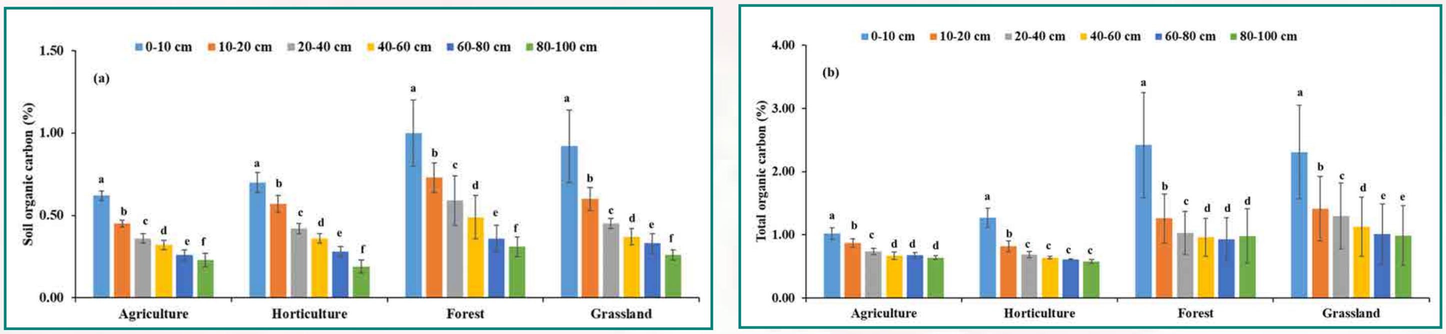


Fig. 2.2.1 Depth-wise distribution (a) soil organic carbon and (b) total organic carbon

2.2.2 Spatial variability of soil nutrients and delineation of soil management zones in an ecologically fragile north-western Indian Himalayan region

A study was conducted to understand the spatial distribution pattern of soil nutrients and their associated soil properties, and to delineate soil nutrients management zones (MZs) in a north-western Indian Himalayan (NWIH) region. A total of 18930 representative surface (0-15 cm depth) soil samples were collected and processed. The processed soil sample were analysed for pH, and electrical conductivity (EC), soil organic carbon (SOC), available N (AN), available P (AP), available potassium (AK), exchangeable Ca (Ex. Ca), exchangeable Mg (Ex. Mg), available S (AS), available Zn (AZn), available Fe (AFe), available Cu (ACu), available Mn (AMn) and available B (AB). The values of studied soil parameters varied widely with coefficient of variation ranging from 11.8 to 156%. Semivariogram analysis revealed stable, exponential and Gaussian best-fit models for different soil parameters with weak (AP and AB), moderate (rest of soil parameters) and strong (AS) spatial dependence. Varied distribution pattern of soil parameters was visualized from ordinary kriging interpolation. Five soil nutrient management zones (MZs) were identified (using fuzzy performance index and normalized classification entropy values) by employing the techniques of principal component analysis and fuzzy c-means clustering. Principal components with eigen value > 1 were considered for further analysis. The soil parameters of identified MZs differed significantly. Thus, the study highlighted the usefulness of MZ delineation technique for site-specific soil nutrient management in different cultivated areas for sustainable crop production (Fig. 2.2.2).

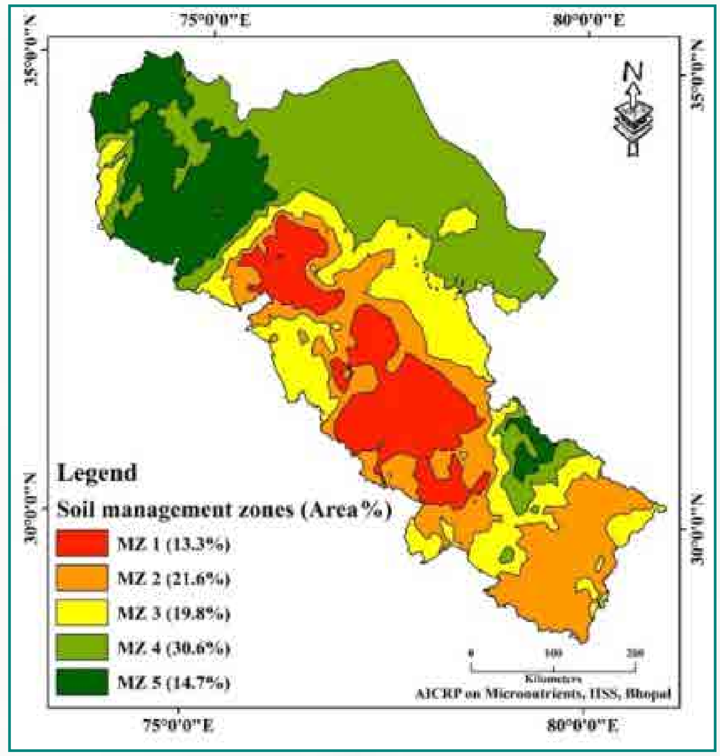
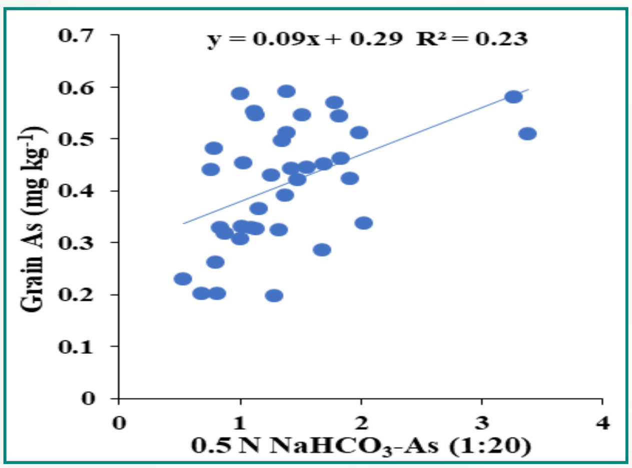
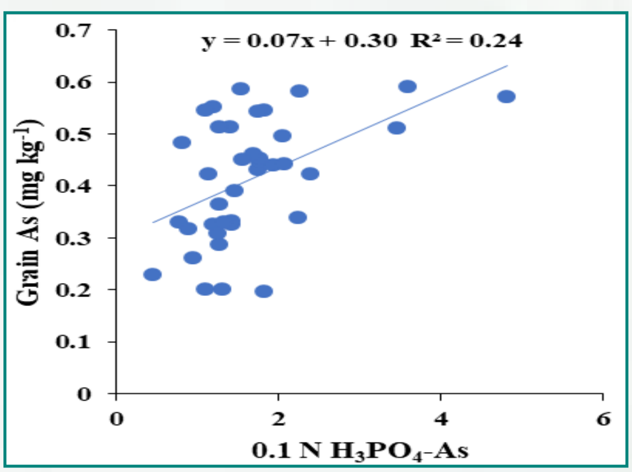


Fig. 2.2.2 Soil nutrient management zones of the study area

2.2.3 Evaluation of different extractants to estimate plant available arsenic in soil

Owing to the similar chemistry of phosphorus (P) and arsenic (As), sodium bicarbonate (0.5 *N* $NaHCO_3$) is commonly used to extract plant accessible As in soil. This extractant has neither been tested widely in relation to plant As, nor this extractant compatible with inductively coupled plasma mass spectrometry (ICP-MS) due to the high concentration of dissolved solid. Subsequently, it is of utmost important to design a suitable chemical extraction method in order to estimate plant available As compatibility with ICPMS. For this purpose, paired soil and plant samples were collected from paddy fields located in Nadia, West Bengal, India. Soil was extracted with 0.5 *M* $NaHCO_3$, 0.1 *N* and 0.5 *N* phosphoric acid (H_3PO_4), 0.1 *N* and 0.5 *N* sulfuric acid (H_2SO_4), 0.1 *N*, 0.5 *N*, 1.0 *N*, 1.5 *N* HNO_3 and 0.01 *M* calcium chloride ($CaCl_2$) solution. Arsenic extracted with $NaHCO_3$, H_3PO_4 and H_2SO_4 was determined in hydride generation-atomic absorption spectrophotometer (HG-AAS), while ICP-MS served to determine As extracted from soil with HNO_3. Olsen-extractable As in soils ranged from 0.48 to 3.57 mg kg^{-1} with a mean value of 1.45 mg kg^{-1}. The extractable As content in soil varied from 0.01 to 10.1 mg kg^{-1} across the extractants. In the case of grain As, 0.1 *N* H_3PO_4, 0.5 *N* $NaHCO_3$ and 1.5 *N* HNO_3 extractable As had distinctly higher correlation coefficients (r = 0.49**, r = 0.47**, r = 0.45**) when compared to other extractants. More or less similar relationships of extractable As were obtained with straw As content like that of rice grain. In view of rapidity of the soil test method for As, 1.5 *N* HNO_3 can be recommended for assessing available As in soil (Fig. 2.2.3).





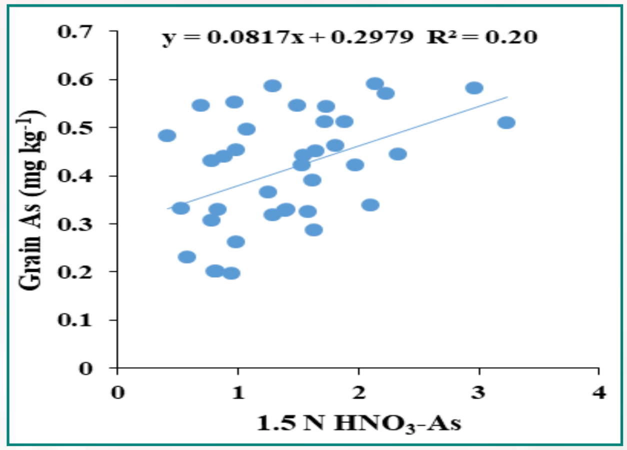


Fig. 2.2.3 Relationship between grain, As and extractants

2.2.4 Biofortification of wheat (*Triticum aestivum* L.) genotypes with zinc and manganese to improve grain yield and quality in sandy loam soil

In a study conducted in Ludhiana, Punjab, 14 wheat genotypes were evaluated for their nutrient use efficiency characteristics using two methods to identify the most efficient Zn and Mn wheat genotypes. The genotypes were categorizedbased on their efficiency and responsiveness under control and Zn + Mn treated conditions. that Zn + Mn treated plots exhibited significantly higher values for plant growth parameters, crop yield, nutrient concentration (Zn, Mn, N, P, and K), quality parameters (crude fiber and protein content), and nutrient utilization efficiency compared to control conditions. The interaction between genotype and Zn + Mn indicated that the application of Zn + Mn significantly affected the studied genotypes for different characteristics. The results of the study indicated that genotypes PBW-824, BWL- 8855, PBW-872, PBW-869 and PBW Zn1 were efficient in terms of crop yield. Based on the quality parameters, genotypes PBW-824 and PBW-869 were the highest ranked among the studied genotypes. The identified Zn + Mn efficient genotypes would be valuable resources for higher crop production along with improved wheat grain quality.

2.2.5 Screening of greengram genotypes for B efficiency

Filed experiments were carried out in the farmer field at Annur, Tamil Nadu with six green gram genotypes (VBN2, VBN4, CO 6, CO7, CO8 and MDU1) to screen B efficient genotypes. The experiment on screening of six green gram genotypes for their B efficiency with various levels of Borax showed that, application of soil test based NPK with various levels of Borax significantly improved the growth, yield and B uptake by all the green gram genotypes. The higher yield of all the genotypes was associated with the addition of NPK+ 10 kg Borax ha^{-1} with the mean yield increase of 21.5%. Based on the higher grain yield, and B absorption and utilization efficiency, the green gram genotypes viz., VBN 4, CO 6 and CO 7 were found B efficient. The genotype MDU 1 recorded lesser yield, poor B absorption and utilization efficiency thus grouped as inefficient (Plate 2.2.5).


Plate 2.2.5 Field view of green gram screening experiment in Tamil Nadu

2.3 AICRP on Soil Test and Crop Response Correlation (STCR)

2.3.1 Development of fertilizer prescription equations under integrated plant nutrient supply system

The different cooperating centers have generated technologies for integrated supply of plant nutrients involving fertilizers, organic manures and biofertilizers. In this technology, the fertilizer nutrient doses are adjusted not only to that contributed from soil but also from various organic sources like FYM, green manure, etc. The combined use of chemical fertilizers along with organics will help in sustaining the soil productivity and maintaining the soil health by way of improvement of soil physical, chemical and biological properties. The work done by various centers for development of IPNS targeted yield equations has been detailed in Table 2.3.1.

Table 2.3.1 Basic data and target yield equation of different crop varieties developed

Crop (variety)	Basic Data					Targeted Yield Equations
	Nutrient	NR (kg/q)	CS (%)	CF (%)	CO (%)	
UAS, Bangalore						
Green gram	N	6.07	29.5	42.2	0.87	FN=14.36 T−0.69SN − 0.87 ON
(BGS-9)	P	2.10	17.7	55.6	0.80	FP_2O_5=3.766T−0.318SP−0.8OP
	K	5.20	52.8	113.3	0.76	FK_2O=4.58T−0.46SK−0.76OK
Little millet	N	2.75	9.36	46.1	0.25	FN=5.97T−0.20SN− 0.25 ON
(GPUL6)	P	1.27	11.3	63.1	0.11	FP_2O_5=2.01T−0.18SP−0.11 OP
	K	3.78	24.3	237.5	0.10	FK_2O=1.59T−0.103SK−0.11OK
BHU, Varanasi						
Radish	N	0.27	17.02	25.75	6.68	FN=1.06T−0.66SN−0.26ON

Crop (variety)	Basic Data					Targeted Yield Equations
	Nutrient	NR (kg/q)	CS (%)	CF (%)	CO (%)	
(Japanee White)	P	0.09	40.71	52.88	2.5	FP_2O_5=0.17T–0.77SP–0.05OP
	K	0.37	29.88	58.05	8.33	FK_2O=0.64T–0.51SK–0.14OK
TNAU, Coimbatore						
Castor hybrid	N	3.2	21.56	30.8	21.4	FN= 10.38 T- 0.70 SN - 0.69 ON
	P	1.23	41.8	26.6	10.3	FP_2O_5=4.62 T- 3.60 SP - 0.89 OP
	K	3.28	19.1	52.1	26.1	FK_2O=6.30 T - 0.44SK - 0.60 OK
Coleus (CO 1)	N	2.03	11.4	38.4	28.2	FN= 5.28 T - 0.30 SN -0.73 ON
	P	1.74	26.9	27.7	11.0	FP_2O_5=6.26 T – 2.22 SP-0.91 OP
	K	3.66	14.2	62.6	29.9	FK_2O=5.84 T - 0.27 SK-0.58 OK
ICAR-CRIJAF, Barrackpore						
	N	2.13	19.87	37.87	16.02	FN =5.62 T –0.52 SN –0.42 ON
Jute (JRO M1)	P	0.78	35.94	36.88	10.89	FP_2O_5= 2.11T –1.92SP–0.30OP
	K	3.62	59.06	107.87	20.01	FK_2O=3.36T–0.55 SK –0.19OK
BCKV, Kalyani						
Frenchbean	N	4.19	14.0	103.7	16.7	FN = 4.66T - 0.14SN - 0.16 ON
(Falguni)	P	0.25	3.6	12.3	1.11	FP_2O_5= 2.01T - 0.29SN - 0.09 OP
	K	3.81	25.9	72.4	12.2	FK_2O= 5.27T - 0.36SN - 0.17 OK
Cauliflower	N	0.49	23.5	41.3	26.24	FN = 0.95 T – 0.47 SN – 0.56ON
	P	0.09	18.7	36.7	5.80	FP_2O_5 = 0.24T – 0.29 SP –0.08OP
	K	0.6	26.7	108.9	20.1	FK_2O = 0.42 T– 0.20 SK–0.23OK
RAU, Bikaner						
Cluster bean	N	7.01	59.4	29.9	42.2	FN= 23.42 T-1.99 SN-1.41 ON
(RGC-1066)	P	0.89	35.5	34.2	50.0	FP_2O_5=2.99T-1.04SP-1.46OP
	K	5.17	25.4	31.0	39.9	FK_2O=16.69T-0.82SK-1.29OK
Lnseed	N	6.61	47.9	96.5	193.1	FN= 6.85T-0.49SN-2.0ON
(Pratap Alsi-2)	P	1.02	35.7	36.9	81.9	FP_2O_5=1.06T-0.96SP-2.21OP
	K	2.91	12.4	105.0	120.4	FK_2O=2.76T-0.11SK-1.14OK
ICAR-IARI, New Delhi						
Wheat	N	2.27	33.6	51.3	12.63	FN= 4.43 T – 0.65 SN – 0.25ON
(HD 3059)	P	0.47	63.0	30.6	8.68	FP_2O_5=1.52 T– SP 2.06 – 0.28OP
	K	1.92	35.54	125.0	7.65	FK_2O=1.54 T- 0.28 KP – 0.06OK
PJTSAU, Hyderabad						
Groundnut (K6)	N	4.46	34.1	131.2	20.1	FN= 4.04 T-0.31SN-0.21ON
	P	1.22	10.4	40.9	15.8	FP_2O_5=.59T-0.66SP-1.02OP
	K	3.28	17.3	53.2	28.3	FK_2O=6.88T-0.48SK-0.24OK
Marigold	N	2.27	58.7	59.3	21.2	FN= 4.53T-3.72SN-0.12ON
(Bidhan Marigold 4)	P	1.56	26.3	24.9	52.8	FP_2O_5=1.58T-0.90SP-1.97OP

Crop (variety)	Basic Data					Targeted Yield Equations
	Nutrient	NR (kg/q)	CS (%)	CF (%)	CO (%)	
	K	2.90	92.3	86.1	187.7	FK_2O=3.57T-1.19SK-1.92OK
Mustard	N	2.22	10.5	63.5	20.2	FN= 4.04T -0.22SN -0.42ON
(NRCHB -101)	P	1.25	10.7	59.1	23.9	FP_2O_5=3.34T-0.55SP -1.56OP
	K	1.33	2.04	71.4	28.2	FK_2O=2.47T-0.03SK -0.34OK
AAU, Jorhat						
Maize	N	2.76	28.4	52.7	43.1	FN= 5.24T - 0.54SN– 0.62ON
(DKC-9144)	P	0.72	57.0	48.3	18.6	FP_2O_5=1.48 T - 1.18 SP – 0.39 OP
	K	1.74	22.1	75.8	48.7	FK_2O=2.29T - 0.29SK – 0.64 OK
ICAR-IISR, Lucknow						
Sugarcane	N	1.7	42.2	43.2	22.6	FN=3.94 T - 0.98 SN - 0.52 ON
(CoLK94184)	P	0.48	143.4	62.5	3.77	FP_2O_5= 0.77 T - 2.30 P - 0.06 OP
	K	2.31	53.2	173.5	12.2	FK_2O=1.33T - 0.31SK - 0.07 OK
PAU, Ludhiana						
Soybean*	N	6.530	1.52	0.992	0.101	FN=8.58T– 0.82 SN– 0.71 ON
(SL-958)	P	2.343	0.54	0.898	0.52	FP_2O_5=1.27T – 0.21 SP– 0.22 OP
	S	2.04	0.31	0.580	1.65	FS=3.43 T– 0.53 SS – 1.65 OS
Mustard	N	7.675	0.641	1.009	0.996	FN=8.58T– 0.82 SN– 0.71 ON
(GSC-7)	P	1.865	0.271	1.037	3.331	FP_2O_5=1.27T – 0.21 SP– 0.22 OP
	K	19.8	2.53	1.92	23.7	FK_2O=3.43 T– 0.53 S – 1.65 OK
	S	6.69	1.29	6.97	1.95	FS=3.43 T– 0.53 SS – 1.65 OS
CSKHPKV, Palampur						
Brinjal	N	0.32	13.22	40.8	6.63	FN=0.78 T – 0.32 SN - 0.16 ON
(Hisar Shyamal)	P	0.06	26.3	19.7	2.22	FP_2O_5= 0.28 T – 1.33 SP – 0.11 OP
	K	0.2	11.4	69.4	5.78	FK_2O=0.28 T- 0.17 SK - 0.08 OK
Turmeric	N	0.26	13.93	42.27	3.91	FN=0.62 T - 0.33 SN - 0.09 ON
(Palam	P	0.07	37.54	15.34	4.24	FP_2O_5= 0.47 T - 2.45 SP - 0.28 OP
Pitamber)	K	0.32	20.43	52.25	9.67	FK_2O=0.62 T - 0.39 SK - 0.19 OK
Pea	N	1.24	33.4	56.8	15	FN= 2.17 T –0.59 SN –0.26 ON
(Palam Triloki)	P	0.11	38.7	13.5	5.97	FP_2O_5= 0.81T –2.86 SP - 0.44 OP
	K	0.72	22.9	69.8	9.1	FK_2O=1.02T - 0.33 SK - 0.13 OK
GBPUAT, Pantnagar						
Coriander	N	2.1	34.9	111.4	13.6	FN= 1.89T-0.31SN-0.12ON
(Pant Haritima)	P	0.62	32.9	88.3	6.75	FP_2O_5=0.70T-0.85SP-0.17OP
	K	1.77	22.7	60.7	12.3	FK_2O=2.91T-0.45SK-0.24OK
Barley	N	2.32	32.7	42.8	8.5	FN= 5.43 T – 0.76 SN- 0.19 ON
(UPB-1008)	P	0.65	74.7	97.7	13.7	FP_2O_5=1.54 T- 1.75 SP-0.32 OP
	K	2.78	38.9	254.6	15.8	FK_2O=1.31 T- 0.18 SK-0.07 OK

Crop (variety)	Basic Data					Targeted Yield Equations
	Nutrient	NR (kg/q)	CS (%)	CF (%)	CO (%)	
DRRPCAU, Pusa						
Marigold	N	1.15	24.7	81.3	28.7	FN= 1.12 T-0.25 SN-O.38 ON
(Marigold Arka)	P	0.36	41.5	46.2	38.7	FP_2O_5=1.69 T-3.04 SP-3.6 OP
	K	1.28	36.3	97.4	54.1	FK_2O=0.92 T-0.29 SK-O.70 OK
MPKV, Rahuri						
Rajmah bean	N	7.04	40.0	78.4	84.7	FN= 8.31 T – 0.47 SN – 1.48 ON
(Phule Rajmahh)	P	1.32	48	19.65	21.7	FP_2O_5= 0.10 T – 2.21 SP – 1.75 OP
	K	3.11	6.66	70.8	78.5	FK_2O=3.96T– 0.08 SK–1.86 OK

*K fertilizer in not recommended in soybean crop in Punjab

Where, FN, FP_2O_5 and FK_2O are required nitrogen, phosphate and potash in kg ha^{-1}, SN, SP and SK are soil available N, P and K, and ON, OP and OK are the amounts of N, P and K (kg ha^{-1}) supplied through organics. Names in paranthesis are the varieties of respective crops.

2.3.2 Post-harvest available soil nutrients (N, P and K) prediction equation

The prediction equation for a post-harvest soil test value can be used to make a fertilizer recommendation for entire cropping system. This is very useful under intensive agriculture as farmers' fields cannot be tested between each season for each constituent crop for practical reasons. The relationships between post-harvest soil test values, fertilizer applied, initial soil test values and fresh yield from the treated plots, for radish crop is presented in Table 2.3.2.

Table 2.3.2 Prediction equations for post-harvest soil test value for radish crop

Nutrient	R^2	Multiple regression equation
N	0.95**	PHN = 14.75336 -0.29847 RY**+1.196025SN**+0.057495FN*
P	0.85**	PHP = 3.49601 +0.07987 RY*+0.141967 SP**0.017162 FP**
K	0.93**	PHK = 47.70546 -0.17663RY**+1.00343 SK**-0.00457 FK

Where PHN, PHP and PHK stand for the post-harvest soil test values of N, P and K (kg ha^{-1}); RY is the fresh fruit yield of radish crop (t ha^{-1}), SN, SP and SK represent the initial soil test values of N, P and K (kg ha^{-1}), respectively and FN, FP and FK are the fertilizer N, P and K applied to radish crop. Appreciably large R^2 values (significant at 1%) were obtained for these equations. This suggests that such regressions can be used with confidence for the prediction of available N, P, and K after harvest of Radish crop for making soil test-based fertilizer recommendation for succeeding crops.

2.3.3 Crop yield and sustainability under long-term STCR experiment at Coimbatore

The 10-years mean data suggested that maximum yield was observed under STCR-IPNS with target yield of 7 t ha^{-1} *kharif* rice and 6 t ha^{-1} *rabi* rice whereas minimum yield was observed from control whereas highest was achieved in STCR–IPNS in both *kharif* as well as *rabi* seasons. The highest sustainable yield index (SYI) was 0.87 and 0.78 in kharif and rabi rice, respectively under STCR–IPNS, and lowest was observed in control (Table 2.3.3 & Fig. 2.3.3).

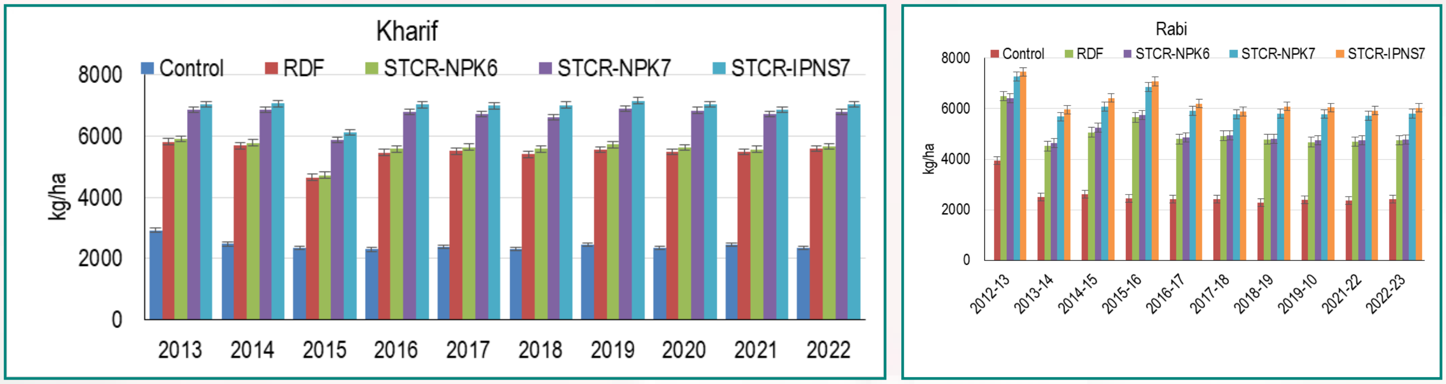


Fig. 2.3.3 Rice yield and sustainability

Table 2.3.3 Sustainable yield index of kharif and rabi rice under long-term STCR nutrient management

Treatments	SYI	
	Kharif	Rabi
Control	0.77	0.53
RDF	0.89	0.68
STCR-NPK6	0.89	0.71
STCR-NPK7	0.93	0.76
STCR-IPNS7	0.93	0.77

2.4 AICRP on Long Term Fertilizer Experiment (LTFE)

Microbial biomass carbon, nitrogen and dehydrogenase activity in soil

Perusal of results revealed that SMBC was significantly higher in plots receiving both FYM and inorganic fertilizers (100% NPK+FYM), 150% NPK and 100% NPK+lime and lowest in control plots (Table 1). There was significant variation in SMBC content in combination with lime or FYM along with inorganic fertilizer in Alfisols. The maximum status of soil microbial biomass carbon (SMBC) was recorded in 100% NPK + FYM followed by lime amended plot (637 mg kg^{-1}) in Alfisols of Palampur. While, the lowest content of SMBC was recorded in control treatment across LTFEs.

Table 1 SMBC (mg kg^{-1}) in soil under different nutrient management options at different LTFE site

Location	Control	100% N	100% NP	100% NPK	150% NPK	100% NPK+ Zn	100% NPK+ Lime	100% NPK+ FYM
Bangalore	196	205	217	258	262	-	248	259
Bhubaneswar	50	96	106	117	119	124	143	158
Coimbatore	191	221	271	265	280	280	-	289
Jabalpur	168	212	238	292	315	286	-	344
Ludhiana	140	210	240	294	311	-	-	392
Palampur	278	179	291	494	455	431	637	687
Parbhani	206	205	209	240	340	321	-	362
Pattambi	194	215	219	233	271	-	270	319
Udaipur	150	193	206	268	317	271	-	365

Soil microbial biomass nitrogen: Application of chemical fertilizers either alone or in combination with organic/lime increased the soil microbial biomass nitrogen (SMBN) significantly over control. Application of lime along with 100% NPK increased the SMBN content significantly over 100% NPK, the increase being 61% in Inceptisols of Bhubaneswar and 21.27% in Alfisols of Palampur, respectively (Table 2).The SMBN content in soil ranged from 6.9 mg kg^{-1} dry soil in unfertilized control plot and 84.8 mg kg^{-1} dry soil in the plots receiving FYM combined with mineral fertilizer. Addition of micronutrient such as Zn recorded significantly higher SMBN content than balanced fertilization i.e. 100% NPK. The SMBN content was lowest in control plot in Mollisols of Pantnagar and found maximum with 100% NPK+ FYM in Bhubaneswar.

Table 2 SMBN (mg kg^{-1}) in soil under different nutrient management options at different LTFE site

Location	Control	100% N	100% NP	100% NPK	150% NPK	100% NPK+Zn	100% NPK+ Lime	100% NPK+ FYM
Bhubaneswar	15.4	35.3	43.9	38.9	53.2	45.0	62.7	84.8
Coimbatore	20.1	25.9	35.5	40.4	45.8	42.7	-	47.4
Jabalpur	21.3	25.1	26.9	35.2	40.5	34.1	-	44.3
Palampur	10.5	12.2	14.1	18.8	20.2	17.2	22.8	25.0
Pantnagar	6.9	34.2	36.2	29.0	27.5	33.2	-	35.2
Udaipur	23.3	25.7	28.4	37.0	38.7	36.8	-	42.9

Dehydrogenase activity: The dehydrogenase is commonly used as an indicator of biological activity in soil. The activity of dehydrogenase enzyme was strongly affected by long term fertilizer use. The highest dehydrogenase activity (DHA) was recorded in 100% NPK + FYM in Mollisols of Pantnagar and lowest in control in Alfisols of Ranchi (Table 3). The application of 100% NPK + FYM @ 5 t ha^{-1} significantly increased the dehydrogenase activity followed by 150% NPK. The application of FYM increased availability of substrates for dehydrogenase and comparatively more activity of dehydrogenase in 100% NPK+ FYM. Further, the 150% NPK also led to enhance DHA that may be attributed to the fact that inorganic sources of nutrients stimulated the activity of microorganisms to utilize the native pool of organic carbon as a source of carbon, which act as substrate for dehydrogenase. Lowest dehydrogenase activity was measured in unfertilized control across LTFEs.

Table 3 DHA (µg TPF g^{-1} soil 24 hr^{-1}) in soil under different nutrient management options at different LTFE site

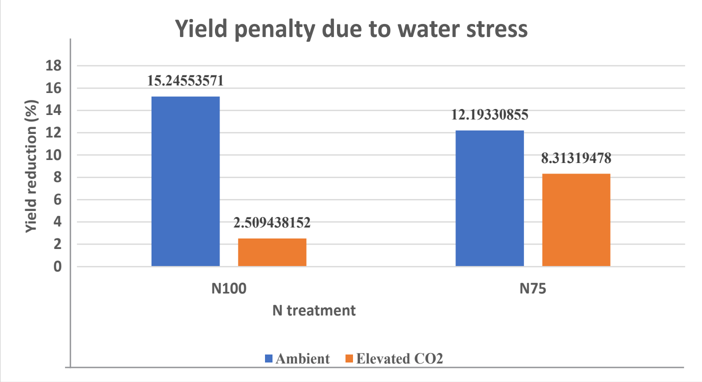
Location	Control	100% N	100% NP	100% NPK	150% NPK	100% NPK+Zn	100% NPK+ Lime	100% NPK+ FYM
Akola	32.9	38.0	40.1	45.3	52.9	-	-	63.0
Bangalore	40.4	33.0	43.1	56.5	58.5	-	59.5	67.8
Bhubaneswar	10.5	11.8	24.1	33.0	51.0	30.5	26.7	59.2
Coimbatore	7.4	8.2	9.6	9.5	8.7	9.8	-	11.4
Jabalpur	9.3	10.9	10.0	12.7	13.7	12.9	-	14.1
Palampur	19.8	13.9	29.9	38.7	26.8	37.9	40.6	44.2

Location	Control	100% N	100% NP	100% NPK	150% NPK	100% NPK+Zn	100% NPK+ Lime	100% NPK+ FYM
Parbhani	43.9	49.2	52.9	50.9	64.4	62.0	-	67.2
Raipur	35.1	42.2	43.4	49.3	52.0	54.1	-	55.4
Udaipur	30.6	34.4	37.2	39.4	44.2	39.6	-	46.0

Theme II : Conservation Agriculture, Carbon Sequestration and Climate Change

2.4.1 Alleviation of water stress under CO_2 elevation in wheat crop

A field experiment was conducted during the rabi season of 2022-23 to investigate the interaction between water and nitrogen stress under climate change conditions in wheat crop (variety HI 1544). The experiment was set up in open top field chambers (OTCs) with two levels of CO_2 (ambient and approximately 550 μ mol mol^{-1}), two water stress levels (optimum water supply (W1) and two irrigations less (W2)), and two nitrogen levels (N75 and N100). The results showed that under water stress (two irrigations less), yield reduction ranged from 3% to 15%. Under the recommended dose of N application, when two irrigations were skipped, there was a yield loss of 15% under ambient environment (as compared to the fully irrigated condition), whereas, under elevated CO_2 environment, the yield penalty was only 3%. At 75% N application, the yield penalty under ambient condition was 12% as compared to 8% under elevated CO_2 environment. With N stress (i.e., 25% reduction in fertilizer-N supply), yield reduction varied from 7-14% under



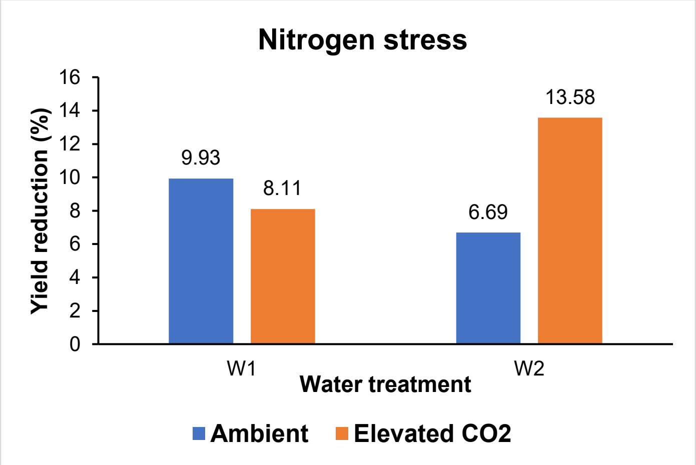


Fig. 2.4.1 Yield penalty in wheat crop due to water and nitrogen stress under Elevated CO_2

different situations. When N stress is combined with water stress, the yield penalty under elevated CO_2 was the highest at 14%, indicating higher demand of N under elevated CO_2 environment (Fig. 2.4.1).

2.4.2 Development of water and nutrient management practices for wheat crop in conservation agriculture for Vertisols of central India

During the winter season, wheat (cv. HI 1544) was grown with three irrigation methods (flood, sprinkler, and drip irrigation), three tillage management treatments (CT, RT, and NT), and four levels of fertilizer treatments (100% RDF, 75% RDF, STCR and Leaf colour chart-based fertilizer management, LCC). Flood irrigated plots received 5 post sowing irrigations with seasonal total of 402 mm water including 61 mm rainfall during the cropping season. In sprinkler irrigation plots, 334 mm of irrigation water (about 80% of the flood irrigation) was applied through micro sprinkler twice a week, while in drip irrigation treatment, 266 mm of irrigation water (about 60% of the flood irrigation water) was applied at alternate days throughout the season. Results revealed that the leaf area index (LAI) and NDVI were not significantly affected by the irrigation methods, tillage systems and nutrient doses. The grain and straw yields showed no significant variation with irrigation methods and tillage systems, but were significantly affected by different nutrient doses. The grain and straw yields were significantly higher under STCR and LCC doses as compared to 75 and 100 % RDF (Table 2.4.2a). Water use efficiency (WUE) was significantly higher under drip irrigation (DI), followed by sprinkler irrigation (SI), and lowest under flood irrigation (FI) (Table 2.4.2b). Additionally, the drip irrigation and No-tillage plots showed higher available K. It can be concluded that the conservation agricultural system maintained yield levels comparable to conventional practices while simultaneously saving time, labour, and input costs. Furthermore, it also improved soil health and ensured the sustainability of yield. (Plate 2.4.2).

Table 2.4.2a Effect of tillage and nutrients on wheat yield under different irrigation systems

	Flood Irrigation (FI)				Sprinkler Irrigation (SI)				Drip Irrigation (DI)			
	CT	RT	NT	Mean	CT	RT	NT	Mean	CT	RT	NT	Mean
F1	37.1	35.3	35.6	36.0	37.1	44.1	40.7	40.6	43.6	40.3	41.2	41.7
F2	32.7	34.9	39.1	35.6	38.8	39.2	40.8	39.6	31.6	31.0	39.0	33.9
F3	39.5	41.1	41.7	40.8	41.4	43.7	41.3	42.1	52.2	45.8	43.8	47.3
F4	45.0	35.5	37.3	39.2	45.9	36.1	42.2	41.4	44.2	42.0	43.7	43.3
Mean	38.6	36.7	38.4	--	40.8	40.7	41.3	--	42.9	39.8	41.9	--

Mean of irrigation methods (A)		Mean of Tillage systems (B)		Mean of Nutrient doses (C)	
FI	37.9	CT	40.8	F1	39.4
SI	40.9	RT	39.1	F2	36.3
DI	41.5	NT	40.5	F3	43.5
CD (0.05)	NS	CD (0.05)	NS	F4	41.3
--	--	--	--	CD (0.05)	3.93

Table 2.4.2b Effect of tillage and nutrients under on WUE of wheat under different irrigation systems

	Flood Irrigation (FI)				Sprinkler Irrigation (SI)				Drip Irrigation (DI)			
	CT	RT	NT	Mean	CT	RT	NT	Mean	CT	RT	NT	Mean
F1	9.20	8.80	9.00	9.20	13.60	16.10	14.90	14.90	16.40	15.10	15.50	15.50
F2	8.10	9.70	8.90	8.10	14.20	14.40	15.00	14.50	11.90	11.60	14.70	14.70
F3	9.80	10.40	10.10	9.80	15.20	16.00	15.10	15.40	19.60	17.20	16.50	16.50
F4	11.20	9.30	9.80	11.20	16.80	13.20	15.50	15.20	16.60	15.80	16.40	16.40
Mean	9.58	9.55	9.45	--	14.95	14.93	15.13	--	16.13	14.93	15.78	--

Mean of irrigation methods (A)		Mean of Tillage systems (B)		Mean of Nutrient doses (C)	
FI	9.40	CT	12.60	F1	12.30
SI	12.30	RT	12.10	F2	11.10
DI	15.60	NT	12.60	F3	13.50
CD (0.05)	1.112	CD (0.05)	NS	F4	12.80
--	--	--	--	CD (0.05)	1.285

Plate 2.4.2 Field view of the drip and sprinkler irrigation systems under the CA

2.4.3 Impacts of conservation agriculture on runoff and soil loss under different cropping systems in Vertisols

An experiment (Plate 2.4.3) was laid out with two cropping systems namely Soybean-Wheat and Maize-Chickpea to evaluate various parameters under various tillage systems with different crop residue levels i.e. (i) Conventional Tillage (ii) Reduced Tillage + 30 % crop residue (iii) Reduced Tillage + 60 % crop residue (iv) No- Tillage + 30 % crop residue (v) No- Tillage + 60 % crop residue. No significant variation was observed in soil pH, bulk density and EC values under various treatments. Although, bulk density showed no variation among treatments at 0-5 and 5-10 cm soil depth, however the values were increasing with increase in the soil depth. Similarly, there was no significant difference in soil pH, EC and bulk density values among different cropping systems. The total annual rainfall for 2023 was 997 mm in which 815 mm of rainfall was received during monsoon season. Only six events were recorded with runoff and soil loss under various treatments. The prolong mid-season gap in rainfall adversely affected the growth of soybean crop along with increased incidence in the insects and diseases attack. There was no significant variation observed in grain yield among various treatments under two cropping systems. Yield attributes including harvest index observed without any marked difference (Table 2.4.3).

Table 2.4.3 Effect of conservation agriculture on bulk density (BD) under different cropping systems

Treatment	BD (0-5 cm)	BD (0-10 cm)	BD (0-5 cm)	BD (0-10 cm)
	Soybean-Wheat		Maize- Chickpea	
CT	1.30	1.44	1.32	1.42
RT-30%	1.32	1.41	1.32	1.43
RT-60%	1.34	1.42	1.33	1.40
NT-30%	1.32	1.43	1.34	1.42
NT-60%	1.33	1.41	1.32	1.43

Plate 2.4.3 Field experimental set up for determining the impact of CA on run off and soil loss

2.4.4 Soil carbon pool dynamics under different levels of residue retention under no-till system in soybean-wheat cropping system (CRP -CA)

A study was conducted to assess dynamics of soil organic carbon (SOC) under no-tillage (NT) and residue retention (RR) in the Vertisols of central India. The experiment was initiated in the year 2015 with four different levels of residues (0, 30, 60, and 90%) under no till system. The site was established on a Vertisol under sub-humid, dryland conditions to examine the impact of NT along with residue retention on soybean (*Glycine max* L.) and wheat (*Triticum aestivum* L) and maize (*Zea mays*) and chickpea (*Cicer aerietinum* L) production. Retention of residues of previous crop significantly affected soil total carbon under both the cropping systems. As the levels of residue increased, soil total carbon also increased under the no till system. However, the effect was only confined to 0to 10 cm of soil depth. No significant impact of residue retention was recorded in 10-20 cm of soil depth. Moreover, no till system without residue retention could not make any significant change in soil total carbon content. Retention of 30, 60 and 90% of residues of previous crops resulted in 28.9, 32.7 and 41.1%, respectively increase in soil carbon concentration in maize-chickpea cropping system. However, this increase in soil total carbon could not make any significant change in soil carbon content of recalcitrant pool. The trend was similar for oxidizable carbon (WBC) also. The increase in carbon mainly contributed to mineralizable pool (active+slow) of soil carbon. Here, retention of 60 and 90% of residue resulted in enhancement of mineralizable pool of soil carbon by 48.5 and 78.8%, respectively under maize-chickpea rotation (Table 2.4.4a).

In case of soybean-wheat rotation, retention of 90% of residue resulted in 19% improvement in soil total carbon in 0-10 cm of soil depth. A 17% and 22% increase in recalcitrant and oxidizable carbon content was recorded in 90% residue retained treatment in 0-10 cm of soil depth.

In order to determine active and slow pool of soil organic carbon under maize-chickpea rotation, a carbon mineralization study was conducted for duration of 90 days under laboratory condition. Cumulative carbon mineralized from 50 g of soil is depicted in Figure 1. The highest carbon mineralization (53.97 mg C-CO_2/50 g of soil) was recorded under the treatment of no till system with 90% retention of residues of previous crops. This was followed by 60, 30 and 0% of residue-retained treatments. The lowest carbon mineralization was recorded from conventionally tilled plot with no residue retained (42.87 mg C-CO_2/50 g of soil). Separation of active and slow pools was done using thedouble decomposition model. The size and turnover rates of eachpool were estimated by curve fitting the CO_2evolved per unit oftime (Ct) using a two-component model (Paul et al., 1997) shownin Eq. (1)

$$C_t = C_a e^{-kat} + C_s e^{-kst} \quad (1)$$

where, $C_t$is sum of active (Ca) + slow pool carbon (Cs) pools; C_a and$C_s$are the sizes of the active and slow carbon pools and k_a, and $k_s$are the decay constants of respective pools.The double decomposition equations fitted with the non-linearregression (SPSS window version)was used in the Marquardt algorithm.

A significant difference in C concentration of the acid non-hydrolysable fraction occurred among treatments (Table 2.4.4b). No till system with 90% of residue retained treatment recorded highest concentration of active pool of carbon (0.61 g kg^{-1}) and the lowest was recorded in CT with no residue retention treatment (0.47 g kg^{-1}). No till system resulted in 32% improvement in carbon in slow pool. Retention of residue have greater impact on soil carbon in slow pool. Retention of 90% of residue resulted in 89% improvement in carbon in slow pool. The data of decay constant of active pool suggest that mean residence time (MRT) of active pool under different treatments ranged between 8-11 days where MRT of slow pool under different treatments ranged between 2-16 years (Fig. 2.4.4).

Table 2.4.4a Effect of different levels of residue retention on soil carbon concentration

Treatments	Total carbon (%)		Recalcitrant carbon (%)		WBC (%)		Active+Slow (%)	
Maize-Chickpea	0-10 cm	10-20 cm	0-10 cm	10-20 cm	0-10 cm	10-20 cm	0-10 cm	10-20 cm
NT-0% Residue retention	1.28ab	0.84a	0.86a	0.62c	0.97a	0.54b	0.42ab	0.22a
NT-30% Residue retention	1.38b	0.77a	0.94a	0.56a	1.10a	0.50ab	0.44ab	0.21a

Treatments	Total carbon (%)		Recalcitrant carbon (%)		WBC (%)		Active+Slow (%)	
Maize-Chickpea	0-10 cm	10-20 cm	0-10 cm	10-20 cm	0-10 cm	10-20 cm	0-10 cm	10-20 cm
NT-60% Residue retention	1.42b	0.73a	0.92a	0.53a	1.14a	0.43a	0.49bc	0.19a
NT-90% Residue retention	1.51b	0.77a	0.91a	0.56a	1.15a	0.48ab	0.59c	0.21a
CT-0% Residue retention	1.07a	0.80a	0.75a	0.59b	0.88a	0.47ab	0.33a	0.21a
Soybean-wheat								
NT-0% Residue retention	1.12a	0.73a	0.76a	0.56a	0.88a	0.73b	0.36a	0.18a
NT-30% Residue retention	1.14a	0.75a	0.76a	0.57a	0.88a	0.75b	0.38a	0.19a
NT-60% Residue retention	1.23ab	0.72a	0.81ab	0.56a	0.92a	0.72b	0.42a	0.16a
NT-90% Residue retention	1.33b	0.75a	0.89b	0.57a	1.08b	0.75b	0.45a	0.17a
CT-0% Residue retention	1.13a	0.77a	0.75a	0.59a	0.86a	0.52a	0.38a	0.18a

Table 2.4.4b Carbon pool dynamics as affected by tillage and different levels of residue retention

Treatments	TC (%)	Ca (%)	Ka (days^{-1})	Cs (%)	Ks (days^{-1})	Cr (%)
NT-0% Residue retention	1.28	0.050	0.105	0.37	0.00137	0.86
NT-30% Residue retention	1.38	0.048	0.113	0.38	0.00137	0.94
NT-60% Residue retention	1.42	0.059	0.090	0.43	0.00145	0.92
NT-90% Residue retention	1.51	0.061	0.101	0.53	0.00105	0.91
CT-0% Residue retention	1.08	0.047	0.109	0.28	0.000169	0.75

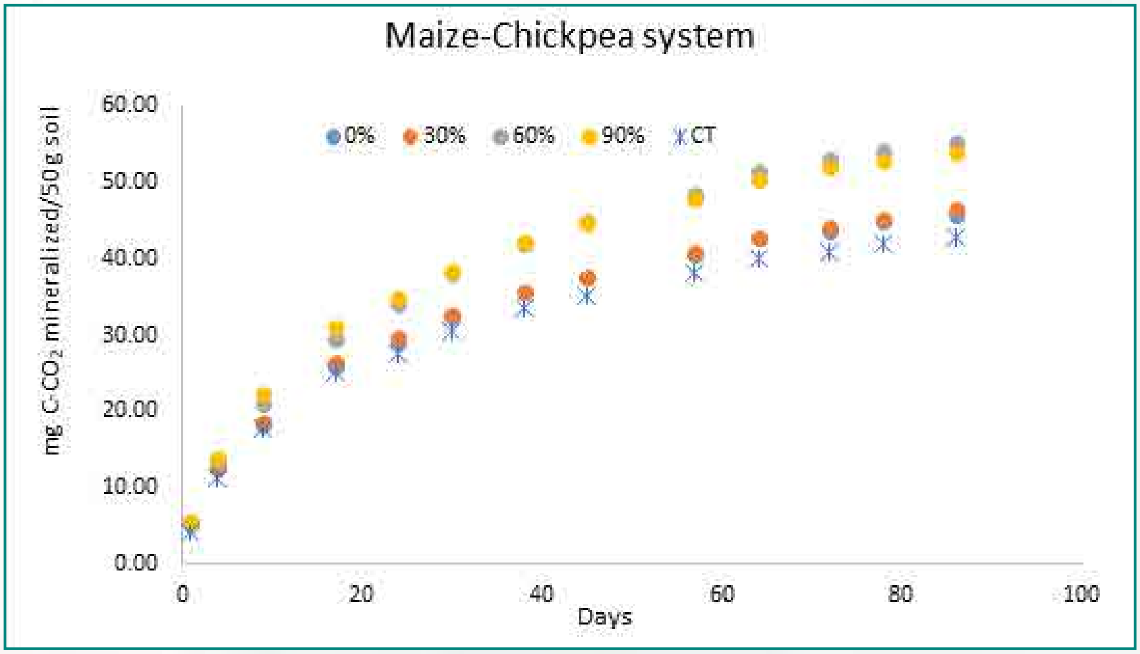


Fig. 2.4.4 Cumulative soil carbon mineralization-Maize-Chickpea rotation

2.4.5 Suitable adaptive water management practices for wheat crop in Central India using simulation modelling

Simulation modelling can be a valuable tool to identify suitable adaptive strategies. By analyzing various scenarios, such as different irrigation schedules and soil types, simulation modelling can help farmers make informed decisions about water usage and crop yield. With the right approach, adaptive water management practices can be implemented to ensure the sustainability and profitability of wheat farming in the region. This study employed a well-calibrated and validated APSIM crop model to assess the wheat yield in Madhya Pradesh as well as to identify the suitable adaptive management practices for improving its yield. The findings demonstrate that four irrigations of 50 mm with 70% of efficiency along with crop residue resulted in highest average wheat crop yield of 3800 kg ha^{-1} under different farm resource conditions (Fig. 2.4.5). Therefore, farmers of central India are suggested to use this irrigation practice for achieving higher crop yields.

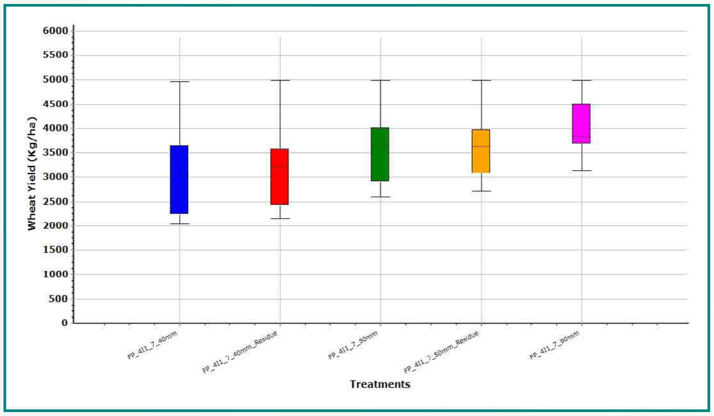


Fig. 2.4.5 Adaptive water management practices for wheat crop in central India

2.4.6 Validation of APSIM crop model for Rice-Wheat cropping system in humid sub-tropical agro-climatic region

Soil organic matter dynamics in terrestrial ecosystems are controlled by complex interactions between various factors such as climate, soil and agricultural management practices. We utilized a process-based crop model APSIM to simulate long-term soil organic carbon (SOC) dynamics for a rice-wheat cropping system under different nitrogen (N) and farmyard manure management (FYM) practices for a 24-year-old experimental dataset in Raipur. The APSIM was parameterized and validated to predict grain yield and SOC stock. The validated model was then used to evaluate the impacts of different management practices on SOC dynamics in the top 30 cm of soil through scenario modelling. We found that the APSIM model was robust in predicting long-term changes in SOC stock with R^2 of 0.87 and model efficiency (ME) of 0.89 in different N and FYM treatments under different climatic scenarios as depicted in the Fig. 2.4.6.

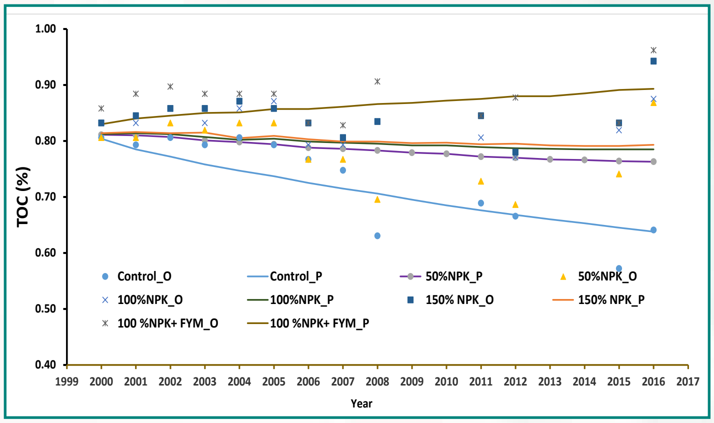


Fig. 2.4.6 Observed vs predicted SOC (%) under different nutrient management practices in a LTFE at Raipur

2.4.7 Estimation of minimum crop residue thresholds for soil carbon benefits through APSIM model in subtropical central Indian Vertisols

Crop residue application greatly affects soil fertility and is a key part of conservation agriculture. A modelling study was conducted to estimate the benefits of nitrogen and crop residue management on soil properties in subtropical central Indian Vertisols. In this study, the APSIM model was used for a soybean-wheat cropping system in Vertisols. The simulations with various residue retentions, fertility levels, and N inputs revealed that residue management significantly affected soil organic carbon (SOC) concentration. The threshold residue retention for no change in SOC content was found to be around 10% for adequately fertilized crops and 30% for N-limited ones. In the conditions where SOC was higher (1%), approximately 60% residue retention was the threshold level for N-limited condition. This level was reduced to 30% and 20% in the case of medium and high levels of N management (Fig. 2.4.7).

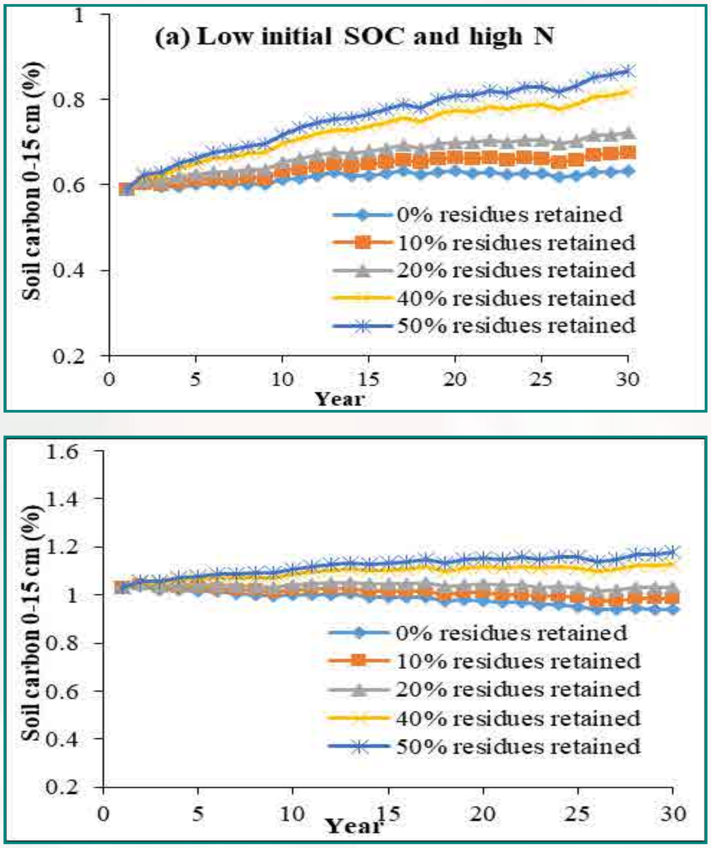


Fig. 2.4.7 Effect of residue and soil fertility management on SOC in 0-15 cm soil at (a) low initial SOC and high N, (b) high initial SOC and high N

2.4.8 Changes in soil organic carbon fractions and mean residence time after 10 years of implementation of conventional and conservation tillage practices

Land management practices, including tillage and fertilizer management practices, can alter the different pools of soil organic carbon (SOC). However, the impact of these land impact practices is highly variable depending upon the soil and climate type. To better understand this relationship, a study was conducted to investigate the influence of 10-year implementation of conventional tillage (CT) and no-tillage (NT) with different levels of nitrogen (N) management practices on different pools of SOC in the maize-wheat cropping system. The study showed that the active pools of SOC were significantly higher in the NT than in CT under all N management practices. Additionally, the active pools of SOC increased with a higher N application rate, with the maximum active pool of SOC observed at N100%. On the other hand, the tillage system did not significantly affect the passive pools of SOC, except under the 150% N application rate. These findings suggest that NT practices, along with proper N management, can help to increase the amount of active SOC stored in the soil, which can positively impact soil health and overall agricultural productivity (Fig. 2.4.8).

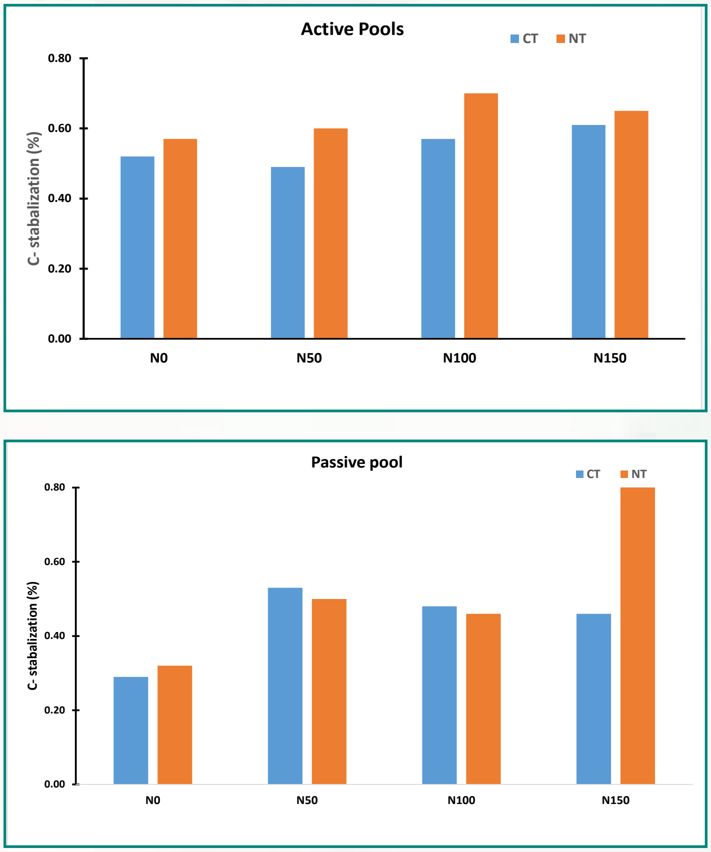


Fig. 2.4.8 Comparison of mean value of active and passive SOC pools under different tillage and nitrogen treatments

2.4.9 Effect of climate change on water-soluble and exchangeable micronutrients in soil

The study under FACE system in Vertisols of Central India revealed that the combination of elevated levels of carbon dioxide (CO_2) and temperature significantly impacted the water-soluble and exchangeable Zinc (Zn) concentration in the soil. While the increased levels of CO_2 and temperature positively affected the availability of micronutrients in soil, the enhancement was not significant enough to reach the level of statistical significance. The reason for this could be attributed to the soil acidification caused by the elevated levels of

CO_2, which in turn led to the mineralization of organically bound metals. This finding shed light on the intricate relationship between soil health and environmental factors and underscores the importance of mitigating the negative impacts of climate change on our earth's ecosystems (Table 2.4.9).

Table 2.4.9 Water-soluble and exchangeable micronutrients as affected by climate change

Treatments	Micronutrients (mg kg^{-1})			
	Cu	Zn	Fe	Mn
Control-T1	1.96	4.31	13.4	4.08
Elevated CO_2 (600 ppm)+Ambient temp.-T2	1.62	4.93	15.6	5.90
Ambient CO_2 + Elevated temp. (+2 degree C)-T3	1.42	5.27	16.1	5.40
Ambient CO_2 + Elevated temp. (+3 degree C)-T4	1.77	5.74	15.5	6.44
Elevated CO_2 (600 ppm)+ Elevated temp. (2 degree C)-T5	1.32	5.31	16.8	5.78
Elevated CO_2 (600 ppm) + Elevated temp. (3 degrees C)-T6	1.03	5.11	15.5	5.37
CD (p= 0.05)	NS	0.52	NS	NS

2.4.10 Impact of tillage on water balance and soil surface temperature in maize based cropping system in Vertisols of Central India

The evaluation of the field water cycle for a winter maize-wheat cropping system in RCP 4.5 and 8.5 future climatic scenario under no tillage (NT) and conventional tillage (CT) was undertaken to estimate the field water dynamics for optimization of agricultural water management strategies for mitigating the impacts of climate change. In this study, the agro-hydrological Soil–Water–Atmosphere–Plant (SWAP) model was used to evaluate the field water cycle. The SWAP model was first calibrated and validated using the field experimental data including soil water content and soil temperature. The root mean square error (RMSE) was 1.09 for soil temperature up to 10 cm soil depth. The SWAP model simulated field water balance under different climatic scenarios with reasonable level of accuracy. This study also indicated that the soil profile moisture in no-tillage was comparatively higher than that of CT (Fig. 2.4.10).

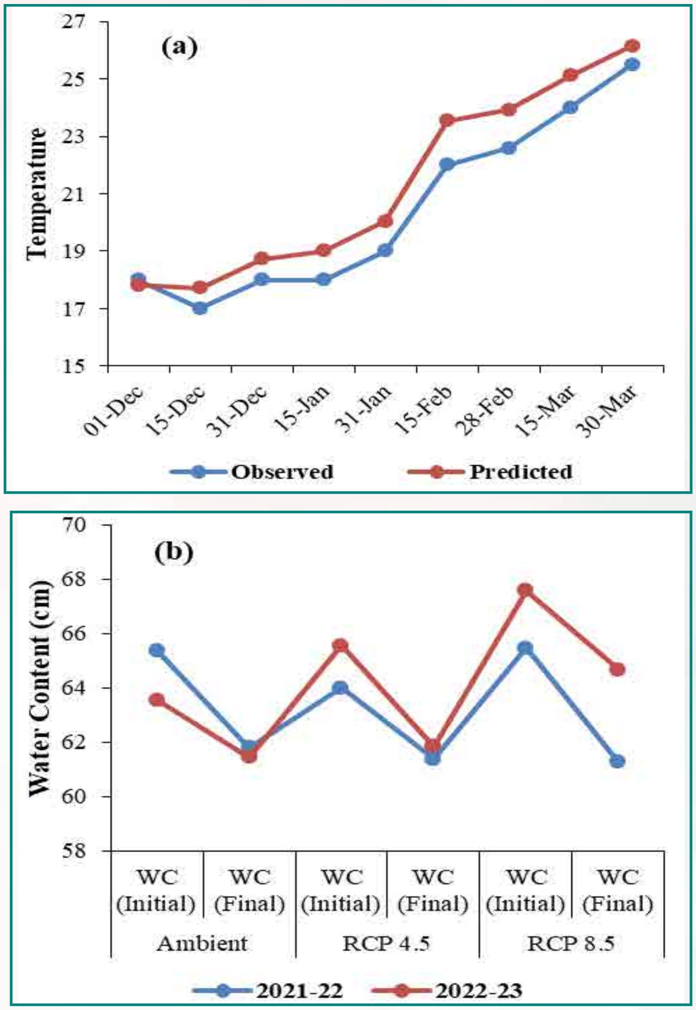


Fig. 2.4.10.(a) Observed and Predicted soil temperature by SWAP model in the NT (b) Initial and Final Soil Water Content (WC) in NT under ambient, RCP 4.5 and RCP 8.5 climate change scenarios

2.4.11 Spatio-temporal trend analysis of long-term ESA CCI surface soil moisture content across different agro-ecological regions of India

The spatio-temporal trends in near-surface soil moisture across different agroecological regions of India were studied using the European Space Agency Climate Change Initiative (ESA CCI) surface soil moisture data spanning from 1979 to 2021 (43 years). The non-parametric Mann-Kendall trend test was applied to detect the presence of a monotonic trend, and Sen's slope estimator to compute the magnitude of the trend at a 5% level of significance on a grid basis at monthly time scales. Interestingly, a vast majority of India (94.09%) did not show a significant temporal trend ($p < 0.05$) in SWC. Only 2.75% indicated a declining trend, and 3.16% showed an increasing trend with a slope of 0.0002 m^3 m $year^{-1}$. The maximum percentage of areas having a decreasing trend were found in the August month (11.28%), belonging to northern and central India having alluvial, red, and black soils. The maximum percentage of areas showing increasing trend were found in the December month (12.39%), of which, most of the area belonged to northern and central India as well as its eastern and western coastal regions. During most of the months, the 'Warm per-humid ecoregion with brown and red hill soils' depicted a maximum percentage of area with a negative trend, while there was no particular agro-ecological region which was showing increasing trend during most of the months (Fig. 2.4.11).

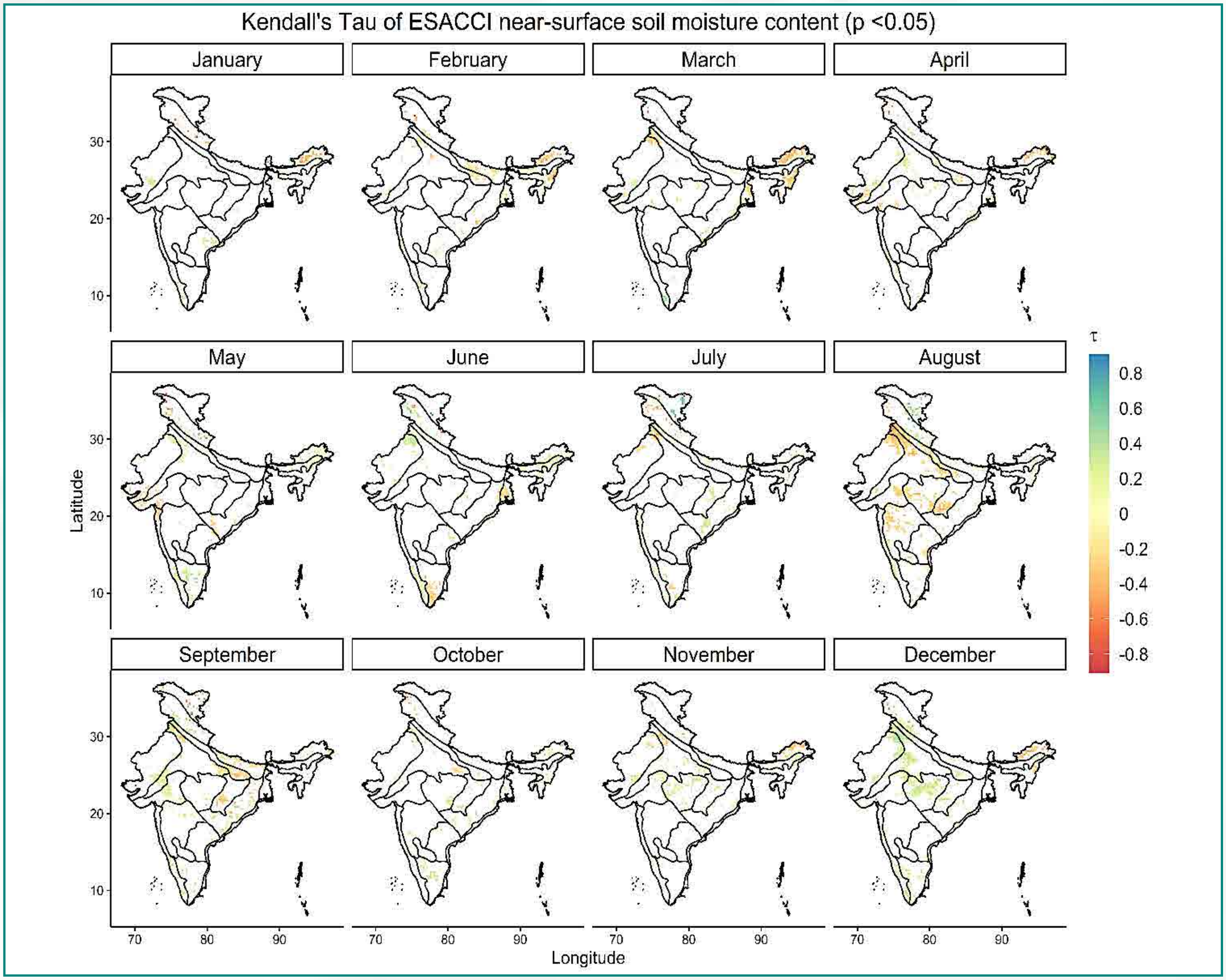


Fig. 2.4.11 Temporal trend in the monthly mean of the ESA CCI near-surface soil moisture content ($p < 0.05$)

Theme III : Microbial Diversity and Genomics

2.5.1 Deciphering thermophiles from hot springs of Central India for rapid decomposition of crop residues

The experiment was laid out with completely randomized block design (CRBD), experiments were conducted with two different straw *viz.*, wheat straw and paddy straw. For each straw, 5 treatments were set with 3 replications; totalling 15 samples per straw type. The treatment consists of different combinations *viz.*, wheat /paddy straw (control)(T1); wheat /paddy straw + TLC bacteria (T2); wheat / paddy straw + EKCEL decomposer(T3); wheat/paddy straw + Pusa decomposer(T4); wheat/paddy straw + waste decomposer(T5). After 30 days, compost samples were collected and analysed for C:N ratio, lignin/cellulose ratio, total N,P,K (Table 2.5.1).

Table 2.5.1 Effect of decomposition of wheat and paddy straw with different decomposers.

	C : N	Lignin : Cellulose	Total N %	Total P %	Total K %
Wheat Straw					
T1	58.9 ± 0.9 a	0.82± 0.04 e	0.69 ±0.01d	0.99±0.00d	0.86±0.01e
T2	23.29 ± 0.6 e	1.79 ± 0.02 a	0.98 ±0.01a	1.49 ±0.06a	1.37±0.01a
T3	26.79 ± 2.1d	1.65 ± 0.00 b	0.95 ±0.01b	1.34±0.00b	1.28±0.02b
T4	30.56 ± 0.7 c	1.43 ± 0.07 c	0.95 ±0.01b	1.20±0.05c	1.09±0.01c
T5	46.29 ±01.2 b	1 ± 0.04 d	0.75 ±0.01c	1.00±0.01d	0.92±0.06d
Paddy Straw					
T1	48.05± 2.5 a	0.75± 0.02 e	0.82±0.01d	0.28±0.00d	1.78±0.07d
T2	15.02±2.0 d	1.63± 0.04a	1.17±0.05 a	0.55±0.04 a	2.10±0.00a
T3	19.65±0.5 c	1.54± 0.00 b	1.07±0.02b	0.45±0.03 b	2.04±0.01b
T4	22.39±2.0c	1.33± 0.09 c	1.01±0.01c	0.34±0.02c	1.94±0.01c
T5	40.42±3.2 b	0.92± 0.00 d	0.82±0.01d	0.29±0.01d	1.78±0.01d

2.5.2 Evaluation of organic, inorganic and integrated crop management practices (AI-NPOF project)

Wheat, mustard, chickpea and linseed were sown during *rabi* season 2023 at research farm of ICAR-Indian Institute of Soil Science. The highest seed yield of wheat, mustard, chickpea and linseed were recorded in 50 % organic + 50 % inorganic treatment followed by 100% organicas compared to 100% inorganic treatment. However, the lowest yield was recorded in 25 % organic + 25 % inorganic + natural farming treatment.

The soil organic carbon was recorded higher in 100% organic management (1.02%) followed by 50 % organic + 50 % Inorganic (0.91%) and lowest was found in 100 % inorganic (61%). Among the cropping systems, soybean-wheat recorded highest SOC followed by soybean-chickpea, soybean-mustard and soybean-linseed. Similarly, soil available nutrients (NPK) were also found highest under treatment receiving 100 nutrients through organic manure.

Enzyme activity in terms of fluorescein diacetate (FDA), dehydrogenase (DHA) and alkaline phosphatase were determined in soil as influenced by different nutrient management practices (Fig. 2.5.2a, b). Fluorescein diacetate hydrolysis activity was found to be highest under 100% organic plot which was closely at par to 50% organic+ natural farming plot and 50% organic+50 % inorganic plot as compared to 100 % inorganic treatment.

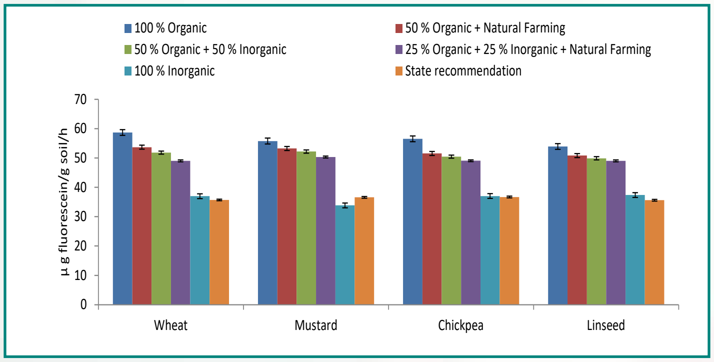


Fig. 2.5.2a Fluorescein diacetate (FDA) hydrolysis activity as affected by different nutrient sources in different crops

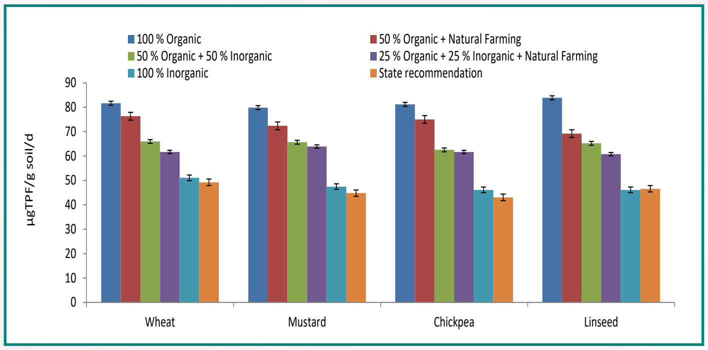


Fig. 2.5.2b Soil dehydrogenase activity as affected by different nutrient sources under different crops nutrient sources under different crops

2.5.3. Evaluation of response of different varieties of mustard crop under organic farming

Performence of different varieties of mustard were evaluated for their yield response to screen out promising varieties for organic management practices for central India. Twelve varieties of mustard grown under organic nutrient management practices were tested at ICAR-IISS Bhopal Centre. Mustard varieties were tested and found that Among the different varieties of mustard, Aravali (1223 kg ha^{-1}) was out performed in yield followed by CS-52 (1140 kg ha^{-1}), Maya, DRMR-IJ – 31, PM-22, NRCDR-2 (Fig. 2.5.3).

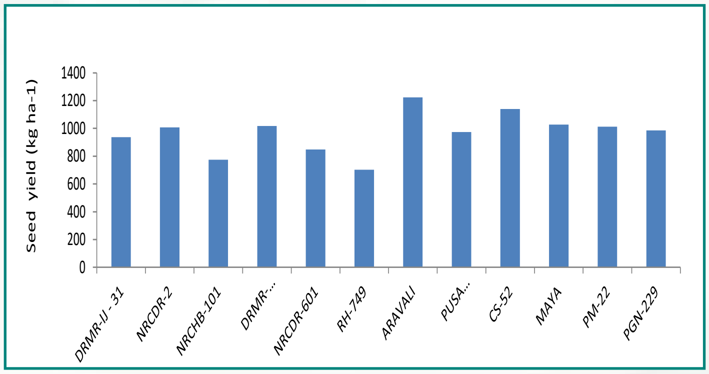


Fig. 2.5.3 Performance evaluation of different varieties of mustard crops under organic practices

2.5.4 Evaluation of natural farming practices in different agro-ecology

During *rabi* season 2023 at research farm of ICAR-Indian Institute of Soil Science, wheat as main crop and mustard as intercrop was grown adopting different nutrient management practices. The grain yield trend of wheat was recorded highest in integrated crop management practices with chemical pesticide (ICMP), which was at par with integrated crop management practices with natural farming (ICMNF) followed by AI-NPOF package, Complete NF, and least in control treatment. The yield of intercrop mustard also followed similar trend (Fig. 2.5.4a). Soil microbial count and enzyme activity were found to be highest under treatment receiving nutrients 100% through organic manure (T3) which was closely similar to T4 and T5 whereas, nutrients were supplied in combination with organic manure and inorganic fertilizers. However, the lowest FDA activity was recorded in control treatment (T1) (Fig. 2.5.4b).

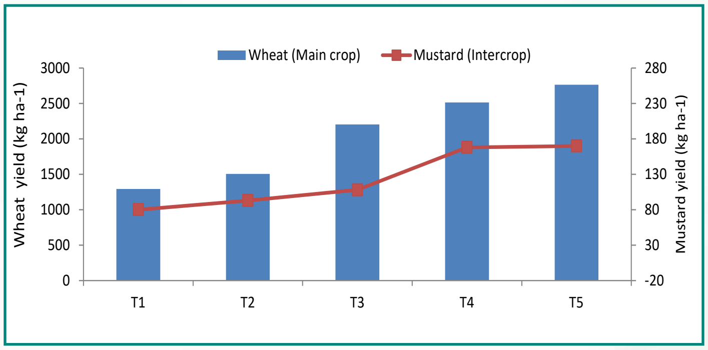


Fig. 2.5.4a Yield of wheat and mustard under different nutrient management practices

Treatments: (T1) Control, (T2) Complete NF, (T3) AI-NPOF package, (T4) Integrated crop management with natural farming, (T5)Integrated crop management with pesticides

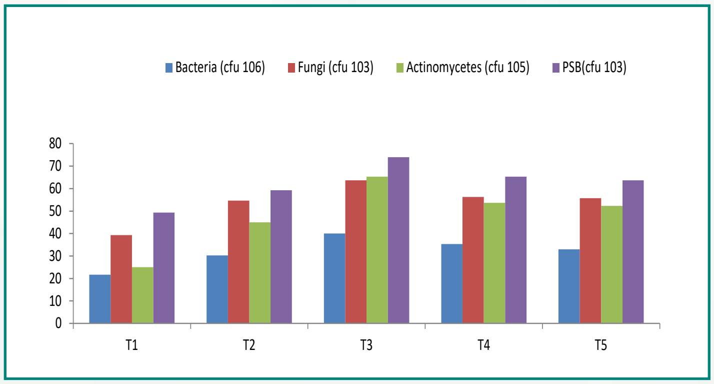


Fig. 2.5.4b Effect of different nutrient management on soil microbial count

2.5.5 Effect of organic nutrient management practices on soil K fractions in Vertisols of central India

In long-term organic manurial trial experiment under All India-Network Programme on Organic Farming (AI-NPOF), six different treatments (T1: 100% nutrient through organic sources, T2: 50% organic and natural farming (NF), T3: 50% organic + 50% inorganic sources, T4: 25% organic+ 25% inorganic + NF, T5: 100% Inorganic and T6: State recommendations) were evaluated for different soil K fractions such as, Water soluble K (WSK), Exchangeable K (Exch K) and Non-exchangeable K (Non Ex K).The results highlighted that nutrient management had no significant impact on WSK while it had significant impact on Exch K fractions. T3 (50% organic + 50% inorganic sources) maintained the highest Exch K followed by T1 whereas all the treatments were statistically similar. In case of Non Ex K, T6 (State recommendations) maintained the highest value followed by T5 (100% Inorganic) whereas T3 (50% organic + 50% inorganic sources) exhibited the lowest value. The application of organics in treatments such as, T1, T2, T3 and T4 might have helped in distortion of silicate structure which in turn probably reduced the Non Exch K. The increase in yield of crops in the organic treatments may also indicate that the demand of K in these treatments by crops are high which in turn may trigger the transfer of K to more soluble and available pool from non-exchangeable pools (Fig. 2.5.5).

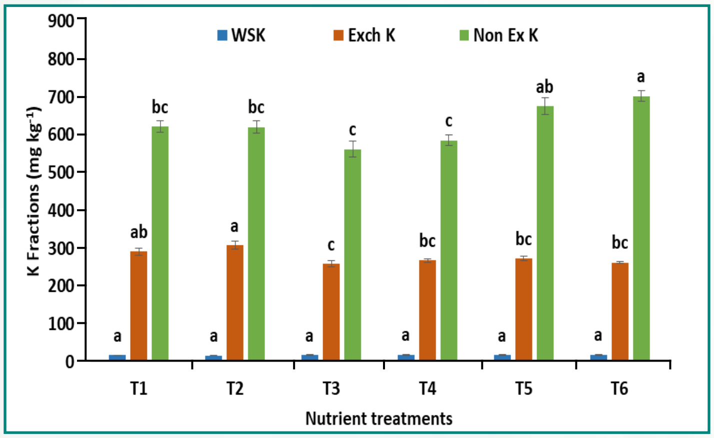


Fig. 2.5.5 Long term nutrient management effect on soil potassium (K) fractions (mg kg^{-1})

2.5.6 Impact of natural and organic agriculture system on Oxidizable soil organic carbon (SOC) and SOC stock in Vertisols of central India

As part of the All India-Network Programme on Organic Farming (AI-NPOF), an investigation was initiated during the 2021 kharif season to assess the influence of natural farming methods on soil and crop parameters. The experiment involved five distinct treatments (T1-Control, T2-Complete Natural Farming (NF), T3-Organic farming (OF), T4-Integrated Crop Management + Natural Farming (ICM-NF), and T5-Integrated Crop Management with chemical pesticides (ICM-P)). The evaluation focused on oxidizable soil organic carbon (SOC) status using the Walkley and Black (1934) method, analyzing both surface (0-15 cm) and subsurface layers (15-30 cm). Bulk Density (BD) was also monitored, and SOC stock was calculated.The findings revealed that nutrient management significantly impacted SOC (%) and SOC stock primarily at the surface level (Fig. 2.5.6) compared to deeper layers. T3 (50% organic + 50% inorganic sources) demonstrated the highest SOC (%) and SOC stock (Mg ha^{-1}), followed by T4. Among all treatments, T1 (Control) exhibited the lowest SOC (%) and SOC stock. The application of both organic and inorganic substances increased labile C fractions, potentially enhancing microbial populations and soil nutrient status. The resulting increase in yield could also lead to the release of organics into the soil, contributing to the improvement in SOC status as reflected in SOC stock.

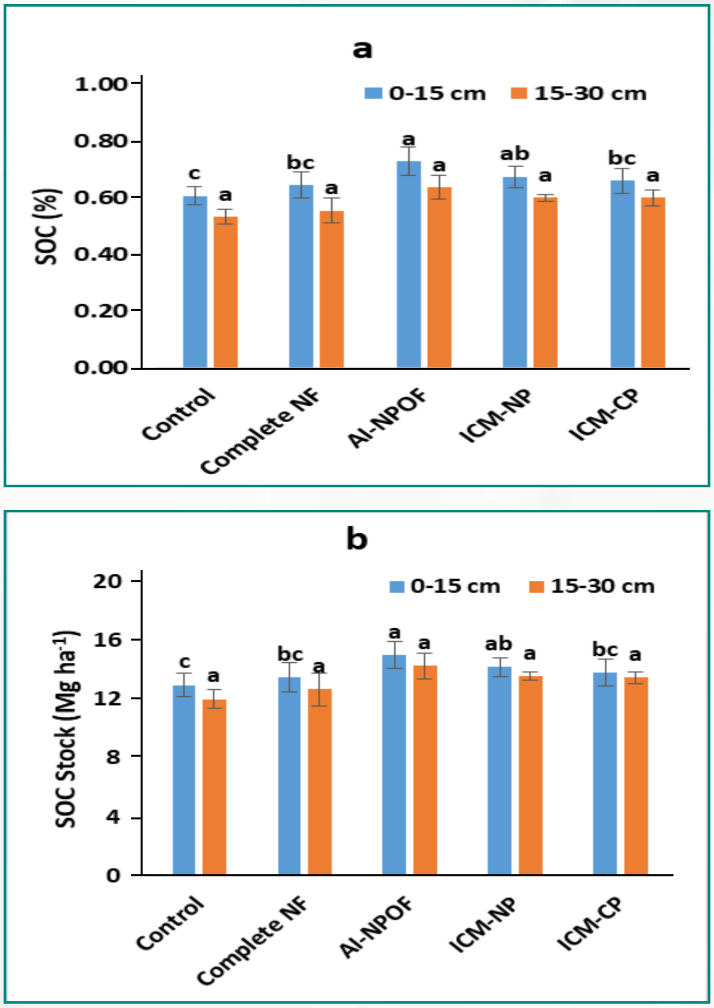


Fig. 2.5.6 Impact of natural and organic farming practices on (a) SOC (%) and (b) SOC stock

2.5.7 Potential of endophytic fungi isolated from municipal solid waste dumping site for toxic trace elements tolerance and plant growth promotion

In the present study, the endophytic fungi were isolated from dominant plants growing near municipal solid waste dumping site. Total 14 endophytic fungi were isolated from ten different plant roots; 12 isolates were of morphologically distinct. In toxic trace elements tolerance study, few isolates could tolerate Pb and Cr in the range of 150 to 200 ppm concentration, while others could tolerate Cd and Hg up to 50 ppm concentration with their biomass growth. Identified fungal isolates belong to genera *Fusarium* and *Curvularia* show highest tolerance against Pb, Cr, Hg, and Cd elements with tolerance index more than 100%. These isolates with higher tolerance can be used as potential partner of hyper accumulator plants in microbe-assisted phytoremediation of trace elements contaminated soil. Some of the endophytes isolates namely *Aspergillus, Fusarium* and *Alternaria*sp has great potential for phosphorus solubilization and Indole Acetic-acid production whereas the *Curvularia, Fusarium* and *Paecilomyces* has great potential for siderophore production (Fig. 2.5.7).

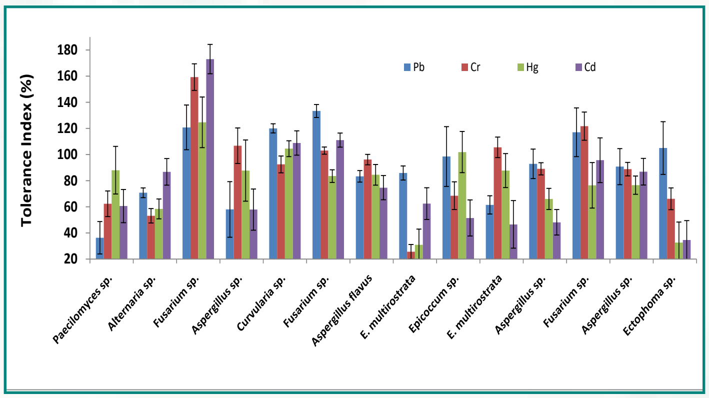


Fig 2.5.7 Different endophytic fungal isolates and their heavy metal tolerance index

2.5.8 Effect of 'Bio.Soilz' on soil nutrient availability and microbial activity under Maize-Wheat cropping system in Vertisols of Central India

The field experimental trial at ICAR-IISS farm evaluated the effect of Bio.Soilz soil chemical properties, microbial activities and crop performance with maize-wheat cropping sequence. Soil treatment has been applied with the *BioSoilz* second season wheat (2022-23) and maize (2023) with the variety crop HD 1544 and NMH-51 (Nirmal) respectively. The soil chemical parameters after wheat crop (2022-23) showed minor variation with respect to pH and EC. The soil organic carbon mostly varied with the treatment and maximum organic carbon was observed when biosoilz was applied in combination RDF. The microbial activity dehydrogenase was found at higher with increasing doses of biosoilz application as compared to control. The yield of wheat was found higher side with the application of Biosoilz and less was recorded when only biosoilz applied alone but better than the control. Similarly, under second season maize, the soil chemical and microbial activity and crop performance followed similar trend. The yield of maize was found higher side with the application of Biosoilz better than the control treatment (Plate 2.5.8).

Plate 2.5.8 Bio.Soilz field experimental trial with (a) maize and (b) wheat crops

2.5.9 Autotrophic C fixation potential under different land use system of central India

Autotrophic carbon fixation potential derived from soil RuBisCO enzyme activity has been found to be ranging from 13.56 to 35.79 μ g CO_2-C g^{-1} soil day^{-1} in different land use systems such agroforestry,

forestry, grassland and horticulture system of central India. However, in case of NPOF organic farming experiment the highest autotrophic C fixation potential (48.48 μ g CO_2-C g^{-1} soil day^{-1}) was noticed in 100% inorganic treatment. Similar trend was also noticed in LTFE Raipur soil where highest autotrophic C fixation potential (26.51 μ g CO_2-C g^{-1} soil day^{-1}) was recorded in 100% NPK treatment (Table 2.5.9).

Table 2.5.9 Autotrophic C fixation potential under different land use system of central India

Manage	Soil Depth	
Land use systems	0-15 cm	15-30 cm
Agroforestry	34.43	37.17
Grassland	19.88	28.93
Forestry	14.55	12.61
Horticulture	35.23	33.46
Land use effect: $p<0.05$;Depth effect $p<0.05$; Land use effect *Depth $p<0.05$		
NPOF Treatment	0-15 cm	15-30 cm
100% Organic	40.08	28.60
50% Organic + 50%Inorganic	41.38	33.13
100% Inorganic	48.48	36.69
Treatment effect: $p<0.05$; Depth effect $p<0.05$; Treatment effect *Depth $p<0.05$		
LTFE Raipur	0-15 cm	15-30 cm
Control	9.69	19.39
100% N	20.36	16.16
100% NP	24.24	14.55
100% NPK	26.51	21.67
100% NPK+ FYM	13.89	18.43
Treatment effect $p<0.05$; Depth effect $p<0.05$; Treatment effect *Depth $p<0.05$		

2.5.10 Major regulating factor of soil microbial autotrophic and heterotrophic contribution in soil C dynamics under different land use system

An automatic linear regression analysis based on forward stepwise method has been executed keeping soil RuBisCO enzyme activity as the dependent variable. Model had adjusted R^2 value of 0.99. It has been found that the major regulating factor of RuBisCO enzyme activity is TN (predictor importance = 0.52) followed by soil pH (predictor importance = 0.27) > NO_3-N (predictor importance = 0.13) >GMea (predictor importance = 0.05). Specific enzyme activity of phenol oxidase in terms of unit of total organic carbon (TOC),has been found to be governed by total glomalin related soil protein (TGRSP; predictor importance = 0.37) > specific activity of protease (predictor importance = 0.34) > specific activity of urease enzyme (predictor importance = 0.23) determined by automatic linear regression analysis (adjusted R^2 value of 0.84). Similarly, for TGRSP the major regulator has been found to be NH_4-N (predictor importance = 0.77) > specific activity of N-acetyl-ß-d-glucosaminidase (NAG; predictor importance = 0.13) (adjusted R^2 value of 0.975) where both of these parameters are negatively correlated to TGRSP. From these multivariate relationships it is quite evident that total N content as well as mineral N content of soil and their dynamics mediated through different N cycling enzymes have played a crucial role in maintaining soil C dynamics. Moreover, TGRSP has been emerged as a great source of soil N underpinning both the autotrophic and heterotrophic C pathways as well.

2.5.11 Differential partitioning of seed inhabiting methylotrophs in endospheres of wheat plant

Experiments were conducted to quantify microbial population in seed, root, stem and leaves of wheat plants (variety HI 8759 Pusa Tejas and HI 1605 Pusa Ujala). Methylotrophs were quantified both by culturing and real time PCR targeting methanol dehydrogenase gene (MXF). In general, the abundance of endophytic methylotrophs varied in the order of leaf > stem > root > seed. The major endophytes of wheat plant were *Methylobacterium* sp. *Methylorubrum* sp. *Pantoea* sp. *Microbacterium* sp. *Curtobacterium* sp. *Pseudomonas* sp. *Rhizobium* sp. and *Burkholderia* sp. Methylotrophs occurring in root exhibited higher N fixing and P solubilizing properties than those were found in shoot. No pink pigmented methylotrophs were observed in root tissue. To undermine the selective occurrence of methylotrophs, plant extracts were further analyzed in HPLC-MS. Results highlighted that methylotrophs from seed are preferentially transmitted to shoot but not to root, and this phenomenon is regulated by analkaloid identified as pegamine (Plate 2.5.11).

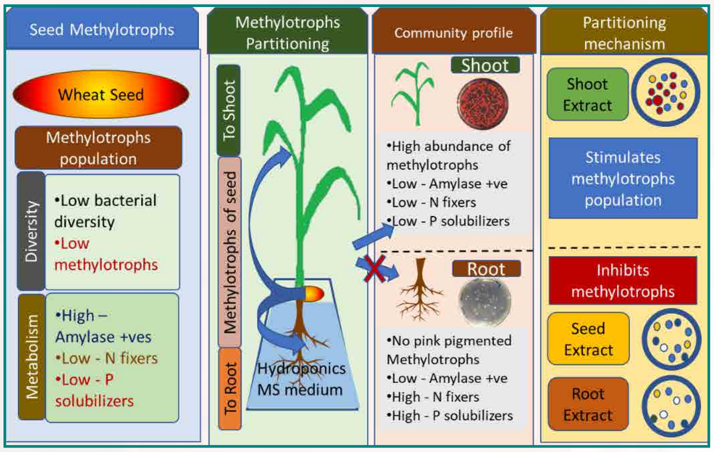


Plate 2.5.11 Partitioning of methylotrophs in plant parts of wheat

2.6 AINP on Soil Biodiversity and Biofertilizer

2.6.1 Siderophore based microbial formulation to improve nutrient utilization

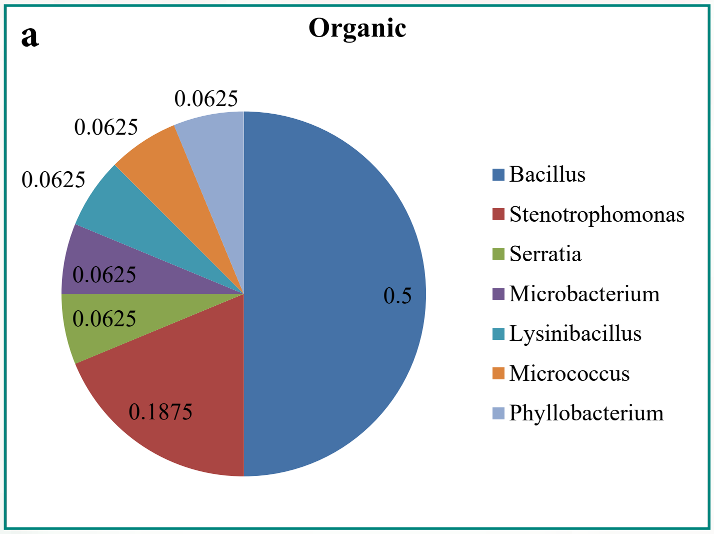
A phosphorous solubilizing bacterium isolated from soil, identified as *Parabur kholderia* sp. igkv1, was sequenced and studied for its effect on legume nodulation. Inoculation of this bacteria along with or without *Bradyrhizobium* sp. BRP2 improved nodulation in soybean, chickpea and pigeonpea under field as well as in plants grown in sterile sand. Further investigations involved extracting siderophores from the bacterium using an XAD amberlite column, testing their phosphate solubilization capabilities. Remarkably, these siderophores were effective at solubilizing complex phosphate salts such calcium phosphate, aluminum phosphate, and ferrous phosphate, making them more accessible to plants. This solubilization activity, alongside the chelation of ferric ions essential for nodulation, suggests a dual effect on legumes. A subsequent experiment tested various concentrations of siderophores (0.1,0.5, and 1 mM) on chickpea, soybean and pigeonpea, with the 1mM concentration proving most effective for improving nodulation. This study underscores the potential of using a siderophores-Rhizobium combination as a biofertiizers to enhance biological nitrogen fixation in legumes (Plate 2.6.1).

2.6.2 Diversity of bacterial endophytes in floriculture crop chrysanthemum

A study was conducted to evaluate endophytes of floriculture crop chrysanthemum (*Dendranthema grandiflora* tzvelev) at the AINP SBB centre located at YSPUHF, Solan, Himachal Pradesh. Crop was grown under organic and inorganic fertilizer treatments. A total 44 bacterial endophytes showing plant growth promoting traits were selected for sequencing of 16S rDNA. Amplification of all the bacterial isolates produced an amplicon of 1400 bp size.Sequence analysis revealed the presence of bacteria belonging to 14 different genera.The isolates exhibited nucleotide homology of 91 to 99.77%. Bacterial isolates under organic teatment were dominated by *Bacillus* (50%), *Stenotrophomonas* (18.75%) and 6% each of *Lysinibacillus, Micrococcus, Phyllobacterium, Serratia* and *Microbacterium.* Isolates from inorganic treatment were 39.28% *Bacillus,* 10.71% *Stenotrophomonas,* 10.71% *Pseudomonas,* 14.28 % *Serratia* and 3.57% each of *Cellulosi microbium,*

Plate 2.6.1 Evaluation of siderophore based bioformulation in pigeon pea and soybean

Streptomyces, Klebsiella, Pantoea, Arthrobacter, Microbacterium and *Staphylococcus.* Study highlighted that organic fertilizer enhanced endophytic bacterial diversity in floriculture crop compared to inorganic amendment (Fig. 2.6.2).



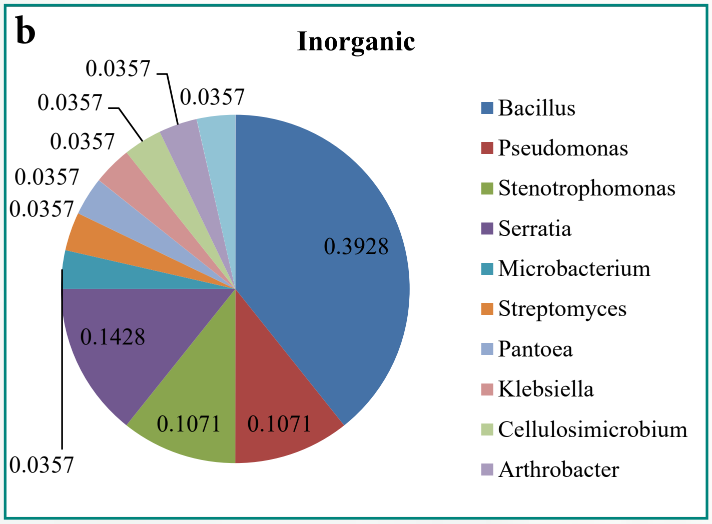


Fig.2.6.2 Endophytic bacterial diversity under (a)organic and (b)Inorganic amendments

2.6.3 Millet biofertilizers demonstration for tribal farmers

Biofertilizers effective for millets were developed at the AINP SBB centre located at TNAU Coimbatore. A nutrition deficiency awareness camp organized for the tribal peoples of Sathyamangalam reserve forest tribal villages by ICAR-Sugarcane Research Institute, Coimbatore. Under this program, Azospirillum and Phosphobacteria biofertilizers and millet seeds (Pearl millet, finger millet, kodo millet, and little millet) were supplied as input for the Tribal farmers. For this, 250 ml-sachet of biofertilizers were specially made and supplied to them. Nearly 450 Tribal families from seven villages (Ittarai, Thallamalai, RamarPalam, Kuttikumam, Nagalur, Kottadi, Hasanur) received these bioinputs. The method of application of biofertilizer for millets was demonstrated to the beneficiaries (Plate 2.6.3).

Plate 2.6.3 Biofertilizer sachets (Azospirillum and Phosphobacteria) for millets (Left) and Demonstration of biofertilizer usage for millets to the tribal farmers (Right).

2.6.4 Soil Biological Health Kit –Evaluation at the farmers field

Soil biological health kit or SRI gel probe developed by AINP SBB centre located at TNAU Coimbatore. The kit was demonstrated and distributed to farmers in Tamil nadu for evaluation. Kit measure the respiration rate of the soil, indicating overall biological activities of soil. Each kit contains four SRI gel probes, incubation jars, nutrient amendments, and an instruction manual. Kits were provided to farmer and allowed them to perform the testing by themselves. One hundred thirty farmers each with four soil samples tested about 600 soil samples using this kit. The soils were also analyzed for soil organic carbon, microbial biomass carbon, respiration rate, and dehydrogenase activity. The SRI gel color values were correlated with the observed biological indicators. The farmers showed positive responses to using the SRI gel probe and did not show any troubleshooting or difficulties using the SRI gel probe. They felt that the SRI gel probe was a simple tool, easy to interpret the results, and recommends organic amendments and management practices to improve soil health.

Theme IV : Soil Pollution, Remediation and Environmental security

2.7.1 Impact of fly ash application on soil health and crop yield in Vertisol of Central India

A long-term field experiment was carried out in AEZ 10.1 (ICAR-IISS, Bhopal) to study the effect of fly ash application on soil health and crop productivity. Following the second year of soybean -wheat cropping system, significant increases were observed in both seed and straw yields of soybean with application of 200 t ha^{-1} ash (13% and 15%) and 400 t ha^{-1} ash (17% and 15%), respectively. Notably, soybean seed yield in T4 treatment (Ash 20 t ha^{-1} (every year) along with RDF and FYM @ 5 t ha^{-1}) was significantly higher than that in T12 treatment (Ash 20 t ha^{-1} (every year) along with RDF), which indicates that application of FYM significantly improved soybean seed yield in ash treated soil (Table 2.7.1). Regarding changes in soil physical properties, the bulk density of surface soil layers (0-7.5 cm) and (7.5-15 cm) exhibited a significant decrease (18%) due to ash application of at higher levels ($\geq$200 t ha^{-1}). Additionally, there was an increasing trend in infiltration rate attributed to fly ash application; however, no significant change in soil penetration resistance was observed due to ash applications. Further, higher rates of ash ($\geq$200 t ha^{-1}) application were found to significantly increase the available P content in soil. During the second-year soybean crop (*kharif* season), the considerable rainfall experienced during the plant growth period significantly affected plant growth due to water stagnation. However, in plots receiving high rates of pond ash (200 t ha^{-1} or more), such adverse effects of water stagnation on crop growth were not observed. (Plate 2.7.1).The concentrations of cationic micronutrients Zn, Cu, Fe and Mn in soybean seeds did not exhibit significant changes due to ash application, even at highest rate. However, concentration of boron in soybean grain significantly increased with application of ash @ 200 t ha^{-1} and @ 400 t ha^{-1}. Similarly in soybean straw, concentrations of Fe, Mn, Zn, Cu and B did not change significantly due to ash application even at highest rate.

R1 **R2** **R3**

Plate 2.7.1 Treatments: T2R1, T6R1, T12R1 (1st column downward sequence); T11R2, T8R2, T2R2 (2nd column downward sequence); T4R3, T10R3, T1R3 (3rd column downward sequence).

Table 2.7.1 Growth and yield parameters of soybean crop (2nd year)

Treatment	Nodule no./ plant at 43 DAS	No. of branches/plant			Test weight (g/1000 seed)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
		30 DAS	60 DAS	90 DAS			
T_1	40.8	4.5	5.5	6.3	86.3	2458.3	2716.7
T_2	48.8	4.1	6.5	7.1	88.3	2522.9	2900.0
T3	32.9	4.0	6.1	6.5	88.6	2562.5	2985.4
T_4	53.4	4.8	5.7	6.6	88.1	2604.2	2915.8
T_5	32.0	4.5	6.6	6.7	89.7	2666.7	2914.2
T_6	51.9	4.1	5.2	6.3	87.1	2643.8	2891.7
T_7	43.4	4.7	6.0	6.3	89.3	2650.0	2935.4
T_8	45.3	4.0	5.4	7.1	89.7	2729.2	3012.5
T_9	37.6	4.0	5.5	6.4	92.3	2733.3	3110.4
T_{10}	44.1	4.1	5.9	6.1	91.6	2841.7	3337.5
T_{11}	35.9	3.9	6.2	6.5	92.0	2963.3	3328.8
T_{12}	34.8	4.5	5.5	6.5	85.0	2375.0	2750.0
T_{13}	32.1	4.1	5.3	6.3	86.4	2350.0	2595.8
LSD (P=0.05)	NS	NS	NS	NS	NS	222.88	264.07

T1-Control (only recommended NPK to every crop); T2-FYM @ 5 t ha^{-1} (every kharif season) + Recommended NPK (every crop); T3-Ash 10 t ha^{-1} (every year) + T2; T4-Ash 20 t ha^{-1} (every year) + T2; T5-Ash 40 t ha^{-1} (every year) + T2; T6-Ash 20 t ha^{-1} (every alternate year) + T2; T7 -Ash 40 t ha^{-1} (every alternate year) + T2; T8-Ash 80 t ha^{-1} (every alternate year) + T2; T9-Ash 100 t ha^{-1} (once) + T2; T10-Ash 200 t ha^{-1} (once) + T2; T11-Ash 400 t ha^{-1} (once) + T2; T12-Ash 20 t ha^{-1} (every year) + T1; T13-Only Ash 20 t ha^{-1} (every year).

2.7.2. Wheat residue effect on nitrous oxide emission in Alfisols varied nutrient stoichiometry

Crop residue return and nutrient applications are extensively practiced in agriculture; however, significant uncertainties persist regarding their impacts on nitrous oxide (N_2O) emissions. The present study investigated the responses of N_2O emissions in the Alfisol to four wheat residue application rates (R0: no straw; R5: @5 Mg ha ha^{-1}; R10: @10 Mg ha^{-1}; R15: @15 Mg ha^{-1}) and two management levels (surface and incorporated) under three nutrient (NPK) application rates (N0: no nutrient and NL: nutrient addition to achieve 30% humification in residue level @ 5 t ha^{-1}: NH: 3 x NL) were investigated in laboratory-based soil incubation experiment. The results revealed a significant ($p<0.05$) interaction effect of residue, nutrient application rate, and residue placement on N_2O emission. The N_2O fluxes ranged from -2.3 µg N_2O-N kg^{-1} soil (R5 N0 surface) to 43.8 µg N_2O-N kg^{-1} soil (R10 NH incorporated). Surface return of crop residue decreased the N_2O emission by 171% (N0), 101% (NL), 90% (NH) in R5, 49% (N0), 81% (NL), 90% (NH) and 32% (NH) in R15, respectively. In contrast, higher residue application rates (R10 and R15) and no/low nutrient application rates (N0 and NL) enhanced the magnitude of N_2O emission by 49 to 88% in surface return residue compared to incorporation. In conclusion, this study highlights the need for a holistic approach to agricultural management considering residue application, nutrient strategies, and residue placement techniques to optimize N_2O emissions while ensuring optimal soil health and crop productivity (Fig. 2.7.2).

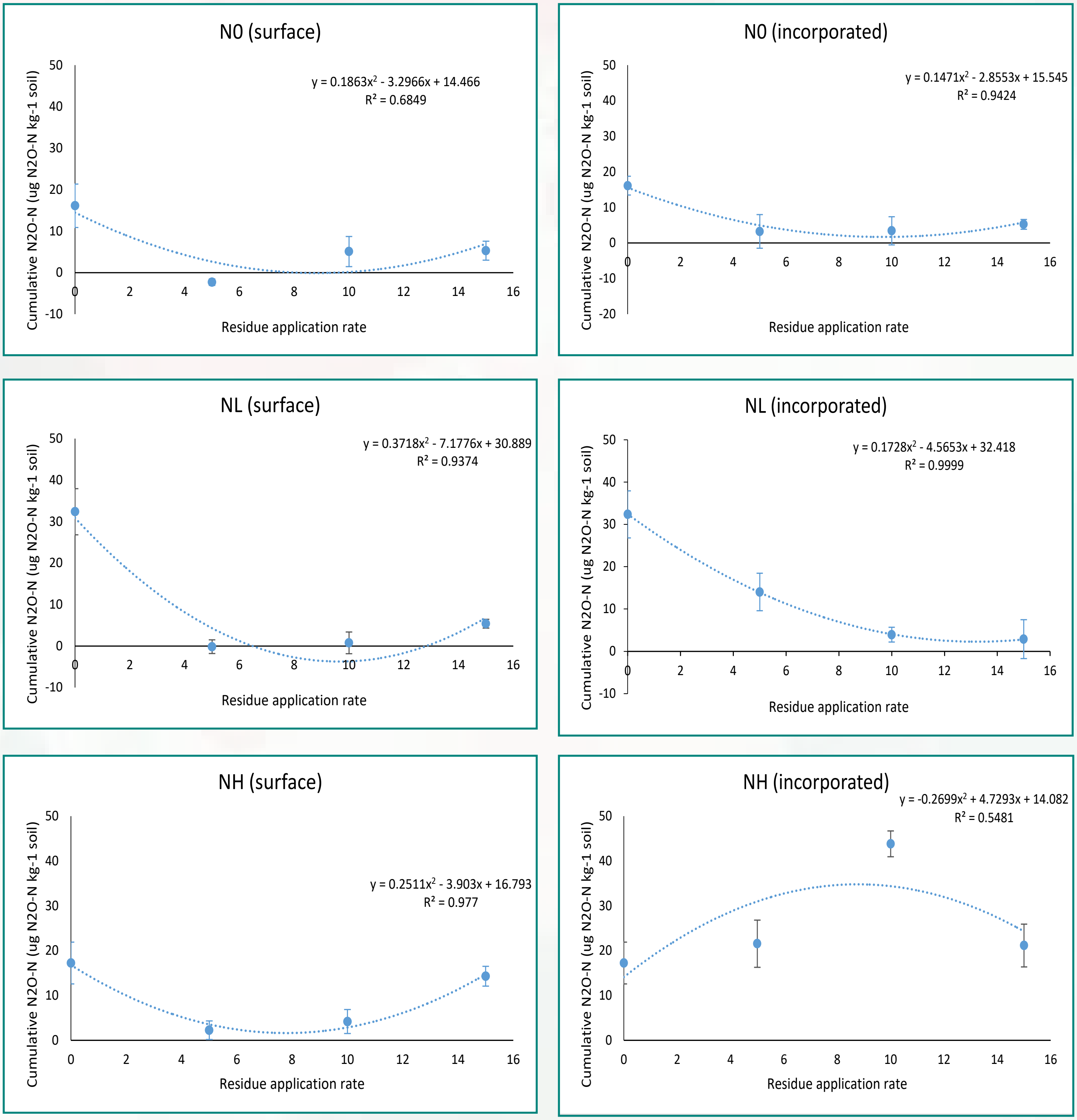


Fig. 2.7.2 Effect of wheat residue application rates and placement under different nutrient stoichiometry on soil nitrous oxide emission in Alfisol

2.7.3 Wheat residue, nutrient levels influence soil carbon, microbial biomass in Alfisols

An experiment was conducted to evaluate the effect of wheat residue application rates (R0: no straw; R5: @5 Mg ha^{-1}; R10: @10 Mg ha^{-1}; R15: @15 Mg ha^{-1}) and two placement levels (surface and incorporated) under three nutrient (NPK) application rates (N0: no nutrient and NL: nutrient addition to achieve 30% humification in residue level @ 5 t ha^{-1}: NH: 3 x NL) on labile soil organic carbon (OC) and soil microbial biomass carbon (SMBC) in laboratory-based soil incubation study. After 116 days of incubation, significant ($p<0.05$) interaction effect were observed between residue application and nutrient rates,and residue placement on labile OC. However, significant interactions ($p<0.05$) were found only between residue application rate and placement, and between residue application rate and nutrient on SMBC. Labile OC was the lowest in treatment receiving residue @10 Mg ha^{-1} with surface application and NH (403.26 mg kg^{-1} soil), compared to 528.87 mg kg^{-1} soil in treatment with residu @15 Mg ha^{-1} incorporated and NL. The effect of residue application @10t ha^{-1} with surface placement under N0 nutrient showed the lowest SMBC (218.15 mg kg^{-1} soil), while surface application of residue @15 t ha^{-1} under low nutrient exhibited the highest (1064.68 mg kg^{-1} soil) (Fig. 2.7.3).

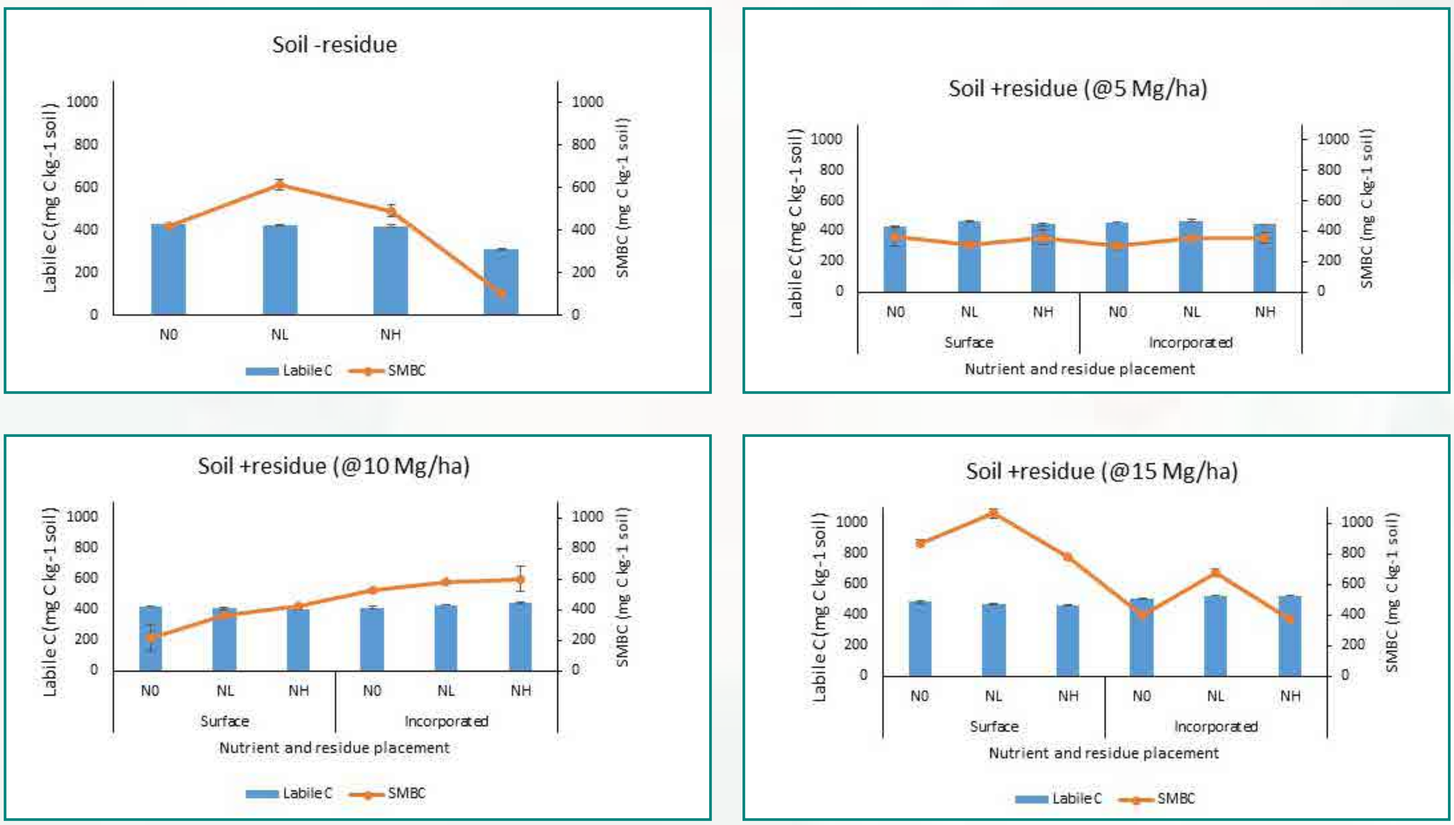
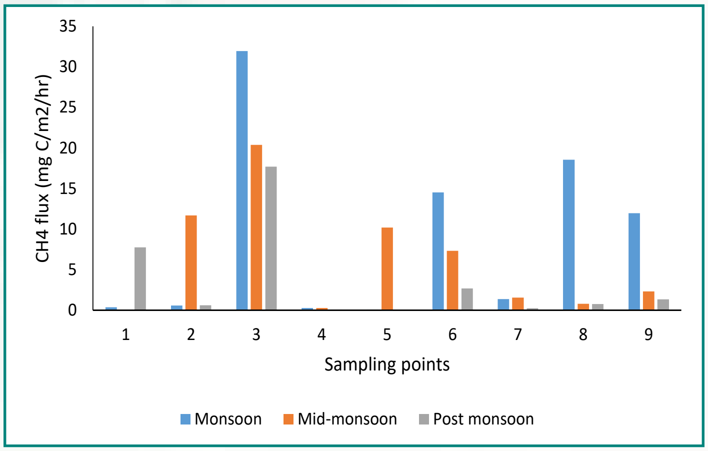


Fig. 2.7.3 Effect of wheat residue application rates and placement under different nutrient levels on labile soil organic carbon and soil microbial biomass carbon in Alfisol

2.7.4 Spatiotemporal changes in water and sediment: physicochemical properties, nutrient dynamics, and greenhouse gas emission in the Bhoj wetland

A study was undertaken to assess the effect of different land uses and inlet sources on the water quality of the upper lake of Bhoj wetland. In this study, sampling was done from nine locations based on the inletsources. The results indicated that most water quality parameters are within the acceptable limit of WHO except for nitrate, phosphate, and BOD in both seasons (monsoon and winter). Nitrate (0.5 mg L^{-1}) and phosphate (0.1 mg L^{-1}) were above the eutrophic threshold limit, except for nitrate during monsoon season. Among the nine sites, Karballa (site no 3) showed the poorest water quality and the highest emission of greenhouse gases (methane and nitrous oxide) due to urban sewage influx from Bhopal city (Fig. 2.7.4).



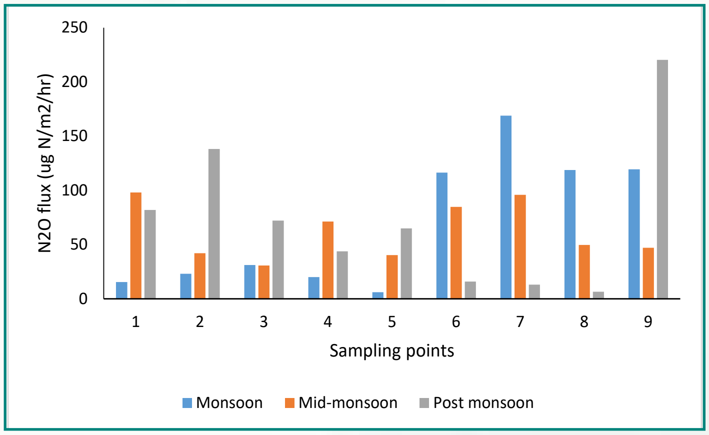
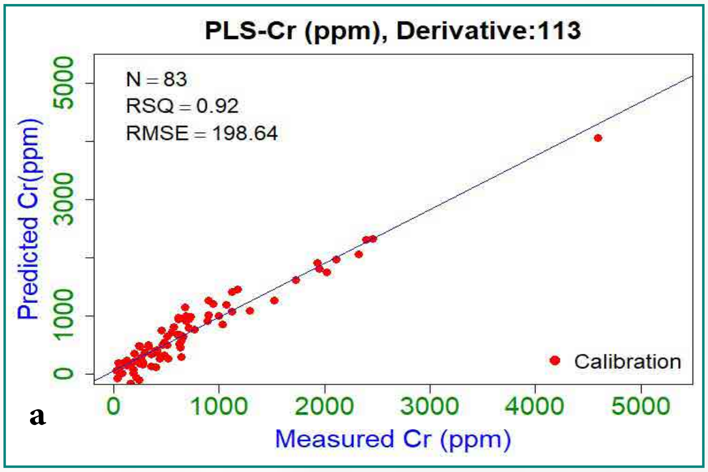


Fig. 2.7.4 Spatio-temporal changes in methane and nitrous oxide emissions in the Bhoj wetland, Bhopal.

2.7.5 Prediction of Chromium content in alluvial soil of Jajmau Industrial area, Kanpur using Visible Near Infrared (VNIR) Spectroscopy

The Jajmau industrial area in Kanpur has more than 400 tanning industries located along the left bank of Ganga River. This region, where discharge waste accumulates and the dumping site are located, is severely contaminated with chromium. A total of 116 geo-referenced surface soil samples were collected gridwise at an interval of 250 meters. Soil diffuse reflectance spectra were recorded for each soil sample using a FieldSpec Pro FR spectroradiometer (Analytical Spectral Devices Inc., Boulder, Colorado) at wavelengths ranging from 350 to 2500 nm with a spectral sampling interval of 1 nm at ICAR-NBSSLUP,



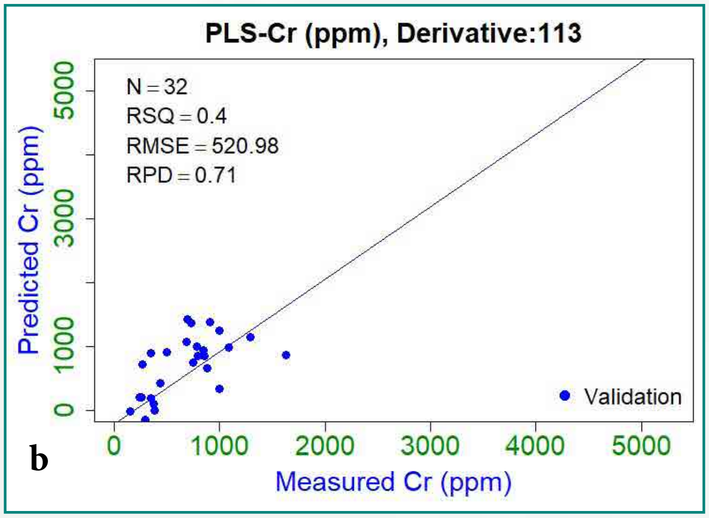


Fig. 2.7.5 The calibrated (a) and validated (b) PLSR model for predicting Chromium content (ppm) in Jajmau soil

Nagpur. The spectral values were associated with point data at 10 nm interval. The Partial Least Square Regression (PLSR) model was developed using R studio software to rapidly estimate the Chromium content (ppm) in soil. The model was evaluated using an independent dataset with first derivative using statistical criteria such as the ratio of performance of deviation (RPD), coefficient of determination (R^2) and root mean square error (RMSE). The R^2 (0.92 and 0.4) and RMSE (198.64 and 520.98) values for calibration and validation indicates that chromium could be predicted with reasonable accuracy using Visble Near Infrared (VNIR) Spectroscopy (Fig. 2.7.5).

2.7.6 Heavy metal distribution in soils of Singrauli coal mine areas

Geo-referenced soil samples were collected from the Singrauli open cast coal mine viz. Jhingurda and Jayant areas as well as from agricultural fields in nearby mine site villages viz. Madhauli, Marwani, Banauli, Bindhanagar and Gharauli. The average concentration of Zn, Cu, Cd and Ni in Jhingurda coal mine site samples exceeded the desirable maximum level outlined for unpolluted soils (WHO, 1996) which were 50, 36, 0.8 and 35 ppm, respectively. Moreover, the average concentration of Zn in Jayant coal - sludge samples were beyond the desirable maximum level set for unpolluted soils (WHO, 1996) which were 50 and 35 ppm, respectively. In addition, Ni concentration in coal sludge samples from Jayant mine site significantly exceeded the permissible limit of 35 ppm (Table 2.7.6).

Table 2.7.6 Descriptive statistics of total heavy metal content (ppm) of Singrauli coal mine areas

Places	Sample	Parameter	Fe	Mn	Zn	Cu	Cd	Co	Cr	Pb	Ni
Jhingurda Mine site	Coal	Min	4372.50	100.65	98.51	37.05	0.90	19.98	52.34	15.20	64.81
		Max	4628.55	210.52	107.05	42.51	1.10	26.35	60.55	19.47	77.20
		Mean	4500.53	155.59	102.78	39.78	1.00	23.17	56.45	17.34	71.01
	Mine soil	Min	4716.50	118.55	23.80	21.85	0.20	16.25	56.05	27.30	31.25
		Max	4923.00	237.60	50.40	21.90	0.85	16.40	90.45	35.35	32.25
		Mean	4819.75	178.08	37.10	21.88	0.53	16.33	73.25	31.33	31.75
Jayant Mine site	Coal	Min	3734.00	494.50	64.00	21.60	0.10	7.00	31.85	7.05	11.05
		Max	4061.50	567.50	68.35	23.90	0.25	7.75	39.75	8.55	12.50
		Mean	3897.75	531.00	66.18	22.75	0.18	7.38	35.80	7.80	11.78
	Coal sludge	Min	3578.00	692.00	116.35	30.05	0.15	37.40	40.30	33.80	54.70
		Max	4316.50	737.00	118.05	30.40	0.18	37.80	56.20	34.60	55.75
		Mean	3947.25	714.50	117.20	30.23	0.17	37.60	48.25	34.20	55.23
Marwani dam site	Soil	Min	7760.00	303.75	39.35	16.70	0.05	6.95	20.20	21.05	11.65
		Max	8025.00	316.75	46.90	22.25	0.08	7.35	71.50	29.25	17.75
		Mean	7892.50	310.25	43.13	19.48	0.07	7.15	45.85	25.15	14.70
Agricultural field	Soil	Min	6575.00	190.20	22.35	17.75	0.05	7.00	24.10	8.70	11.90
		Max	10940.00	473.65	113.25	55.05	0.40	22.05	105.05	26.80	51.35
		Mean	8973.08	352.21	45.83	35.51	0.17	12.48	61.24	15.15	27.00

2.7.7 Sustainable uses of municipal sludge in leafy vegetable (*Spinacia oleracea* L.) production

Urbanization and the proliferation of sewage treatment plants (STPs) have led to a significant increase in the production of municipal sludge, much of which is reportedly being disposed of in open fields. The present investigation aimed to assess the performances of dry- (DS) and fresh- (FS) municipal sludge on spinach yield under mesocosm column experiment . The treatments comprised of graded doses of DS and FS (equivalent of 0, 20 and 40 t ha^{-1}), along with biochar (equivalent of 0, 5 and 10 t ha^{-1}) and lime (0.8 t ha^{-1}). Results revealed that the plant uptake (major-, micro-, and toxic metals), soil health and leachate parameters (pH, EC, micro-, and toxic metals) have significantly increased over control. Higher doses of biocharled to improvements in seed germination percentage, leaf and root dry weight, and chlorophyll content, while reducing NO_3^--N, Fe, Mn, Zn, Cu, and Pb content in the leachate. However, reduced activities of dehydrogenase (DHA) and Fluorescein diacetate (FDA) were observed under DS as compared to FS. Spinach uptake of metals remained below permissible limits, and hazard quotient (HQ) calculations indicated the safe utilization of municipal sludge (particularly at 40 t ha^{-1} with 10 t ha^{-1} biochar) for spinach production without adverse effects on environmental sustainability or the human food chain In long run, application of municipal sludge may enhance the crop-soil performances and potentially contribute to soil C sequestration.

2.7.8 Impact of fly ash as soil medium on crop yield and heavy metal contamination in plant

Fly ash is recognized as a beneficial soil amendment and a source of certain plant nutrients, particularly micronutrients. It has the potential to enhance the physico-chemical properties of soil by increasing porosity and water holding capacity. A study was conducted to assess the impact of fly ash, both alone and in combination with various amendments (such as FYM, biochar, pond silt, and biogas slurry), on spinach crop yield and the assessment of heavy metal risk potential in soil and plants. In all treatments, the recommended dose of NPK fertilizer for spinach crop was applied as a basal application (50% N and full dose of P and K), with the remaining fertilizer (50% N) applied 15 days after sowing. The results indicated a significant effect on the dry matter yield of spinach leaves and roots in pots where fly ash was used as a soil medium, either alone or in combination with various amendments. The dry matter yield of spinach leaves (6.23 g pot^{-1}) and roots (1.73 g pot^{-1}) was highest in pots containing alluvial soil and lowest in pots where fly ash alone was used as a soil medium. However, the addition of various amendments (FYM, biochar, pond silt, and biogas slurry) to fly ash at both application rates (5% and 10%) significantly improved the dry matter yield of spinach crops, except in the case of biochar-treated fly ash medium. A similar trend was also observed in the dry matter yield of lablab crops (Table 2.7.8 & Plate 2.7.8).

Table: 2.7.8. Effect of fly ash as soil medium on dry matter yield of spinach crop

Treatment	Spinach DMY (g/pot)	
	Leaf	Root
Alluvial Soil	6.23^{a}	1.73^{b}
Fly Ash alone	5.30^{c}	0.90^{e}
Fly Ash + FYM (5%)	5.73^{b}	1.33^{cd}
Fly Ash + FYM (10%)	6.31^{a}	1.62^{b}
Fly Ash + Biochar (5%)	5.33^{c}	1.10^{de}
Fly Ash + Biochar (10%)	5.40^{c}	1.47^{bc}
Fly Ash + Pond Silt (5%)	5.94^{b}	2.10^{a}
Fly Ash + Pond Silt (10%)	6.23^{a}	1.73^{b}
Fly Ash + Bio Gas Slurry (5%)	5.30^{c}	0.90^{e}
Fly Ash + Bio Gas Slurry (10%)	5.73^{b}	1.33^{cd}

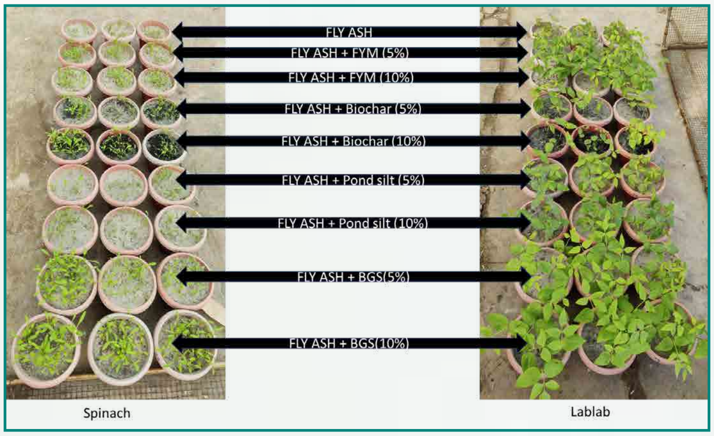


Plate. 2.7.8 Fly ash as soil medium and its effect on spinach growth

2.7.9 Preparation and characterization of municipal sludge biochar product for safe utilization in agriculture

A study was conducted to prepare municipal sludge biochar (MSB) and evaluate the impact for sustainable crop production and soil health. Municipal Sludge (MS) was collected from the landfill site of the Sewage Treatment Plant (STP) located in Sehore. Subsequently, the dry sludge underwent processing, resulting in the preparation of municipal sludge biochar (MSB) using a batch-type tubular stainless steel Pyrolyzer (pyrolysis reactor) at ICAR-CIAE, Bhopal. The reactor was fabricated from stainless steel sheet with an internal diameter of 100 mm and length of 600 mm. In each batch, 1 kg of dried MS was loaded into a perforated cassette which was placed inside the reactor. The parameters like temperature (450°C) and residence time (2hrs) were optimized for better recovery of biochar (40%). The prepared MSB were processed, air dried and characterized using standard protocol. The result indicates that the pH of municipal sludge (MS) and municipal sludge biochar (MSB) were 6.54 and 6.84, respectively. Electrical conductivity (EC) of MS and MSB was 3.77 and 1.59 d Sm^{-1} respectively. Furthermore, fecal coliform presence was found to be absent in MSB, while it measured 4.7×10^{3} MPN g^{-1} dw as per the method of APHA 23rd Edition in MS (Plate 2.7.9).

Plate. 2.7.9 Municipal Sludge Biochar

2.7.10 Hydrothermal modified fly ash for remediation technology of heavy metal (Cd, Pb and Cr) contaminated soil

Weathered fly ash samples from Singrauli were hydrothermally modified in two ways: ash sample was treated with 3N HCl at 90-95 °C for 48 hrs with occasional stirring followed by washing with distilled water (AcMFA) and ash sample was treated with 3N NaOH at 90-95 °C for 48 hrs with occasional stirring followed by washing with distilled water (AlMFA). Cation exchange capacity (CEC) of AlMFA increased considerably (113 meq/100g) as compared to AcMFA (2.4 meq/100g) and untreated ash (UFA: 3.4 meq/100g). The sorption of heavy metals increased with pH of the solution. AlMFA completely removed Cd and Pb from solution due to significant increase in CEC. On the other hand, acid treatment reduced sorption of Cd and Pb at pH 5 and 7. The XRD and FTIR results showed that mineralogical changes occurred during alkali/NaOH treatment might have helped cadmium and lead adsorption. The alkali/NaOH treated fly ash exhibited structural changes in Si-O-Fe bonding and allophane mineral formation. The application of modified fly ash (@ 5%) not only countered the Cd toxicity but also improved the spinach biomass growth by more than 15% compared to uncontaminated soil. Application of AIMFA resulted in reduction in DTPA extractable Cd (>28%) and spinach leaf Cd (45%). The highest per cent reduction of 55.6% in spinach leaf Pb content as compared to control was observed in a Pb contaminated soil amended with alkali modified fly ash. Similarly, the highest per cent reduction of 64.6% in spinach leaf Cr content as compared to control was observed in a Cr contaminated soil amended with acid modified fly ash. To conclude, application of alkali modified fly ash as soil amendment has greater potential in reducing the mobility of heavy metal in soil and its subsequent transfer to edible plant parts (spinach leaf) as evidenced by reduction in DTPA extractable Cd & Pb in soil and lower transfer coefficient value in a Cd and Pb Contaminated soil (Fig. 2.7.10 & Plate 2.7.10).

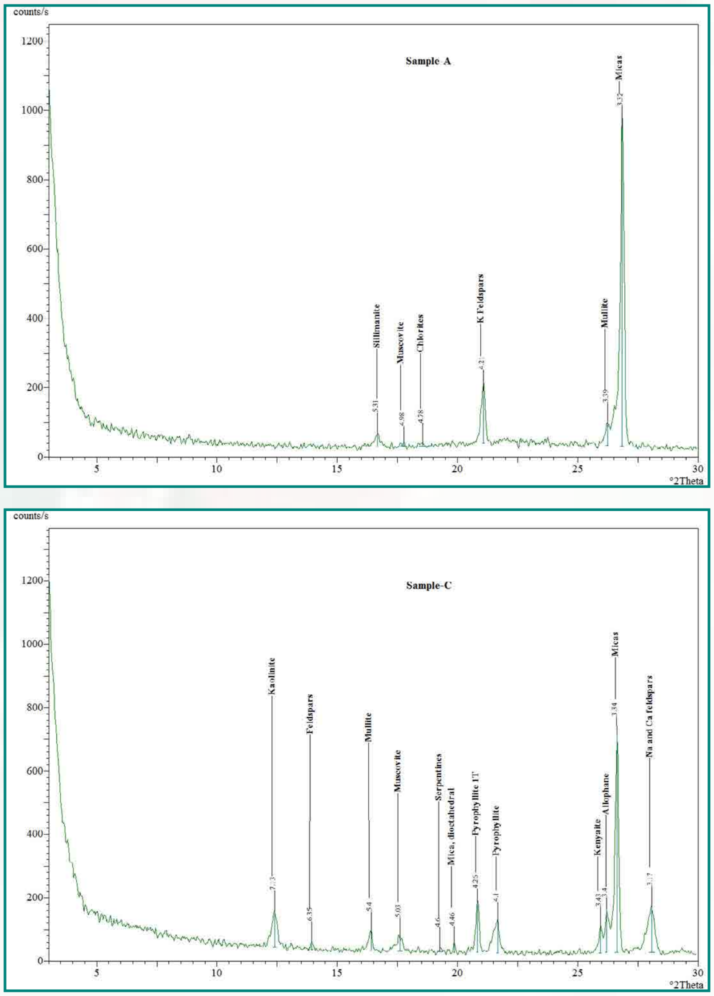


Fig. 2.7.10 XRD patterns of the hydrothermal modified fly ash

Fig. 2.7.10 Pot culture experiment showing the effect of various amendments addition on spinach growth in a Cd contaminated soil

2.7.11 Municipal solid waste co-composting with zeolite and pigeon pea biochar as additives for heavy metal stabilization and safe disposal

Soil amended with increasing levels of compost (uncontaminated MSWC, contaminated MSWC, co-composted products of MSWC and physical mixture with additives MSWC) from 80 to 120 t ha^{-1} resulted in significant increase in SOC content at the end of 60 days after incubation over control (no compost addition). Significant effect on pH and EC was also observed in the uncontaminated and contaminated MSWC amended soil over control. The 1M $CaCl_2$ and DTPA extractable Cd, Pb and Ni was significantly higher in contaminated MSWC as compared to control and uncontaminated MSWC at their respective level of application (40, 80 or 120 t ha^{-1}) (Fig. 2.7.11a). The results further revealed that increase in period of incubation from 0 to 60 days, resulted in significant decrease in 1M CaCl2 and DTPA extractable Cd,

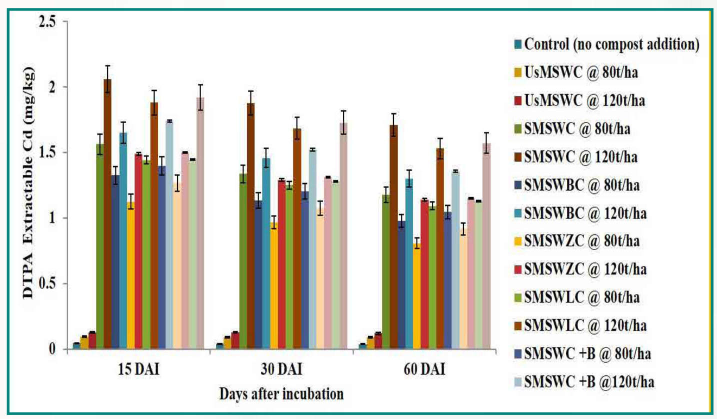


Fig. 2.7.11a Effect of MSWC and co-compost with additives on DTPA extractable cadmium content in soil over 60 days period

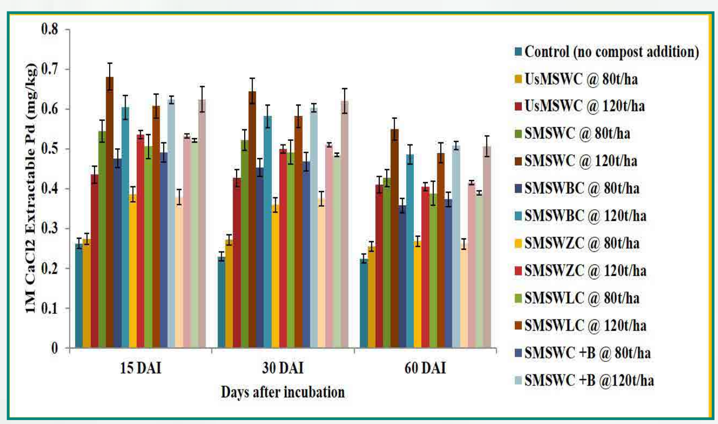


Fig. 2.7.11b Effect of MSWC and co-compost with additives on 1 M $CaCl^2$ extractable cadmium content in soil over 60 days period

Pb and Ni. Among the co-composted products or physically mixture compost products, soil amended with municipal solid waste zeolite compost (MSWZC), municipal solid waste biochar compost (MSWBC) and municipal solid waste lime compost (MSWLC) showed significantly greater reduction in bioavailable content (1M $CaCl_2$ and DTPA extractable Cd, Pb and Ni) over contaminated MSWC. The average per cent reduction in DTPA extractable Cd, Pb and Ni from the incubation study was highest in soil amended with co-composed product of zeolite MSWZC (33, 27 and 20%) followed by MSWBC (21, 12 and 10%) and CMSWLC (9, 6 and 10%), respectively. Similarly, the average per cent reduction in 1M $CaCl_2$ extractable Cd, Pb and Ni was highest in soil amended with co-composed product of zeolite SMSWZC (37, 32 and 25%) followed by SMSWBC (20, 14 and 10%) and SMSWLC (17, 10 and 7%), respectively (Fig. 2.7.11b). The results from the pot culture experiment also revealed that among the co-composted products, municipal solid waste zeolite compost application significantly improved spinach yield, improved soil fertility, reduced the bioavailable heavy metal content in soil and reduced the heavy metal mobility (transfer coefficient values) from the soil to the plant system.

3 TRANSFER OF TECHNOLOGY

3.1 TOT by ICAR-IISS

3.1 Capacity Building Programmme

3.1.1 Frontline Demonstrations under the Farmer FIRST Programme

Under the crop and natural resource management modules, 60 frontline demonstrations (FLDs) were carried out in an area of 24.28 hectares in six villages of Bhopal district in Madhya Pradesh for *kharif* crops viz., soybean (JS-2069) and rice (PB-1637) and *rabi crops* viz., wheat (HI-1544) and chickpea (RVG-202) during the 2023-24. Yield from the soybean crop grown under conservation agriculture-based tillage and nutrient management (17.9 q ha^{-1}) was almost equal to that of farmers practice (17.4 q ha^{-1}). However, yield form the rice crop under the intervention (39.8 q ha^{-1}) was not so promising compare to farmers' practice (53.1 q ha^{-1}). Yields of wheat and chickpea crops (2022 *rabi* season) recorded as 50.2 q ha^{-1} and 17.3 q ha^{-1}, respectively under the intervention and that of farmers' practice were 46.5 q $ha^{-1}$and 15.3 q ha^{-1}, respectively.

Under the horticulture module, 53 FLDs on package of practice recommendations for improved vegetable production were carried out in an area of 5.62 ha for brinjal (40) and okra (13) crops. Crop yields from these FLDs recorded as 39.3 t ha^{-1} for brinjal and 13.4 t ha^{-1} for okra crops. Also, under conservation agriculture based Agri-horti system area under fruit crops like Mango (Dussheri), Guava (L-49) and Lemon (Kagzi lime) were expanded from 11.1 ha to 14.2 ha.

Paddy crop under Direct Seeded system

Soybean crop under Zero tillage system

Performance of Okra crop under package of practice recommendations

Performance of Brinjal under package of practice recommendations

On farm demonstration of 'microbial decomposer based in-situ residue recycling' was conducted in the FFP villages Khamkheda, Kalyanpura, Bherupura, Kanchbavli during May 16-17, 2023.

Input Distribution

Under the FFP programme, portable vermibeds, seedlings of fruit plants and fertilizers were distributed to the project farmers during June 02-04-2023.

Distribution of fertilizers to farmers

Distribution of fruit plant seedlings to farmers

Under TSP project activities for the *kharif* 2023, liquid bio-formulations were distributed to 200 tribal farmers of 6 villages in the Betul district of Madhya Pradesh during June 02-04, 2023.

Seed packets of 30 quintals of HYVs of paddy, 10 quintals of summer green gram seeds and 75 number of vermibeds were distributed to 100 tribal farmers of Rajnandgaon district, Chhattisgarh to improve the seed replacement ratio with high yielding rice varieties and balanced nutrient management for maintaining soil health. In Barwani district of MP, 10 q wheat and 10 q chickpea was distributed to tribal Farmers.

Microbial based agricultural waste management using vermicomposting

Mother culture multiplication was done at ICAR-IISS Bhopal. 135 kg worm mother culture was multiplied during the period of January - December 2023 for distribution to the farmers under the Swachhata Action Plan(SAP) project in the adopted villages.

Distribution of vermi beds and worm mother culture

vermibeds were distributed to the farmers for establishment of vermicomposting units for safe disposal of farm waste, thus promoting swachhta in the village and creating wealth out of waste. Worm mother culture was also provided to the farmers for establishment of vermicomposting units.

S. No	Name of Village	No. of Vermibed	Worm Mother Culture (Kg)	Date
1	Beenapur	-	6	23.01.2023
2	Khajuri	4	6	24.04.2023
3	Beenapur		8	25.04.2023
4	Rasuliya Pathar, Ratibad	5	10	04.08.2023
5	Khajuri, Khamkheda	-	8	10.08.2023
6	Rasuliya, Pathar, Beenapur	-	10	22.08.2023
7	Beenapur, Ratibad	3	8	18.09.2023
8	Rasuliya Pathar	2	8	21.09.2023
9	Khajur	2	10	02.11.2023
10	Rasuliya, Pathar	4	4	08.11.2023
11	Khajur	4	8	13.11.2023
12	Beenapur	2	6	17.11.2023
13	Ratibad	-	8	04.12.2023
14	Rasuliya, Pathar		6	07.12.2023
15	Ratibad	2	10	15.12.2023
16	Rasuliya, Pathar		8	21.12.2023
	Total	**28**	**124**	

Multiplication of microbial cultures for in situ crop residue management

The microbial cultures were multiplied on large scale in laboratory, for preparation of capsules. These capsules will be distributed among the farmers and also to set up demonstration of in situ decomposition of wheat residue in selected villages. The farmers visiting the institute were elaborated about use of decomposer capsules for composting in field and pit. The microbes in capsules can be easily activated by the farmers in Sugar-Bran solution to use in compost pit.

Multiplication of microbial cultures

Decomposer capsules packet

Swachhata awareness campaign

Various activities were organized under the Swachhata Action Plan (SAP) project in different villages by the institute for developing capacity building of the farmers for rapid recycling of farm wastes through vermicompost techniques. Farmers were made aware to eliminate open defecation and efficient crop residue management without burning. The various activities were organized as detailed given below;

S. No	Name of village and institute	No. of participants	Date
1	Ratibad	25	18.01.2023
2	Rasuliya Pathar	10	12.02.2023
3	Beenapur	15	16.02.2023
4	Khajuri	15	20.02.2023
5	Rasuliya Pathar	25	06.03.2023
6	Beenapur	25	14.03.2023
7	Ratibad	20	15.03.2023
8	Khajuri	20	17.03.2023
9	Khamkheda	20	20.03.2023
10	Swachhta campaign at ICAR-IISS, Bhopal	60	02.03.2023
11	Rasuliya Pathar	80	12.06.2023
12	Ratibad	30	28.06.2023
13	Khamkheda	25	13.07.2023
14	Beenapur	25	25.09.2023
15	ICAR-IISS Bhopal	16	27.09.2023
16	ICAR-IISS Bhopal	20	29.09.2023
17	ICAR-IISS Bhopal	15	01.10.2023
18	ICAR-IISS Bhopal	20	02.10. 2023
19	Ratibad	40	03.10.2023
20	Beenapur	20	04.10.2023
21	Hinoti Sadak	15	05.10.2023
22	Rasuliya Pathar	20	06.10.2023
23	Beenapur	15	09.10.2023
24	ICAR-IISS Bhopal	40	10.10.2023
25	ICAR-IISS Bhopal	20	11.10.2023
26	Khamkheda	20	12.10.2023
27	Raipur	20	13.10.2023
28	Khamkheda	60	16.10.2023
29	Shahpur	15	17.10.2023
30	ICAR-IISS Bhopal	20	18.10.2023
31	Khajuri	15	19.10.2023
32	ICAR-IISS Bhopal	25	20.10.2023
33	Kalyanpur	100	23.10.2023
34	Barkhedi Hazzam	15	25.10.2023
35	ICAR-IISS Bhopal	20	26.10.2023
36	ICAR-IISS Bhopal	15	27.10.2023
37	ICAR-IISS Bhopal	20	30.10.2023
38	Shahpur	20	31.10.2023
39	ICAR-IISS Bhopal	10	16.12.2023
40	ICAR-IISS Bhopal	15	17.12.2023
41	Raipur	20	18.12.2023
42	Swachhta Pakhavada ICAR-IISS Bhopal	20	19.12.2023
43	Swachhta Pakhavadal ICAR-IISS Bhopal	190	20.12.2023
44	Swachhta Pakhavada ICAR-IISS Bhopal	200	21.12.2023
45	Swachhta Pakhavada ICAR-IISS Bhopal	30	22.12.2023
46	Kisan Diwas at Rasuliya Pathar	135	23.12.2023
47	Hinotiyajagir	15	24.12.2023
48	Raipur	15	25.12.2023
49	ICAR-IISS Bhopal	20	26.12.2023
50	ICAR-IISS Bhopal	30	27.12.2023
51	ICAR-IISS Bhopal	40	28.12.2023
52	ICAR-IISS Bhopal	190	29.12.2023
53	ICAR-IISS Bhopal	30	30.12.2023
54	ICAR-IISS Bhopal	20	31.12.2023
	Total	**1981**	

Pledge ceremony and Tree plantation on the occasion of Swachhta Pakhwada

Kisan Divas (Farmer's Day) was organized on the occasion of National Farmers Day at Rasuliya Pathar, Bhopal, Madhya Pradesh on December 23, 2023. In this program, about 150 farmers from Rasuliya Pathar, Tara Sewaniya, Ratibad, Ratanpur and Kalakedi and Scientists from IISS, Bhopal have participated. Scientists delivered the lectures on different aspects and advised farmers about vermicomposting techniques, microbial-based vermicomposting to manage crop residue, balanced fertilization through soil testing, conservation agriculture and management practices for horticulture crops. Besides, farmers are also sensitized about the cleanliness and sanitation activities during the program.

Kisan Diwasat Rasuliya Pathar

Training programs

Various training program were organized under the Swachhta Campaign in different villages by the institute involving farming community and members of the civil society. Farmers were made aware to eliminate open defecation and encouraged to adopt efficient crop residue management practices without burning. Various training program were organized as detailed below:

S. No	Name of Village/ Event	No. of participants	Date
1.	Trainees from CIAE, Bhopal	30	02.01.2023
2.	Farmers from Beenapur and Hinoti Sadak	50	16.01.2023
3.	Farmers from Beenapur and Khajuri	50	23.01.2023
4.	Farmers from Ratibad village	30	24.01.2023
5.	Tribal farmers from different villages	50	25.01.2023
6.	Farmers from Rasuliya Pathar village	30	26.01.2023
7.	Farmers from Rasuliya Pathar and Ratibad	30	30.01.2023
8.	Farmers from Ratibad village	25	06.02.2023
9.	Beenapur	30	22.06.2023
10.	Khajuri	35	26.06.2023
11.	Rasuliya Pathar	20	30.06.2023
12.	Beenapur	30	07.07.2023
13.	Khajuri	35	12.07.2023
14.	Rasuliya Pathar	20	18.07.2023
15.	ICAR-IISS Bhopal	50	13.08.2023
16.	ICAR-IISS Bhopal	30	18.08.2023
17.	Ratibad	15	04.09.2023

S. No	Name of Village/ Event	No. of participants	Date
18.	Khamkheda	25	01.11.2023
19.	Beenapur	30	03.11.2023
20.	Rasuliya Pathar	20	07.11.2023
21.	ICAR-IISS, Bhopal	35	16.11.2023
22.	ICAR-IISS, Bhopal	40	20.11.2023
23.	Ratibad	50	06.12.2023
	Total	**760**	

Follow up programme

Regular follow up programs were organised at beneficiary farmer's field. In this program, farmers were instructed to maintain proper moisture in their vermi-beds and use the prepared vermicompost to their fields. The farmers were also made aware about the harmful effects of crop residue burning and the possible ways for recycling the crop residues without burning.

One day training cum workshop on "Improving the livelihood of farm women through managing soil health, waste to wealth and women nutrition was conducted on March 6, 2023 at Borkhedi, Phanda Tehsil in which 150 Farm women participated.

ICAR Foundation & Technology Day, July 16-18, 2023.

ICAR Foundation & Technology Day, July 16-18, 2023.

Dr. H. Pathak, Secretary DARE and DG, ICAR visiting NRM Stall during G20 meet at Varanasi

XVI Agricultural Science Congress of NAAS at ICAR-CMFRI during October 10-13, 2023

10th Bhopal Vigyan Mela at BHEL, Bhopal during September 15-18, 2023

Science Fiesta, Regional Science Centre, Bhopal during January 10-12, 2023

Pusa Krishi Mela during March 2-4, 2023

3.2 Demonstration of Nutrient management technology in the farmer's field

A total of 17 demonstrations on balanced use of fertilizers and integrated nutrient management were conducted during the kharif season from July to November, 2023. Twelve demonstrations on soybeans and five on maize under SCSP at farmer's fields in Raipur, Kanera, Khichital and Karond Khurd villages were undertaken.

Drone demonstration in farmers' field at Parwalia Sadak village

Under the Agri Drone Project, a field-day demonstration of pesticide application through drone was demonstrated amongst the farmers of Parwalia Sadak.

Distribution of agri-inputs to the farmers under SCSP project

Fertilizers and seeds of soybean and maize in kharif and chickpea and wheat in rabi season were distributed during 2023 in different villages of Bhopal under SCSP project.

Climate-smart intervention to reduce greenhouse gas emissions in adopted villages

Climate-smart interventions are crucial to reduce greenhouse gas emissions, and sustainable farming practices offer an effective solution. For example, rice farmers can adopt an alternate wetting and drying (AWD) technique, which involves draining the fields periodically instead of constantly flooding them. Similarly, for chickpea cultivation, adopting reduced tillage and residue management practices can help sequester carbon in the soil and reduce greenhouse gas emissions. These interventions can be further improved by using appropriate fertilizers and drainage systems. By adopting these climate-smart interventions, farmers can contribute to sustainable agriculture and reduce greenhouse gas emissions. In the NICRA-adopted village Momanpur, several climate-smart interventions for rice, chickpea, wheat, soybean, and green gram have been identified using the CCAF-mitigation option tools. These interventions are listed in following table and are currently being implemented in the village.

Climate-smart options for NICRA-adopted village Momanpur

Crops	Farmer practices	Intervention-1	Intervention-2	Intervention-3
Rice	Puddling + N 120 Kg, P_2O_5 60 Kg & K_2O 60 Kg + Residue Burning (8080)	Puddling + N 120 Kg, P_2O_5 60 Kg & K_2O 60 Kg + Residue not Burning (7327)	Puddling + N 120 Kg, P_2O_5 60 Kg & K_2O 60 Kg+ Multiple drainage + Short drainage + Not Burning (3583)	Reduce tillage + N 120 Kg, P_2O_5 60 Kg & K_2O 60 Kg + Multiple drainage+ Long drainage + Residue not burned (2073)
Chickpea	Two tillage + N 40 Kg + P_2O_5 60Kg + Residue not burned (711.8)	One tillage + N 40 Kg + P_2O_5 60Kg + Residue not burned (354)	No-tillage + N 40 Kg + P_2O_5 60Kg + Residue not burned (104)	No tillage+ N 40 Kg + P_2O_5 60Kg + Residue incorporation 2.5 ton + Residue not burned (86.2)
Wheat	Two tillage + N 130 kg, P_2O_5 60 & K_2O 60 Kg + Residue burning (2367)	Two tillage + N 120 kg, P_2O_5 60 & K_2O 60 Kg + Residue Not burning (1487)	Reduce tillage + N 120 kg, P_2O_5 60 & K_2O 60 Kg + Residue Not burning (1129)	No-tillage + N 120 kg, P_2O_5 60 & K_2O 60 Kg + Residue Not burning (879)
Soybean	Two tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Not burned (1111)	One tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Not burned (753)	No-tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Not burned (503)	No-tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Residue 2.5 ton + Not burned (309)
Green gram	Two tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Not burned (920)	One tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Not burned (562)	No-tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Not burned (313)	Two tillage + N 40 Kg, P_2O_5 60 & K_2O 20 Kg + Compost 2.5 Ton + Residue 2.5 Ton + Not burned (-74.0)

(Value in parenthesis is in Kg CO_2 Eq ha^{-1})

On-farm Demonstration of resource conservation technology

To popularize resource conservation technologies among farmers, different packages of RCTs viz, (a) Reduced tillage (RT) + Broad Bed furrow (BBF) + Maize-chickpea; (b) No-tillage (NT) + BBF + Maize-chickpea; (c) RT + BBF + Soybean-Wheat; (d) NT + BBF + Soybean-Wheat; (e) RT + BBF + soybean-chickpea (intercropping, 3:2) and (f) NT + BBF + soybean-chickpea (intercropping, 3:2) were demonstrated. Ten years of continuous treatment showed a 20% increase in maize yield and 15% increase in soybean yield under the BBF system.

Resource conservation technology demonstration on wheat and chickpea

Enhancement of soil health and livelihood of tribals of Barwani district in Madhya Pradesh

During 2023, the agricultural inputs like seeds and planting material were distributed to the tribal farmers in different blocks of Barwani district under TSP project. The field demonstration trials were conducted at different tribal farmer's field to see the effect of improved practices over farmers' practices. Under Improved Practice, improved variety and balanced recommended dose of fertilizers were used and for Farmers' practices, the local variety and imbalance nutrient dose of fertilizer were used. The crop yield of wheat and chickpea was increased by 34.5 to 34.7 % higher under improved practices over farmer's practice.

Frontline demonstrations trial under TSP project in Barwaniof Madhya Pradesh

Name of crops	No of Field Trials	Improved Practices (IP) Average crop yield	Farmers Practices (FP) Average crop yield under	Change in yield (%) over FP
Wheat	50	5990 kg ha^{-1}	4440 kg ha^{-1}	34.7%
Chickpea	66	2210 kg ha^{-1}	1640 kg ha^{-1}	34.5 %

Technology developed

- Mohanty, S.R, Kollah, B. and Devi, M.H. Rao DLN (2023).Phosphate solubilizing bacterial liquid biofertilizer (PSB 1). ICAR, New Delhi.
- Mohanty, S.R, Kollah, B. and Devi, M.H. Rao DLN (2023).Rhizobium biofertilizer for pigeon pea (Rhizo-1). ICAR, New Delhi

Field demonstration

- In-situ decomposition technology promotion by scientist of division of Soil Biology through Ekcel decomposer: Demonstration for in-situ wheat residue decomposition was done in 6 farmers field under Farmers First Project and 6 farmers field under Swachhta Action Plan Project.

- In-situ decomposition by Ekcel decomposer capsule was demonstrated during May 16-17, 2023 on about one acres of land at Khamkheda and kanchhavli village of Bhopal district. Similarly, it was also demonstrated during National Campaign on Soil Health Management (Nutrient Efficiency and Soil Organic Carbon Management) on May 23, 2023.

3.3. Tribal Sub-Plan/Scheduled Tribe Component

3.3.1 Enhancement of soil health and livelihood of tribals in Central India

Krishi Mela cum Workshop on Natural Farming at Rajnandgaon district of Chhattisgarh

ICAR- Indian Institute of Soil Science, Bhopal (M.P.) organized Krishi Mela cum Krishak Sangosthi on Natural Farming during March 27-29, 2023 at KVK Surgi, Rajnandgaon district, Chhattisgarh. During this occasion 30 quintals of HYVs of paddy, 10 quintals of summer green gram seeds and 75 number of vermibeds were distributed to tribal farmers. Altogether 550 tribal farmers including progressive farmers attended the Mela and Sangosthi. Earlier on March 27, 2023, 25 number of vermibeds, seedlings of horticultural fruit crops like papaya and moringa were also distributed among the tribal beneficiary farmers at Mading Piding (Bhursa village), Mohala Block, Rajnandgaon. About 100 farmers were sensitized about the importance

Krishi Mela cum Workshop on Natural Farming at KVK Surgi, Rajnandgaon district, Chhattisgarh of fruit crops in enhancing farm income and livelihood. The team from ICAR IISS Bhopal also visited the adopted villages on March 29, 2023 and reviewed the on farm-demonstrations of project activities.

Mera Gaon Mera Gaurav (MGMG) Activities

Under MGMG, various team members visited adopted villages periodically, interacted with the farmers and discussed about their agricultural activities and related problems.

Adopted Villages under MGMG by the Institute

Group	Members	Name of five villages adopted by Group Leader
1	Dr. S.P. Datta, Director, ICAR-IISS Dr. A.B. Singh, PS, & Nodal Officer, MGMG Dr. Sudeshna Bhattacharjya, Scientist, SBD Dr. Narayan Lal, Scientist, SC&F	Dobra, Khejra, Perwalia Sadak, Badarkha Sadak, Mubarakpur
2	Dr. R. Elanchezhian, PS SCF Dr. P. Tripathi PS & Co-Nodal officer Dr. N.K. Sinha, Scientist, SPD Mr. Abinash Das, Scientist, SBD	Acharpura, Parewakheda, Arwali, Hazampura and Parewaliasahani
3	Dr. S.R. Mohanty, PS & I/c BNF Dr. R.H. Wanjari, PS, LTFE Dr. R.K. Singh, PS SPD Dr. K. Bharati, PS, SBD Mrs. Seema Bhardwaj, Scientist, SPD (Study leave)	Choupdakala, Ghatkheri, Sayyaid Semara, Emaliya Chopra and Amoni
4	Dr. J.K. Saha, HOD, ESS Dr. Sanjay Srivastava, PS SCF Dr. MadhumountiSaha, Scientist, ESS Dr. Dinesh Kumar Yadav, Scientist, ESS Dr. Alka Rani, Scientist, SPD	Islam Nagar, Dewalkhedi, Bharonpura, Kalyanpura, Puraman Bhavan
5	Dr. K.M. Hati, PS, SPD Dr. S.K. Behera, PS MSPE Dr. Dhiraj Kumar, Scientist LTFE Dr. K.C. Shinogi, Scientist, ITMU	Bankhedi, Baroda, Sojna, Amaravadi and Kuravadi
6	Dr. A.K. Vishwakarma, PS & Nodal Officer, MGMG Dr. Pramod Jha, PS SCF Dr. J.K. Thakur, Scientist, SBD Dr. Gurav Priya Pandurang, Scientist SCF	Sagoni, Munirgarh, Gudawal, Chhattarpura, Chiklodkhurd
7	Dr. A. K. Biswas, HOD, SC&F Dr. Brij Lal Lakaria, PS, SC&F Dr. Bharat P. Meena, Scientist, SC&F Dr. Khushboo Rani, Scientist SCF	Golkhedi, Binapur, Kanchbavli, Khamkheda and Raslakhedi
8	Dr. R.S. Choudhary, HOD, SPD Dr. Abhijit Sarkar, Scientist, ESS Dr. Jitendra Kumar, Sr Scientist SPD Dr. Asha Sahu, Sr. Scientist SBD	Raipur, Kanera, Momanpur, Kadhaiya and Karodkhurd
9	Dr. P. Dey, PC, STCR Dr. N.K. Lenka, PS, SC&F Dr. M. Vassanda Coumar, SS, ESS Dr. Immanuel Chongboi Haokip, Scientist, STCR	Ratibad, Rasuliya Pathar, Mugaliahat, Ratanpur Sadak Chandukhedi
10	Dr. A.K. Tripathi, PS, SBD Dr. J. Somasundaram, PS, SPD Mr. Rahul Mishra, Scientist, ESS Dr. Mayanglambom Homeshwari Devi, Scientist, SBB	Dobra Jagir, Kolua Khurd, Sagoni Kalan, Chor Sagoni, Adampur Chhawni
11	Dr. Ajay, PS, ESS Dr. Tapan Adhikari, PS, ESS Dr. Sangeeta Lenka, SS, ESS Dr. Asit Mandal, Sr. Scientist SBD	Shahpur, Devpur, Kasi Barkeda, Sagoni, and Barkedi Hajam

Radio Talk/TV Programme

- Dr. J. K. Thakur delivered talk as an Expert in Krishi Darshan Programmme (Kenchuakhad ka mahatv), date of broadcasting April 12, 2023.
- Dr. J. K. Thakur delivered talk as an Expert in Krishi Darshan Programmme (खरीफ फसल की जैविक खेती एवं मृदा स्वास्थ्य) date of broadcasting June 03, 2023.
- Dr. Asha Sahu gave talk on "Soil Health" to Akashvani Bhopal on the occasion of World Soil Day 2023.
- Dr. Asha Sahu gave talk on "Importance of World Soil Day" to DD Madhya Pradesh on the occasion of World Soil Day, December 5, 2023.

4 TRAINING AND CAPACITY BUILDING

4.1. Training Attended

a. Participation in Training (Category-wise)

S. No.	Category	No. of employees undergone training during 2023
1	Scientist	8
2	Technical	0
3	Administrative & Finance	0
4	Skilled Supporting Staff	0
	Total	**8**

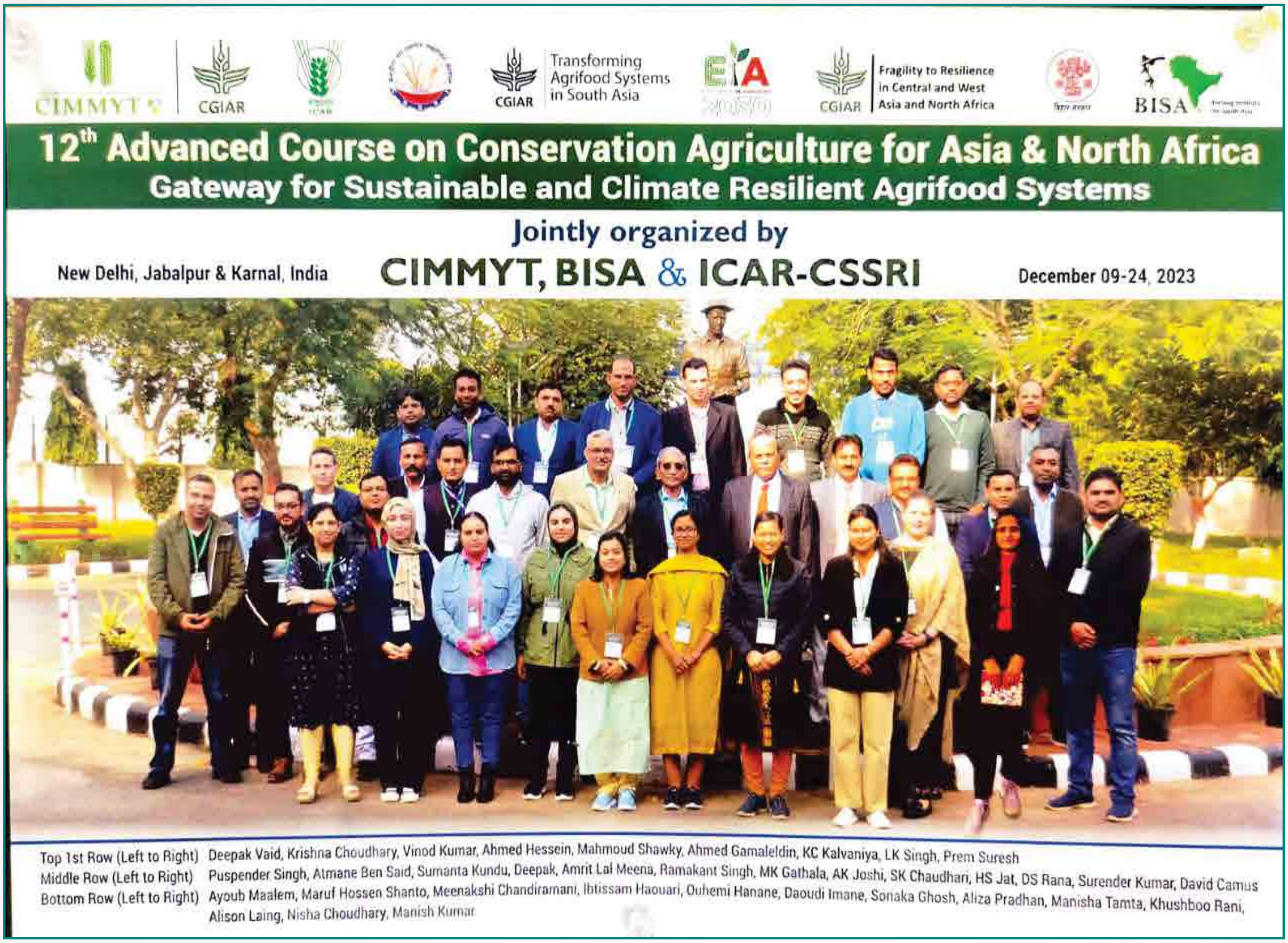
b. HRD fund allocation and utilization (Rs. in Lakhs April 2023 to March 2024)

S. No.	RE for HRD	Actual Expenditure for HRD
1.	10.00	9.38

c. Training attended during January to December 2023

C1 Category: Scientific staff

S. No	Name of employee	Title	Organizer	Duration
1	Dr. Jitendra Kumar	NAHEP CAAST sponsored Training cum Workshop on "Airborne Hyperspectral Remote Sensing for Agriculture	Division of Agricultural Physics, ICAR Indian Agricultural Research Institute, New Delhi	January 16-25, 2023
2	Drs Immanuel C Haokip and M. Homeshwari Devi	Short course on Integrated precision agriculture tools with conservation agriculture for improving input use efficiency, resource conservation and farmers income	ICAR-IISS, Bhopal	February 15–24, 2023
3	Drs Khushboo Rani and Abinash Das	National Training Workshop on "Big Data Analytics in Agriculture (Online Mode)	ICAR-NAARM, Hyderabad	March 9-10, 2023
4	Dr Immanuel C Haokip	Training programme on Analysis of Experimental Data using R	ICAR-NAARM, Hyderabad	August 21-25, 2023
5	Dr. Jitendra Kumar	Remote Sensing & GIS in Predictive Soil Mapping	IIRS, Dehradun	October 9-20, 2023
6	Dr. JK Thakur	Training programme on Next Generation Sequencing and Data Analysis	NAARM, Hyderabad	October 16-20, 2023
7	Dr Khushboo Rani	12th Advanced Course on Conservation Agriculture for Asia and North Africa	CIMMYT, Borlaug Institute for South Asia and ICAR- Central Soil Salinity Research Institute (CSSRI), Karnal	December 9-24, 2023



C2 Category Technical staff : Nil

C3 Category Administrative & Finance : Nil

4.2. Professional Attachment Training organized for Scientist Probationers

S. No.	Name of the Scientist	Name of the College/ Institute/University	Duration	Name of the Scientist/Mentor
1	Mr. Rakesh Kumar	ICAR-CIFRI, Barrackpore, West Bengal	August 21 - November 20 2023	Dr. Sangeeta Lenka
2	Mr. Amit Kumar Das	ICAR-IISS, Mau Uttar Pradesh	August 21 - November 19, 2023	Dr. S.R. Mohanty
3	Dr. Priti Tigga	ICAR-CAFRI, Jhansi	August 28 - November 28, 2023	Dr. N.K. Sinha
4	Md. Basit Raza	ICAR-DFR, Pune	August 24 - November 24, 2023	Dr. S.K. Behera

4.3. Research Guidance for Degree Students

S. No.	Name of the Student	Name of the College/ Institute/University	Degree	Name of the Guide/ Co-Guide
1	Mr. Girraj Dhakad	College of Agriculture, RVSKVV, Gwalior	M.Sc. (Ag) Soil Science	Dr. A.K. Biswas Dr. Khushboo Rani
2	Ms. Neeta Mahawar	College of Agriculture, RVSKVV, Gwalior	Ph. D. Soil Science	Dr Sanjay Srivastava
3	Mr. Ram Swroop Lamror	College of Agriculture, RVSKVV, Gwalior	M.Sc. Soil Science	Dr Pramod Jha
4	Ms. Shivani Sankla	R.A.K College of Agriculture Sehore, RVSKVV, Gwalior	M.Sc. (Ag.) Soil Science & Agril. Chem.	Dr. Asha Sahu
5	Ms. Soniya Sisodiya	R.A.K College of Agriculture Sehore, RVSKVV, Gwalior	M.Sc. (Ag.) Soil Science & Agril. Chem.	Dr. Sudeshna Bhattacharjya
6	Mr. Shubham Singh	College of Agriculture, RVSKVV, Gwalior	PhD Soil Science & Agril. Chem.	Dr.A.B. Singh Dr. Asit Mandal
7	Mr. Manjeet Tomar	Bundelkhand College of Agriculture, Jhansi, U.P.	M.Sc. (Ag.) Soil Science & Agril. Chem..	Dr. A.B. Singh
8	Mr. Om Prakash Yadav	R.A.K College of Agriculture Sehore, RVSKVV, Gwalior	M.Sc. (Ag.) Soil Science & Agril. Chem.	Dr. J. K. Thakur
9	Miss Divya Pipalde	College of Agriculture, RVSKVV, Gwalior	M.Sc. Soil Science	Dr. Nisha Sahu
10	Mr. Eklavya Thakur	IGKV Raipur	M.Sc. Soil Science	Dr R. Elanchezhian
11	Mr. Harish Kumar	IGKV Raipur	M.Sc. Soil Science	Dr. M. Vassanda Coumar
12	Mr. Rakesh Kumar Yadav	College of Agriculture, RVSKVV, Gwalior	M.Sc. Soil Science	Dr. D.K. Yadav

Training imparted to the farmers/Extensions officers/Students/Visits

Name of Scientist	Event	Date	Venue	Remarks/Beneficiary
Drs. R. Elanchezhian, P Tripathi, MV Coumar, N Lal, N Sahu, DK Yadav	Kisan Sanghosthi	March 27 to 28, 2023	KVK, Rajnandgoan, CG	Tribal farmers under TSP
Drs. S. R. Mohanty, Asit Mandal, J. K. Thakur, B. P. Meena, N. K. Sinha, A K Tripathi and Abinash Das	Natural farming and Soil Health	August 02-04, 2023	ICAR-IISS, Bhopal	Farmers under ATMA, Kaimur, Bihar
Drs. S Bhattacharjya, DK Yadav and Nisha Sahu	Exposure visit	January 5, 2023	ICAR-IISS, Bhopal	38 B.Tech. (Agril. Engg.) students from College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra
Drs. Sudeshna Bhattacharjya, Dinesh K. Yadav and Abinash Das	Exposure visit	April 21, 2023	ICAR-IISS, Bhopal	55 students of B. Sc Agriculture, SAM Global University, Raisen
Drs. S Bhattacharjya, Nisha Sahu, M. H Devi and Immanuel C. Haokip	Exposure visit	May 1, 2023	ICAR-IISS, Bhopal	Kumari Devi Choubey College of Agriculture and Research Station, Saja
Drs. Sangeeta Lenka, Jyoti Thakur, Jitendra Kumar, and Khusboo Rani	Exposure visit	December 29, 2023	ICAR-IISS, Bhopal	Navodaya Vidyalaya, Bhopal
Dr Abinash Das	Exposure visit	October 18, 2023	ICAR-IISS, Bhopal	Bhopal School of Social Sciences

5 AWARDS, HONOURS AND RECOGNITIONS

Awards

- Dr.Sanjib Kumar Behera received Fellowship of National Academy of Biological Sciences, Chennai, Tamil Nadu on January 25, 2023 at Periyar University.

- Dr Bharat Prakash Meena awarded ISA-Associateship Fellow Award - 2021 by the Indian Society of Agronomy, New Delhi during XXII Biennial National Symposium on "Climate Smart Agronomy for Resilient Production Systems and Livelihood Security" at ICAR-Central Coastal Agricultural Research Institute, Goa from November 22–24, 2023.

- Dr N Lal Received Best Scientist 12th Science and Technology Award on June 18, 2023 by Educationexpo, EET CRS, Banglore.

- Dr N Lal received Young Scientist Award on October 30, 2023 by Royal Science Forum, Salem, India.

- Dr. Asit Mandal has received 2023 Eminent Scientist of the year Award 2023 by National Environmental Science Academy, New Delhi

- Dr. S R Mohanty received Fellowship of National Academy of Biological Sciences, Chennai, Tamil Nadu on January 25, 2023 at Periyar University

- Ms. Madhumonti Saha awarded Fellowship for training of young scientists by M.P. Council of Science and Technology (MPCST) in March, 2023.

- Dr. D.K. Yadav recived Fellowship for Training of Young Scientists (FTYS) in 38th M.P. Young Scientist during March 2023, M.P. Council of Science and Technology, Madhya Pradesh.

- Dr. Sangeeta Lenka received the prestigious U. S. Department of Agriculture-FAS (Scientific Exchange Program) Climate Smart Agriculture (CSA) Fellowship 2022.

- Dr. Sangeeta Lenka was selected as recipient of Indian Association of Soil and water Conservationists Gold Medal Award for the year 2022.

- Drs. S.R.Mohanty, B.Kollah, A.Sahu, S.Bhattacharjya, J.K. Thakur, A. Mandal, M.H. Devi, A.K. Tripathi and A.B.Singh have received "The ISSS-Dr. J.S.P. Yadav Memorial Award for excellence in Soil science" on October 3, 2023 at the 87th Annual Convention of the Society, ICAR-IISS, Bhopal.

Awards and Honours

- RH Wanjari received Best Oral Presentation (2nd) Award at National Seminar on "Abiotic Stress Management for Sustainable Millet based Production Systems" at ICAR-NIASM Baramati (Pune) during August 22-23, 2023.

Receiving Best Oral Presentation Award at National Seminar on "Abiotic Stress Management for Sustainable Millet based Production Systems" at ICAR-NIASM Baramati (Pune) during August 22-23, 2023

- Dhiraj Kumar received Dhiru Morarji Memorial Award in the Discipline of Agricultural Sciences from FAI, New Delhi (First Prize) for the article entitled "Impact of Fertilizer Consumption on Soil Health and Environmental Quality in India" published in October 2022 issue of Indian Journal of Fertilisers. The award was given on December 6, 2023 in New Delhi. The authors include Dhiraj Kumar, Nishant K Sinha, Immanuel Chongboi Haokip, Jitendra Kumar, RH Wanjari, Shilpi Verma, Monoranjan Mohanty, Somasundaram Jayaraman, R Elanchezhian and Rahul Mishra.

Receiving Dhiru Morarji Memorial Award for Best Article in Agricultural Sciences for the Year 2022-23 from Fertilizer Association of India. The Award was given by Shri Mansukh Mandviya Ji, Union Minister of Fertilizer and Chemicals, Government of India, New Delhi

- Dhiraj Kumar nominated as Member, Working Group WG 1: Integrated Nutrient Management under Panel on Agricultural Resource Management, By-Product Management and other Integrated System Management (FAD 22/ Panel IV), Bureau of Indian Standards.

Honours and Recognitions

Dr. R Elanchezhian acted as Invited Speaker at the National Conference of Plant Physiology organized by ISPP and ICAR IARI New Delhi during December 9-12, 2023.

Dr. R Elanchezhian acted as Editor of Plant Physiology Reports of Indian Society for Plant Physiology.

Dr. R Elanchezhian acted as Reviewer / Referee for the journal FCR, JPN, BMC journals, and Plant Physiology Reports (Springer Nature)

Dr. Rahul Mishra received Conference Awards ISES 2023, Annual Meeting, USA.

Dr. Rahul Mishra received Best Poster Presentation Award in International Conference on One Health - One World held at RVSKVV Gwalior (M.P.) dated December 28-29, 2023.

Dr. N.K. Lenka acted as a Guest of Honour in the Millet Conclave and Closing Workshop of Smallholder Adaptive Farming and Biodiversity Network on April 4, 2023 at Sagar, Madhya Pradesh.

Dr. R.S. Chaudhary was recognized as a Member in the Evaluation Committee of SwachhtaSarthi Fellowship Cohort assigned by the office of the Principal Scientific Adviser (PSA), GoI, 2023.

Dr. R.S. Chaudhary was recognized as Member in the Editorial Board of the Indian Journal of Agricultural Physics, ISAP, New Delhi.

Dr. R.S. Chaudhary was recognized as Member in the Editorial Board of the Indian Journal of Soil Conservation, Dehradun.

Dr. R.S. Chaudhary was recognized as Member in the Judging Committee for "Dr. Shibendu Shankar Ray Best Doctoral Thesis Award" of ISAP, New Delhi, January 2023.

Dr. R.S. Chaudhary was recognized as a Chairman in the technical session during National Symposium on Digital Farming -The Future of Indian Agriculture' from February 2-3, 2023 organized by ISAP, New Delhi at ICAR-IISS, Bhopal.

Dr. R.S. Chaudhary was recognized as a Member in the DPC Committee (DG Nominee) for assessment of Scientist under CAS at ICAR-IISWC, Dehradun, Uttarakhand on October 17, 2023.

Dr. R. K. Singh acted as a Rapporteur in "National Symposium on Digital Farming: The Future of Agriculture" by Indian Society of Agrophysics at ICAR-IISS, Bhopal during February 2-3, 2023.

Dr. Alka Rani received best poster presentation award in the '5th International Conference on Sustainable Natural Resources Management Under Global Climate Change' organized by Soil Conservation Society of India at NASC complex, New Delhi during November 7-10, 2023.

Dr. B.P. Meena received Best Poster Award in International conference on Development and Promotion of Millets and Seed Spices for Livelihood Security at Agriculture University, Jodhpur, during February 24-26, 2023.

Dr. Khushboo Rani received Best poster presentation award on the paper at the 87th annual convention of Indian Society of Soil Science held during October 03-06, 2023 at ICAR-Indian Institute of Soil Science, Bhopal.

Dr. Pramod Jha delivered Lead lecture on Carbon Sequestration in Agricultural Soils during 1st International Conference on Decarbonizing Agriculture ICDA-2023, November 25-27, 2023 Mangalore, Karnataka

Dr. Pramod Jha delivered invited lecture in National Seminar on "Role of Chemistry in Agriculture" Organized by L. N. Mithila University, Darbhanga on January 21, 2023.

Dr. Pramod Jha acted as member of the judging committee for the Indian Society of Soil Science Zonal Award contest on August 23, 2023 at SKN college of Agriculture, Jobner, Jaipur-Rajasthan.

Dr. N. Lal evaluated Ph.D. (Horticulture Fruit Science) thesis of RVSKVV, Gwalior, MP.

Dr. N. Lal evaluated M.Sc. (Horticulture Fruit Science) thesis College of Horticulture, Mandsaur, RVSKVV, Gwalior, MP.

Dr. N. Lal conducted online Ph.D. Viva-voce of Horticulture-Fruit Science student, RVSKVV, Gwalior, MP on July 14, 2023.

Dr. A.K. Biswas has been elected as Vice-President of ISSS for the biennial 2024-25.

Dr. Sanjay Srivastava acted as Ph D thesis examiner and conducted viva-voce for GBPUA&T, Pantnagar.

Dr. Sanjay Srivastava acted as NABL technical assessor to conduct the technical assessment of Laboratories (Conformity Assessment Bodies) at Hyderabad and Mumbai.

Dr. Pramod Jha acted as the editor of Journal of Indian Society of Soil Science, New Delhi during 2023-24.

Dr. Pramod Jha acted as the editor of Pantnagar Journal of Research, Pantnagar during 2023-24.

Dr. Asha Sahu acted as Invited Speaker (online) on 3rdInternational Conference on Plant Science and Molecular Biology during May 17-19, 2023.

Dr. Asha Sahu acted as Invited Speaker (online) on "International Conference on Agriculture and Plant Science" during September 6-7, 2023.

Dr. Asha Sahu acted as Invited Speaker (online) in the 6th International Conference on Recycling and Waste Management during August 21-22, 2023.

Dr. Asha Sahu acted as Invited Speaker (online) in the 5th International Conference on Renewable Energy, Resources and Sustainable Technologies during November 13-14, 2023.

Dr. Asha Sahu acted as an External Examiner took practical viva of M.Sc. Microbiology students of Department of Microbiology, Barkatullah University on June 17, 2023.

Dr. Asha Sahu delivered invited talk during training program on "Swachchta Action Plan" July 18- 20, 2023 organized by SIAET, Bhopal.

Dr. J.K. Thakur acted as jury member in Annual convention and national webinar on "Next-gen Management of Agro-chemicals for Achieving Sustainable Development Goals" during March 24 & 25, 2023.

Dr. J.K. Thakur acted as External member for assessment of IARI Student (Ms. Elakkya M., Ph.D. student on January 17, 2023.

Dr. J.K. Thakur acted as invited speaker in A one-day Panel discussion on Natural Farming: Reality and Concerns November 24, 2023 via Online organized ICAR RC for NEH Region.

Dr. Asit Mandal received Best Poster Presentation Award by Indian Society of Soil Science, at the 87th Annual Convention of the society on October 5, 2023 at ICAR-IISS, Bhopal.

Dr. Asit Mandal acted as External Advisory Board Member at the SYMBIOREM Consortium Meeting I held on 1st May (virtual mode).

Dr. Asit Mandal acted as Associate Editors to the Editorial Board of Soil Pollution & Remediation (specialty section of Frontiers in Soil Science).

Dr. Asit Mandal acted as Academic Editor of 'International Journal of Plant & Soil Science'.

Dr. Asit Mandal acted as Guest Editor for the Frontier in Microbiology.

Dr. M Homeshwari Devi, certified as Excellence in reviewing European Journal of Nutrition and Food Safety, December 28, 2023.

Dr. M Homeshwari Devi, certified as Excellence in reviewing International Journal of plant and Soil Science, December 8, 2023.

Dr. Abinash Das received Dr. S.P. Raychaudhuri Gold Medal for Best Ph.D. Dissertation from Delhi chapter of Indian Society of Soil Science for the year 2023.

Dr. Abinash Das received the commendation certificate for best Ph.D thesis presentation at the 87th annual convention of Indian Society of Soil Science held during October 03-06, 2023 at ICAR-Indian Institute of Soil Science, Bhopal.

Dr. Sudeshna Bhattacharjya acted as Academic Editor of *PLOS ONE*.

Dr. Sudeshna Bhattacharjya delivered invited expert talk at Planet A channel, Deutsche Well in Berlin, Germany in May, 2023.

Dr. Sudeshna Bhattacharjya acted as External Examiner for viva-voce of M.Sc. Agronomy by Barkatullah University, Bhopal.

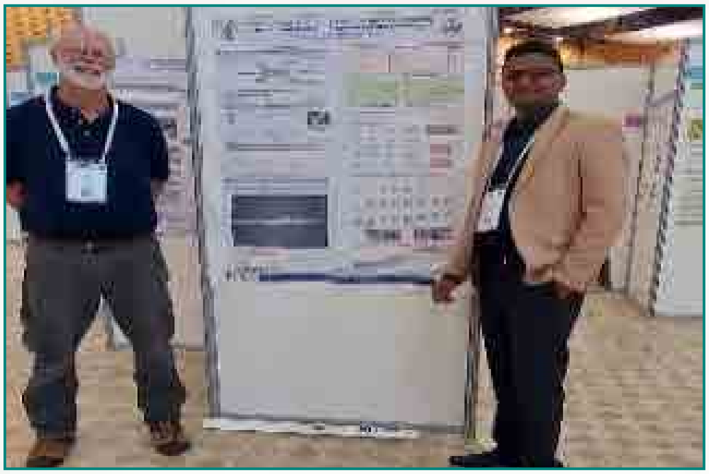
Dr. Nisha Sahu acted as Coordinator in Organizing one day Workshop cum training on Improving the livelihood of farm women through soil health and nutrition at Borkhedi village, Bhopal district on 6 March, 2023.

Dr. D.K. Yadav acted as Organizing committee member of 15th IUPAC International Congress of Crop Protection Chemistry during 14-15 March, 2023 at NASC Complex, New Delhi.

Drs. Nisha Sahu, Narayan Lal and DK Yadav acted as Conveners in organizing 3 days workshop cum training programme with about 300 farmers at Rajnandgaon, Chhatisgarh during March 27- 29, 2023.

Dr. D.K. Yadav acted as External Examiner to the Agriculture University, Kota, Rajasthan during Academic Session 2023-24.

Dr. D.K. Yadav received International Travel Support (ITS) Grant by SERB, New Delhi and participated in 12th International Congress of Plant Pathology during August 20-25, 2023 at Lyon, France.



Dr. Sangeeta Lenka acted as a guest speaker in the Regional Advisory Group meeting on Climate Change and its Impact organized by NABARD on October 9, 2023.

Dr. Sangeeta Lenka acted as the external examiner of five M.Sc. students for Soil Science and Agricultural Chemistry from OUAT, Bhubaneswar.

Dr. Sangeeta Lenka acted as the mentor of professional attachment trainee scientist Mr. Rakesh Kumar from ICAR-CIFRI, Barrackpore, West Bengal for three months from August 21 to November 20 2023.

Dr. Sangeeta Lenka acted as the external examiner of Ph.D. thesis of Ms. Priya Bhattacharya (M.Sc, Agricultural Physics) from the Indian Agricultural Research Institute.

Dr. Sangeeta Lenka acted as the external examiner of Ph.D. thesis of Mr. Libi Robin P. (M.Sc, Agri.) from Tamil Nadu Agricultural University.

Dr. B.P. Meena acted as expert for Viva voce and thesis examination at Department of Agronomy at institute of Agricultural Sciences, BHU, Varanasi on November 27, 2023

6 LINKAGES AND COLLABORATION

The Institute has linkages with several ICAR institutes and SAUs located throughout the country. The three AICRPs (LTFE, MSPE & STCR), one AINP on SBB and one CRP on CA stationed at ICAR-IISS Bhopal have 94 cooperating centers spread across the country. The Institute is undertaking external funded projects and national and international organizations (ICRAF, CEFIPRA, UKRI, NASF, DST, DBT, NICRA, MPCOST, EPCO) involving linkage with several ICAR Institutes. Besides, several private firms, *viz.*, M/s Blu Soils Agro Pvt. Ltd, Patna, M/s Groweco Ventures LLP, Indore are collaborating with the Institute on various R&D activities.

The institute is running academic activities for PG programs under the ICAR Global University at Bhopal hub. Also, efforts have been made to strengthen research collaborative activities with SAUs through guidance of PG students by the Institute scientists.

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; Dr PDKV, Akola; IGKVV, Raipur; ICAR-IARI, New Delhi; ICAR-CRIJAF, Barrackpore; ICAR-IASRI, New Delhi	3	15	18
AICRP on MSPE PJTSAU, Hyderabad; RAU, Pusa; AAU, Anand;HAU, Hisar; JNKVV, Jabalpur; Dr 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
AICRP on STCR PJTSAU, Hyderabad; RAU, Pusa; IGKV, Raipur; ICAR-IARI, New Delhi; HAU, Hisar; HPKV, Palampur, GKVK, Bengaluru; KAU, Vellanikara; JNKVV, Jabalpur; MPKV, Rahuri; OUAT, Bhubaneswar; PAU, Ludhiana; SKRAU, Bikaner; TNAU, Coimbatore; GPUAT, Pantnagar; BCKVV, Kalyani; ICAR-CRIJAF, Barrackpore; PAJANCOA, Puduchery; BHU, Varanasi; AAU, Jorhat; JAU, Gujarat; SKUAT, Srinagar; BAU, Ranchi; ICAR-IISR, Lucknow; ICAR-Complex, Manipur	4	21	25
AINP on Soil Biodiversity-Biofertilizers AAU, Jorhat; ANGRAU, Amaravathi; BAU, Ranchi; HAU, Hisar; JNKVV, Jabalpur; KAU, Thrissur; MAU, Parbhani; MPUAT, Udaipur; OUAT, Bhubaneswar; RAU, Pusa; TNAU, Coimbatore; YSPUHF, Solan; CRRI, Hazaribagh; ICAR-IARI, New Delhi; DGR, Junagarh; GBPUAT, Pantnagar; UAS, Dharwad	3	14	17
CRP on CA ICAR-IISS Bhopal, ICAR-CRIDA Hyderabad, ICAR-IARI Delhi, ICAR-DWR Jabalpur, ICAR-RCER Patna, ICAR-CSSRI Karnal, ICAR-NIASM Baramati, ICAR-IIWBR Karnal, ICAR-NRRI Cuttack, ICAR-IIFSR Modipuram, ICAR-CIAE Bhopal	11	0	13

The institute established Industry linkages with the commercialization of institute technology with NextGen Agro, Wardha, Maharashtra; WS Telematics Pvt Ltd, New Delhi and Digital Rural India Mission Pvt Ltd, Amravati, Maharashtra

7 ONGOING RESEARCH PROJECTS

7.1 Programme I: Soil Health and Input Use Efficiency

(A) Institute Project

1. Long-term evaluation of integrated plant nutrient supply modules for sustainable productivity in Vertisol

   Investigators: BP Meena, AK Biswas, AB Singh, RS Chaudhary, RH Wanjari, Khushboo Rani, Hiranmoy Das

2. Mineralogy of Vertisols in relation K availability in central and western India

   Investigators: Gurav Priya Pandurang, AO Shirale, BP Meena, BL Lakaria, Sanjay Srivastava, P Chandran (ICAR-NBSS&LUP, Nagpur), S Sandeep

3. Micronutrients distribution in major soil orders of India as influenced by soil properties and land use pattern

   Investigators: SK Behera, AK Shukla, Rahul Mishra, NK Sinha, JK Thakur, K Kartikeyan (ICAR-NBSS&LUP, Nagpur)

4. Enhancement of Soil Health and Livelihood of Tribals in Central India

   Investigators: RH Wanjari, R Elanchezhian, Prabhat Tripathi, RK Singh, KC Shinogi, MV Coumar, Narayan Lal, J Somasundaram, AO Shirale, Asit Mandal, Hiranmoy Das, AB Singh, Asha Sahu, SK Behera, AK Vishwakarma, M Mohanty, Seema Bhardwaj, Madhumonti Saha, Sanjay Srivastava, K Bharati, Priya Gurav, BP Meena, AK Tripathi, Abhijit Sarkar, NK Sinha, JK Thakur, Khushboo Rani, DK Yadav, Immanuel C Haokip, Dhiraj Kumar, Rahul Mishra, M Homeshwari Devi, I/c KVK Barwani (MP), I/c KVK Rajnandgaon (Chhattisgarh) and I/c KVK Betul (MP)

5. Assessment of nutrient (N & P) use efficiency in wheat genotypes for improved crop productivity

   Investigators: R Elanchezhian, AO Shirale, BP Meena, Alka Rani, Sanjay Srivastava, Ajay, AK Biswas, MV Coumar, AB Singh and Renu Pandey (ICAR-IARI, New Delhi).

6. Soil health assessment and input use efficiency

   a. Development of agri-horticultural system for central India under Vertisols, its impact on soil health and improvement in productivity and quality of fruits

      Investigators: Narayan Lal, BL Lakaria, AK Vishwakarma, Asha Sahu, Hironmoy Das, AK Biswas and Pradip Dey

7. Studying of climate change impact on nitrogen dynamics and water use in two contrasting cropping system of Central India

   Investigators: NK Lenka, Sangeeta Lenka, Pramod Jha, JK Thakur, BP Meena

8. Enhancing livelihood security of subsistence farming community through improvement in soil health crop productivity and capacity building in Bhopal district of Madhya Pradesh

   Investigators: BL Lakaria, Ajay, AK Vishwakarma, Jitendra Kumar, Dolamani Amat and all scientists

9. Phosphorus potassium and zinc dynamics under conservation agriculture in diverse agro-ecological zones

   Investigators: Khushboo Rani, Priya Gurav, PramodJha, AK Vishwakarma, Sanjay Srivastava and AK Biswas

10. Effect of long-term nutrient management on various fractions and forms of soil organic carbon and nitrogen, carbon stabilization and biological activity in dominant cropping systems

    Investigators: Dhiraj Kumar, RH Wanjari, Pramod Jha, Somasundaram Jayaraman, Jitendra Kumar, Sudeshna Bhattacharjya, Immanuel C Haokip and Rahul Mishra

11. Assessing soil quality and yield sustainability under long term soil test crop response correlation (STCR) based nutrient in major soil orders of India

Investigators: Immanuel C Haokip, Pradip Dey, NK Lenka, Dhiraj Kumar, MHomeshwari Devi, Khushboo Rani, RH Wanjari, AK Tripathi

(B) Externally Funded Projects

12. All India Network Programme on Organic Farming (ICAR, New Delhi)

    Investigators: AB Singh, BP Meena, BLLakaria, R Elanchezhian,JK Thakur, NK Sinha, Abinash Das

13. Ensuring food security, sustainability and soil health through resource conservation-based farmer FIRST approach in central India, (ICAR New Delhi)

    Investigators: AK Patra, AK Vishwakarma, RK Singh, AB Singh, BL Lakaria, RH Wanjari, K Bharati, Asha Sahu, Shinogi KC, AO Shirale, Hiranmoy Das, D.K. Yadav, Immanuel CH, Sanjay Srivastava

14. Studies on N-(n-butyl) Thiophosphoric Triamide (NBPT) as a Urease Inhibitor for Improving Nitrogen Use Efficiency in major cropping systems in India funded by ICAR- CIMMYT collaboration

    Investigators: Pramod Jha, R Elanchezhian, BL Lakaria, BP Meena, Pradip Dey, AK Biswas

15. Development of Nano Sensor and its application through cloud-based network for real time irrigation to soil and plant funded by NASF, ICAR, New Delhi

    Investigators: Tapan Adhikari, CD Singh, Samir Kumar Pal, SN Bose

16. Hyperspectral reflectance and multi-nutrient extrant based assessment of soil properties for sustainable soil health in India funded by NASF

    Investigators: MV Coumar, Pradip Dey, Immanuel C.H.

17. Sustainable biochar production agroforestry systems and its application: A climate resilient soil management approach funded by ICRAF, Nairobi

    Investigators: BL Lakaria, Pramod Jha, AK Biswas, AK Vishwakarma, BP Meena, M Vassanda Coumar, Jitendra Kumar, Abinash Das, AK Patra, Javed Rizvi, SK Dhyani, Aqeel Hasan Rizvi, Archna Singh, Jamal Pervez Noor

18. Assessment of Traditional Knowledge System of Tribal Farmers for Managing Land Resources funded by DST, MoSC, New Delhi

    Investigators: Shinogi KC, Sanjay Srivastava, Sudesna Bhattacharjya, Dinesh Kumar Yadav

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

A. Institute Projects

19. Climate change impact on water productivity of major crops in central India

    Investigators: NK Sinha, M Mohanty, J Somasundaram, Pramod Jha, Alka Rani, Seema Bhardwaj, Hiranmoy Das, KM Hati, RS Chaudhary

20. Impacts of conservation agriculture on runoff and soil loss under different cropping system in Vertisols

    Investigators: Prabhat Tripathi, RK Singh, RS Chaudhary, Seema Bhardwaj, J Somasundaram, M Mohanty, KM Hati, Rahul Mishra.

21. Impact of climate change on soil processes

    a. Impact of climate change on soil physical process in maize based cropping systems in vertisols of central India

       Investigators: Jitendra Kumar, NK Sinha, M Mohanty, J Somasundaram, Alka Rani, KM Hati and RS Chaudhary

    b. Downscaling of satellite-derived soil moisture product and its application for agricultural drought monitoring and outlook

       Investigators: Alka Rani, NK Sinha, M Mohanty, Jitendra Kumar, Seema Bhardwaj, RS Chaudhary, KM Hati and RK Singh

B. External funded projects

22. Assessment of important soil properties of India using mid-infrared spectroscopy (ICAR-ICRAF, Nairobi)

    Investigators: NK Sinha, KM Hati, M Mohanty, Pramod Jha, RS Chaudhary, JK Thakur, MV Coumar, Pradip Dey, Dhiraj Kumar, AK Patra, Javed Rizvi

23. CRP-Conservation Agriculture (LCPC: Dr AK Biswas and DLCPC: Dr RSChaudhary) (ICAR)

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

       Investigators: KM Hati (PPI), J Somasundaram, AK Vishwakarma, RK Singh, Pramod Jha

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

       Investigators: AK Vishwakarma, RH Wanjari, RK Singh, KC Shinogi, AK Tripathi (BP Meena PI w.e.f August 21, 2023)

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

       Investigators: J Somasundaram, BP Meena and Abhay Shirale, (P. Tripathi as PI w.e.f. 1 August, 2023)

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

       Investigators: RK Singh, Sanjay Srivastava, Priya Gurav and NK Sinha

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

       Investigators: Pramod Jha, BLLakaria, M Mohanty, JK Thakur and K Bharati

24. Modelling soil carbon storage and dynamics in different agro-ecosystems of India under the changing climate scenarios funded by NICRA

    Investigators: NK Sinha, M Mohanty, Pramod Jha, J Somasundaram, Dhiraj Kumar, RH Wanjari, Prabhat Tripathi, J Kumar and R Mishra

25. Integrated assessment of soils and crops under varying climate conditions to improve nutrient dynamics and efficiencies, carbon sequestration and greenhouse gas mitigation funded by NICRA

    Investigators:NK Sinha, M Mohanty, J Somasundaram, Pramod Jha, K Bharati, Jitendra Kumar, Sangeeta Lenka, JK Thakur, Abinash Das, KM Hati, RS Chaudhary, Dhiraj Kumar, T Adhikari and R Mishra

26. ICAR Network Program on Precision Agriculture

    Investigators: NK Sinha, J Somasundaram, MMohanty, S Srivastava, Jitendra Kumar, Dhiraj Kumar, Alka Rani, CH Immanual, RS Chaudhary, N Sahu and Rahul Mishra

7.3 Programme III – Soil Microbial Diversity and Biotechnology

A. Institute Project

27. Characterization and prospecting of soil biota for enhancing nutrient use efficiency

    a. Deciphering thermophiles from hot springs of Central India for rapid decomposition of crop residues

       Investigators: Asha Sahu, Sudeshna Bhattacharjya, Dolamani Amat, Nisha Sahu, K Bharati and Anita Tilwari

    b. Exploring endophytic microbial diversity of selected major field crops of India for nutrient supplementation and biocontrol

       Investigators: JK Thakur, Asit Mandal, Dolamani Amat and MC Manna

    c. Effect of in-situ decomposition of crop residue mediated by lignocellulolytic microbes on soil health under rice-wheat cropping system

       Investigators: Abinash Das, Dolamani Amat

    d. Silicon solubilizing bacteria for enhancing nutrient use efficiency of Rice-wheat cropping system in Vertisol of central India

       Investigators: M. Homeshwari Devi

B. Externally Funded Projects

28. Evaluation of Soybean-rhizobia interaction under elevated CO_2 and temperature to develop climate ready microbial inoculants for central India (ICAR, AMAAS)

    Investigators: SR Mohanty, K Bharati, Asit Mandal

29. Microbial based agricultural waste management using vermi composting funded by Swachchta Action Plan, ICAR, New Delhi

Investigators: AK Patra (Project leader), AK Vishwakarma (PI), JK Thakur, AB Singh, BL Lakaria, BP Meena (PI w.e.f 21 August 2023) RS Chaudhary, Asha Sahu, Asit Mandal DK Yadav, Abhijit Sarkar

30. Phyllosphere methylotroph driven bioconversion of atmospheric greenhouse gas and volatiles to plant metabolites leveraging primary productivity in major crops and mitigation of climate change funded by Indo-France

    Investigators: SP Datta, SR Mohanty, K Bharati, AK Patra, M. Homeshwari Devi

7.4 Programme IV: Soil Pollution, Remediation and Environmental Security

A. Institute Project

31. Quantitative assessment of acid mine drainage affected areas in Madhya Pradesh

    Investigators: Madhumonti Saha, Ajay, Abhijit Sarkar, JK Saha and Hiranmoy Das

32. Heavy metal and its remediation for sustainable crop production and environmental protection

    a. Assessment/quantification of soil heavy metals using spectroscopy and multi spectral remote data from industrial areas of Kanpur

    Investigators:Nisha Sahu, JK Saha, NK Sinha, H Biswas (ICAR-NBSSLUP Nagpur), MrunaliniKan cheti (ICAR-IIPR, Kanpur), Rahul Mishra

    b. Municipal solid waste compost quality assessment for sustainable crop production and environmental protection

    Investigators: M Vassanda Coumar, Tapan Adhikari, Abhijit Sarkar, Nisha Sahu, JK Saha, Hiranmoy Das, Ajay, DK Yadav and SK Meena (CPCB)

    c. Quantification of heavy metal concentration in contaminated soils, sludge and compost using pXRF and ICP-OES”

    Investigators: Rahul Mishra, NK Sinha, KM Hati, MV Coumar, M Mohanty, Abhijit Sarkar, Dhiraj Kumar, DK Yadav, RS Chaudhary, JK Saha and Nisha Sahu

    d. Risk minimization and economic exploration of municipal sludge

    Investigators: Abhijit Sarkar, Add S Lenka, M Saha, DK Yadav, R Mishra, A Das, MV Coumar, Ajay, JK Saha and AK Patra

B. Externally Funded Projects

33. Use of fly ash in agriculture for sustainable crop protection and environmental protection fundedby NTPC, Noida

    Investigators: JK Saha, MV Coumar, AK Patra, Tapan Adhikari, Ajay, KM Hati, Abhijit Sarkar, Rahul Mishra, Sangeeta Lenka, Asit Mandal, AK Vishwakarma, Madhumonti Saha, Hiranmoy Das, Nisha Sahu, DK Yadav, BP Meena

34. Investigation of potentials of soil as a sink for nitrous oxide and strategies for mitigation nitrous oxide emission funded by DST SERB–POWER Fellowship

    Investigators: Sangeeta Lenka

35. Do agricultural micro plastics undermine food security and sustainable development in less economically developed countries?

    Investigators: AK Patra, Tapan Adhikari, JK Thakur, Asit Mandal

36. Valorization of sewage sludge: Waste to wealth using nanotechnology for circular economy funded by MPCST

    Investigators: Dinesh Kumar Yadav, Sangeeta Lenka, Abhijit Sarkar, MV Coumar, JK Saha

Collaborative projects in other institutes where ICAR-IISS scientists are associated

- Development and promotion of CA machinery (ICAR-IISS, Bhopal and ICAR-CIAE, Bhopal)

  Investigators: Dushyant Singh, NS Chandel, AK Vishwakarma

- Enhancing input use efficiency and productivity of pulses production system in central India (ICAR-IISS, Bhopal and ICAR-IIPR, Kanpur)

  Investigators: Sandeep Kumar, Narendra Kumar, Pramod Jha, R Elanchezhian

- Monitoring, mapping and development of agricultural farms using GIS at ICAR-CIAE

  Investigators: Shashi Rawat, K Singh, HS Pandey and Khushboo Rani

- Hyper spectral reflectance and multi nutrient extractant based rapid assessment of soil properties for sustainable soil health in India

  Investigators: P Santra, P Dey, MV Coumar and Immanuel C Haokip

8 CONSULTANCIES, CONTRACTUAL SERVICES, PATENTS AND TECHNOLOGY COMMERCIALIZATION

Consultancies /Contractual Services

S. No.	Title	Sponsorer	Project team
1	Evaluating the effect of Bio.soilz on soil nutrient availability and microbial activity under maize-wheat cropping system in Vertisols of Central India	M/s Blu Soils Agro Pvt. Ltd, Patna	Asit Mandal, JK Thakur, AB Singh, R Elanchezhian, AK Patra
2	On farm evaluation of ECOWELL ORGANIC PRODUCTS under soybean-wheat cropping system	M/s Groweco Ventures LLP, Indore	Asha Sahu, Sudeshna Bhattacharjya, Dolamani Amat, K. Bharati, AB Singh, AK Patra

ITMU filed the following patents:

IPRs	Application/Registration No.	Name of Innovation Technology/ Product/ Plant Variety	Date of application Filed/ submitted
Patent	202311021215	Non contact sensing of water potential in a matrix	24 March 2023
Patent	202311034460	Bacterial exopolysaccharide based bioformulation and uses thereof	17 May 2023

Commercialization of technology

Dr Sanjay Srivastava, PI, Mridaparikshak and I/c, ITMU with the assistance of PME Cell of the institute has commercialized the technology of refill of Mridaparikshak Mini Lab to WS Telematics Pvt. Ltd., January 16-17, 2023 (Rs. 100000 +GST as license fee).

9 PUBLICATIONS

9.1 Papers in Research journal

9.1.1. International/ National (NAAS rating more than 6)

1. Behera SK, Shukla AK, Pachauri SP, ShuklaV, SikaniyaY, Srivastava PC(2023). Spatio-temporal variability of available sulphur and micronutrients (Zn, Fe, Cu, Mn, B and Mo) in soils of a hilly region of northern India. *Catena* 226, 107082. https://doi.org/10.1016/j.catena.2023.107082.(NAAS rating:12.37)
2. Bharati K, Verma H, Parmar R, Devi MH, Atoliya N, Bajpai A, Shinoji KC, Singh AB, Patra A, Jain D, Dubey G and Mohanty SR (2023). Methane consumption under the influence of different nitrogen sources in a tropical soil ecosystem. Pedobiologia - *Journal of Soil Ecology*.doi:https://doi.org/10.1016/j.pedobi.2023.150891 (IF: 2.128)..(NAAS rating: 8.13)
3. Bhattacharjya S, Ghosh A, Sahu A, Agnihotri R, Pal N, Sharma P, Manna MC, Sharma MP, Singh AB (2023). Utilizing Soil Metabolomics to Investigate the Untapped Metabolic Potential of Soil Microbial Communities and Their Role in Driving Soil Ecosystem Processes: a review. *Applied Soil Ecology*. 195, 105238. (NAAS rating:11.51)
4. Bhattacharyya R, Bhatia AI, Ghosh BN, Santra P, Mandal D, Kumar G, Singh R, Madhu M, Ghosh A, Mandal AK, Ranjan PI, Ashim D, Parbodh CS, Mandal UK, Jha P, Anil KS. Lalitha M, Kumar M, Panwar NR, Sarkar D, Patra AK, Kundu S, Fullen MA, Poesen J, Das BS, Reddy NN, Chaudhari SK (2023).Soil Degradation and Mitigation in Agricultural Lands in the Indian Anthropocene.*European Journal of Soil Science,* 74(4), e13388.(NAAS rating:10.18)
5. Bhavya N, Murthy RK, Govinda K, Uday Kumar SN, Basavaraj PK, Saqeebulla HM, Gangamrutha GV, Srivastava S (2023). Fertilizer prescription model through soil test crop response approach for carrot (Daucuscarota) on an Alfisols of Southern India, *Theoretical Biology Forum*, 12 (2), 93-100. (NAAS rating: 6.46)
6. Choudhary M, Sinha NK, Mohanty M, Jayaraman S, Kumari N, Jyoti B, Srivastava A, Thakur JK, Kumar N, Jha P, Kumar D, Kumar J, Mishra R, Wanjari RH, Chaudhary RS, Hati KM, Bisht J, Pattanayak A (2023). Response of contrasting nutrient management regimes on soil aggregation, aggregate associated carbon and macronutrients in a 43-year long-term experiment. *Sustainability* 15(3): 2679. (NAAS rating: 9.89)
7. Das A, Purakayastha TJ, Ahmed N, Das R, Biswas S, Shivay YS, SehgalVK, Rani K, Trivedi A, Tigga P, Sahoo J, Chakraborty R, Sen S (2023). Influence of Clay Mineralogy on Soil Organic Carbon Stabilization under Tropical Climate, India. *Journal of Soil Science and Plant Nutrition,* 23(1), 1003-1018. (NAAS rating: 9.61)
8. Dhaliwal, SS, Sharma V, Shukla AK, Kaur J, Verma V, Kaur M, Behera SK, Singh, P(2023). S genotypes to Mn application for yield and quality parameters under Mn deficient soil of north-western India. *Journal of Plant Nutrition*46(15), 3697-3714. https://doi.org/10.1080/01904167.2023.2211596. (NAAS rating: 8.28)
9. Dhaliwal, SS, Sharma V, Shukla AK, Behera SK, Verma V, Kaur M, Singh P, Alamri S, Skalicky M, Hossain A(2023).Biofortification of wheat (*Triticumaestivum* L.) genotypes with zinc and manganese lead to improve the grain yield and quality in sandy loam soil. *Frontiers in Sustainable Food Systems* 7,1164011. https://doi.org/10.3389/fsufs.2023.1164011. (NAAS rating: 11.01)
10. Dhaliwal SS., Sharma V, Shukla AK, Behera SK, Verma V, Kaur L, Verma G(2023). Optimization of phosphorus (P) induced zinc (Zn) deficiency in low and high P soils and monitoring their effect on productivity, Zn and P uptake by wheat (*Triticumaestivum* L.). *Journal of Plant Nutrition*46(6), 917-928.https://doi.org/10.1080/01904167.2022.2144365.(NAAS rating: 8.28)
11. Dotaniya CK, Lakaria BL, Sharma Y, Meena BP, Shirale AO, Dotaniya ML, Biswas AK, Doutaniya

RK, Sanwal RC, Reager ML (2023). Estimation of Potassium by Mehlich-3 Extractant Under Integrated Nutrient Management.*National Academy Science Letters*:1-4 (NAAS rating: 6.65).

12. Dotaniya CK, Lakaria BL, Sharma Y, Meena BP, Wanjari RH, Shirale AO, Dotaniya ML, Aher SB, Gurav P, Jha P, Biswas AK, Yadav SR, Kumar K, Doutaniya RK, Reager ML, Lata M, Sanwal RC (2023). Potassium fractions in black soil mediated by integrated nutrient management modules under maize-chickpea cropping sequence. *PLoS One*. 18(9):e0292221. (NAAS rating: 9.75).

13. Dutta A, Lenka NK, Hazra KK, (2023). Impact of heat stress on soil-plant phosphorus dynamics and yield of chickpea. *Journal of Plant Nutrition*. https://doi.org/10.1080/01904167.2023.2275075. (NAAS rating:8.28)

14. Fagodiya RK, Singh A, Singh R, Rani S, Kumar S, Rai AK, Sheoran P, Chandra P, Yadav RK, Sharma PC, Biswas AK, Chaudhari SK (2023). The food-energy-water-carbon nexus of the rice-wheat production system in the western Indo-Gangetic Plain of India: An impact of irrigation system, conservational tillage and residue management. *Science of The Total Environment*.860:160428 (NAAS rating:16.75)

15. Garnaik S, Samant PK , Mandal M, Sethi D, Wanjari RH, Mohanty TR, Dwivedi SK, Parihar CM and Nayak HS (2023). Long-term assessment of diverse nutrient management strategies in a rice-rice cropping system: analyzing yield trends, resource use efficiency and economic viability over a sixteen-year period. *Journal of Plant Nutrition* 47(2): 1-21 (DOI: 10.1080/01904167.2023.2291018). (NAAS rating: 8.10)

16. Kumar J, Kalita H, Rekhung W, Alone RA, Angami T, Jini D, Makdoh B, Touthang L, Khatri N, Singh AP, Sinha NK, Kumar D, Chaudhary RS (2023). Dynamics of soil organic carbon of jhum agriculture landuse system in the heterogeneous hill of Arunachal Pradesh, India. *Scientific Reports* 13(1): 12156 DOI: 10.1038/s41598-023-38421-1. (NAAS rating: 10.60).

17. Kumar A, Das A, Singh D, Das MK, Srivastava GP, Singh JP, Tilgam J, Thapa S, Das S, Chakdar H (2023). Soil health restoration in degraded lands: *A microbiological perspective. Land Degradation & Development.* (NAAS rating: 10.70)

18. Kumar J, Kalita H, RekhungW, Alone RA, Angami, T, Jini D, Chaudhary RS (2023). Dynamics of soil organic carbon of jhum agriculture land-use system in the heterogeneous hill of Arunachal Pradesh, India. *Scientific Reports*, 13(1), 12156.(NAAS rating: 11.00)

19. Kumar NS, Sambhaji MS, Jha BK, Kumar R, Mishra MS, Singh JS, Kumar A, Biswas AK, Choudhary AK, Choudhary JS, Hansraj H, Das A, Babu S, Layek J, Upadhyaya A, Bhatt BP, Chaudhari SK (2023). Intensification of Rice-Fallow Agroecosystem of South Asia with Oilseeds and Pulses: Impacts on System Productivity, Soil Carbon Dynamics and Energetics.*Sustainability*.15(2): 1054. (NAAS rating:9.89)

20. Lal N, Kumar A and Pandey SD (2023). Effects of tree trunk, branch and leaf traits onMorphological diversity of Litchi chinensisSonn. *Bangladesh Journal of Botany*. 52(1): 197-202. (NAAS rating: 6.34)

21. Lal N, Kumar A, Pandey SD, Nath V (2023). Screening of litchi genotypes for fruit cracking and the relationship of cracking to fruit and leaf traits. *Erwerbs-Obstbau*.65: 479–485. (NAAS rating: 7.21)

22. Lal N, Kumar A, Singh A, Marboh ES, Gupta AK, Pandey SD, Nath V (2023). Standardization of number of flowers to be pollinated per panicle for hybridization in litchi and assessment of effective duration of pollination. *Erwerbs-Obstbau*.65:487–492. (NAAS rating: 7.21)

23. Lal N, Pandey SK, Nath V (2023). Genetic diversity and grouping of litchi genotypes based on83 qualitative and quantitative traits. *Erwerbs-Obstbau*.65:1003–1012. (NAAS rating: 7.21)

24. Lal N, Pongener A, Kumar A, Pandey SD (2023). Studies on bioactive compounds and antioxidant activity of litchi (Litchi *ChinensisSonn.*) fruit cultivars under field conditions.*National Academy of Science Letters.* 46(1):7–10.(NAAS rating: 6.65)

25. Lal N, Singh A, Kumar A, Pandey SD (2023). Assessment of Variability, Correlation and

Path Analysis for the Selection of Elite Clones in Litchi Based on Certain Traits. *Erwerbs-Obstbau*.65:501-507. (NAAS rating: 7.21)

26. Lal N, Singh A, Kumar A, Marboh ES, Gupta AK, Pongener A, Nath V, Pandey SD (2023). Hurdles in developing hybrids: Experience from a decade of hybridization in litchi. *Euphytica*. 219: 216. (NAAS rating: 8.19)

27. Lal N, Singh A, Singh SK, Kumar A, Pandey SD, Nath V(2023). Morphological diversity in litchi based on phenological traits. *Indian Journal of Horticulture*. 80(1): 30-36. (NAAS rating: 6.0).

28. Lal N, Biswas AK (2023). Allelopathic Interaction and Eco-physiological Mechanisms in Agri-horticultural Systems: A Review.*Erwerbs-Obstbau*: 1-12 (NAAS rating 7.21).

29. Mahawar N, Srivastava S, Gupta SC, Trivedi SK (2023). Comparison between DTPA Extracting Methods for Available Zinc with Multinutrient Extractants in Vertisols and Inceptisols, International, *Journal of Plant & Soil Science*, 35 (18), 1299-1304. (NAAS rating: 9.61)

30. Meena SN, Sharma SK, Singh P, Asha Ram, Meena BP, Jain D, Singh D,Debnath S, Yadav S, DhakadU, VermaP,Meena J K, Nandan S(2023). Tillage-based nutrient management practices for sustaining productivity and soil health in the soybean-wheat cropping system in Vertisols of the Indian semi-arid tropics. *Frontiers in Sustainable Food Systems*. 7, 1234344. doi: 10.3389/fsufs.2023.1234344.(NAAS rating: 11.01)

31. Mishra R, Datta SP, Golui D, Meena MC, Dwivedi BS, Rahman MM, Bandyopadhyay K, Bhatia A, Pandey PS (2023). Evaluation of different extractants to estimate bioavailable arsenic in soil. *Communications in Soil Science and Plant Analysis, pp*.1-16.(NAAS rating:7.58)

32. Mohanty SR, Mahawar H, Bajpai A, Dubey G, Parmar R, Atoliya N, Devi MH, Singh AB, Jain D, Patra A, Kollah B. (2023). Methylotroph bacteria and cellular metabolite carotenoid alleviate ultraviolet radiation-driven abiotic stress in plants. *Front. Microbial*. 13: 899268. doi: 10.3389/fmicb.2022.899268.(NAAS rating: 12.06)

33. Murthy RK, Nagaraju B, Kasturappa G, Sugaturu Narayanaswamy UK, Pujari KB, Hussain Sab MS, Srivastava S, Dey P (2023). Modelling soil, plant and fertilizer relationship to optimize nutrient management for chilli (Capsicum annuum L) under Alfisols of Southern India, *Archives of Agronomy and Soil Science,* 69 (15), 1-17.(NAAS rating:8.24)

34. Nandi R, Mukherjee S, Bandyopadhyay PK, Saha M, Singh KC, Ghatak P, Kundu A, Saha S, Nath R, Chakraborti P (2023). Assessment and mitigation of soil water stress of rainfed lentil (*Lens culinaries*Medik) through sowing time, tillage and potassic fertilization disparities. *Agricultural Water Management* 277, 108120. https://doi.org/10.1016/j.agwat.2022.108120 (NAAS rating: 12.61)

35. Pradhan A, Wakchaure GC, DhanashriS, Minhas PS, Biswas AK, REDDY KS (2023). Impact of residue retention and nutrient management on carbon sequestration, soil biological properties, and yield in multi-ratoon sugarcane.*Frontiers in Sustainable Food Systems*.7:1288569(NAAS rating:11.01)

36. Pratibha G, Manjunath M, Raju BMK, Srinivas I, Rao KV, Shanker AK, Prasad JVNS, Rao MS, Sumanta K, Indoria AK, Kumar U, Rao KS, Anna Sk, Rao CS, Singh VK, Biswas AK, Chaudhari SK (2023).Soil bacterial community structure and functioning in a long-term conservation agriculture experiment under semi-arid rainfed production system.*Frontiers in Microbiology*.14: 1102682.(NAAS rating:12.06)

37. Rani K, Datta A, Jat H, Choudhary S, Sharma M, PC and Jat ML (2023). Assessing the availability of potassium and its quantity-intensity relations under long term conservation agriculture based cereal systems in North-West India. *Soil and Tillage Research,* 228, 105644. (NAAS rating: 13.37)

38. Roy P, Bhattacharyya R, Biswas DR, Singh R, Das TK, Sharma DK, Yadav S, Joseph AM, & Jha P (2023). Effect of using Agrogeotextiles on soil carbon sequestration in the Indian Himalayas. *The Indian Journal of Agricultural Sciences*, 93(7), 768–773. (NAAS rating: 6.37)

39. Roy P, Bhattacharyya R, Singh RJ, Sharma NK, Kumar G, Madhu M, Biswas DR, Ghosh A, Das S, Joseph AK, Das TK, Kumar SN, Jat SL, Saharawat Y and

Jha P. (2023). Impact of agro-geotextiles on soil aggregation and organic carbon sequestration under conservation tilled maize-based cropping system in the Indian Himalayas. *Frontiers in Environmental Science-Soil Processes*.11: 1309106. (NAAS rating: 11.41)

40. Saha M, Sarkar A, Das M, Ghosh A, Yadav DK, Biswas SS (2023). Crop Diversification in Rice-Based Agroecosystem: Medium-Term Effects on Soil Properties, Carbon and Other Nutrients' Stoichiometry, and System Productivity. *Journal of Soil Science and Plant Nutrition* 12, 1-7. (NAAS rating: 9.61)

41. Singh K, Thakuria D, Puyam A, Devi MH, Kumar V (2023). Root nodulation and yield of French bean (*Phaseoulus vulgaris*) are altered by fallow length in slash-and-burn agriculture. *Archieves of Agronomy and Soil Science*. DOI: 10.1080/03650340.2023.2241843 (IF: 2.242). (NAAS rating:8.24)

42. Shirale AO, Meena BP, Biswas AK,Gurav Priya P., Srivastava S, DasH, Thakur JK, PatraAK, RaoA. S. (2023) Characterization and K Release Pattern of Glauconite in Contrasting Soils of India. *Journal of Soil Science and Plant Nutrition*https://doi.org/10.1007/s42729-023-01379-0.(NAAS rating:9.61)

43. Shukla AK, Behera SK,Lakaria BL, Tripathi A(2023). Effect of land use and soil depth on distribution of phyto-available nutrients and SOC pools of Vertisols in central India. *Environmental Monitoring and Assessment* 195, 1405. https://doi.org/10.1007/s10661-023-12032-9.(NAAS rating: 9.31)

44. Vishwakarma AK, Meena BP, Das H, Jha P, Biswas AK, Bharati K, Hati KM, Chaudhary RS, Shirale AO, Lakaria BL, Gurav Priya P, Patra AK (2023). Impact of sequential herbicides application on crop productivity, weed and nutrient dynamics in soybean under conservation agriculture in Vertisols of Central India. *Plos one*. 18(1):e0279434(NAAS rating: 9.75)

45. Yadav RK, Purakaystha TJ, Kumar D, Jha PK, Mahala DM, Yadav DK, Khan MA, Singh S, Singh S, Prasad PVV (2023). Long-term impact of manuring on soil organic matter quality under field cropping systems. *Frontiers in Environmental Science* 11: 1116930 https://doi.org/10.3389/fenvs.2023.1116930. (NAAS rating: 10.60)

9.1.2 International / National (NAAS rating less than 6)

1. Bhinda NK, Singh Y, Dixit AK, Kumar D(2023). Effect of sulphur, zinc and boron on growth and yield of irrigated Indian mustard (*Brassica juncea* L.) in Bundelkhand region. *Journal of Oilseed Brassica* 14(2): 99-104. (NAAS rating: 4.78).

2. Das A, Purakayastha TJ, Ahmed N, Das R, Biswas S, Shivay YS, Sehgal VK, Rani K(2023). Assessment of Soil Carbon Mineralization and Stock in Mineralogically Different Agricultural Soils of India. *Journal of the Indian Society of Soil Science,* 71(2), 180-191 (NAAS rating: 5.31)

3. Devi MH, Haokip IC, Sahu A, Bhattacharjya S, Bharati K and Mohanty SR (2023). The crucial role of elevated carbon dioxide and temperature on soil biodiversity in agricultural ecosystems: A comprehensive review. *Biological Forum: An International Journal*. 15(9): 922-931. (NAAS rating: 5.11)

4. Dhaliwal SS, Sharma V, Shukla AK, Gupta RK, Verma V, Kaur M, Behera SK, Singh P (2023). Residual effect of organic and inorganic fertilizers on growth, yield and nutrient uptake in wheat under a basmati rice–wheat cropping system in north-western India. *Agriculture* 13, 556. https://doi.org/10.3390/agriculture13030556 (Impact factor 3.3)

5. Dhaliwal SS, Shukla AK, Behera SK, Dubey SK, Sharma S, Randhawa MK, Kaur G, Walia SS, Toor AS (2023). Impact of fertilization and tillage practices on transformations of carbon, essential plant nutrients and microbial biota composition in soils - A review. *Technology in Agronomy*https://doi.org/10.48130/tia-0023-0020

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55. एम वसन्दा कुमार, आर.के. सिंह, जितेंद्र कुमार, धीरज कुमार, आर.एच. वंजारी, असित मंडल, जे. सोमसुंदरम, राहुल मिश्रा, खुशबू रानी, नारायण लाल, ए.बी. सिंह, आर इलनचेलियन, डी. के.जैन, एस.के. बड़ोदिया और जितेंद्र अलवा (2023). सोयाबीन फसल की आधुनिक खेती.

9.6 Folder/Extension leaflets/Brochure

1. Mohanty SR, M Saha, Rani A, Immanuel CH, RaniK ICAR-IISS Newsletter Vol 26. No.1 (January-June, 2023)

2. Kumar Dhiraj, Kumar Jitendra, Mishra Rahul, Singh RK, Wanjari RH, Mandal Asit, Rani Khushboo, Lal Narayan , Sinha NK, Somasundaram J, Coumar MV, Nagwanshi Anil, Singh AB, Badodiya SK (2023). कृषि वानिकी के माध्यम से किसानों की आजीविका में सुधार I Hindi Folder (Under TSP Programme), ICAR-IISS, Bhopal.

3. आर. इलनचेलियन, दिनेश कुमार यादव, एम. वसन्दा कुमार, प्रभात त्रिपाठी, नारायण लाल, निशा साहू, अतुल डांगे, मनीष कुमार सिंह, बी. एस. राजपूत, आर. के. सिंह, आर. एच. वंजारी एवं ए. बी. सिंह (2023). "फसलों में नाइट्रोजन प्रबंधन के लिए लीफ कलर चार्ट", भाकृअनुप–भारतीय मृदा विज्ञान संस्थान द्वारा प्रकाशित।

4 एम, वसन्दा कुमार, दिनेश कुमार यादव, आर. इलनचेलियन, प्रभात त्रिपाठी, नारायण लाल, निशा साहू, अंजली घृतलहरे, आर. के. सिंह एवं ए. बी. सिंह (2023). "मृदा परीक्षण आधुनिक खेती में किसानों की आवश्यकता",भाकृअनुप–भारतीय मृदा विज्ञान संस्थान द्वारा प्रकाशित।

5. दिनेश कुमार यादव, आर. इलनचेलियन, प्रभात त्रिपाठी, एम, वसन्दा कुमार, नारायण लाल, निशा साहू, अंजली घृतलहरे, आर. के. सिंह एवं ए. बी. सिंह (2023). "कीटनाशकों के सुरक्षित उपयोग के लिए रखीं जाने वाली सावधानियाँ",भाकृअनुप–भारतीय मृदा विज्ञान संस्थान द्वारा प्रकाशित।

6. नारायण लाल, आर. इलनचेलियन, निशा साहू, प्रभात त्रिपाठी, एम. वसन्दा कुमार, दिनेश कुमार यादव, गुंजन झा, आर. के. सिंह एवं ए. बी. सिंह, आर. इलनचेलियन, दिनेश कुमार यादव, एम. वसन्दा कुमार, प्रभात त्रिपाठी, नारायण लाल, निशा साहू, अतुल डांगे, मनीष कुमार सिंह, बी. एस. राजपूत, आर. के. सिंह, आर. एच. वंजारी एवं ए. बी. सिंह (2023). "फसलों में नाइट्रोजन प्रबंधन के लिए लीफ कलर चाम के हानिकारक कीटव्याधियां एवं उनका प्रबंधन", भाकृअनुप–भारतीय मृदा विज्ञान संस्थान द्वारा प्रकाशित।

7. नारायण लाल, दिनेश कुमार यादव, प्रभात त्रिपाठी, आर. इलनचेलियन, एम, वसन्दा कुमार, निशा साहू, सुरभि जैन, आर. के. सिंह एवं ए. बी. सिंह (2023). "वैज्ञानिक तरीके से बागवानी कैसे करें", भाकृअनुप–भारतीय मृदा विज्ञान संस्थान द्वारा प्रकाशित।

8. नारायण लाल, प्रभात त्रिपाठी, निशा साहू, आर. इलनचेलियन, दिनेश कुमार यादव, एम, वसन्दा कुमार, मोहनिषा जंघेल, आर. के. सिंह एवं ए. बी. सिंह (2023). "फल मक्खी: अमरूद के बाग में एक हानिकारक कीट", भाकृअनुप–भारतीय मृदा विज्ञान संस्थान द्वारा प्रकाशित।

9. प्रभात त्रिपाठी, दिनेश कुमार यादव, आर. इलनचेलियन, एम, वसन्दा कुमार, नारायण लाल, निशा साहू, पी. कोठारी, बी. एस. राजपूत, अतुल डांगे, आर. के. सिंह एवं ए. बी. सिंह (2023). "बीज प्रमाणीकरण पर जानकारी", भाकृअनुप–भारतीय मृदा विज्ञान संस्थान द्वारा प्रकाशित।

Video:

- Asha Sahu "International Women's Day" (https://icar.org.in/content/icar-institutes-celebrate-international-women%E2%80%99s-day-2023)
- S Srivastava, NK Sinha, KC Shinogi, N Lal, S Bhattachrjya and Asha Sahu "A journey of ICAR-IISS" (released on the occasion of 36th Foundation Day (link: https://www.youtube.com/watch?v=VwilWs2csl8)

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Dr. Rahul Mishra, Scientist	Chairman
Dr. Dinesh Kumar Yadav, Scientist	Member
Shri. M.K. Mulani, SFAO	In-charge
Shri. P.K. Chauhan, T-5	Member
Shri. Sunny Kumar, PA	Member
Shri. Sanjay Narayan Gharde	Member
Shri. Jagannath Gour, SSS	Care Taker

Swachh Bharat Mission

Dr. B. P. Meena, Sr. Scientist	Nodal Officer
Dr. Asit Mandal, Sr. Scientist	Member
Dr. J.K. Thakur, Sr. Scientist	Member
Dr. Asha Sahu, Sr. Scientist	Member
Dr. Jitendra Kumar, Sr. Scientist	Member
Dr. Abinash Das, Scientist	Member
Shri. Kalicharan, SSS	Member
Shri. Janak Singh, SSS	Member

Agricultural Knowledge Management Unit (AKMU)

Dr. N.K. Sinha, Sr. Scientist	In-charge
Dr. Rahul Mishra, Scientist	Member
Dr. Dhiraj Kumar, Scientist	Member

Vehicle Operation Advisory Committee

Dr. Asit Mandal, Sr. Scientist	Chairman
Dr. Jitendra Kumar, Sr. Scientist	Member
Dr. Dinesh Kumar Yadav, Scientist	Member
Shri. M.K. Mulani, SFAO	In-charge
Shri. Deepak Kaul, CTO	Member
Shri. Pramod K.Chauhan, TO	Member
Shri. Hira Lal Gupta, Assistant	Member
Shri. Sanjay Kumar Parihar, TA	Member

Right To Information (RTI Cell)

Dr. R. Elanchezhian, Pr. Scientist & I/c PME	Nodal officer & CPIO (Scientific)
Dr. J.K. Thakur, Sr. Scientist	Member
Dr. Immanuel Chongboi Haokip, Scientist	Member
S.A.O	CPIO (Admin. Matters)
Shri Sanjay Kumar Kori, PA	Office Staff
ShriSanjay Kumar Parihar, TA	Office Staff

Screen House

Dr. M.Vassanda Coumar, Sr. Scientist	Incharge
Dr. Immanuel Chongboi Haokip, Scientist	Member
Dr. M. Homeshwari Devi, Scientist	Member

Dr. Khushboo Rani, Scientist	Member
Dr. Abinash Das, Scientist	Member

HRD (Training)

Dr. J.K. Saha, Pr. Scientist	Nodal Officer
Dr. R.K. Singh, Pr. Scientist	Member
Dr. Kollah Bharati, Pr. Scientist	Member
Dr. Immanuel Chongboi Haokip, Scientist	Member
Dr. M. Homeshwari Devi, Scientist	Member
Dr. Dinesh Kumar Yadav, Scientist	Member

Mera Gaon Mera Gaurav

Dr. Prabhat Tripathi, Pr. Scientist	Nodal Officer
Dr. Sangeeta Lenka, Pr. Scientist	Member
Dr. Jitendra Kumar, Sr. Scientist	Member
Dr. Sudeshna Bhattacharjya, Scientist	Member
Dr. Dhiraj Kumar, Scientist	Member

TSP/STC Programme Implementation Committee

Dr. R.K. Singh, Pr. Scientist	Chairman
Dr. R.H. Wanjari, Pr. Scientist	Member
Dr. Asit Mandal, Sr. Scientist	Member
Dr. K.C. Shinogi, Sr. Scientist	Member
Dr. B.P. Meena, Sr. Scientist	Member
Dr. Jitendra Kumar, Sr. Scientist	Member
Dr. Dhiraj Kumar, Scientist	Member
Dr. Dinesh Kumar Yadav, Scientist	Member
Shri M.K.Mulani, S.F.A.O	Member
S.A.O	Member
Shri Sanjay Katinga, UDC	Member

Schedule Castes Sub Plan (SCSP)

Dr. Ajay, Pr. Scientist	Chairman
Dr. Jitendra Kumar, Sr. Scientist	Member
Dr. Narayan Lal, Sr. Scientist	Member
Dr. Dhiraj Kumar, Scientist	Member
Dr. Immanuel Chongboi Haokip, Scientist	Member
Dr. M. Homeshwari Devi, Scientist	Member
Dr. Abinash Das, Scientist	Member
Shri M.K. Mulani, S.F.A.O	Member
S.A.O	Member
Dr. B.P. Meena, Sr. Scientist	Member Secretary

Campus Development and Facility Committee

Dr. Sanjay Srivastava, Pr. Scientist &I/c PC STCR	Chairman
Dr. Dhiraj Kumar, Scientist	Member
Dr. Sudeshna Bhattacharjya, Scientist	Member
Dr. Dinesh Kumar Yadav, Scientist	Member

Dr. Khushboo Rani, Scientist	Member
Dr. Abinash Das, Scientist	Member
Shri M.K. Mulani, S.F.A.O	Member
S.A.O	Member
Shri Venny Joy, Private Secretary	Member
Shri Hukum Singh TO	Member
Shri Sukram Sen, TO	Member
Shri Sunny Kumar, PA	Member
Shri Kalicharan, SSS	Member

Punctuality Committee/Biometric Monitoring Committee

Dr. S.K. Behera, HOD (SC&F)	Chairman
Dr. Tapan Adhikari, HOD (ESS)	Member
Dr. N.K. Lenka, HOD (SPD)	Member
Dr. S.R. Mohanty, HOD (SBD)	Member
Dr. Pramod Jha, Pr.Scientist	Member
Shri M.K.Mulani, S.F.A.O	Member
S.A.O	Member
Shri Hira Lal Gupta, Assistant, IJSC Member	Member

Externally Funded Project Evaluation Committee

Director	Chairman
All Heads	Member
All I/c PCs/NC	Member
SAO	Member
Shri M.K. Mulani, SFAO	Member
PI of Project	Member
I/c PME Cell	Member Secretary

Proprietary Committee

Dr. Pramod Jha, Pr. Scientist	Chairman
Dr. S.K. Behera, Pr. Scientist & HOD (SC&F)	Member
Dr. Sangeeta Lenka, Pr. Scientist	Member
Dr. J.K. Thakur, Sr. Scienstist	Member
AAO (P&S)	Member

11 IMPORTANT MEETINGS/ACTIVITIES

Republic Day

The 74th Republic Daywas celebrated on January 26, 2023 in the Institute premises with great gaiety and fervor. Dr A.B. Singh Director, addressed the gathering and requested all the staff and their family members to work with sincerity for the welfare of the nation.

International Women's Day

The women's cell of ICAR-Indian Institute of Soil Science organized the international women's day program at village Borkhedi, Phanda Tehsil, Bhopal District, on March 6, 2022. A one-day training cum workshop was organized to sensitize and train the farm women on "Improving the livelihood of farm women through managing soil health, waste to wealth and women nutrition" About 150 farm women, including the scientist and technical staff of the Institute, participated in the program.

36th Foundation Day

The ICAR-IISS, Bhopal celebrated its 36th Foundation Day on April 16, 2023. On this occasion, Dr S.K. Chaudhari, Deputy Director General (Natural resource Management) ICAR, New Delhi graced the occasion as Chief Guest. The Guest of Honour, Prof Dr. S.K. Sanyal delivered the Foundation Day Lecture and emphasized on the need for maintaining soil physical properties for better soil chemical and biological environment. Former Directors of the Institute namely Dr. PN Takkar and Dr. CL Acharya graced the occasion virtually and complimented the Institute for its achievements and service to the farming community. Dr SP Datta Director, ICAR-IISS, Bhopal presented about the achievements of the institute including several national and international awards in last 2 years. On this occasion the institute also felicitated the progressive farmers, scientists and other staff completing 30 and 20 years of service and scientists attaining new heights in their careers. The institute also released new publications and mobile Apps for the benefit of farmers.

International Yoga Day

The ICAR-IISS, Bhopal celebrated the 9th International Yoga Day on June 21, 2023 with a demonstration cum awareness lecture on yoga. Dr. AB Singh, I/c Director, ICAR- IISS, Bhopal inaugurated the program and briefed about the importance of yoga in modern life. He further highlighted the significance of yoga and emphasized its relevance in today's lifestyle, stressing the need of healthy body for a healthy mind. In this program, various exercises, yoga asanas, pranayama, etc. were demonstrated and conducted by Yoga expert Miss Jyoti Bishnoi. She explained the benefits of regular practice of these asanas and pranayama for relieving several health issues such as diabetes, heart and lung diseases. Scientists, technical and administrative officers of the institute participated in the program.

Institute Research Council (IRC)

IRC meeting was held on June 6-8 & June 15-16 and July 25, 2023 to review the progress of the projects and activities of the scientists. Dr. SP Datta, Director chaired the session and 44 ongoing projects including external funded and 6 new projects werepresented and reviewed. An on-field IRC was also organized on August 16, 2023 to review the field experiments.

Independence Day

The 77th Independence Day was celebrated on August 15, 2023 in the Institute premises with great gaiety and fervor. Dr SP Datta, Director, addressed the gathering and requested all the staff and their family members to work for the welfare of the nation.

हिन्दी पखवाड़ा

संस्थान में 6–20 सितंबर, 2023 के दौरान हिंदी पखवाड़ा मनाया गया। वाद–विवाद, प्रश्नोत्तरी, हिंदी शब्दावली (शब्द ज्ञान) और टाइपिंग टेस्ट जैसी कई प्रतियोगिताएं आयोजित की गईं और निदेषक, आईसीएआर–आईआईएसएस ने विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कार वितरित किए।

Vigilance Awareness Week

Vigilance Awareness Week 2023 was organized by the ICAR-IISS, Bhopal, from October 30 to November 5, 2023, with the theme, "Say no to corruption; commit to the nation". Awareness week was started with a pledge, which was administered by the staff of the institute. During this period, essays, debates, and quiz competitions were organized among the institute staff. An expert talk was delivered by the Chief Administrative Officer of the CIAE, Bhopal, on day-to-day office work and procedures. Shri Pramod Kumar Manjhi, the Deputy Inspector General (CBI), as chief guest, and Dr. Dhirendra Shukla, OSD, M.P. higher education, as special guest, graced the event. The director of the institute, Dr. S.P. Datta presided over the event and the winners of the competitions were awarded with prizes and certificates.

World Soil Day and Agri Education Day

Soil Health Awareness Programme was celebrated at ICAR-Indian Institute of Soil Science (IISS), Bhopal during December 4-6, 2023. World Soil Day (WSD) was celebrated on December 5, 2023 with the theme of WSD is ***"Soil and Water, a source of life"***. On December 4, 2023 Soil Health Awareness Programme begun with the delivery of a lecture on "Soil Science" by Dr. S.P. Datta, Director, ICAR-IISS, Bhopal to educate the school children on the occasion of Agri. Education Day. About 50 students participated in the program with their teachers. This was followed by a Quiz Competition on "Soil Health" amongst the School Children.On December 5, a massive March Past was organized by the scientists, staff members and students of ICAR- IISS, Bhopal to spread awareness among the public on the importance of soil and water in human life, ecosystem and protection of these precious resources. Dr. S.P. Datta, Director welcomed the chief guest Dr. A.K. Singh, Former VC Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior. The chief guest delivered the World Soil Day lecture and highlighted the importance of scientific use of water for higher productivity of soil. He also stressed upon the ecosystem services provided by soil and the need to quantify them for optimum soil management. In the lecture, he exhorted the audience the need

for maintaining soil health to maintain human and environment health. The programme is also being extended to Village Level for mass awareness amongst the farmers on "Soil Health".

ICAR-Central Zone Sports Meet

ICAR IISS Contingent participated in the "ICAR-Central Zone Sports Meet" during December 18-22, 2023 to and won several gold, silver and bronze medals.



12 PARTICIPATION OF SCIENTISTS IN CONFERENCES/ SYMPOSIA/ SEMINARS/ WORKSHOPS /MEETING

Name	Programme	Venue/ Organizer	Period
Dr. RS Chaudhary	Regional Thematic Workshop on "Diversification of Crops"	Madhya Pradesh, Uttar Pradesh and Rajasthan	January 25, 2023
Dr. Asit Mandal	Laboratory Biosafety and Biosecurity organized by ICAR-National Institute of High Security Animal Disease	Anand Nagar, Bhopal.	January 30 - February 3rd 2023
All the Scientists	National Symposium on Digital Farming: The Future of Indian Agriculture	ICAR-IISS, Bhopal& ISAP New Delhi	February 2-3, 2023
Dr. Narayan Lal	7th International Conference on Multidisciplinary Research in Rural, Agriculture & Industry Development	Hotel Pukhraj, Bhopal by SSMWA	February 12-13, 2023
All the Scientists	Interaction with Dr Francois Bringel, Director of CNRS, University of Strasbourg, France	ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh	February 14, 2023
Drs. Narayan Lal, Immanuel ICand M. Homeshwari Devi	ICAR short course on "Integrating Precision agriculture tools with conservation agriculture for improving input use efficiency, resource conservation and farmers income	ICAR-IISS, Bhopal	February 15-24, 2023
Dr. RS Chaudhary	State level Interface Meeting with ICAR Institutes, SAUs, Senior Officers from State Governments and KVKs of Madhya Pradesh	Online	February 21, 2023
Dr. BP Meena	International conference on Development and Promotion of Millets and Seed Spices for Livelihood Security	Agriculture University, Jodhpur, Rajasthan	February 24-26, 2023
All the Scientists	Special Lecture on "National Science Day" through virtual mode	ICAR	February 28, 2023
All the Scientists	Annual Review Meeting for the NTPC fly ash project	ICAR-IISS, Bhopal	March 2-3, 2023.
Dr. Narayan Lal and Abinash Das	Pusa Krishi Vigyan Mela- 2023	ICAR-IARI, New Delhi	March 2-4, 2023
Drs Datta SP and S Srivastava	ICAR-Industry Stakeholder Consultationmeet	National Agricultural Science Complex, New Delhi	March 6, 2023
Dr. Asit Mandal	"Big Data Analytics in Agriculture" (online mode)	ICAR-NAARM, Hyderabad	March 9-10, 2023
Dr.DK Yadav	15th IUPAC International Congress of Crop Protection Chemistry	NASC Complex, New Delhi	March 14-15, 2023
Dr Immanuel C Haokip	International Conference on 'Natural Farming for Revitalizing Environment and Resilient Agriculture	CAU, Imphal	March 17-19, 2023
Ms. M Saha	38th M.P. Young Scientist Congress	Samrat Ashok Technological Institute, Vidisha	March 17-19, 2023
Dr. Asit Mandal & Dr. Abhijit Sarkar	Multivariate Data Analysis" (online mode)	ICAR-NAARM, Hyderabad	March 20-27, 2023

Name	Programme	Venue/ Organizer	Period
Dr. DK Yadav	Workshop on "Alternatives to Single Use Plastic (SUP)"	Central Pollution Control Board, Regional Directorate, Kolkata	March 23, 2023
All the Scientists	10th Annual Convention and National Webinar of Societies for Fertilizers and Environment	Online	March 24-25, 2023
Dr. Asit Mandal and Dr. Dhiraj Kumar	FAD 22 meeting on Integrated Nutrient Management (INM) held through virtual mode	Bureau of Indian Standards (BIS)	April 13, 2023 & June 9, 2023
Dr. Sanjay Srivastava and Mr. SK Pariha	G-20 Meet	Varanasi, UP	April 18-19, 2023
All Scientists	World Intellectual Property Day	ICAR-IISS, Bhopal	April 26, 2023
Dr. Asit Mandal	External Advisory Board Member at the SYMBIOREM consortium Meeting I	Online	May 01, 2023
Dr. Dhiraj Kumar	2nd Meeting of FAD 22/Panel IV: Panel on Agricultural Resource Management, By-Product Management and other Integrated System Management	Bureau of Indian Standards (BIS)	May 12, 2023
All the Scientists	National Campaign on "Soil Health Management (Nutrient Use Efficiency and Soil Organic Carbon Management)"	ICAR-IISS, Bhopal	May 22- 23, 2023
Dr. Sanjay Srivastava	Meeting (online) of Joint Working Group on fertilizers between India and Morocco	Ministry of Chemicals and Fertilizers, Government of India	June 2, 2023
Drs. RH Wanjari and Dhiraj Kumar	Meeting with officials from Somaiya Vidyavihar University, Mumbai to explore the introductory discussion on issues such as Soil Health, GPS & GIS, Conservation Agriculture and Potential for collaboration with ICAR-IISS, Bhopal	Online	June 2, 2023
Dr. S Lenka	Iowa Smart Climate Agriculture Conference	College of Agriculture and Life Science, Iowa State University	June 6-7, 2023
All the Scientists	Interactive session on "Women Social Status in the aftermath of Independence"	AKAM Activity by ICAR-IIWBR Karnal	June 7, 2023
All the Scientists	Attended a training on ARMS organized by Nodal Officer (Dr. B.L. Lakaria)		June 19, 2023
Dr. Sanjay Srivastava	*ChintanShivir* on Agriculture organized by INM Division, DA&FW, New Delhi	NASC, New Delhi	July 7-8, 2023
Drs. SP Datta, Sanjay Srivastava, JK Thakur, NK Sinha and SK Parihar	Foundation/Technology Day 2023 and showcasing the MIR technology	ICAR, New Delhi	July 16-17, 2023
All the scientists	ICAR Foundation Day		July 16, 2023
Drs. Sanjay Srivastava, S.K. Behera, S.R. Mohanty, RH Wanjari and Dhiraj Kumar	XXVII Meeting of ICAR Regional Committee VII	ICAR-CIAE, Bhopal	August 18, 2023
Dr. Sanjay Srivastava	30th Zonal Workshop of KVKs(Madhya Pradesh and Chhattisgarh)	KVK ICAR-CIAE, Bhopal	August 19-21, 2023
Drs. Asit Mandal, JK Thakur and Tapan Adhikari	National seminar (online) on "Microplastics: Current Scenario, Challenges & Future Perspective"	ICAR-NIREH, Bhopal	August 22-23, 2023
Dr. S R Mohanty	Project meeting	University of Strasbourg, France	September 10-19, 2023.

Name	Programme	Venue/ Organizer	Period
Dr. Dinesh K. Yadav	International Youth Conference	hybrid mode	September 21-24, 2023
Dr. Nisha Sahu	Remtech Europe Program on Soil Remediation	Online	September 22, 2023
Dr. Khushboo Rani	Third Virtual International Conference "Plant security and food safety: Microbiology, Soil Science, Food Quality and Agricultural Genetics".	Nicolaus Copernicus University in Toruń, Poland	September 26-27, 2023
Dr. Asit Mandal	Training on Pedagogical development Programme	NAAS, New Delhi	September 25-30, 2023
Dr. Pramod Jha	1st International Conference on Decarbonizing Agriculture	Mangalore, Karnataka	November 25 -27, 2023
All the Scientists	Global Symposium on Soils and Water by FAO	Online	October 2-5, 2023
All the Scientists	87th Annual Convention of Indian Society of Soil Science	ICAR-IISS, Bhopal & ISSS, New Delhi	October 3-6, 2023
All the Scientists	Special symposium on "Natural Resources Management for Sustainable Millets (*Shree Anna*) Production in India"	ICAR-IISS, Bhopal & ISSS, New Delhi	October 04, 2023.
Drs. SP Datta, S Srivastava, T Adhikari, SK Behera, NK Sinha, JK Thakur, D Kumar, KC Shinogi, R Mishra	XVI Agricultural Science Congress	NAAS at ICAR-CMFRI Kochi, Kerala	October 10-12, 2023
Dr. S Srivastava	Soil testing and soil fertility mapping using remote sensing/drone technology	Online	October 25, 2023
Dr. Alka Rani	5th International Conference on Sustainable Natural Resources Management Under Global Climate Change'	Soil Conservation Society of India at NASC complex, New Delhi	November 7-10, 2023
Dr. S Srivastava	Asian knowledge hub: webinar on soil testing kits	Online	November 7, 2023
Dr. Nisha Sahu	IIRS-ISRO survey of working professional in the field of Remote Sensing and GIS	Online	November 10, 2023
Dr. DK Yadav	"3rd Pedagogy Development Program for Enhancing Pedagogical Competencies for Agricultural Education"	NAAS, NASC Complex, New Delhi	November 20-24, 2023
Dr. BP Meena	Biennial National Symposium on "Climate Smart Agronomy for Resilient Production Systems and Livelihood Security"	ICAR-Central Coastal Agricultural Research Institute, Goa	November 22–24, 2023
Dr. KC Shinogi	National Workshop of Farmer FIRST Programme (FFP)	ICAR at by CSKHPKV, Palampur, Himachal Pradesh	November 28-30, 2023
All the Scientists	Global Soil Partnership World Soil Day 2023 (FAO)	Online	December 5, 2023
All the Scientists	Kisan Diwas	ICAR-IISS, Bhopal	December 23, 2023
Drs. SK Behera, BP Meena, MV Coumar, A Sarkar, S Bhardwaj, R Mishra	International conference on One Health, One World (linking soil health with plant, animal, and human health)	RVSKVV Gwalior& Hybrid mode	December 28–29, 2023
Drs. R Elanchezhian and Ajay	National Conference of Plant Physiology organized by ISPP and during	ICAR IARI New Delhi	December 9-12, 2023

13 WORKSHOPS, SEMINARS AND TRAININGS ORGANIZED

Workshop/Webinar/Conference/Meeting/Day/Mela/Pakhwada/Week/Campaign/Symposium

Title	Course Directors/ Coordinators	Duration	Sponsored by
National Symposium on 'Digital Farming: The Future of Indian Agriculture'	Dr. J. Somasundaram, N. K. Sinha	February 2-3, 2023	Indian Society of Agrophysics and ICAR-IISS, Bhopal
World IP Day	Dr Sanjay Srivastava	April 26, 2023	ICAR IISS Bhopal
Review meeting of AINP SBB	Drs. S.R. Mohanty, M. Homeshwari Devi and S.P. Datta	May 9, 2023	ICAR-IISS, Bhopal
XXIX Biennial AICRP on MSPE workshop at Odisha University of Agriculture and Technology (OUAT), Bhubaneswar	Drs. S.P. Datta, S.K. Behera, Rahul Mishra	June 23-25, 2023	AICRP on MSPE, ICAR IISS Bhopal
Work shop on AGROTAIN Incorporated Urea Produces with N-TEGRATIONTM Technology for Improving Nitrogen Use Efficiency in Major Cropping Systems of India	Drs. Pramod Jha, BP Meena, R Elanchezhian	August 26-27, 2023	ICAR-IISS, Bhopal
87th Annual Convention of ISSS	Dr. A.K. Biswas and Bhopal chapter ISSS	October 3-6, 2023	ICAR-Indian Institute of Soil Science, Bhopal
Field day on Integrated nutrient management for sustainable soil health under SCSP project	Dr. S.P. Datta, Ajay, T. Adhikari, R. Elanchezhian, P. Tripathi, B. P. Meena, K.C. Shinoji, Jitendra Kumar, D. K. Yadav	December 7, 2023	ICAR-IISS, Bhopal
Kisan Diwas" (Farmer's Day) on the occasion of National Farmers Day at Rasuliya Pathar, Bhopal	Dr BP Meena	December 23, 2023	ICAR-IISS, Bhopal

Training

Programme	Course Directors/Coordinators	Duration	Sponsored by
Training-cum-exposure visit programme on Resource Conservation Technologies for the Tribal Farmers of Madhya Pradesh	Drs. A. B. Singh, A. K. Biswas, R. K. Singh, Shinogi K.C, Sanjay Srivastava, A. K. Tripathi, K. Bharati, N. K. Sinha, J. K. Thakur, Asha Sahu, B. P. Meena, Priya Gurav, Abhijit Sarkar, Madumonti Saha, Immanuel C. haokip, M.Homeshwari	January 23-27, 2023	ICAR-IISS, Bhopal
ICAR Short Course on Integrating Precision Agriculture Tools with Conservation Agriculture for Improving Input Use Efficiency, Resource Conservation and Farmers Income	AK Vishwakarma, Pramod Jha and AK Biswas	February 15 – 24, 2023	ICAR, New Delhi

Programme	Course Directors/Coordinators	Duration	Sponsored by
Soil Health Assessment and Management	Dr. Pramod Jha, Dr BP Meena and Dr Khushboo Rani	February 20-24, 2023	Department of Farmers Welfare & Agriculture Development, Bhopal
Application of Geo-spatial Tools in Soil Science	Drs. N.K. Sinha, J. Somasundaram, Jitendra Kumar, D. Kumar, R. Mishra, N. Sahu, K.M. Hathi andR.S. Chaudhary,	February 27 – March 5, 2023	ICAR-IISS, Bhopal and JNKVV, Jabalpur, Madhya Pradesh.
Climate-Smart Agriculture and Soil Health Management	Drs. S.P. Datta, A.B. Singh, J. kumar, N.K. Sinha, J. Somasundaram, J.K.Thakur, D. Kumar, R. Mishra, P. Jha, R.K. Singh, P. Tripathi, K.M. Hati and R.S. Chaudhary	March 15–19, 2023	ICAR-IISS, Bhopal
Training on soil health management and agricultural input distribution	Drs. R.K. Singh, A.B. Singh and S.K. Badodiya	March 21, 2023	ICAR-IISS, Bhopal and KVK, Barwani
Krishi Mela cum Krishak Sangosthi on Natural Farming	Drs. R. Elanchezhian, Prabhat Tripathi, M.V. Coumar, Narayan Lal, Nisha Sahu and Dinesh Kumar Yadav	March 27-29, 2023	ICAR-IISS, Bhopal and KVK Surgi, Rajnandgaon
Training on Soil Pollutants Impact Assessment and Remediation of Contaminated Sites	Drs. M. Vassanda Coumar, Sangeeta Lenka, Nisha Sahu, Rahul Mishra	May 23-25, 2023	CPCB, New Delhi
Training on soil health Management and agricultural input distribution programme	Drs. R.K. Singh, Jitendra Kumar, Asit Mandal, Dhiraj Kumar and S. K. Badodiya	November 21, 2023	ICAR-IISS, Bhopal and KVK Barwani
Application of Geo-spatial Tools in Soil Science	Drs. N.K. Sinha, N.K. Lenka, J. Kumar, D. Kumar and R. Mishra	December 5-11, 2023	ICAR-IISS, Bhopal and CSK, HPKV, Palampur, Himachal Pradesh.

Glimpses of events Organized by the institute

AICRP workshop

DDG, NRM adressing at workshop

CSA NICRA Training

Agrotain workshop

AICRP workshop

DDG NRM adressing at workshop

CPCB sponsored training

Kisan Diwas

Participants under SCSP training

Women cell imparting training to Farm Women

Farm Women Training under SCSP

Ayurveda Day on November 10, 2023

Review meeting of AINP SBB

National Symposium on 'Digital Farming: The Future of Indian Agriculture'

The National Symposium on 'Digital Farming: The Future of Indian Agriculture' was organized by Indian Society of Agrophysics and ICAR-IISS, Bhopal. The symposium was chaired by Dr. Suresh Kumar Chaudhari, DDG (NRM) & President (ISAP). In this programme, Dr. A.K. Singh, Former Vice-Chancellor (RVSKVV, Gwalior) and former DDG (NRM), Dr. Ashok K Patra, Former Director (ICAR-IISS, Bhopal), Dr A. B. Singh, Director (Acting), ICAR-IISS and other distinguished delegates graced the occasion. The symposium was attended by about 150 delegates, including Scientists, Academicians, Research Associates, young professionals and students from different Research Institutes and Universities from all over India.

National Campaign on Soil Health Management (Nutrient Use Efficiency and SOC Management)

A National Campaign LiFE (Lifestyle For Environment) was organized on May 22, 2023 at ICAR-IISS, Bhopal. In this national campaign on Soil Health Management (Nutrient Use Efficiency and SOC Management), 700 farmers from Madhya Pradesh and subject matter specialists from AICRPs/State Agriculture Universities/State Departments of Agriculture/KVKs participated. The program was graced by Dr. Milind Wadodkar, Chief Soil Survey Officer, Soil and Land Use Survey of India, GoI, New Delhi and attended by all the scientists of ICAR-IISS including HoDs, In-Charges AICRPs, scientists from their centers and farmers from different parts of the country. In this programme, Dr. Siba Prasad Datta, Director ICAR-Indian Institute of Soil Science, Bhopal welcomed all the participants of the function (online and offline). He stressed the farmers to adopt a simple life i.e. living in harmony with nature. He also mentioned the citations of simple living and preservation of soil health mentioned in our epics. The mother earth renders so many soil functions such as purification of water, carbon & nutrient cycling, diluting and denaturing the pesticides thereby improving soil health. He also requested farmers to adopt balanced and integrated use of nutrient in soil as it can maintain sufficient carbon content in soil.

87th Annual Convention of Indian Society of Soil Science

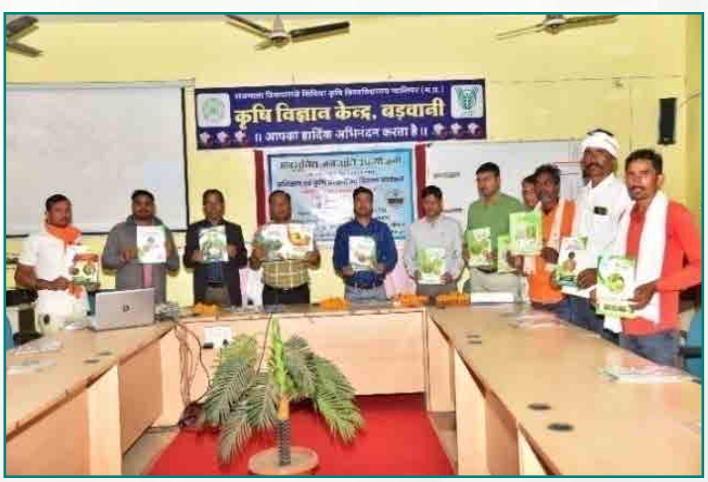
The 87th Annual Convention of Indian Society of Soil Science (ISSS) was held during October 3-6, 2023 at ICAR- Indian Institute of Soil Science, Bhopal. More than 400 delegates comprising of scientists, teachers, researchers, students and farmers from all over the country took part in the event. Shri Kamal Patel ji, Hon'ble Minister, Farmers Welfare and Agriculture Development Department, Government of Madhya Pradesh inaugurated the convention and emphasized on soil health to maintain human and animal health through natural farming. He reminded the audience of the damage inflicted on the land and water resources of the country by imbalance and excessive use of fertilizers and pesticides to crops and called upon the scientists to work for nature-based agriculture. During the convention, Dr. Himanshu Pathak, Secretary (DARE) and Director General (ICAR), stressed upon the urgent need for both research and awareness about soil among different stakeholders. Dr. Pathak appreciated the work of Indian Society of Soil Science, the establishment of a centre of excellence for fertilizer research, increased research on climate-resilient soil for agricultural purposes, research on soil for horticultural crops, and greater awareness of the proper use of fertilizer. Dr. Suresh Kumar Chaudhari, Deputy Director General (Natural Resource Management), who was the Guest of Honour, highlighted the significance of climate change mitigation and climate-resilient agriculture. He also stressed upon the role of society in promoting soil health and education. Dr. SP Datta, Director of ICAR-IISS, emphasized the importance of soil for the survival of living beings. He also referred to ancient texts such as Rig Veda and Manusmriti to highlight the importance of soil. The convention saw participation from about 400 delegates from different parts of the country, who made different deliberations on various aspects of soil science. The convention has brought out very useful recommendation covering aspects of soil research and millet production. The convention was supported by ICAR, Madhya Pradesh State Agricultural Marketing (Mandi) Board, NABARD, Indian Farmers Fertilizer Cooperative, ITC, KRIBHCO Fertilizers Limited, etc. At the end of the event, Dr. AK Biswas, Organizing Secretary, expressed his gratitude and appreciation on behalf of the organizers by proposing a vote of thanks.

Trainings under TSP project

Training on soil health management and agricultural input distribution programme organized by Indian Institute of Soil Science, Bhopal at KVK Barwani on March 21, 2023 under TSP project. The program was coordinated by Dr. R.K. Singh, Dr A.B. Singh and Dr. S.K. Badodiya, Inchrge, KVK, Barwani. About 50 tribal farmers participated in one-day training programme from different villages of Barwani district. At end the programme, the vermibeds were distributed to the tribal farmers for preparation of vermicompost at farmers' field level.

Training-cum-exposure visit programme was conducted at ICAR-IISS, Bhopal during January 23-27, 2023. Total 23 participants attended the training program for the tribal farmers of Betul district of Madhya Pradesh. This training was organized on Training – cum- Exposure Visit on Resource Conservation technologies. The program was coordinated by Drs. A. B. Singh, A. K. Biswas, R. K. Singh, Shinogi K.C, Sanjay Srivastava, A. K. Tripathi, K. Bharati, N. K. Sinha, J. K. Thakur, Asha Sahu, B. P. Meena, Priya Gurav, Abhijit Sarkar, Madumonti Saha, Immanuel CHaokip, M.Homeshwari.

Training on soil health management and agricultural input distribution programme organized by Indian Institute of Soil Science, Bhopal at KVK Barwani on November 21, 2023 under TSP project. The program was coordinated by Dr. R.K. Singh, Dr. Jitendra Kumar Dr. Asit Mandal and Dr. Dhiraj Kumar Dr. S. K. Badodiya, In-charge, KVK, Barwani. About 50 tribal farmers were participated in one-day training programme from different villages of Barwani district. During the training programme, the wheat and chickpea seeds were distributed to the tribal farmers for preparation of vermicompost at farmers' field level.



Workshop on Natural Farming and Krishi Mela – cum – Krishak Sangosthi at Rajnandgaon, Chhattisgarh

ICAR- Indian Institute of Soil Science, Bhopal (M.P.) organized Krishi Mela cum Sangosthi on Natural Farming during March 27-29, 2023 at KVK Surgi, Rajnandgaon district, Chhattisgarh. Padmashri Smt. Phoolbasan Bai Yadav, President of the Maa Bamleshwari Janhit Karya Samiti graced the Krishi Mela cum KrishakSangosthi as Chief Guest on March 28, 2023 and emphasized on importance of organic and natural farming practices for crop and soil health improvement. During this occasion 30 quintals of HYVs of paddy, 10 quintals of summer green gram seeds and 75 number of vermibeds were distributed to tribal farmers. The Kishak Sangosthi on Natural Farming was addressed by Dr. R. Elanchezhian, Dr. Prabhat Tripathi, Dr. M. Vassanda Coumar, Dr. Nisha Sahu, Dr Narayan Lal and Dr Dinesh Kumar Yadav (ICAR-IISS, Bhopal), Dr R.N. Singh (Dean College of Agriculture Surgi), Dr. RK Swarnakar (Head, KVK Rajnandgaon), Dr. Anjali Ghratlehre, Dr Atul Dange, Dr. Gunjan Jha (KVK Rajnandgaon), Shri Anand Sahu, Sarpanch Surgi, Smt. Khulbeshwari Sahu, Secretary, and Smt. Madhulika Ramteke, Ma Bambleshwari FPO, Dongargarh, Rajnandgaon. Altogether 550 tribal farmers including progressive farmers attended the Mela and Sangosthi. Earlier on March 27, 2023, 25 number of vermibeds, seedlings of horticultural fruit crops like papaya and moringa were also distributed among the tribal beneficiary farmers at Mading Piding (Bhursa village), Mohala Block, Rajnandgaon in which 100 farmers were sensitized about the importance of fruit crops in enhancing farm income and livelihood. The team from ICAR IISS Bhopal also visited the adopted villages on March 29, 2023 and reviewed the on farm-demonstrations of project activities. The events were given a wide coverage in the local press and media.

Krishi Mela cum Workshop on Natural Farming at KVK Surgi, Rajnandgaon district, Chhattisgarh

Activities organized under AICRP on STCR centres on World Soil Day 2023

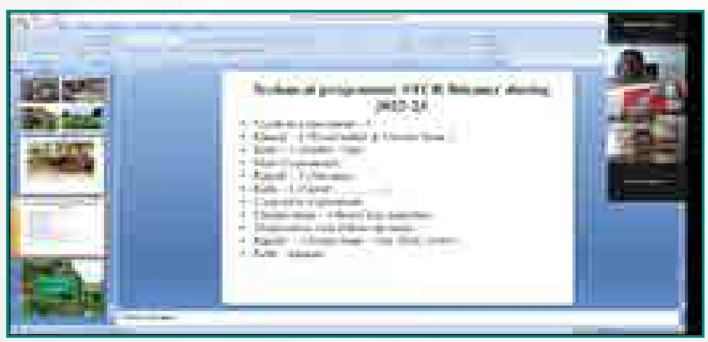
ICAR-RC for NEH Region, Manipur

PJST SAU, Hyderabad

ICAR-CRIJAFT, Barrackpore

IGKV, Raipur

BCKV, Mohanpur



Interaction Meeting on May 03, 2023

Media coverage of various activities organized

14 DISTINGUISHED VISITORS

Dr. Francoise Bringel, Professor and Director of CNRS University of Strasbourg, France visited on February 14, 2023

Shri Kamal Patel Ji, Minister of Agriculture and Farmers Welfare, Govt. of M.P. and Dr. Himanshu Pathak visited on October 3, 2023

Dr. S.K. Chaudhari and Dr. S.K. Sanyal visited on April 15, 2023

Dr. S.K. Chaudhari, DDG (NRM) & President (ISAP) visited on February 2-3, 2023

Dr. A.K. Singh, Former VC (RVSKVV) and former DDG (NRM) visited on December 11, 2023

Dr. Himanshu Pathak, Secretary DARE and DG, ICAR visited on August 19, 2023

Dr. JK Ladha, Adjunct Professor, University of California visited on August 26-27, 2023

Dr. RK Yadav, Director, CSSRI, Karnal visited on August 26-27, 2023

15 Infrastructure Development

Instruments/ Equipment Purchased

During the year 2023, Air Conditioners (16),Tissue Homogenizer (1),Total Internet Security for Internet System (150), Kjeldahl Digestion cum Distillation Assembly (1), Double Distillation Water Unit (1), Scanner (1), Laboratory Hot Air Oven (1), Workstation (2), Desktop Computer (5), SPAD Meter(1), Ladder(1), Spectro Radiometer(1), Nanodrop Spectrophotometer(2), Microwave Digestion System (1), Drones (2), Green Seeker(1), Fire Extinguisher (6), UPS (4), Multifunction Printers (2), Submersible Pump(1), Laptop (5), Electronic Weighing Scale(1), Electronic Weighing Scale(1), LG LCD Monitor(1),Sequencing and bacterial diveristy analysis from soil Metagenome (15), pH Meters (4), Muffle Furnace(1), Fume Hood(1), Laser Colour Printers (3), Lawn Mower(1),Water Bath cum Shaker(1), Autoclave(1), Video Conferencing Camera(1), EPABX System(1), Manual Power Sprayers (5), Voltage Stabilizers (5), RO Water Purification System (1), Water Coolers (3), Tablet (Samsung 3&4GB) (3), Biometric Devices (2), Bund Former (1), Rotary Evaporator (1), Portable Water Purification Systems with inbuilt Water Cooler (5), Smart Television TV Sets (5), Orbital Shaking Incubator (1), Analytical Balance (1), Hydraulic MB Plough (1), Multifunction Printers (9) and furnitures for lab and training hostel were purchased.

Library

The library section maintained books, journals, bulletins and annual report and provided lending, referencing and reprographic services etc. The library exchanged publications of the institute with other ICAR institutes and SAUs. During the period under report, the library has acquired the documents as mentioned below:

Documents	Addition during 2023	Total
Books	02	2656
Bound Journals	00	3180
Annual Reports	10	2746
Foreign and Indian Journals	Nil	Nil

Farm Activities

Agriculture farm section is act as a service section to assist the field experiments of research projects at the institute premises as well as outside the institutes i.e. adopted villages. During the year all inputs such as seeds, manure &fertilizers and irrigations etc. required for various field trials in kharif, rabi & summer season were arranged and managed by agriculture farm section. Agriculture farm also prepared lay outs of all the field experiments as per their technical programme. Weeding, irrigations, harvesting & threshing, storage and sale of various farm produce also managed by farm section. Farm section also extended its services to horticulture section and maintenance section of the institute. Apart from these farm section also involved in general face lifting of residential area at the institute. During the reporting period farm section procured M.B Plough, disc type bund former (Ridger), tines seed drill and duck foot cultivator. During kharif major crops were Soybean, Maize, Paddy and Pigeon pea. The total revenue of Rs. 13, 13 525 was earned by the farm section during the period.

Pigeon pea crop

Soybean crop

16 Scientific, Technical, Administrative, Supporting Personnel

Details of manpower

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
DIRECTOR'S CELL				
Dr. Siba Prasad Datta	Director	Soil Chemistry/Fertility/ Microbiology	25.07.1994	13.02.2023
Mr Venny Joy	Private Secretary	Office Staff	14.02.1991	23.03.1998
Mr Sunny Kumar	Personal Assistant	Office Staff	21.12.2011	21.12.2011
Mr Sukhram Sen	Senior Technical Assistant	Staff Car Driver	25.01.1991	25.01.1991
Mr Darashram	Skilled Supporting Staff	Lab Attendant	15.03.1990	15.03.1990
DIVISION OF SOIL PHYSICS				
Dr. Narendra Kumar Lenka	Pr. Scientist & Head	Soil Physics/Soil & Water Conservation	30.11.2000	09.10.2009
Dr. Ranjeet Singh Chaudhary	Pr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1993	09.12.1999
Dr. Rakesh Kumar 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. Nishant Kumar Sinha	Sr. Scientist	Agricultural Physics	20.04.2010	27.08.2010
Dr. Jitendra Kumar	Sr. Scientist	Soil Science/Soil Physics	15.09.2011	02.01.2020
Dr. Alka Rani	Scientist	Soil Science	04.01.2019	12.04.2019
Shri R. K. Mandloi	Chief Technical Officer	T-9	19.06.1989	19.06.1989
Mr. Jai Singh	Asst. Chief Technical Officer	T-7-8	22.05.1990	22.05.1990
Mr. Janak Singh Mehra	Skilled Supporting Staff	Khalasi	08.09.1997	08.09.1997
DIVISION OF SOIL CHEMISTRY AND FERTILITY				
Dr. Sanjib Kumar Behera	Pr. Scientist& Head	Soil Science & Agricultural Chemistry	08.01.2007	27.06.2017
Dr. Ashis Kumar 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. R Elanchezhian	Pr. Scientist	Plant Physiology	09.11.1998	17.2.2012

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
Dr. Pramod Jha	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	16.04.2003	17.07.2009
Dr. Shinogi KC	Sr. Scientist	Agricultural Extension	27.04.2011	05.09.2011
Dr. Bharat Prakash Meena	Sr. Scientist	Agronomy	15.09.2011	22.12.2011
Dr. Narayan Lal	Scientist	Fruit Science	01.01.2013	24.12.2019
Dr. Khushboo Rani	Scientist	Soil Science	05.10.2020	13.01.2021
Mr. Deepak Kaul	Chief Technical Officer	T-9	29.12.1988	29.12.1988
Mr. Khilan Singh	Technical Officer	T-9	29.12.1988	29.12.1988
Mr. Harish Kumar	Technician	T-1	14.03.1990	14.03.1990
DIVISION OF SOIL BIOLOGY				
Dr. Santosh Ranjan Mohanty	Pr. Scientist & Head	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
Dr. Amar Bahadur Singh	Pr. Scientist	Biochemistry	22.03.1999	22.03.1999
Dr. Awadesh Kumar Tripathi	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	05.08.1991	25.07.1992
Dr. KollahBharati	Pr. Scientist	Microbiology – Plant Science	29.10.2009	05.04.2011
Dr. Asit Mandal	Sr. Scientist	Soil Chemistry/Fertility	23.06.2009	30.10.2009
Dr. Jyoti Kumar Thakur	Sr. Scientist	Agricultural Microbiology	20.04.2010	27.08.2010
Dr. Asha Sahu	Sr. Scientist	Soil Chemistry/Fertility/ Microbiology	03.05.2010	03.05.2010
Dr. Sudeshna Bhattacharjya	Scientist	Soil Science	01.01.2015	10.04.2015
Dr. Abinash Das	Scientist	Soil Science	05.10.2020	13.01.2021
Mr Sant Kumar Rai	Sr. Technical Asstt	(T-4)	15.06.1989	15.06.1989
Mr Kalicharan	Skilled Supporting Staff	Lab attendant	10.06.1999	10.06.1999
DIVISION OF ENVIRONMENTAL SOIL SCIENCE				
Dr. Tapan Adhikari	Pr. Scientist & Head	Soil Chemistry/Fertility/ Microbiology	22.03.1996	07.11.1996
Dr. Jayant Kumar Saha	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	21.01.1992	02.01.1993
Dr. Ajay	Pr. Scientist	Plant Physiology	12.04.1993	31.08.1999
Dr. Sangeeta Lenka	Pr. Scientist	Soil Physics/Soil & Water Conservation	08.01.2007	18.05.2007
Dr. M Vassanda Coumar	Sr. Scientist	Soil Chemistry/Fertility	04.11.2009	15.03.2010
Dr. Nisha Sahu	Sr .Scientist	Soil Chemistry/Fertility/ Microbiology	23.01.2012	30.11.2019
Dr. Abhijit Sarkar	Scientist	Soil Science	05.07.2016	29.06.2018
Mrs. Madhumonti Saha	Scientist	Soil Science	05.07.2017	29.06.2018

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
Dr. Dinesh Kumar Yadav	Scientist	Agricultural Chemicals	05.10.2020	12.01.2021
Smt Seema Sahu	Chief Technical Officer	T-9	14.04.1987	24.01.1989
Mr Shahab Siddiqui	Chief Technical Officer	T-9	05.10.1992	05.10.1992
Mr Ram Bharose	Skilled Supporting Staff	Lab attendant	20.03.1990	20.03.1990
AICRP-LTFE				
Dr. Ravi Harishchandra Wanjari	Pr. Scientist	Agronomy	07.01.1999	07.01.1999
Dr Dhiraj Kumar	Scientist	Soil Science & Agricultural Chemistry	01.01.2015	13.08.2020
Mr Jagannath Gour	Skilled Supporting Staff	Lab attendant	20.07.1992	20.07.1992
AICRP-MSPE				
Dr. Sanjib Kumar Behera	Pr. Scientist & I/c PC MSN	Soil Science & Agricultural Chemistry	08.01.2007	27.06.2017
Mrs. Seema Bhardwaj	Scientist	Soil Science (Pedology)	07.01.2008	07.07.2018
Dr. Rahul Mishra	Scientist	Soil Science	05.10.2020	11.01.2021
Mrs. Geeta Yadav	Private Secretary	Office Staff	26.12.1995	26.12.1995
Mr. Pramod Kumar Chouhan	Technical Officer	T-5	15.02.1993	15.02.1993
AICRP-STCR				
Dr. Sanjay Srivastava	Pr. Scientist & I/c PC (STCR)	Soil Chemistry/Fertility/ Microbiology	22.03.1996	02.09.1996
Dr. Immanuel Chongboi Haokip	Scientist	Soil Science	07.01.2020	04.04.2020
Mrs. Yojana Meshram	Private Secretary	Office Staff	12.05.1997	12.05.1997
Mrs. Kavita Bai	Skilled Supporting Staff	Safaiwala	20.12.1988	20.12.1988
AINP-BIOFERTILIZERS				
Dr. Santosh Ranjan Mohanty	Pr. Scientist, Head& I/C Network Coordinator	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
Dr. M Homeshwari Devi	Scientist	Soil Science	07.01.2020	04.04.2020
PME CELL				
Dr. R Elanchezhian	Pr. Scientist	I/c PME Cell	09.11.1998	17.02.2012
Mr. Sanjay Kumar Kori	Personal Assistant	Office Staff	03.01.2012	03.01.2012
Mr. Sanjay Kumar Parihar	Technical Assistant	T-3	29.06.2019	29.06.2019
ITMU				
Dr. Sanjay Srivastava	Pr. Scientist	Officer In-Charge	22.03.1996	02.09.1996

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
Mr. Sanjay Kumar Parihar	Technical Assistant	T-3	29.06.2019	29.06.2019
AKMU				
Dr. Nishant Kumar Sinha	Sr. Scientist	Agricultural Physics	20.04.2010	27.08.2010
Remot Sensing & GIS Laboratory				
Dr. Nishant Kumar Sinha	Sr. Scientist	Agricultural Physics	20.04.2010	27.08.2010
LIBRARY SECTION				
Mrs. Nirmala Mahajan	Chief Technical Officer	T-9	15.03.1993	15.03.1993
CENTRAL LAB				
Dr. Santosh Ranjan Mohanty	Pr. Scientist & Head	Officer In-Charge	18.06.2009	18.06.2009
FARM SECTION				
Dr. Awadesh Kumar Tripathi	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	05.08.1991	25.07.1992
Mr. Om Prakash Shukla	Technical Officer	T-5 (Tractor Mech.)	22.04.1989	22.04.1989
Mr. Chandrabhan Tulsiram Wankhede	Technical Officer	T-5 (Electrician)	03.08.1992	03.08.1992
Mr. Dashrat Rao Darwai	Sr. Technical Officer	T-6 (Field Assistant)	23.01.1993	23.01.1993
Mr. Hukum Singh	Technical Officer	T-5	30.12.1988	30.12.1988
Mr. Bhagwat Prasad	Technician	T-1	24.01.1992	24.01.1992
Mr. Lalaram Sahu	Skilled Supporting Staff	Beldar	24.07.1992	24.07.1992
Mr. Rakesh Kumar Sen	Skilled Supporting Staff	Beldar	08.09.1997	08.09.1997
VEHICLE SECTION				
Shri Mahesh Kumar Mulani	Senior Finance & Accounts Officer	Finance & Accounts	04.12.1987	13.10.2021
ADMINISTRATION SECTION				
Shri Ashish Chobey	Administrative Officer	Administration	17.05.2013	08.06.2022
Mr. Anupam Sahasi Rajput	AAO	Establishment-Recruitment, Bill & DDO	14.03.1990	14.03.1990
Mrs. Babita Tiwari	AAO	Purchase & Store	30.05.1996	30.05.1996
Mr. Bansi Lal Sarsodia	Assistant	Purchase section	10.09.1997	10.09.1997
Mr. Hira Lal Gupta	Assistant	Bill section	23.12.1988	23.12.1988
Mr. Om Prakash Yadav	Assistant	Audit & Account	19.12.1988	19.12.1988
Mr. Sanjay Katinga	UDC	Cash Section	20.06.1989	20.06.1989
Mrs. Raksha Dixit	UDC	Establishment Section	24.05.2013	24.05.2013

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
Mr. BhoiLal Uikey	LDC	Diary & Dispatch Section	13.11.1995	13.11.1995
Mr. Arun Kumar Mishra	LDC	Purchase & Store Section	01.09.1993	10.06.1999
Mr. Sanjay Narayan Gharde	LDC	Audit & Accounts Section	15.06.1999	15.06.1999
Mr. Pramod Kumar Raut	Skilled Supporting Staff	Beldar	21.07.1992	21.07.1992
Mr. Dharam Raj Singh	Skilled Supporting Staff	Messenger	10.09.1993	14.06.1999

Retirement

- Shri Rajesh Kumar Mandloi, Chief Technical Officer retired on superannuation on 31.03.2023.
- Shri Khilan Singh Raghuvanshi, Technical Officerretired on superannuation on 30 .04.2023.
- Smt Seema Sahu, Chief Technical Officer retired on superannuation on 30.06.2023.
- Dr A B Singh, Principal Scientist retired on superannuation on 31.07.2023.
- Shri Om Prakash Shukla, Technical Officer retired on superannuation on 31.12.2023.

Joining

- Shri P S Sunil Kumar, Senior Administative Officer joined on 31.03.2023

Transfer

- Dr Pradip Dey, Principal Scientist & I/c PC STCR has relieved on 03.02.2023 to join the post of Director at ICAR-ATARI, Kolkata.
- Dr K M Hati, Principal Scientist has transferred to ICAR-NBSS&LUP on 24.03.2023.
- Shri Ashish Chobey, Administrative Officer has transferred to ICAR-NISHAD, Bhopal on 03.04.2023.
- Dr Priya Gurav Pandurang, Scientist is transferred to ICAR-CRIDA, Hyderabad on 23.06.2023.
- Dr J Somasundaram, Principal Scientist has relieved on 14.07.2023 to join the post of Head, at ICAR-IISWC, Research Centre-Udhagamandalam, ICAR-IISWC, Dehradun.
- Dr Brij Lal Lakaria, Principal Scientist is relieved on 21.07.2023 to join the post of Head, at ICAR-IISWC, Research Centre-Chandigarh, ICAR-IISWC, Dehradun.

Probation Clearance

- Dr. M. Homeshwari Devi, Scientist cleared probation period on 24.11.2023 w.e.f. 07.01.2022.
- Dr. Immanuel Chongboi Haokip, Scientist cleared probation period on 24.11.2023 w.e.f. 07.01.2022
- Dr. Rahul Mishra, Scientist cleared probation period on 24.11.2023 w.e.f. 05.10.2022
- Dr. Dinesh Kumar Mishra, Scientist cleared probation period on 24.11.2023 w.e.f. 05.10.2022
- Dr. Abinash Das, Scientist cleared probation period on 24.11.2023 w.e.f. 05.10.2022
- Dr. Khushboo Rani, Scientist cleared probation period on 24.11.2023 w.e.f. 05.10.2022
- Shri Prashant Gour, Lower Division Clerk cleared probation period on 15.12.2023 w.e.f. 15.01.2023.

Promotion

- Dr. Narayan Lal, Scientist promoted from Scientist to Senior Scientist on 04.07.2023 w.e.f. 01.01.2023.
- Shri Bhagwat Prasad, Skilled Supporting Staff promoted to the post of Technician on 29.09.2023.
- Shri Harish Kumar, Skilled Supporting Staff promoted to the post of Technician on 29.09.2023.

NOTES

NOTES

स्वस्थ मृदा
स्वस्थ फसल
स्वस्थ जीवन

International Decade of Soils
2015 - 2024

Healthy soil for a healthy life

https://iiss.icar.gov.in
https://www.facebook.com/IndianInstituteofSoilScience
https://www.youtube.com/channel/UCHMN0IJwvONVWcjyOFGZeEw