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International Decade of Soils 2015-2024

Healthy soil for a healthy life

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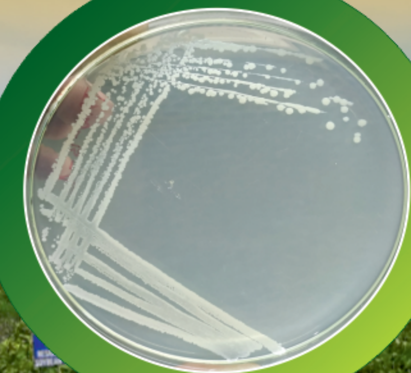
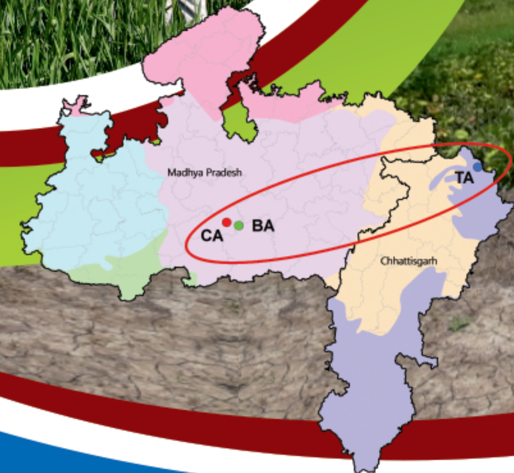
Annual Report
2021





भाकृअनुप- भारतीय मृदा विज्ञान संस्थान

ICAR - INDIAN INSTITUTE OF SOIL SCIENCE

Nabibagh, Berasia Road, Bhopal – 462 038 (M.P.)
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With Best Compliments

(Ashok K. Patra)
Director
ICAR-Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal – 462038

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PREFACE

Soil science research is vital to develop healthy soils for agricultural prosperity including food security, climate change adaptation and mitigation, and sustainable development for all. It is well established that fertile soils are the key to produce healthy food with all the necessary nutrients for healthy people. Therefore, best management of soil health can result into improved soil and crop productivity, help reduce soil, water and air pollution, regulate water resources availability, support a diverse and active biotic community, and allows for carbon neutral footprint. The intensive farming practices under the present scenario have led to deterioration of soil health and adversely affected the nutrient cycling and posed a great threat to soil and other biodiversity. We need to acknowledge that to arrest further decline in soil health and to improve agricultural productivity, an in-depth knowledge of soils is essential. This acknowledgement has bestowed a greater sense of responsibility on us towards thorough research on the sustainable management of soil resources to provide suitable technological interventions.

ICAR-Indian Institute of Soil Science (ICAR-IISS), Bhopal is engaged in research with a mandate "to provide scientific basis for enhancing and sustaining productivity of soil resource with minimal environmental degradation". Over the years, the institute has developed several scalable technologies with field-level validation for improvement of soil health and to address the emerging issues and challenges. This annual report clearly illustrates the multi-scale approaches and work done in the area of soil health and input use efficiency, conservation agriculture and carbon sequestration, greenhouse gas emission, 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 across the length and breadth of the country through various AICRP/AINP/CRP centres.

During the year reported, some new technologies and methodologies were developed and refined by the institute, viz., microbial decomposer capsules for off-situ or in-situ decomposition of farm waste and crop residues; STCR based IPNS modules for maize-chickpea cropping systems; use of modified glauconitic shales for supply of potassium to wheat crop; application of biochar in rice and okra; delineation of Sulphur and multi-micronutrients deficiency in 615 districts of India; sustainability indices i.e. Sustainable Yield Index (SYI) and Soil Quality Index (SQI) across alfisols; CA practices for improved soil health and C sequestration; decadal impact analysis of present and future climate on grain yield of soybean and maize; natural farming practices in soybean; organic management practices for wheat, mustard and chickpea; thermotolerant bacterial isolates from hot springs for their plant growth promoting attributes; endophytic fungi for bioremediation of heavy metals, and use of fly ash for remediation of heavy metals pollution in soil. Besides, on the basic research front, efficient wheat genotypes were assessed for nutrient use efficiency; developed fertilizer prescription equations under integrated plant nutrient supply systems; assessed methane consumption in response to different nitrogen sources in a tropical soil ecosystem, and evaluated the effect of long term use of FYM and inorganic fertilizers on soil microbial community and potential nitrification. The institute has also played a leadership role and highly committed to create awareness among people on soil health management across the country.

Further, this report presents glimpse of all the significant activities undertaken by the institute during the difficult time of COVID 19 pandemic. It is thus, a great pleasure for me to bring out the Annual Report 2021 of the ICAR-Indian Institute of Soil Science.

On this occasion, I take this opportunity to express my sincere appreciation to all the Project Coordinators and Head of the Divisions for compiling the information at AICRP/AINP/CRP and 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, A.K. Tripathi, R.K. Singh, Kollah Bharati, J.K. Thakur, Abhijit Sarkar and Priya Gurav Pandurang for their dedicated efforts in compiling and editing the report. The service rendered by Mr. S.K. Kori and Mr. S.K. Parihar in collecting information and typesetting the manuscript is appreciated.

I acknowledge, with a deep sense of gratitude and respect to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for his constant guidance and 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. Adlul Islam, Assistant Director General (SWM) for their active involvement, full co-operation and full-support and constructive suggestions in carrying out various research and development activities for the overall progress of the institute.

Bhopal
June 2022

(Ashok K. Patra)
Director

CONTENTS

कार्यकारी सारांश

विषयवस्तु I: मृदा स्वास्थ्य और पोषक तत्व उपयोग दक्षता

मिट्टी की उर्वरता

- पिछले दो वर्षों के दौरान प्रदर्शन के आधार पर भारत और विदेशों से विकसित 120 जीनोटाइपों से नाइट्रोजन और फॉस्फोरस उपयोग दक्षता के लिए गेहूँ के कुशल जीनोटाइपों का चयन किया गया। कुछ जीनोटाइपों में दानों की उपज और नाइट्रोजन ग्रहण और उपयोग दक्षता उल्लेखनीय रूप से उच्च दर्ज की गई। इन जीनोटाइप में गैस एक्सचेंज पैरामीटर सहित मॉर्फो–फिजियोलॉजिकल पैरामीटर में पर्याप्त भिन्नताएँ दर्ज की गईं।
- वर्टिसोल मृदा पर आईपीएनएस मॉड्यूल मृदा जैविक कार्बन की मात्रा विभिन्न कार्बन और उनके स्टॉक को गोबर की खाद की उच्च मात्रा (25 टन प्रति हे.) के प्रयोग के साथ बढ़ाया और इसके बाद GRD और 100% NPK आधारित 5 टन प्रति हे. गोबर की खाद + STCR आधारित 75% NPK मॉड्यूल के साथ अर्थपूर्ण रूप से अधिक थी और उसके बाद गोबर की खाद (20 टन प्रति हे.) 75% NPK + कुक्कुट खाद एवं GRD और 100% NPK आधारित STCR में पाई गई।
- STCR आधारित INM मॉड्यूल (STCR का 5 टन FYM + 75%NPK) को अपनाने से GRD की तुलना में ऊर्जा की आवश्यकता में 14%, खेती की लागत में 6.5% और कार्बन फुटप्रिंट (CF) में स्थानिक पैमाने पर 17% की कमी आई है। STCR आधारित INM मॉड्यूल ने GRD की तुलना में ऊर्जा उपयोग दक्षता (EUE) ऊर्जा उत्पादकता (EP) और ऊर्जा लाभप्रदाता (EPF) को क्रमशः 28.5%, 31.5% और 31.8% बढ़ाया। INM मॉड्यूल ने GRD की तुलना में सिस्टम उत्पादकता में 17.0%, कार्बन दक्षता (CE) में 19.3% और कार्बन स्थिरता सूचकांक (CSI) में 21% की वृद्धि हुई।
- FYM और माइक्रोबियल कल्चर के साथ 1.5% की दर से ग्लूकोनाइट के प्रयोग से गेहूँ का उच्चतम बायोमास और अनाज उपज दर्ज किया गया। ग्लौकोनाइटेलोन (0.5 से 1.5%) के प्रयोग से भी गेहूँ की वृद्धि और उपज में उल्लेखनीय सुधार देखा गया।
- सबसे कम फॉस्फोरस अवशोषण मैक्सिमा, एमपीबीसी, मानक फॉस्फोरस की आवश्यकता जैविक खेती में दर्ज की गई। इसके बाद 90 प्रतिशत अवशेषों के समावेश के साथ संरक्षण कृषि में पाई गई। जबकि सर्वोच्च फॉस्फोरस अवशोषण मैक्सिमा, एमपीबीसी, मानक फॉस्फोरस आवश्यकता को एसटीसीआर आधारित पोषक तत्व प्रबंधन प्रणाली के बाद पूर्ण नियंत्रण में दर्ज किया गया।
- विभिन्न मिट्टी श्रृंखलाओं के महीन मिट्टी के अंश के XRD ने बहुत कम मात्रा में वर्मीक्यूलाइट, क्लोराइट, माइका और फेल्डस्पार के साथ स्मेक्टाइट का प्रभुत्व दिखाया। ग्रीन–केली परीक्षण (हॉफमैन–क्लेमेन प्रभाव) ने संकेत दिया कि सभी मिट्टी श्रृंखला के सभी सूक्ष्म मृत्तिका के नमूने बीडेलाइट–नॉनट्रोनाइट और मॉन्टमोरिलोनाइट का मिश्रण हैं जिसमें बीडेलाइट–नॉनट्रोनाइट की मात्रा अधिक है।
- पिछली फसलों के 90% अवशेषों में प्रतिधारण के परिणामस्वरूप 0–10 सेमी परत में बगैर फसल अवशेष के खेत की तुलना में पीओएम–सी में 54.5% और पीओएम–एन में 47% की वृद्धि हुई है। इसी तरह 30 और 60% अवशेष प्रतिधारण के परिणामस्वरूप नियंत्रण की तुलना में मिट्टी की नाइट्रोजन खनिजीकरण क्षमता में 72 और 18% सुधार हुआ।
- RDF के साथ 8 टन/हे. लकड़ी बायोचार और 5 टन/है. खाद के प्रयोग से धान की फसल में सांख्यिकीय रूप से उच्च अनाज उपज दर्ज की गई। लकड़ी के नारियल की भूसी बायोचार की तुलना में ओडिशा के इंसेप्टिसोल (बेलपाड़ा) और अल्फिसोल (नुआपाड़ा) में भिंडी की उपज में फसल अवशेषों के बायोचार के उपयोग से उल्लेखनीय रूप से उच्च फली उपज प्राप्त हुई है।
- MIR के माध्यम से मिट्टी के गुणों का अनुमान लगाया गया और मृत्तिका (R^2: 0.84, RMSE: 2.89), सिल्ट (R^2: 0.75, RMSE: 3.28), रेत प्रतिशत (R^2: 0.71, RMSE: 4.14) स्थाई म्लानि बिंदु पर मृदा जल प्रतिधारण (R^2: 0.74, RMSE: 1.52) और FC (R^2: 0.70, RMSE: 2.37), कार्बनिक कार्बन की मात्रा (R^2: 0.72, RMSE: 0.11) और pH (R^2: 0.73, RMSE: 0.46) पीएलएसआर तकनीकों के माध्यम से विकसित मॉडलों के लिए स्वतंत्र डेटा सेट के लिए अच्छी पूर्वानुमान प्राप्त की गई।
- गेहूँ, सरसों, चना और अलसी के दानों की उच्चतम उपज 100% जैविक उपचार के बाद 50% जैविक + 50% अकार्बनिक उपचार में दर्ज की गई। मूँगफली की किस्म GPBD–5 ने 12 परीक्षण किस्मों में से

उच्चतम उपज (1989 किग्रा./हे.) और सरसों की किस्म अरावलीगा ने जैविक पोषक तत्व प्रबंधन अभ्यास के तहत उच्चतम उपज (1988 किग्रा हे.) प्रदर्शित की प्राकृतिक खेती प्रयोग में, सोयाबीन की उच्चतम बीज उपज कीटनाशक (आईसीएमपी) उपचार के साथ एकीकृत फसल प्रबंधन में दर्ज की गई, जो प्राकृतिक खेती (आईसीएमएनएफ) और एआई–एनपीओएफ पैकेज के साथ एकीकृत फसल प्रबंधन के बराबर थी।

- एल्फीसोल (एलटीएफई पालमपुर) और वर्टिसोल (एलटीएफई परभणी) में लंबे समय तक के उर्वरक का उपयोग नहीं करने से अविनिमेय–पोटैशियम के भंडारण में कमी आई और 100% नाइट्रोजन उपचार में विनिमेय–पोटैशियम में वृद्धि हुई।
- एल टी एफ ई बैरकपुर (इनसेप्टिसोल) और एल टी एफ ई पालमपुर (एल्फीसोल) में यह देखा गया कि 100% NPK +FYM अनुप्रयोग में माइक्रोबियल ऑटोट्रॉफिक कार्बन स्थिरीकरण क्षमता 40-45 ug CO_2-C g^{-1} मृदा दिन तक हो सकती है। इसके अलावा, एलटीएफई बैरकपुर और एलटीएफई पालमपुर में यह देखा गया कि लंबे समय तक (100% एन और 100% एनपी) असंतुलित उर्वरक प्रयोग ने मिट्टी की जैविक फॉस्फोरस आपूर्तिशक्ति को कम कर दिया।
- कागजी नींबू और आम में पुरानी, रोगग्रस्त और अनुत्पादक टहनियों को हटाकर हल्की छंटाई करने से भरपूर फूल और फल लगते हैं। आंवला में हल्की छटाई और प्राकृतिक संसाधनों का उपयोग करके बिना किसी इनपुट के अच्छे फल प्राप्त हुए और लगभग 70–100 किलोग्राम/पेड़ के फल काटे गए।
- चयनित ग्राम समूहों में संतुलित और आईएनएम अभ्यास के तहत सोयाबीन, मक्का, गेहूँ और चने के दानों की उपज में काफी सुधार हुआ।
- आदिवासी बसे हुए क्षेत्रों के सतही जल संसाधनों के जैविक विश्लेषण से हानिकारक फेकल कैलीफॉर्म बैक्टीरिया की उपस्थिति का पता चला है। इसके अलावा इलाके की प्रमुख स्वदेशी कृषि तकनीकों पर ITK को भूमि की तैयारी, नमी संरक्षण, कीट और रोग नियंत्रण पर प्रलेखित किया गया।
- आईसीएआर–सिरकॉट नैनो–सल्फर का मूल्यांकन सरसों की फसल के लिए उर्वरक सूत्रीकरण के रूप में किया गया। सरसों के बीज की उपज, स्टोवर की उपज और सल्फर की मात्रा में 60 किग्रा प्रति हे. तक सल्फर की बढ़ती मात्रा नियंत्रण और 30 किग्रा प्रति हे. सल्फर से बेहतर और 45 किग्रा. प्रति हे. सल्फर के बराबर वृद्धि हुई।
- ^{13}सी स्थिर आइसोटोप अनुमान की प्राकृतिक प्रचुरता ने साबित कर दिया कि आईएनएम ने अकार्बनिक और नियंत्रण उपचार की तुलना में सभी गहराई पर नए कार्बन के अनुपात में काफी सुधार किया है। इसके अलावा जमीन के ऊपर और जमीन के नीचे अवशेषों के अपघटन अध्ययनों से संकेत मिलता है कि 0–6 महीने के दौरान गेहूँ> सोयाबीन> चना> मक्का में बायोमास का प्रतिशत बड़े पैमाने पर नुकसान अधिक था।

अखिल भारतीय समन्वित अनुसंधान परियोजनाएँ

- एल्फीसोल्स के तहत उगाई जाने वाली प्रमुख फसलों में उर्वरकों और खादों के दीर्घावधि प्रयोग ने स्पष्ट रूप से प्रदर्शित किया कि उर्वरकों के असंतुलित उपयोग से विशेष रूप से अकेले 100% नाइट्रोजन के साथ फसल उत्पादकता में गिरावट आई है। हालांकि पोषक तत्वों के संतुलित उपयोग और 100% एनपीके+गोबर की खाद/100% एनपीके + चूने के रूप में एकीकृत पोषक तत्व प्रबंधन से अल्फीसोल के तहत लगभग सभी मिट्टी और स्थानों में फसल उत्पादकता में महत्वपूर्ण सुधार हुआ।
- प्रमुख फसलों द्वारा मुख्य और सूक्ष्म पोषक तत्वों दोनों का पोषक तत्व आईएनएम के साथ उच्चतम पाया गया। यानी 100% एनपीके + गोबर की खाद और उसके बाद बैंगलोर में अपवाद के साथ 100% एनपीके + चूना, जहां 150% एनपीके प्रयोग ने अधिकतम दिया। असंतुलित पोषक तत्वों के उपयोग से इन अम्लीय मिट्टी में प्रमुख फसलों में पोषक तत्वों की मात्रा में कमी आई है।
- एलटीएफई के विभिन्न अल्फिसोल्स में संतुलित और आईएनएम (100% एनपीके +गोबर की खाद) के साथ सस्टेनेबिलिटी इंडेक्स यानी सस्टेनेबल यील्ड इंडेक्स (एसवाईआई) और मृदा गुणवत्ता सूचकांक (एसक्यूआई) में सुधार पाया गया। इसके विपरीत 100% नाइट्रोजन ने प्रमुख फसलों और फसल प्रणालियों की स्थिरता में भारी कमी देखी गई।
- भारत के 28 राज्यों के 615 जिलों में मिट्टी में सल्फर और बहु–सूक्ष्म पोषक तत्वों की परिवर्तनशील और व्यापक कमी देखी गई। लोहा, तांबा और मैंग्नीज की कमियों की तुलना में सल्फर, जिंक और बोरोन की कमियाँ अधिक थीं।
- आईआईएसएस अनुसंधान फार्म में मिट्टी के पोषक

तत्वों की एक फार्म–स्केल स्थानिक परिवर्तनशीलता का मूल्यांकन मिट्टी के गुणों और साइट–विशिष्ट पोषक तत्व प्रबंधन की भविष्यवाणी मानचित्रण के लिए किया गया।

- आईपीएनएस लक्षित उपज समीकरणों के विकास के लिए विभिन्न आईसीआरपी–एसटीसीआर केंद्रों द्वारा किए गए कार्यों का विश्लेषण किया गया।

विषयवस्तु II: संरक्षण कृषि, कार्बन प्रच्छादन (सीक्यूस्ट्रेशन) और जलवायु परिवर्तन

- सोयाबीन–गेहूँ और मक्का–चना फसल प्रणाली में 90% फसल अवशेष प्रतिधारण के तहत 60%, 30% और अवशेषों के प्रतिधारण के बिना की तुलना में फसल वृद्धि, अनाज और पुआल की उपज काफी अधिक दर्ज की गई। इसी तरह, मक्का और फसल कटाई पर खरपतवार बायोमास और खरपतवार घनत्व 90% फसल अवशेष प्रतिधारण के तहत 60%, 30% और बिना अवशेष प्रतिधारण की तुलना में काफी कम दर्ज किया गया पोषक तत्वों की खुराक और विभिन्न शाकनाशी खरपतवार नियंत्रण उपचारों से फसल की वृद्धि,अनाज और पुआल की उपज पर कोई महत्वपूर्ण प्रभाव नहीं पाया गया।
- मक्का के साथ रन ऑफ लौस अधिक देखी गई। ये हानियाँ विभिन्न जुताई और फसल अवशेष उपचारों के तहत 12.43 से 27.69 प्रतिशत तक भिन्न थीं। हालांकि सोयाबीन की फसल के साथ ये 12.46 से 23.76 प्रतिशत रही। विभिन्न जुताई और अवशेष स्तरों के तहत सोयाबीन की फसल के साथ मिट्टी की हानि 0.41 से 3.5 टन/हे. तक भिन्न थी, जबकि मक्का की फसल के साथ यह 0.46 से 3.73 टन/हे. थी। दोनों फसल प्रणाली के तहत पारंपरिक जुताई उपचार के साथ अपवाह हानि और मिट्टी की हानि सबसे अधिक पाई गई।
- ड्रिप सिंचाई (4964 किग्रा./हे.) और फव्वारा सिंचाई (4893 किग्रा./हे.) की तुलना में बाढ़ सिंचाई (5026 किग्रा./हे.) के तहत गेहूँ के दानों की उपज थोड़ी अधिक दर्ज की गई थी, लेकिन सभी सिंचाई विधियाँ काफी समान थीं। हालाँकि, पानी के उपयोग की दक्षता ड्रिप सिंचाई के तहत काफी अधिक थी। इसके बाद फव्वारा सिंचाई और सबसे कम बाढ़ सिंचाई के तहत थी जहाँ सतह के वाष्पीकरण, गहरी जल निकासी के माध्यम से पानी की हानि अधिक थी। जुताई की प्रणालियों में अनाज और पुआल की उपज बहुत अधिक नहीं थी।
- संरक्षण कृषि प्रणाली ने समय, श्रम और इनपुट लागत की सहवर्ती बचत और मिट्टी के स्वास्थ्य मापदंडों में सुधार और गेहूँ और सोयाबीन दोनों फसलों में उपज की स्थिरता के साथ पारंपरिक कृषि पद्धतियों के बराबर उपज स्तर बनाए रखा।
- दैनिक निकट सतह (0–5 सेमी.) वॉल्यूमेट्रिक मिट्टी का नमी डेटा (1980–2019) से पता चला है कि खरीफ के मौसम में सतह की नमी 0.25 से 0.34 M^3/M^3 के बीच थी, जबकि रबी के मौसम दौरान यह 0.15 से 0.24 M^3/M^3 तक थी।
- पारंपरिक जुताई (सीटी) की तुलना में बिना जुताई (एनटी) में सतही मिट्टी पर मृदा कार्बनिक कार्बन सांद्रता पर जुताई और नाइट्रोजन प्रबंधन प्रभाव क्रमशः 13% और 21% बढ़ा। मक्का–गेहूँ में सीटी की तुलना में एनटी के तहत उच्च उपलब्ध एन.पी.के. और एंजाइम गतिविधियां दर्ज की गईं। मृदा कार्बनिक कार्बन की पहचान मृदा गुणवत्ता मूल्यांकन के लिए सबसे महत्वपूर्ण संकेतक के रूप में की गई। परिणाम दर्शाते हैं कि मक्का–गेहूँ प्रणाली में 100% नाइट्रोजन प्रयोग के साथ लंबी अवधि के एनटी अर्ध–शुष्क क्षेत्रों के वर्टिसोल में मृदा गुणवत्ता, फसल उपज और कार्बन – भंडारण में सुधार के लिए एक व्यवहार्य विकल्प हो सकता है।
- सोयाबीन और मक्का के दानों की उपज पर वर्तमान और भवि य की जलवायु के प्रभाव से पता चलता है कि सोयाबीन की उपज में कमी की प्रवृत्ति रीवा > शहडोल > जबलपुर > नर्मदापुरम > भोपाल संभाग हालाँकि मक्का के लिए चंबल > ग्वालियर > जबलपुर > रीवा > सागर के रूप में प्रवृत्ति का पालन किया गया। कुल मिलाकर, आरसीपी अध्ययन के तहत अलग–अलग दशकों में गेहूँ के अनाज की उपज में 45% तक की कमी और चने की उपज में 27% की कमी दर्ज की गई।
- देश में अरहर उगाने वाले 63 स्थानों में सिंचित स्थितियों के तहत उपज क्षमता का विश्लेषण करने के लिए एपीएसआईएम–अरहर मटर मॉड्यूल का उपयोग किया गया। अरहर के क्षेत्र और उत्पादन के आधार पर इन स्थानों को प्राथमिक, द्वितीयक और तृतीयक उत्पादन क्षेत्रों में वर्गीकृत किया गया है। प्राथमिक जिलों के परिणामों से पता चला है कि जल–सीमित उपज क्षमता (Yw) (1749 किग्रा./हे.) की तुलना में उपज क्षमता (Yp) (2328 किग्रा/हे.) थी। प्राथमिक जिले में दर्ज की गई वास्तविक उपज 734 किग्रा./हे. (या) Ya थी। द्वितीयक और तृतीयक क्षेत्रों में, Yp क्रमशः 2299 और 2411 किग्रा./हे. था, जबकि Yw के

तहत क्रमशः 1779 और 1579 किग्रा/हे. थी। हालांकि, द्वितीयक और तृतीयक क्षेत्रों के लिए Ya क्रमशः 759 और 642 किग्रा/हे. था। प्राथमिक, द्वितीयक और तृतीयक उत्पादन में, Yg क्रमशः 1594, 1539 और 1768 किग्रा/हे. बताया गया।

- आधार समय (1980–2010) के लिए चना, गेहूँ, मक्का और सोयाबीन की औसत जल उत्पादकता क्रमशः 0.58, 1.10, 0.36 और 2.00 किग्रा M^3 दर्ज की गई। कुल मिलाकर, चना, गेहूँ और सोयाबीन की फसल के लिए जल उत्पादकता में कमी दर्ज की गई है। हालाँकि, भविष्य के जलवायु परिदृश्यों के तहत मक्का की फसलों के लिए जल उत्पादकता में वृद्धि दर्ज की गई थी। चना, गेहूँ और सोयाबीन के लिए जल उत्पादकता में कमी क्रमशः 19%, 21% और 16% दर्ज की गई। हालांकि विभिन्न आरसीपी और टाइम स्लाइस के लिए जल उत्पादकता में 7% की वृद्धि दर्ज की गई।
- इनक्यूवेशन अध्ययन के तहत यह पाया गया कि नमी की मात्रा और जल स्थिर समुच्चय पर तापमान का प्रभाव महत्वपूर्ण था। क्षेत्र क्षमता (0.33 बार) पर पानी की मात्रा 60^oC पर कम तापमान के औसत से 4-5% अधिक थी, जबकि स्थायी म्लानि बिंदु (15 बार) पर पानी की मात्रा कम तापमान के औसत से थोड़ी कम थी।

विषयवस्तु III: सूक्ष्मजैविक विविधता एवं जैव प्रौद्योगिकी

- छोटी अंहोनी (सीए), बड़ी अंहोनी (बीए) और तातापानी (टीए) गर्म झरनों से अलग किए गए थर्मोटोलरेंट बैक्टीरिया को उनके पौधों के विकास को बढ़ावा देने वाले गुणों के लिए चित्रित किया गया था। चयनित आइसोलेट्स का प्रयोगशाला स्थिति के तहत बीजोपचार पर रेडग्राम के विकास में सुधार दर्शाये।
- मीथेन की खपत (ng CO_2 /ग्राम मिट्टी) से कार्बन डाइऑक्साइड उत्पादन 1000 पीपीएम मीथेन पर 194 से 331 और मीथेन के 10000 पीपीएम में 139 से 272 तक भिन्न होती है। हालांकि उच्च मीथेन सांद्रता पर कार्बन डाईआक्साइड का उत्पादन कम था। यह दर्शाता है कि कार्बन डाईआक्साइड का उपयोग मेथनोट्रोफ्स द्वारा किया गया था। यह पाया गया कि मीथेन खपत के लिए कार्बन डाई आक्साइड एक पूर्ववर्ती अणु है क्योंकि यह सेरीन मार्ग के लिए आवश्यक है और यह मार्ग समग्र मीथेन खपत के लिए महत्वपूर्ण है।
- मिट्टी के पारिस्थितिकी तंत्र में मीथेन की उपस्थिति नोड्यूलेशन और नाइट्रोजन स्थिरीकरण को प्रभावित करके फलीदार फसलों की उत्पादकता को बाधित कर सकती है।
- तीन अलग–अलग मिट्टी के क्रमों पर उगाई गई गेहूँ की जड़ से, कुल 27 आइसोलेट्स प्राप्त किए गए, जिनमें से छह नाइट्रोजन मुक्त माध्यम पर बढ़ सकते थे, पंद्रह आइसोलेट में फॉस्फोरस विलेयन, नौ आइसोलेट में पौटेशियन विलेयन और पाँच में जिंक विलेयन क्षमता थी। विभिन्न मिट्टी के प्रकारों में उगाए गए एक ही मेजबान के एंडोफाइटिक जीवाणुओं में अंतर होता है, ऐसा ARDRA द्वारा प्रकट किया गया।
- फंगल कल्चर के बड़े पैमाने पर गुणन के लिए एक कम लागत वाला मीडिया विकसित किया गया है जो ट्राइकोडर्मास्पेरेलम आइसोलेट आई आई एस एस– एफ1, एस्परगिलस नाइजर आइसोलेट आईआईएसएस–एफ2, राइजोपुसोरिजा आइसोलेट आईआईएसएस–एफ3 और एस्परगिलस फ्लेवस आइसोलेट आईआईएसएस–एफ4 जैसे फंगल कल्चर के विकास और स्पोरुलेशन का समर्थन कर सकता है।
- मृदा जीव विज्ञान प्रभाग द्वारा खेत के कचरे और फसल अवशेषों को गड्डे के साथ–साथ खेत में ही अपघटित करने के लिए माइक्रोबियल डीकंपोजर कैप्सूल विकसित किया गया है।

विषयवस्तु IV: मृदा प्रदूषण और उपचार

- सोयाबीन (किस्म आरवीएस–2001–41) के तेरह उपचार संयोजनों में पौधे की ऊंचाई, कुल क्लोरोफिल में विशेष रूप से 200 टन/हे. या उससे अधिक की दर से फ्लाई ऐश के प्रयोग के साथ उल्लेखनीय रूप से वृद्धि हुई है। औसत स्थूल घनत्व (बीडी), सतह की मिट्टी की अन्तर्ग्रहन दर और मिट्टी की जल धारण क्षमता (डब्ल्यूएचसी) राख प्रयोग की बढ़ती दर के साथ कम हो गई और राख प्रयोग की उच्चतम दर (400 टन/हे. एक बार) के साथ न्यूनतम हो गई। निचली परतों की तुलना में 0–5 सेंमी. परत में उपचारों के कारण कोन वेधन प्रतिरोध मूल्यों में भिन्नता अधिक थी।
- नगर पालिका ठोस अपशिष्ट (MSW) के साथ सह–कम्पोस्टिंग की प्रक्रिया के दौरान एडिटिव के रूप में सॉफ्ट वुड (अरहर) बायोचार (BC) के उपयोग से सह–कम्पोस्ट उत्पाद, MSWBC की गुणवत्ता में सुधार हुआ। मिट्टी में MSWBC & 10% PPB के अनुप्रयोग ने DTPA–निकालने योग्य भारी धातु सामग्री को 14.7% (Ni) से 62.5% (Cd) तक कम कर दिया और मिट्टी से पौधे प्रणाली में भारी धातु गतिशीलता (स्थानांतरण गुणांक मान) को कम कर दिया।

- सिंगरौली ओपन कास्ट कोयला खदान से झिंगुरदा और जयंत क्षेत्रों के साथ–साथ खदान स्थल गांवों के कृषि क्षेत्रों से भू–संदर्भित मिट्टी और पानी के नमूने एकत्र किए गए थे। झींगुरदा कोयला खदान क्षेत्र की मिट्टी जैविक कार्बन में उच्च, उपलब्ध फॉस्फोरस में निम्न से मध्यम और उपलब्ध पोटैशियम में मध्यम थी, जबकि जयंत कोयला खदान क्षेत्र की मिट्टी कार्बनिक कार्बन में उच्च, उपलब्ध फॉस्फोरस में कम से मध्यम लेकिन उपलब्ध पोटैशियम में उच्च थी।
- जाजमऊ औद्योगिक क्षेत्र कानपुर के चर्म शोधन उद्योगों से निकलने वाला प्रवाह लगभग 29 मिलियन लीटर प्रति दिन (MLD) है लेकिन केवल 50% का ही उपचार किया जाता है। लगभग 99% उद्योग क्रोम टैनिंग प्रक्रिया कर रहे हैं। 250 मीटर के अंतराल पर ग्रिड–वार 120 भू–संदर्भित सतही मिट्टी के नमूने एकत्र किए गए।
- एक IoT आधारित स्मार्ट सिंचाई प्रणाली का विकास और परीक्षण किया गया जो किसानों को पीसी या स्मार्टफोन का उपयोग करके कहीं से भी और कभी भी अपने कृषि क्षेत्र की सिंचाई करने में मदद करती है। सिस्टम ने मिट्टी की नमी सेंसर, मिट्टी के तापमान और नमी सेंसर से बना वितरण किया है जो वाई–फाई मॉड्यूल के माध्यम से थिंगस्पीक वेब को मापता है और भेजता है और पर्यावरणीय मापदंडों की स्थिति की निगरानी करता है। क्षेत्र की क्षमता को, स्थायी मुरझाने का बिंदु 30.5 प्रतिशत स्थाई म्लान बिन्दु 15.2 प्रतिशत और उपलब्ध नमी 15.35 प्रतिशत को ध्यान में रखते हुए निम्न सेट बिंदु निर्धारित किया गया था।
- आर्सेनिक अध्ययन के लिए मालदा, मुर्शिदाबाद और दक्षिण 24–परगना के पाँच ब्लॉकों में 10 स्थलों से मिट्टी, सिंचाई के पानी और पौधों के नमूने (आलू, प्याज, लहसुन, चौलाई, बैंगन, टमाटर, गोभी, फूलगोभी और पालक) एकत्र किए गए। मालदा, मुर्शिदाबाद और दक्षिण 24 पगना जिले की मिट्टी में क्रमशः 1.11, 0.78 और 1.23 पीपीएम आर्सेनिक दर्ज किया गया। सिंचाई के पानी में मालदा के लिए सांद्रता 0.46 पीपीएम, मुर्शिदाबाद के लिए 0.37 पीपीएम और दक्षिण 24 परगना के लिए 0.60 पी पी एम थी। मालदा, मुर्शिदाबाद और दक्षिण 24 पगना जिले के पौधों के नमूनों में आर्सेनिक की सांद्रता क्रमशः 0.02 से 0.82, 0.06 से 0.83 और 0.08 से 0.99 पीपीएम के बीच औसत मान 0.31, 0.28 और 0.31 पीपीएम के बीच थी।
- तलचर कोलफील्ड, ओडिशा (बिटुमिनस और सब – बिटुमिनस कोयला) से दो कोयले के नमूने और नेवेली (तमिलनाडु) से लिग्नाइट के नमूने का FTIR और XRD विश्लेषण के माध्यम से विभिन्न प्रकार के कार्यात्मक समूहों और खनिजों का मूल्यांकन किया गया। एक्सआरडी परिणामों से पता चला कि बिटुमिनस में, उप–बिटुमिनस कोयले, क्वार्ट्ज, काओलाइट सिडेराइट और एनाटेज प्रमुख खनिज थे जबकि लिग्नाइट में जिप्सम, काओलिनाईट और क्वार्ट्ज प्रमुख थे। कोयले की राख का FTIR स्पेक्ट्रा कार्बनिक कार्यात्मक समूहों की अनुपस्थिति को दर्शाता है, जो कार्बनिक घटकों के बर्नआउट का संकेत देता है।
- 16 EPA प्राथमिकता PAHs PAHs को मध्य भारत में विविध कृषि भूमि उपयोग प्रणालियों से कृषि सतह मिट्टी (0–5 सेमी.) में मापा गया था। विभिन्न कृषि मिट्टी के नमूनों के 16 पीएएच ND–122.52 माइक्रोग्राम/किग्रा. के बीच थे। 7 कार्सिनोजेनिक पीएएच की कुल सांद्रता ND–101.64 ug kg^{-1} के बीच थी। फ्लाई ऐश से उपचारित मिट्टी में 16 पीएएच का स्तर सीवेज–सिंचित मिट्टी की तुलना में 2–5 गुना अधिक था। चार से पाँच रिंग वाले पीएएच सबसे आम थे।

EXECUTIVE SUMMARY

Theme I: Soil Health and Input Use Efficiency

Soil fertility

- The efficient genotypes of wheat for Nitrogen and Phosphorus use efficiency were selected from 120 genotypes developed from India and abroad based on the performance during last two years. Few genotypes recorded significantly higher grain yield and nitrogen uptake and use efficiency. Ample variations in morpho-physiological parameters including gas exchange parameters were recorded in these genotypes.
- The IPNS modules in Vertisols increased the SOC contents, different carbon and their stocks with application of higher amount of FYM (25 t ha^{-1}) followed by 75% NPK based on STCR + 5 t ha^{-1} FYM as compared to GRD and 100% NPK based on STCR. Maize yield was significantly highest with FYM + STCR based 75% NPK module and followed by FYM @ 20 t ha^{-1} and 75%NPK + poultry manure than GRD and 100% NPK based STCR alone.
- Adoption of STCR based INM module (5 t FYM+ 75%NPK of STCR) minimized the energy requirement by 14%, cost of cultivation by 6.5% and carbon footprint (CF) on a spatial scale by 17% than GRD. STCR based INM module enhanced the EUE, energy productivity (EP) and energy profitability (EPF) by 28.5%, 31.5% and 31.8% respectively, over GRD. INM module also increased system productivity by 17.0%, carbon efficiency (CE) by 19.3% and carbon sustainability index (CSI) by 21% than GRD.
- The application of glauconite @1.5% along with FYM and microbial culture recorded highest biomass and grain yield of wheat. The application of glauconite alone (0.5 to 1.5%) also showed significant improvement in growth and yield of wheat.
- The lowest P sorption maxima, MPBC, standard P requirement was recorded in organic farming followed by conservation agriculture with 90% of residue incorporation. Whereas, the highest P sorption maxima, MPBC, standard P requirement was recorded in absolute control followed by STCR based nutrient management system.
- XRD of the fine clay fraction of various soil series showed the dominance of smectite with very small amount of vermiculite, chlorite, mica and feldspars. The Greene-Kelly test (Hofmann-Klemen effect) indicated that all the fine clay samples of all soil series are a mixture of beidellite-nontronite and montmorillonite in which the amount of the former is more.
- Retention in 90% of residue of previous crops resulted in an increased POM-C by 54.5% and POM-N by 47% in the 0-10 cm layer compared to the no residue retained treatment. Similarly, 30 and 60% of residue retention resulted in 72 and 18% improvement in N mineralization potential of soil in comparison to control.
- The application of wood biochar 8 t ha^{-1} along with RDF and 5 t ha^{-1} manure recorded statistically higher grain yield in the rice crop. Application of crop residue biochar shown significantly higher pod yield of Okra in Inceptisols (Belpada) and Alfisols (Nuapada) of Odisha compared to wood coconut husk biochar.
- Soil properties were estimated through MIR and good predictions for the independent data set were obtained for clay (R^2: 0.84, RMSE: 2.89), silt (R^2: 0.75, RMSE: 3.28), sand percentage (R^2: 0.71, RMSE: 4.14), soil water retention at PWP (R^2: 0.74, RMSE: 1.52) and FC (R^2: 0.70, RMSE: 2.37), SOC content (R^2: 0.72, RMSE: 0.11) and pH (R^2: 0.73, RMSE: 0.46) in models developed through PLSR techniques.
- The highest seed yield of wheat, mustard, chickpea and linseed were recorded in 100% organic treatment followed by 50% organic+50% inorganic treatment. Groundnut variety GPBD-5 exhibited the highest yield (1989 kg ha^{-1}) among 12 tested varieties and mustard variety Aravali gave highest yield of (1988 kg ha^{-1}) under organic nutrient management practice.
- In natural farming experiment, the highest seed yield of soybean was recorded in integrated crop management with pesticide (ICMP) treatment, which was at par with integrated crop management with natural farming (ICMNF) and AI-NPOF package
- No application of K fertilizer for long time reduced Non-exch-K storage and increased exch-K in 100% N treatment in Alfisol (LTFE Palampur) and Vertisol (LTFE Parbhani).
- In LTFE Barrackpore (Inceptisol) and LTFE Palampur (Alfisol), it was observed that microbial autotrophic carbon fixation potential could be up to 40-45 μg CO_2-C g^{-1} soil day^{-1} in 100% NPK +FYM application. Also, in LTFE Barrackpore and LTFE Palampur, it was observed that imbalanced fertilizer application for long term (100% N and 100% NP) reduced the biological P supply power of the soil.
- Light pruning in kagzi lime and mango by removing old, diseased and unproductive shoots resulted in bumper flowering and fruiting. Light pruning in aonla also resulted in good fruiting without any input by using natural resources and about 70-100 kg fruits per tree were harvested.
- The grain yield of soybean, maize, wheat and gram was significantly improved under balanced and INM practice in selected village clusters.
- The biological analysis of surface water resources of tribal inhabited areas showed the presence of harmful fecal caliform bacteria. Besides, ITK on major indigenous agricultural technologies of the locality were documented on land preparation, moisture conservation, pest and diseases control.
- ICAR-CIRCOT Nano-Sulphur was evaluated as fertilizer formulation for mustard crop. Seed yield, Stover yield and sulphur content in mustard was significantly increased with increasing dose of sulphur up to 60 Kg ha^{-1} superior over control, and 30 kg S ha^{-1} and on par with 45 kg S ha^{-1}.
- The natural abundance of ^{13}C stable isotope estimation proved that INM significantly improved the proportion new carbon at all depths compared to inorganic and

control treatments. Also aboveground and below ground residue decomposition studies indicated that during 0-6 months, percent mass loss of biomass was greater in wheat>soybean, chickpea>maize.

AICRPs

- The long term application of fertilizers and manures in major crops grown under Alfisols clearly demonstrated that crop productivity declined with imbalanced use of fertilizers especially 100% N alone. However, balanced use of nutrients and integrated nutrient management in the form of 100% NPK+FYM / 100% NPK + Lime led to significant improvement in crop productivity across almost all soils and locations under Alfisols.
- Nutrient uptake of both macro and micronutrients by major crops was found to be highest with INM i.e. 100% NPK+ FYM followed by 100% NPK+Lime with an exception at Bangalore, where 150% NPK application gave maximum. Imbalanced nutrients application led to decrease in nutrients uptake in major crops in these acid soils.
- The sustainability indices i.e. Sustainable Yield Index (SYI) and Soil Quality Index (SQI) were found to be improved with balanced and INM (100% NPK+FYM) across different Alfisols of LTFE. On the contrary, 100% N led to drastic reduction in the sustainability of major crops and cropping systems.
- Variable and wide spread deficiencies of S and multi-micronutrients in soils were observed in 615 districts of 28 states of India. The deficiencies of S, Zn and B were higher compared to the deficiencies of Fe, Cu and Mn.
- A farm-scale spatial variability of soil nutrients in IISS research farm was assessed for prediction mapping of soil properties and site-specific nutrient management.
- The work done by various AICRP-STCR centers were analyzed for development of IPNS targeted yield equations.

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

- The crop growth, grain and straw yield was recorded significantly higher under 90% crop residue retention over 60%, 30% and without residue retention in soybean-wheat and maize-chickpea cropping systems. However, the weed biomass and weed density was recorded significantly less under 90% crop residue retention over 60%, 30% and without residue retention at crop harvest. The crop growth, grain and straw yield was not found to be significantly affected by nutrient doses and different herbicidal weed control treatments.
- The runoff losses were observed higher with maize, these losses varied from 12.43 to 27.69% under various tillage and crop residue treatments. However, these were 12.46 to 23.76% with soybean crop. The soil loss was varied from 0.41 to 3.5 t ha^{-1} with soybean crop under various tillage and residue levels, while it was 0.46 to 3.73 t ha^{-1} with maize crop. The runoff loss and soil loss were highest with conventional tillage treatment under both the cropping system
- The grain yield of wheat was recorded slightly higher under flood (5026 kg ha^{-1}) over drip (4964 kg ha^{-1}) and sprinkler irrigation (4893 kg ha^{-1}) but the all the irrigation methods were significantly at par. However, the water use efficiency was significantly higher under drip followed by sprinkler and lowest under flood irrigation where losses of water through surface evaporation, deep drainage was higher.
- Conservation agricultural system-maintained yield level on par with the conventional agricultural practices with concomitant savings of time, labour and input cost and improvement in soil health parameters and sustainability of yield in both wheat and soybean crops.
- The daily near surface (0-5 cm) volumetric soil moisture data (1980-2019) showed that near surface soil moisture in the kharif season ranged from 0.25 to 0.34 m^{3}m^{-3} whereas it ranged from 0.15 to 0.24 m^{3}m^{-3} during rabi season.
- Tillage and nitrogen management effect on SOC concentration increased by 13% and 21% at surface soil in No tillage (NT) than conventional tillage (CT). The higher available N, P, K and enzyme activities were recorded under NT than CT in maize-wheat. The SOC is identified as the most important indicator for SQ evaluation. Results highlighted that long–term NT with 100% N application in maize–wheat system could be a viable option for improving SQ, crop yield and C–storage in Vertisol of semi-arid regions.
- The impact of present and future climate on grain yield of soybean and maize showed the trend of decrease in soybean yield as Rewa>Shahdol>Jabalpur >Narmadapuram> Bhopal division; however, for the maize, the trend followed as Chambal > Gwalior > Jabalpur >Rewa>Sagar. Overall, a decrease of up to 45% of wheat grain yield and 27% of chickpea yield were reported in varying decades under the RCPs studies.
- The APSIM-Pigeon pea module was used to analyze the yield potential under irrigated conditions in 63 pigeon pea growing locations in the country. The results from primary districts revealed that yield potential (Yp) was (2328 kg ha^{-1}) compared to water-limited yield potential (Yw) (1749 kg ha^{-1}). The actual yield recorded in the primary district was 734 kg ha^{-1} (Ya). In secondary and tertiary zones, Yp were 2299 and 2411 kg ha^{-1} compared to 1779 and 1579 kg ha^{-1} under Yw, respectively. However, the Ya for secondary and tertiary zones were 759 and 642 kg ha^{-1}, respectively. In primary, secondary, and tertiary production, the Yg was reported 1594, 1539, and 1768 kg ha^{-1}, respectively.
- The average water productivity of chickpea, wheat, maize, and soybean was recorded at 0.58, 1.10, 0.36, and 2.00 kg m^{-3}, respectively, for the base time (1980-2010). The decrease in water productivity for chickpea, wheat, and soybean was reported at 19%, 21%, and 16%, respectively; however, an increase of 7% in water productivity for maize was reported for the different RCPs and time slices.
- Under incubator study, it was found that effect of temperature on moisture content and water stable aggregate was significant. The water content at field capacity (0.33 bar) was 4-5% higher than the mean

average of lower temperature at 60^0C while the water content at permanent wilting point (15 bar) was slightly decreased from the mean average of lower temperature.

Theme III: Microbial Diversity and Genomics

- Thermotolerant bacterial isolated from Choti Anhoni (CA), Badi Anhoni (BA) and Tatapani (TA) hotsprings were characterized for their plant growth promoting attributes. Selected isolates could improve the growth of Redgram upon seed inoculation under laboratory condition.
- Carbondioxide production from CH_4 consumption (ng CO_2 produced g^{-1} soil) varied from 194 to 331 at 1000 ppm CH_4 and 139 to 272 in 10000 ppm of CH_4. However, CO_2 production was lower at higher CH_4 concentration, indicated that CO_2 was used up by methanotrophs. It was found that CO_2 is a precursor molecule for CH_4 consumption as it is essential for serine pathway and this pathway is key to overall CH_4 consumption.
- Occurrence of CH_4 in soil ecosystem can inhibit the productivity of legumes by affecting nodulation and N_2 fixation.
- From the wheat root grown on three different soil orders, total 27 isolates were obtained of which, six could grow on nitrogen free medium, fifteen isolate solubilized P from tricalcium phosphate, nine isolate solubilized potassium from glauconite and five had zinc solubilizing ability. Difference occurred in the endophytic flora of same host grown in different soil types with few of the common organisms found in host of all the soil types as revealed by ARDRA.
- A low cost media is developed for mass multiplication of fungal cultures which could support the growth and sporulation of fungal cultures such as *Trichoderma asperellum* isolate IISS-F1, *Aspergillus niger* isolate IISS-F2, *Rhizopusoryzae* isolate IISS-F3 and *Aspergillus flavus* isolate IISS-F4.
- Microbial decomposer capsules has been developed by soil biology division for *off-situ* or *in-situ* decomposition of farm waste and crop residue in pit as well as in the field.

Theme IV: Soil Pollution, Remediation and Environmental Security

- Plant height, total chlorophyll content of soybean (variety RVS-2001-41) increased significantly particularly with application of fly ash at the rate 200 t ha^{-1} or more. Average bulk density (BD), infiltration rate of surface soil and water holding capacity (WHC) of soil decreased with increasing rate of ash application and minimum with highest rate (400 t ha^{-1} at once)of ash application. Variation in cone penetration resistance values due to treatments was more in 0-5 cm layer as compared to lower layers.
- Use of soft wood (pigeon pea) biochar (BC) as an additive during the process of co-composting with Municipal solid waste (MSW) improved the quality of the co-composted product, MSWBC. Application of MSWBC-10% PPB in soil significantly reduced the DTPA-extractable heavy metal content by 14.7% (Ni) to 62.5% (Cd) and reduced heavy metal mobility (transfer coefficient values) from the soil to the plant system.
- Geo-referenced soil and water samples were collected from the Singrauli open cast coal mine viz. Jhingurda and Jayant areas as well as from agricultural fields of mine site villages. The water samples were analysed for heavy metals of the mine areas. Jhingurda coal mine area soil was high in organic carbon, low to medium in available P and medium in available K, whereas Jayant coal mine area soil was high in organic carbon, low to medium in available P but high in available K.
- Jajmau Industrial area, Kanpur has more than 400 tanning industries and the effluent discharge from these tannery industries is about 29 million litres per day (MLD) but only 50% is treated. Approximately 99% of industries are performing chrome tanning process. Grid wise 120 geo-referenced surface soil samples were collected at an interval of 250 m.
- An IoT based smart irrigation system was developed and tested which irrigate the agricultural field from anywhere and anytime using PC or smartphone. The system composted of a soil moisture sensor, soil temperature and humidity sensors that measure and send it to the Thing Speak web via Wi-Fi module and to monitor the environmental parameters condition. The lower set point was set by considering the field capacity as 30.5%, permanent wilting point 15.2% and 15.35% available moisture content.
- Soil, irrigation water and plant samples (potato, onion, garlic, amaranths, brinjal, tomato, cabbage, cauliflower and spinach) were collected from 10 sites of five blocks of Malda, Murshidabad and South 24-Parganas district of West Bengal for As profiling. In soils of Malda, Murshidabad and South 24 Paganas district recorded 1.11, 0.78 and 1.23 ppm As, respectively; in irrigation water As concentrations were 0.46 ppm for Malda, 0.37 ppm for Murshidabad and 0.60 for South 24 Parganas. Arsenic concentration in plant samples of Malda, Murshidabad and South 24 Paganas district varied from 0.02 to 0.82, 0.06 to 0.83 and from 0.08 to 0.99 ppm with mean value of 0.31, 0.28 and 0.31 ppm, respectively.

PAT

- In two coal sample from Talcher coalfield, Odisha (bituminous and sub-bituminous coal), and lignite sample from Neyveli (Tamil Nadu) different types of functional groups and minerals were assessed through FTIR and XRD analysis. XRD results revealed that in bituminous, sub-bituminous coals, quartz, kaolinite siderite and anatase were dominant minerals while gypsum, kaolinite and quartz were prominent in lignite. The FTIR spectra of coal ashes show the absence of organic functional groups, indicating the burnout of organic components.
- The 16 EPA priority PAHs (∑ 16 PAHs) were measured in agricultural surface soils (0-5 cm) from diverse agricultural land use systems in central India. ∑ 16 PAHs of soil samples ranged from ND–122.52 µg kg^{-1}. Total concentration of 7 carcinogenic PAHs ranged from ND-101.64 µg kg^{-1}. ∑ 16 PAHs levels in fly ash-treated soils were 2-5 times higher than that in sewage-irrigated soils. PAHs containing four to five rings were the most common.

1. Introduction

Soil science research contribute significantly to food and nutritional security, human wellbeing, nature conservancy, and global peace and harmony. It is predicted that achieving critical Sustainable Development Goals (SDGs) of United Nations by 2030 can be facilitated by sustainable soil management. For successful realization of these goals viz. SDG1 (End Poverty), 2 (Zero Hunger), 3 (Good Health and Wellbeing), 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), 13 (Climate Action), and 15 (Life on Land), sustainable management of soil health is important for sustaining agricultural production. Accordingly, GoI has initiated a slew of measures nationwide under Soil Health mission to improve the soil productivity. Hence, it is essential to understand the properties and processes of soil at regional, national and global scales to realize these SDGs. Intensive agriculture with unprecedented exploitation of scarce soil resources worldwide has produced more food grain, but 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. Thus, increasing food-grain production from shrinking land resources requires prioritization of research pursuits, addressing the emerging issues like enhancing 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 concerted efforts to attain its mission and received national and international recognitions. UN FAO has conferred the prestigious King Bhumibol World Soil Day 2020 Award to the institute for its massive outreach and awareness program on soil health management across the country. 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, 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 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, and bio-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 assessment imbibing influence of different physical, chemical and biological soil attributes
- Organic farming and produce quality

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

- Conservation agriculture and carbon sequestration for 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 large 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 green house gases
- Environmental impact risk assessment of nanoparticles on soil health and plant nutrition

1.3 Organization Set-Up

Divisions

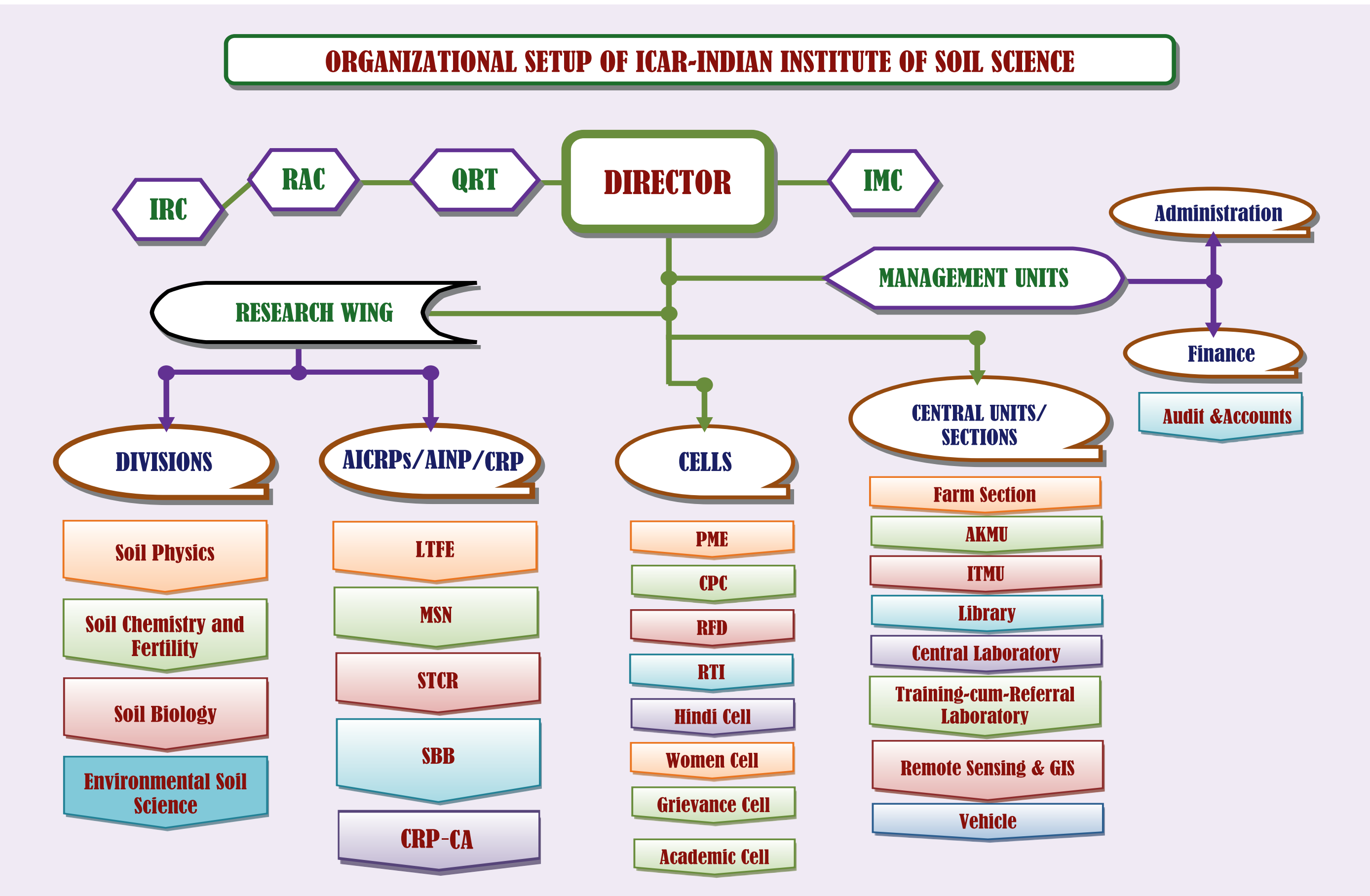
- Soil Physics
- Soil Chemistry & Fertility
- Soil Biology
- Environmental Soil Science

Sections/Central Units/Technical Units/Cells

- Farm
- Administration
- Remote Sensing & GIS
- Prioritization, Monitoring and Evaluation Cell (PME)
- Agriculture Knowledge Management Unit (AKMU)
- Institute Technology Management Unit (ITMU)
- Library, Information and Documentation Unit
- Right to Information (RTI)
- Consultancy Processing Cell (CPC)
- Official Language Cell (Hindi Cell)
- Vehicle
- Training Hostel
- Referral Lab
- Women Cell

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

- AICRP on Long -Term Fertilizer Experiments to Study Changes in Soil Quality, Crop Productivity and Sustainability (LTFE)
- AICRP on Soil Test Crop Response (STCR)
- AICRP on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (MSPE)
- AINP on Soil Biodiversity and Biofertilizers (SBB)
- CRP on Conservation Agriculture



1.4 Manpower

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	2	3
5	Agricultural Physics	0	1	0	1	0	0	1	1
6	Agricultural Statistics	0	0	1	1	0	0	1	1
7	Agronomy	0	1	4	5	0	1	4	5
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	1	0	1
11	Plant Physiology	1	1	1	3	1	1	1	3
12	Soil Science	0	4	27	31	7	6	20	33
	Total	**1**	**10**	**40**	**51**	**8**	**10**	**32**	**50**
13	HODs	4	0	0	4	0	0	0	0
14	Project Coordinators	0	0	0	0	0	0	0	0
15	RMP	1	0	0	1	1	0	0	1
	GRANT TOTAL	**6**	**10**	**40**	**56**	**9**	**10**	**32**	**51**

Technical

S. No.	Posts	Sanctioned	In Position
1	T-1	11	9
2	T-2	-	-
3	T-3	7	6
4	T-4	-	-
5	T-5	-	-
6	T-6	1	0
7	T-7-8	-	-
8	T-9	-	-
	Total	19	15

Administrative

S. No.	Designation	Sanctioned	In Position
1	Sr. Administrative Officer	1	1
2	Finance & Accounts Officer	1	0
3	Assistant Finance & Accounts Officer	1	1
4	Assistant Administrative Officer	1	1
5	Private Secretary	2	2
6	Assistant	6	3
7	Personal Assistant	5	2
8	Stenographer Gr-III	2	2
9	Security Supervisor	1	1
10	Upper Division Clerk	2	2
11	Lower Division Clerk	3	3

12	Skilled Supporting Staff	17	17
	Total	42	35
	Grand total	117	101

1.5 Finance: Budget statement (Lakhs) 1 April 2021 to 31 Mar 2022 is as follows

Institute/AICRPs	Budget	Expenditure
Main ICAR-IISS Institute	2458.71	2458.71
AICRP on MSN	829.53	829.53
AICRP on STCR	931.95	931.89
AICRP on LTFE	574.57	574.56
AINP on SBB	225.65	225.64
CRP on CA	274.99	274.93
Total	**5295.40**	**5295.26**

1.6 Resource Generation

S.No	Head of Account	Rs. In lakh
1	Sale of farm produce	18.44
2	Sale of publication, royalty and advertisement	0.02
3	Licence fee	3.56
4	Interest earned on loans & advances	15.47
5	Receipts from schemes	6.76
6	Analytical and testing fee	0.14
7	Diploma Charges	0.00
8	Interest earned on short term deposits	22.41
9	Recovery of loans and advances	25.19
10	Miscellaneous Receipts	71.99
	Total	**163.98**

2. Research Achievements

Theme - I: Soil Health and Input 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

NUE of selected wheat genotypes grown in nitrogen sufficient and deficient environment

A field experiment was conducted during the *rabi* season of 2021-2022 at ICAR IISS research farm to evaluate nutrient use efficiency traits of 24 selected varieties of wheat. These genotypes were selected from about 120 genotypes of wheat developed from India and abroad based on the performance during last two years for Nitrogen and Phosphorus use efficiency and improved crop yield. The grain yield of the 120 genotypes ranged from 7.05 t ha^{-1} to 1.88 t ha^{-1}. The selected 24 genotypes were evaluated under plots of nutrient gradient with low Nitrogen, low Phosphorus and general recommended dose (GRD) of fertilizer nutrient (120-60-40 kg ha^{-1} of NPK). Ample variations in morpho-physiological parameters like plant height (75-120 cm), SPAD chlorophyll content units (56.7 to 33.8 units), leaf area (485 to 1719 cm^2), days to 50% flowering, gas exchange parameters (Ps rate from 30 to 20.6 μmol CO_2 $m^{-2}s^{-1}$ and stomatal conductance 0.1 to 0.41 mol m^{-2} s^{-1}) were recorded in these genotypes. The plant biomass and yield parameters including nutrient use efficiency parameter of selected genotypes were analyzed for the evaluation of the crop productivity and nutrient use efficiency of wheat. Besides, 96 genotypes of wheat were also maintained for germplasm conservation (Plate 2.1.1 a & b).

Plate : 2.1.1a Field performance of selected genotypes

Plate 2.1.1b Field view of the experimental site

2.1.2 Integrated plant nutrient supply (IPNS) modules for improving soil organic carbon (SOC) pools and their stocks in Vertisols

The IPNS modules increased the SOC contents, different carbon fractions (Cfrac I, Cfrac II, Cfrac III, and Cfrac IV) and their stocks with application of higher amount of FYM (25t ha^{-1}) followed by 75% NPK based on STCR along with 5 t ha^{-1} FYM as compared to GRD and 100% NPK based on STCR. Among the SOC pools, active pools of carbon (Cfrac I and Cfrac II) contributed nearly 56% and passive pools (Cfrac III and Cfrac IV) about 44% in the upper layer (0-15cm). In lower layer (15–30 cm) of soil the active pools of carbon contributed about 46% while passive pool about 54%. Crop yield was higher with application of IPNS modules compared to organic and inorganic modules. Maize yield was highest with FYM based INM modules (FYM + STCR based 75% NPK) followed by FYM at 20 t ha^{-1} and 75%NPK + poultry manure than general recommended dose (GRD) and 100% NPK based STCR alone. Study suggested that adoption of STCR based INM modules is the best technology to improve SOC stocks in Vertisols of Central India. (Plate 2.1.2 a & b)

Plate : 2.1.2a Field performance of chickpea

Plate : 2.1.2b Field performance of maize

2.1.3 Energy and carbon budgeting under integrated nutrient management

The energy input-output for maize-chickpea system under diverse nutrient modules was estimated. Integration of organic sources of nutrients (organic modules) *viz*., MRM, FYM, PM and GLM increased the energy consumption and registered a highest mean energy requirement (40,116 MJ ha^{-1}) than inorganic (20,500 MJ ha^{-1}) and INM modules (21,371 MJ ha^{-1}). Energy input for organic, INM, and inorganic modules were 73%, 51% and 48% respectively. Tillage, accounted 21% of the total energy in inorganic, 11% in organic and 19% in INM. Among the different organic modules, total energy requirement (54,479 MJha^{-1}) was highest in MRM+PM+GLM followed by MRM+FYM+GLM (47,162 MJha^{-1}), while, unfertilized/unmanured plots consumed minimum energy (10,141 MJha^{-1}). FYM+75% STCR registered 14% less energy requirement as compared to GRD due to less fertilizer used. Overall, STCR based INM module (FYM+75%STCR) conserved apprehensible energy over GRD, particularly in fertilizers, pesticides and fuel utilized, leading to about 12% total energy saving. Hence, INM module increased the energy use efficiency and energy productivity by 29% and 32%, respectively. (Fig. 2.1.3a)

The contribution of Carbon Footprints (CFs) among the organic, inorganic and INM modules were attributed to the emissions from fertilizers, manures, diesel, seed, plant protection chemicals and N_2O from field (Plate 2.1.3). The mean data on total CFs indicated that the organic (1946 CO_2-e kg ha^{-1}), inorganic (2066 CO_2-e kg ha^{-1}) and INM (2128 CO_2-e kg ha^{-1}) modules had almost equal contributors in terms of GHGs emission in the system. Results indicated that the CO_2-emissions from fertilizers/manures (38% in INM, 37% in inorganic and 37% in organic) followed by N_2O based estimation (30% in INM, 29% in inorganic and 29% in organic), contributed the highest CFs. FYM+75%STCR reduced the CF by about 17.4% and 13.7% in fertilizers/manures and N_2O from farm, respectively and leading to overall 11.2% total reduction as compared to organic modules (Fig. 2.1.3b)

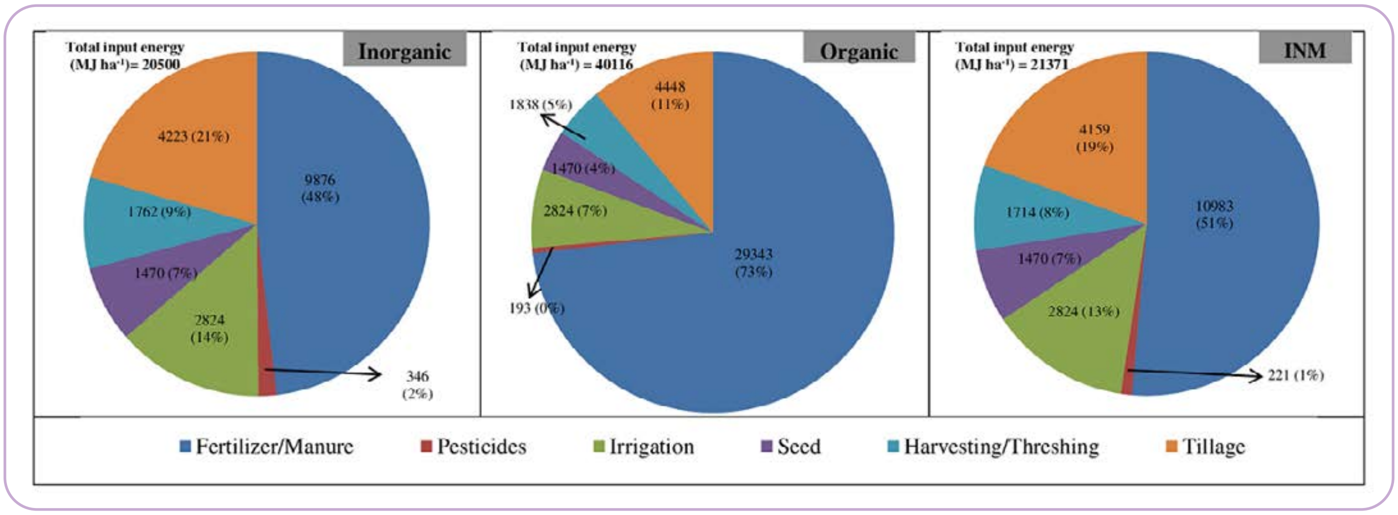


Fig. 2.1.3a Energy use in cereal – legume-cropping system under organic, inorganic and INM modules.

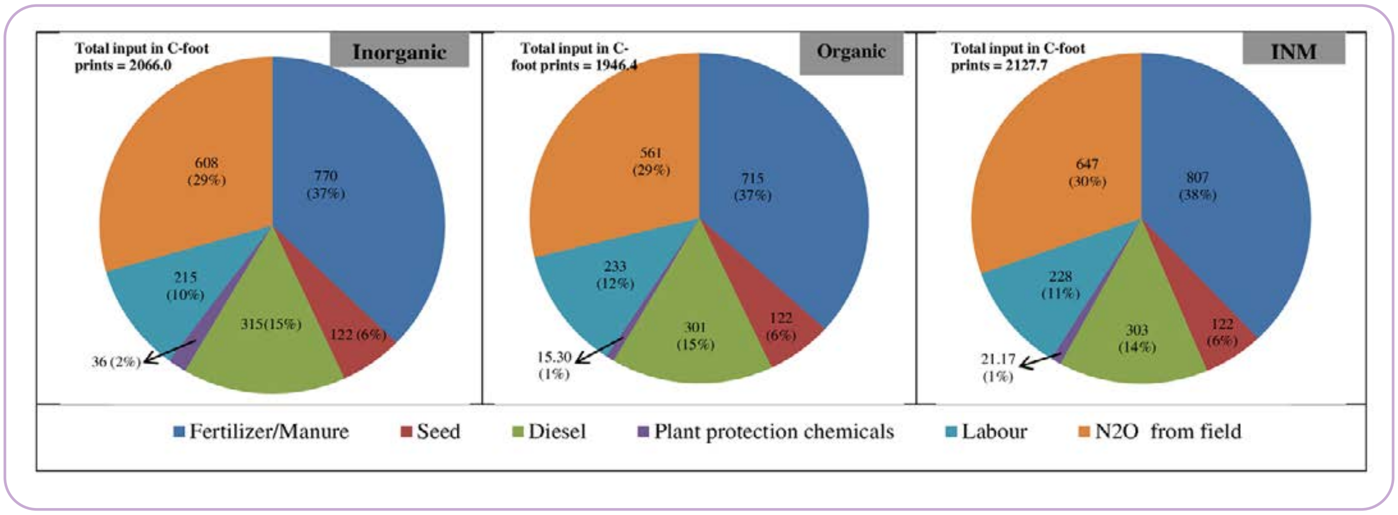


Fig. 2.1.3b Share of different inputs towards carbon footprint (CO_2–eq kg ha^{-1}) of cereal –legume-cropping system under organic, inorganic and INM modules.

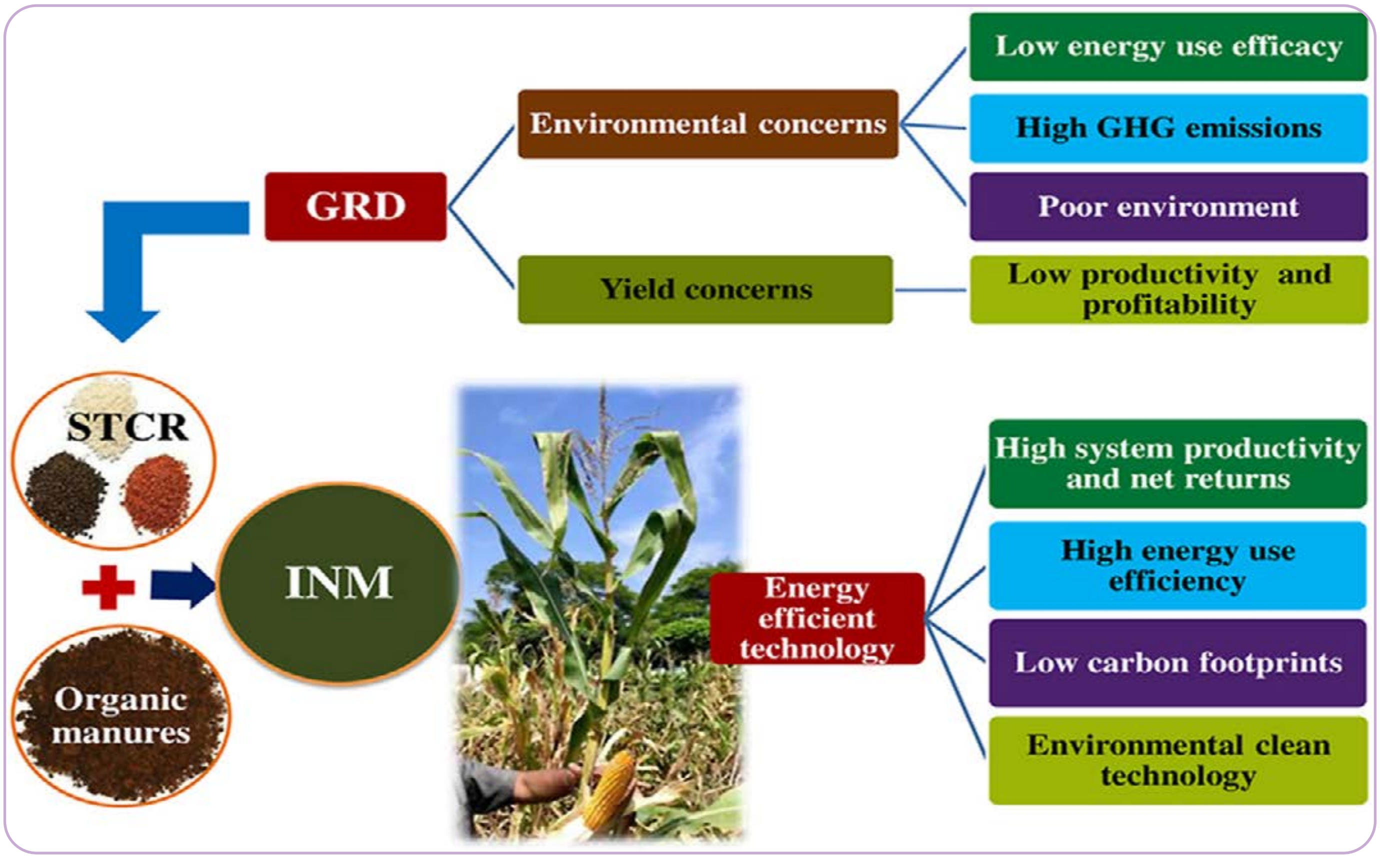
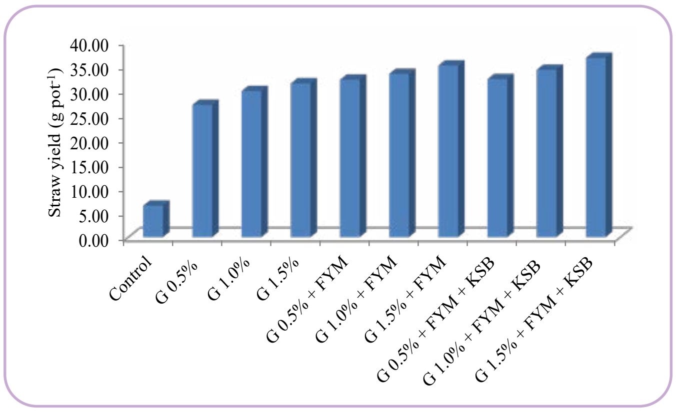


Plate 2.1.3 Inter Selectionship of Nutrient Molecules, Energy use, Carbon Footprints and Productivity

2.1.4 Effect of gluaconite on performance of wheat in Alfisol

Pot experiments were conducted to evaluate the effect of gluconite applied alone or mixed with FYM /KSB on wheat (HI 8498) in Alfisol. The glauconite (0.5, 1.0 and 1.5% of soil weight) was applied along with FYM 10 t ha^{-1} and microbial culture of BDN-1 0.44% of soil weight. Recommended dose of N and P was applied to all treatments except control. The results showed that with the increasing levels of glauconite application, there was a spectacular improvement in growth and yield of wheat. In general, the application of glauconite at 1.5% along with FYM and microbial culture recorded highest biomass yield (36.60 g pot^{-1}) and grain yield (34.43 g pot^{-1}) of wheat (Fig. 2.1.4).



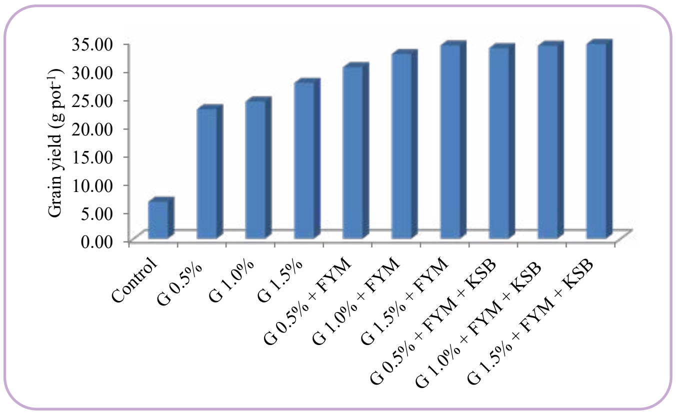


Fig. 2.1.4 Effect of glauconite with and without FYM and KSB on straw and grain yield of wheat

The application of glauconite (0.5 to 1.5%) also showed significant improvement in growth and yield of wheat. The application of 1.5% glauconite recorded the 31.43 g pot^{-1} straw yield and 27.54 g pot^{-1} grain yield.

2.1.5 Phosphate sorption characteristics of a Vertisol in Central India under different nutrient management systems

To study the influence of different nutrient management systems on sorption of phospshorus pools, the soil samples were collected from five different nutrient management systems *viz.*, control (T1), STCR (T2), INM (T3), organic farming (T4) and conservation agriculture with 90% residue retention (T5). It was observed that the treatment T4 had lowest calcium bound P (Fig. 2.1.5a). This indicated that addition of organic products in soil depletes the calcium bound P fraction in soil. The graphical representation of equilibrium P concentration versus rate of P adsorbed on unit mass of soil colloid (Fig. 2.1.5b) were used to calculate the maximum P sorption capacity of the soils and the affinity of the soil to hold P. The phosphorus sorption maxima was determined by fitting the solution P concentration and adsorbed P release to Langmuir and Freundlich equations. The P sorption maxima for different treatments are given in the Table 2.1.5. The P sorption maxima were relatively higher in T1 and T2 and lowest in T4 treatment.

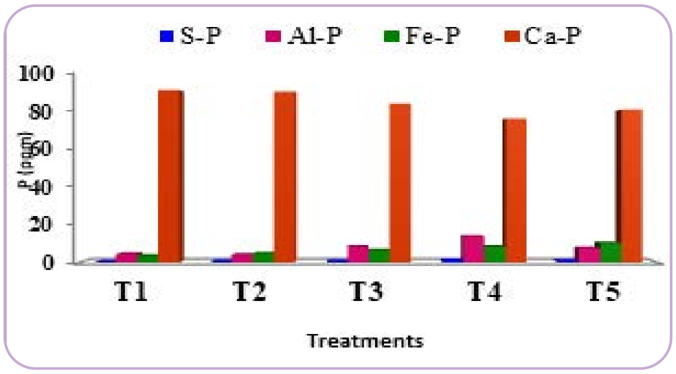


Fig. 2.1.5a. Distribution of phosphorus fractions

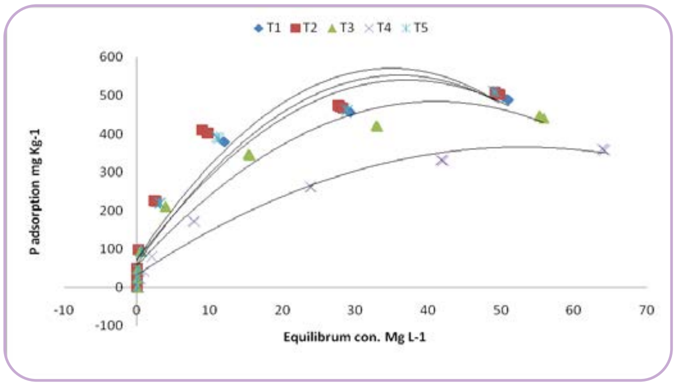


Fig. 2.1.5b. Phosphorus sorption isotherm curves

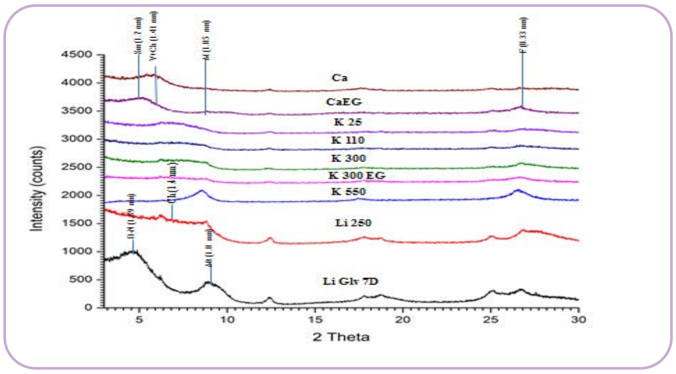
Maximum phosphorus buffering capacity (MPBC) of the soils was in T4 followed by T5 treatment (Table 2.1.5). The lower buffering capacity factor in these treatments indicated the increased presence of P in the solution phase. The highest MPBC was in T2 followed by treatment T1 (Table 2.1.5). The soil with high MPBC had higher adsorption capacity and maintained low P supply in soil solution. The results of this study give knowledge of the ability of the soils to sorb added phosphate that helps in the development of an efficient fertilizer management under different nutrient management system.

Table 2.1.5 Isotherm constants derived from Langmuir and Freundlich adsorption equations in 0.01M$CaCl_2$ solution

Treat-ments	Langmuir constants			Freundlich constants			Supply parameter			Maximum buffering capacity (MBC) (L kg^{-1})	Standard P Require ment (SPR) (mg kg^{-1})
	b (μg g^{-1})	k (ml μg^{-1})	R^2	K (μg g^{-1})	1/n (g ml^{-1})	R^2	R^2	K1	K2		
T1	526	0.35	0.99	124	0.40	0.97	0.95	625	1.63	184.1	34.4
T2	526	0.56	0.99	127	0.41	0.96	0.96	556	1.78	294.6	53.0
T3	455	0.32	0.99	113	0.38	0.98	0.96	370	1.33	145.6	27.4
T4	400	0.1	0.99	87	0.35	0.99	0.99	52	0.15	40.0	7.8
T5	556	0.25	0.99	107	0.45	0.97	0.95	250	0.73	139.0	26.5

2.1.6 Mineralogy of Vertisols in relation to K availability in Central and Western India

X-ray diffractograms of the fine clay fraction of various soil series showed the dominance of smectite with very small amount of vermiculite, chlorite, mica and feldspars (Fig. 2.1.6).The Greene-Kelly test (1953) (Hofmann-Klemen effect) distinguishes between montmorillonite and beidellite by glycerol solvation of the Li-saturated samples. The Li-saturated samples were heated at 250°C for 16 h gave a peak around 0.95 nm for montmorillonite and 1.4 nm peak for beidellite/nontronite, which expanded to 1.8 nm on glycerol solvation. All the fine clay samples gave distinct peaks at ~ 0.95 to 1.1 nm and 1.8 nm. This indicated that the fine clays of these soils were a mixture of beidellite-nontronite and montmorillonite in which the amount of the former was higher (Fig. 2.1.6). Study suggested that beidellite-nontronite dominated as the smectite species in shrink-swell soils of Central and Western India which have implications for K management.



Ca=Ca saturated; Ca-EG=Ca saturated plus ethylene glycol vapour; Li=Li-saturated and heated to 250°C (16h), LiGLV=Li-saturated and heated to 250°C plus glycerol vapour; K-saturated and heated to 25, 110, 300, 550°C. K300EG= K-saturated plus ethylene glycol vapour and heated to 300°C; Sm=Smectite, B/N=beidellite/nontronite; V+Ch = vermiculite plus chlorite; M = mica; Mt = montmorillonite; K = Kaolinite F = Feldspars.

Fig. 2.1.6 X-ray diffractograms of fine clay fraction (<0.2μm) of Sarol series, Indore, MP

2.1.7 Impact of Conservation agricultural practices on soil health, and Carbon Sequestration in different production systems

The impact of 6 years of different levels of residue retention on dynamics of carbon and nitrogen in soil samples soybean-wheat cropping system in Vertisols of central India was invetigated. Residue retention of 30, 60 and 90% resulted 8.75, 22.5 and 38.75% improvement in oxidizable carbon concentration compared to no residue-retained treatment respectively. Retention of residue significantly ($P \leq 0.01$) influenced soil total carbon stock in 0-10 cm of soil depth; but not in 10-20 cm of soil depth. Residue retention practice influenced the SOC and nitrogen stocks only at the surface layer (0-10 cm) (Table 2.1.7). Soil carbon stock under the different treatments ranged between 17.69 to 22.44 Mg ha^{-1} in 0-10 cm of soil depth. In 0-10 cm of soil depth, retention of 30, 60 and 90% residue of previous crops resulted in 3.7, 16.7 and 26.9% improvement in soil carbon stock than no residue-retained plot. The trend was similar for soil nitrogen stock also. There was 24.4% improvement in soil nitrogen stock due to 90% retention of crop residue. It was observed that 60% or more retention of residue only resulted in significant increase in soil N stock, there is no significant impact of residue retention on soil CN ratio. A liner relationship between cumulative carbon input and change in soil carbon stock was observed (Fig. 2.1.7). The intercept of the equation (0.915Mg C ha^{-1}) represent the annual C loss of SOM. Equating this intercept with K x Cs of the Jenkinson, (1988) equation and setting the initial SOC at 17.69 Mg ha^{-1} C in surface 10 cm soil layer, the decay rate of native SOC was 0.0517 y^{-1} that indicated C loss from native SOC during 6 years was 5.1% of the initial SOC content. The $t_{1/2}$ was 19.34 years, indicating that in the event of no addition of carbon to these soils C levels will decline sharply as there is more labile fraction or active pool of carbon in these soils. Retention in 90% of residue of previous crops resulted in an increased POM-C by 54.5% and POM-N by 47% in the 0-10cm layer compared to the no residue treatment. Similarly, 30 and 60% of residue retention resulted in 72 and 18% improvement in N mineralization potential of soil in comparison to control. Results indicated that residue retention practices offer a promising option for enhancing soil quality, particularly for clay soils of central India.

Table 2.1.7 Effect of different of residue retention on soil bulk density, carbon & nitrogen stocks & soil CN ratio

Treatments	Bulk density	Carbon stock	Nitrogen stock	CN ratio
0-10 cm soil depth	Mg m^{-3}	Mg ha^{-1}	Mg ha^{-1}	
NT-0% R	1.40 (0.01)	17.69 (0.78)	1.64 (0.06)	10.77 (0.12)
NT-30% R	1.41 (0.01)	18.34 (0.28)	1.59 (0.05)	11.53 (0.30)
NT-60% R	1.41(0.01)	20.64 (1.08)	1.81 (0.08)	11.42 (0.33)
NT-90% R	1.41(0.02)	22.44 (0.80)	2.04 (0.11)	11.15 (0.63)
CD (P=0.05)	NS	2.43	0.25	NS
CD (P=0.01)	NS	3.36	0.35	NS
10-20 cm soil depth				
NT-0% R	1.39 (0.04)	13.48 (0.74)	0.95 (0.1)	10.66 (0.20)
NT-30% R	1.43 (0.01)	13.18 (0.25)	0.91 (0.0)	10.19 (0.33)
NT-60% R	1.45 (0.01)	14.25 (0.65)	0.91 (0.1)	10.87 (0.33)
NT-90% R	1.45 (0.03)	13.72 (0.54)	0.91 (0.0)	10.45 (0.30)
CD (P=0.05)	NS	NS	NS	NS
CD (P=0.01)	NS	NS	NS	NS

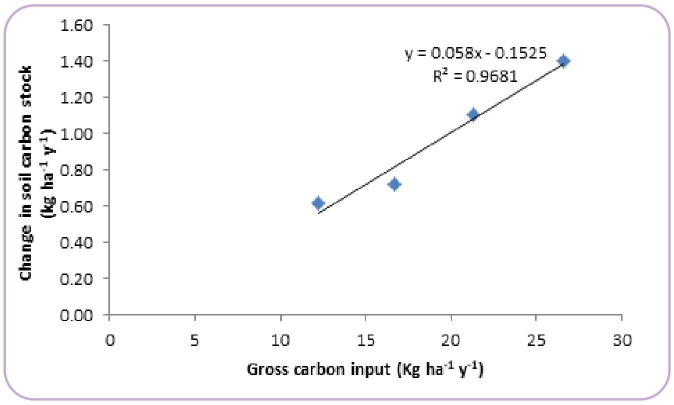


Fig. 2.1.7 Relationship between gross carbon input of change in soil carbon stock (0-10 cm depth)

2.1.8 Effect of biochar, fertilizer and manure on productivity of rice

A field experiment conducted at the research farm of ICAR-IISS to study effect of biochar on rice productivity (Plate 2.1.8a). Biochar representing Wood Biochar (WB), wood coconut husk biochar (WCB) and crop residue biochar (CRB) were applied at 0, 4 and 8 t ha^{-1}. Fertilizers applied at none (0) and RDF and manure at 0, 5 t ha^{-1}. The mean grain yield of rice under WB, manure and fertilizer application varied between 1263 and 3539 kg ha^{-1}. Fertilizer application resulted in significant improvement in grain yield. WB application at the three levels were at par with each other. Manure application at 5 t ha^{-1} showed some improvement in the rice grain yield but statistically higher grain yield was recorded with application of 8 t ha^{-1} wood biochar along with RDF. The mean rice grain yield 2274, 2299 and 2347 kg ha^{-1} were recorded with the application of 0, 4 and 8 t ha^{-1} wood biochar. Application of recommended dose of fertilizer could increase the mean rice grain yield from 1456 to 3092 kg ha^{-1} at 0 t ha^{-1} wood biochar application; 1424 to 3173 kg ha^{-1} at 4 t ha^{-1} wood biochar application while it increased from 1421 to 3273 kg ha^{-1} at 8 t ha^{-1} wood biochar application. The mean grain yield of rice under wood coconut husk biochar (WCB), manure and fertilizer application varied between 1197 and 2931 kg ha^{-1}. The mean rice grain yield of rice under crop residue biochar (CRB), manure and fertilizer application varied between 1419 and 2943 kg ha^{-1}.

Rice grain yield under WB

Rice grain yield under CRB

Plate 2.1.8a Effect of biochar on rice productivity

A green house study was conducted to assess the effect of WCB (wood coconut husk biochar) and CRB (crop residue biochar) application on okra crop in Inceptisols (Belpada) and Alfisols (Nuapada) of Odisha. The results showed that the pod yield of okra varied between 93 and 185 g pot^{-1} in soils of Belpada. A significant improvement in pod yield was observed with fertilizer and FYM application. Application of 4 or 8 g kg^{-1} soil WCB with and without FYM was found statistically at par with each other. CRB application at 4 g kg^{-1} along with FYM 5 g kg^{-1} significantly improved the okra pod yield over fertilizer application alone. Further, application of 8 g kg^{-1} soil with FYM significantly increased the pod yield of okra. Compared to WCB, the application of CRB has shown significantly higher pod yield of okra. In soils of Nuapada, the pod yield of okra was just 14 g pot^{-1} in absolute control which increased significantly with fertilizer application. Application of manure further enhanced the pod yield significantly. Application of WCB at 4 and 8 g kg^{-1} soil did not increase the pod yield of okra significantly. Application of CRB has shown significant improvement in pod yield of okra (Plate 2.1.8b).

Belpada

Nuapada


Plate 2.1.8b Performance of okra grown with biochar at green house

2.1.9 Estimation of soil properties using mid infrared spectra through machine learning approaches.

The mid-infrared diffuse reflectance spectra, in the waveband ranged from 4000 to 500 cm^{-1}, of about 450 soil samples were measured in the laboratory using a DRIFT module Bruker Alpha Fourier-transform MIR spectrometer. The corresponding Savitzky – Golay first-derivative pre-processed soil spectral data were used to develop calibration models. Calibration models were developed with 70% of the samples and the remaining 30% of the samples were used for validation or testing of the predictive models. Three widely used multivariate regression techniques namely, partial least-squares (PLS), random forest and support-vector machines (SVM) were compared to obtain the most suited predictive models for individual soil properties. The co-efficient of determination (R^2), root mean square error (RMSE) and residual prediction deviation (RPD) were compared to assess the accuracy and robustness of predictive models. Predictive models developed with PSLR techniques performed better than the other two regression techniques for all the soil properties except for available potassium and EC, where SVM regression model performed slightly better. Not all properties studied could be predicted with an acceptable level of accuracy using the spectroscopic technique. Good predictions for the independent validation of data set were obtained for clay (R^2: 0.84, RMSE: 2.89), silt (R^2: 0.75, RMSE: 3.28), sand percentage (R^2: 0.71, RMSE: 4.14), soil water retention at PWP (R^2: 0.74, RMSE: 1.52) and FC (R^2: 0.70, RMSE: 2.37), SOC content (R^2: 0.72, RMSE: 0.11) and pH (R^2: 0.73, RMSE: 0.46) in models developed through PLSR technique (Table 2.1.9).

Table 2.1.9 Goodness of support vector machine (SVM), random forest (RF) and partial least square (PLS) regression model fit (R2, RMSE and RPD) for the prediction of selected soil physical properties for calibration and validation

Soil physical properties		SVM			RF			PLS		
		R^2	RMSE	RPD	R^2	RMSE	RPD	R^2	RMSE	RPD
Sand	Calibration	0.98	1.18	6.54	0.96	2.20	3.52	0.80	3.47	2.23
(%)	Validation	0.69	4.29	1.78	0.52	5.46	1.40	0.71	4.14	1.84
Silt	Calibration	0.96	1.38	4.99	0.96	2.05	3.36	0.76	3.37	2.04
(%)	Validation	0.72	3.59	1.82	0.65	4.12	1.59	0.75	3.28	1.99
Clay	Calibration	0.99	0.70	10.49	0.97	1.39	5.30	0.94	2.46	2.99
(%)	Validation	0.68	4.42	1.61	0.81	3.14	2.27	0.84	2.89	2.47
SWR_FC (%, w/w)	Calibration	0.99	0.42	10.53	0.95	1.30	3.44	0.76	2.17	2.05
	Validation	0.66	2.71	1.66	0.51	3.23	1.39	0.70	2.37	1.82
SWR_PWP (%, w/w)	Calibration	0.99	0.31	10.33	0.96	0.81	3.89	0.75	1.57	2.01
	Validation	0.68	1.67	1.75	0.68	1.67	1.75	0.74	1.52	1.92

SWR_FC: Soil water retention at field capacity; SWR_PWP: Soil water retention at permanent wilting point; R^2: coefficient of determination; RMSE: Root mean square error; and RPD: Residual prediction deviation.

2.1.10 Evaluation of organic, inorganic and integrated crop management practices in different cropping systems

Field experiments were conducted during kharif and rabi season 2021 at research farm of ICAR-IISS to evaluate different fertilizer regimes on major crops.

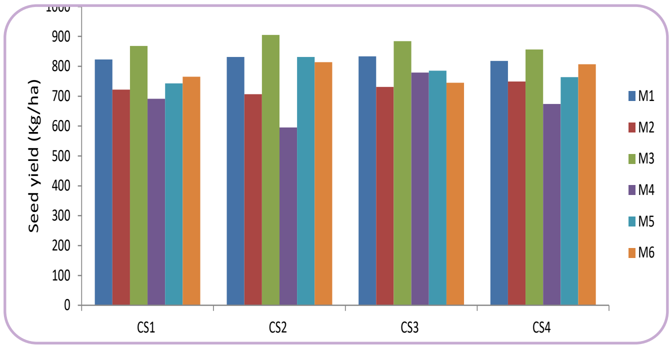


Fig. 2.1.10 Yield of soybean (kg ha^{-1}) under different nutrient management practices (kharif 2021)

The grain yield of soybean was higher in 50 % organic + 50% inorganic treatment followed by 100 % organic, 100% inorganic and 50 % organic + natural farming treatment. The lowest yield was in 25 % organic + 25 % inorganic + natural farming treatment. During the rabi season, seed yield of wheat, mustard, chickpea and linseed significantly differed with nutrient management practices. The highest seed yield of wheat, mustard, chickpea and linseed were recorded in 100% organic treatment followed by 50% organic+50% inorganic treatment, 100% inorganic, state recommendation and natural farming treatments (Fig. 2.1.10).

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

Management practice: (M1) 100% Organic (Organic manure equivalent to 100 % N requirement of the system), (M2) 50 % organic (Organic manure equivalent to 75 % N requirement of the system) +Natural farming, (M3) 50 % Organic + 50 % inorganic, (M4) 25 % Organic + 25 % Inorganic + Natural Farming, (M5) 100% inorganic package, (M6) State recommendations

2.1.11 Evaluation of groundnut and mustard crops under organic farming

Twelve varieties of groundnut and mustard were evaluated under different organic nutrient management practices at ICAR-IISS Bhopal to screen promising varieties for organic management practices for central India. GPBD-5 (1989 kg ha^{-1}) variety of groundnut outperformed among all the tested varieties followed by GJG-17 (1962 kg ha^{-1}) and DH-86 (1847 kg ha^{-1}).

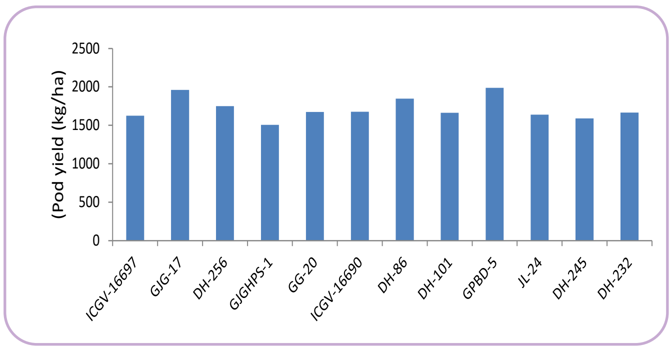


Fig. 2.1.11a Performance evaluation of different varieties of groundnut crops under organic practices

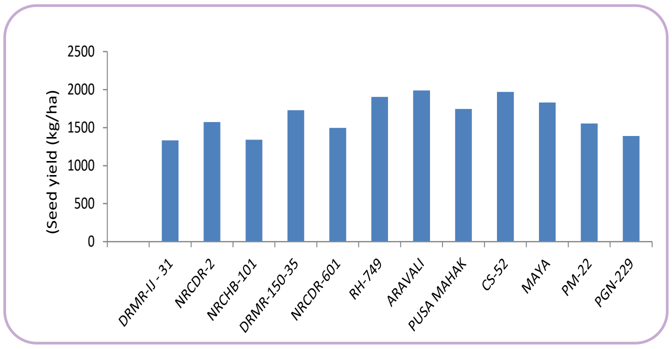


Fig. 2.1.11b Performance evaluation of different varieties of mustard crops under organic practices

Among the different varieties of mustard Aravali (1988 kg ha^{-1}) was recorded highest yield followed by CS-52 (1970 kg ha^{-1}) and RH-749 (1905 kg ha^{-1}) (Fig. 2.1.11a and b).

2.1.12 Assessment of Soil Biological properties under different nutrient management systems

Enzyme activity in terms of Fluorescein diacetate (FDA), dehydrogenase and alkaline phosphatase were determined in soil as influenced by different nutrient management practices. FDA activity was highest under 100% organic plot as compared to 100% inorganic indicating beneficial effect of addition of organic on soil microorganisms (Fig. 2.1.12a). Among the cropping systems, soybean-wheat recorded higher FDA followed by soybean-chickpea, soybean-linseed and soybean-mustard. Dehydrogenase (Fig. 2.1.12b) and alkaline phosphatase activities (Fig. 2.1.12c) were highest in organic management compared to inorganic and integrated management.Study highlighted that soil enzymaic activities were dependable parameter of soil organic carbon.

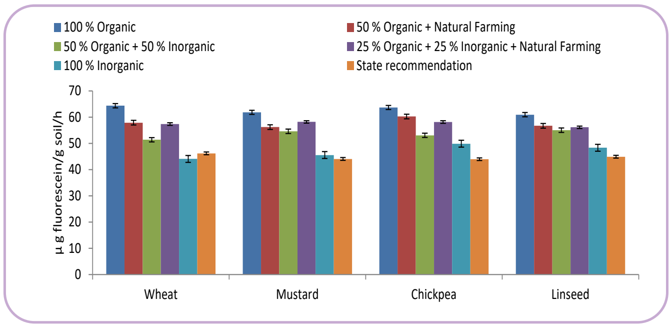


Fig. 2.1.12a Activity as affected by different nutrient sources in different crops (Kharif-2021)

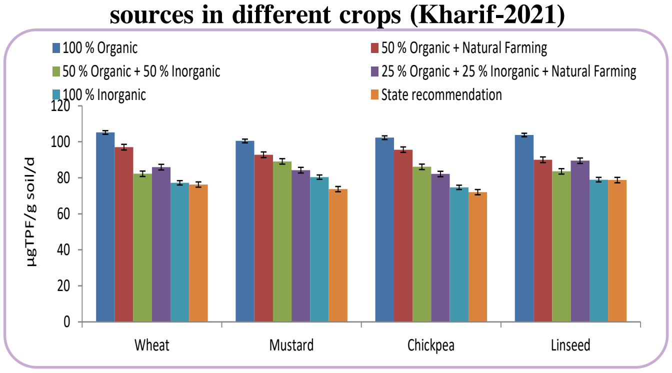


Fig. 2.1.12b Soil dehydrogenase activity as affected by different nutrient sources under different crops (Kharif-2021)

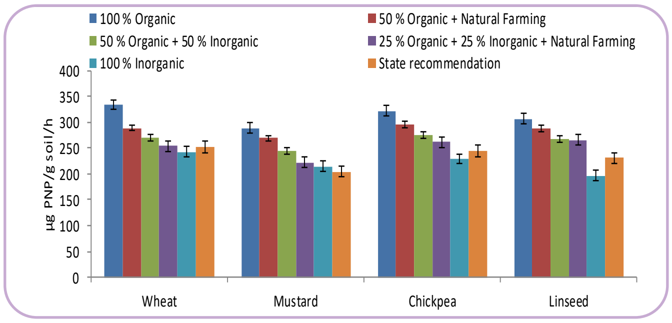


Fig. 2.1.12c Alkaline phosphatase activity as affected by different nutrient sources under different crops (Kharif-2021)

2.1.13 Evaluation of Natural Farming Practices in different agro-ecology

Field experiments were conducted during kharif and rabi season 2021 at research farm of ICAR-IISS. The highest seed yield was recorded in integrated crop management practice with pesticide treatment (ICMP) in soybean, which was at par with integrated crop management with natural farming (ICMNF) and AI-NPOF package treatments as compared to control. Maize was grown as an intercrop during kharif season. However, among the natural farming treatments with addition/omission of the components, the crop growth and yield parameters of soybean crop were quite improved under complete natural farming (comprising all the components of NF) treatment followed by NF-4, NF-2 and NF-1 treatment. Similarly, during rabi season, highest wheat yield was in ICMP, which was at par with ICMNF and AI-NPOF package. Among the natural farming treatments, highest grain yield was recorded in complete natural farming treatment.

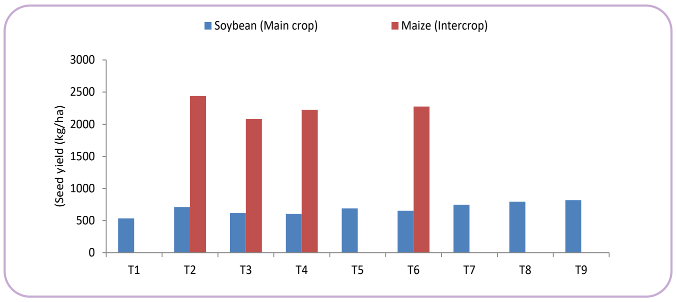
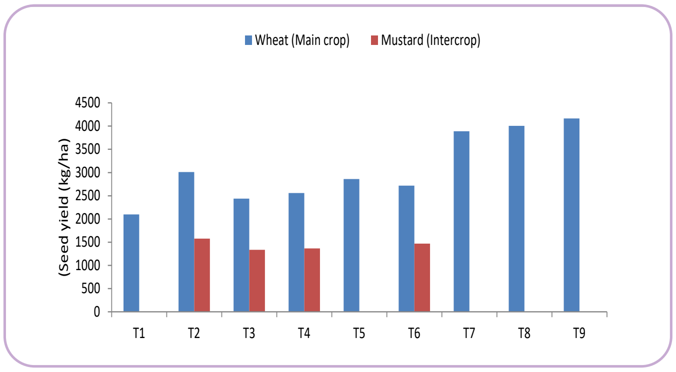


Fig. 2.1.13a Yield of soybean (Main crop) and maize (Intercrop) under different nutrient management practices



Treatments: (T1) Control, (T2) Complete NF, (T3) NF-1 (without Beejamrit +Ghanjeevamrit+Jeevamrit), (T4) NF-2 (without-Crop residue mulching), (T5) NF-3 (without intercropping), (T6) NF-4 (without Whapasa), (T7) AI-NPOF package, (T8) Integrated crop management with natural farming, (T9) Integrated crop management with pesticides

Fig. 2.1.13b Yield of wheat (Main crop) and mustard (Intercrop) under different nutrient management practices

Mustard was grown as an intercrop in natural farming experiment. The highest seed yield was under complete natural farming treatment followed by NF (without Whapasa), NF (without-Crop residue mulching) and NF (without Beejamrit +Ghanjeevamrit+Jeevamrit) treatment (Fig. 2.1.13a and b).

2.1.14 Status of potassium fractions under Long Term Fertilizer Experiments (Alfisol and Vertisol) of India

In a study K fractions in soils of LTFE Palampur (Alfisol) and Parbhani (Vertisol) were estimated and results indicated that without application of K for long time reduced non-exch-K storage and increased exch-K in 100% N treatment. Highest water-soluble K (WSK) was found in integrated nutrient management (100% NPK+FYM) treatment. Microbial biomass K (MBK) had no correlation with other K fractions. Likewise, no application of K fertilizer for long time has reduced non-exch-K storage and increased exch-K in 100% N treatment in LTFE Parbhani (Vertisol). Highest WSK and MBK were found in 100% NPK+FYM treatment. MBK has also been found to be well correlated with WSK only.

LTFE Palampur (Alfisol)

Treatment	Water soluble K (mg kg^{-1})	Exchangeable K (mg kg^{-1})	Non exchangeable K (mg kg^{-1})	Microbial biomass K (mg kg^{-1})
Control	4.28 a	46.97 a	217.20 NS	15.48 NS
100% N	6.20 b	74.05 d	213.20 NS	16.67 NS
100% NP	6.93 b	63.08 c	225.20 NS	12.50 NS
100% NPK	8.95 c	54.55 b	235.20 NS	9.52 NS
100% NPK+FYM	9.90 c	51.10 b	245.20 NS	9.52 NS

LTFE Parbhani (Vertisol)

Treatment	Water soluble K (mg kg^{-1})	Exchangeable K (mg kg^{-1})	Non exchangeable K (mg kg^{-1})	Microbial biomass K (mg kg^{-1})
Control	8.17 ab	252.00 NS	265.73 NS	39.68 a
Fallow	8.33 ab	290.83 NS	279.07 NS	77.78 ab
100% N	7.00 a	301.83 NS	215.07 NS	42.06 a
100% NP	7.67 ab	239.67 NS	244.4 NS	118.25 bc
100% NPK	9.83 bc	254.67 NS	277.73 NS	134.92 bc
100% NPK+FYM	11.50 c	249.67 NS	295.07 NS	165.08 c

2.1.15 Enzymatic stoichiometry: Indicator of nutrient limitation in different LTFE soils

Hydrolytic enzymes for obtaining C, N, phosphate and their stoichiometric ratios have been used to reveal the nutrient status for microorganisms. A higher vector length and vector angle (calculated by plotting C:N versus C:P ratios) indicate higher C demand relative to soil nutrients (N and P) and higher P demand compared with N, respectively. Enumeration of enzyme stoichiometry has reflected significantly higher C limitation on soil microbial community under imbalanced fertilizer application based on vector length calculation and higher P limitation as compared to N under imbalanced fertilizer application based on vector angle calculation (Fig. 2.1.15).

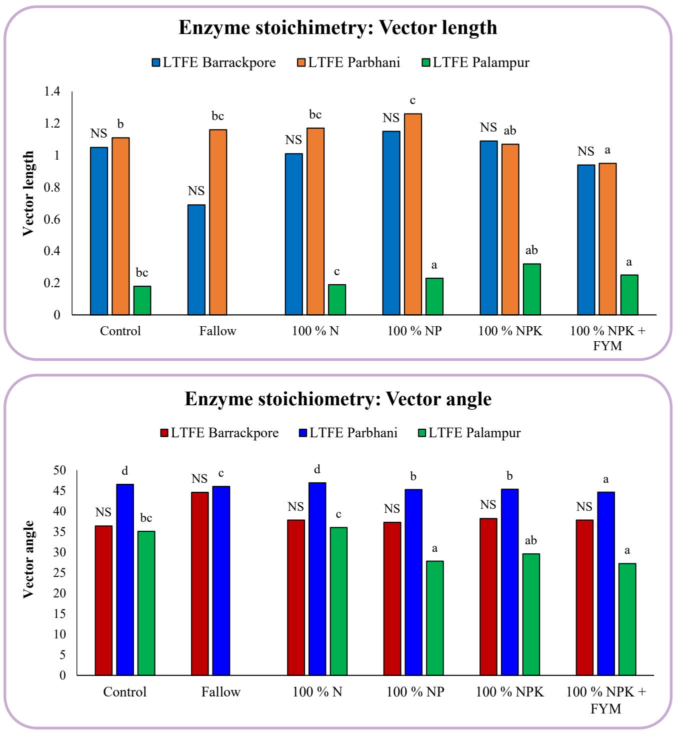


Fig. 2.1.15 Enzyme stoichiometry a) Vector length; b) Vector angle in LTFE soils

2.1.16 Microbial autotrophic carbon fixation potential in three Long Term Fertilizer Experiments

Microbial autotrophy in soil has been reported to contribute about 4% of the total CO_2 fixed by terrestrial ecosystems each year. RuBisCO enzyme activity has been used as indicator for defining the status of microbial autotrophic contribution in soil C fixation. Increasing trend of RuBisCO enzyme activity and autotrophic C-fixation potential was noticed from control, imbalanced fertilizer application to balanced fertilizer application and integrated nutrient management treatment (100% NPK +FYM) in LTFE Palmpur and LTFE Barrackpore, but not in LTFE Parbhani (Fig. 2.1.16). It has been found that microbial autotrophic carbon fixation potential could be up to 40-45 μg CO_2-C g^{-1} soil day^{-1} in 100% NPK +FYM treatment in both LTFE Barrackpore (Inceptisol) and LTFE Palampur (Alfisol). This study highlights the need to consider potential contribution of microbial autotrophic carbon fixation in soil carbon cycle estimation and further appraisal of soil C sequestration potential.

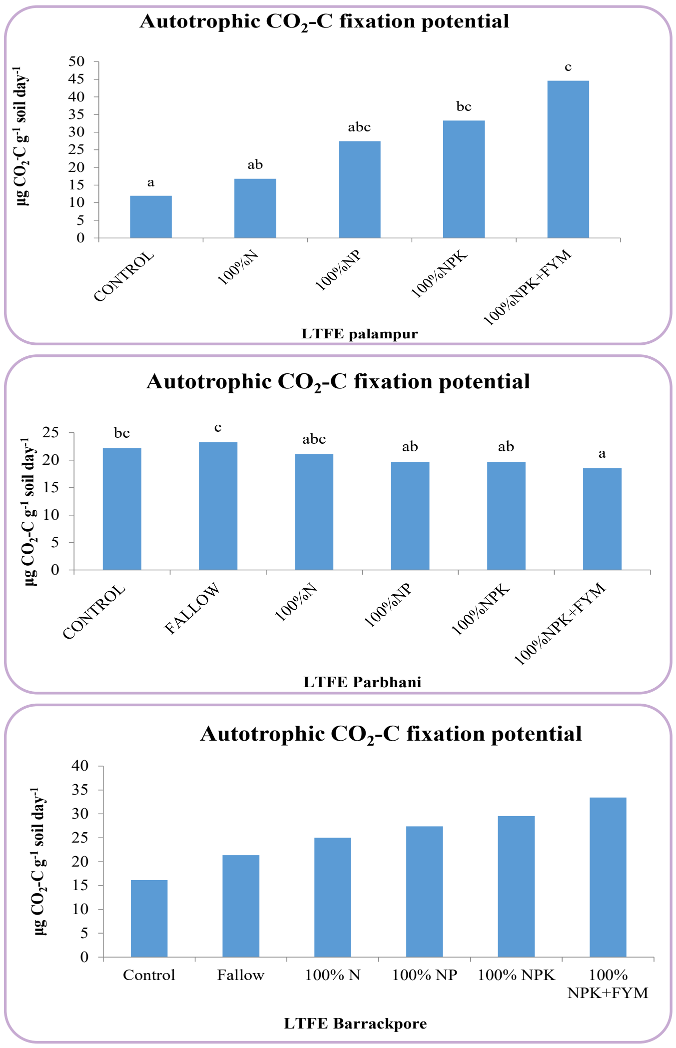


Fig. 2.1.16 Microbial autotrophic carbon fixation potential in a) LTFE Palampur, b) LTFE Parbhani and c) LTFE Barrackpore

2.1.17 Biological P supply power of soil through solubilisation/mineralization

Biological P supply power of the LTFE soil has been determined by incubating soil with Pikovskaya media where the P source was used as tricalcium phosphate (TCP)/aluminium phosphate (Al-P)/ferric phosphate (Fe-P) and Inositol hexa phosphate. Results revealed that 100% NPK+FYM had the highest P supply power from inositol hexa phosphate in LTFE Barrackpore, LTFE Parbhani and LTFE Palampur. The P supply power from TCP, Al-p and Fe-P followed the trend: TCP > Al-P > Fe-P in all the treatments in LTFE Barrackpore, LTFE Parbhani and LTFE Palampur (Fig. 2.1.17). In LTFE Barrackpore and LTFE Palampur, it is evident that the imbalanced fertilizer application for long term (100% N and 100% NP) had declined the biological P supply power of soil, even from control, however, the P supply power was recovered up to level of control in 100% NPK+FYM treatment. Nevertheless, no consistent pattern was noticed in P supply power in LTFE Parbhani soil. Here, P supply power from Fe-P was found to be improved as compared to control, but no significant improvement was noticed in P supply power from TCP and Al-P.

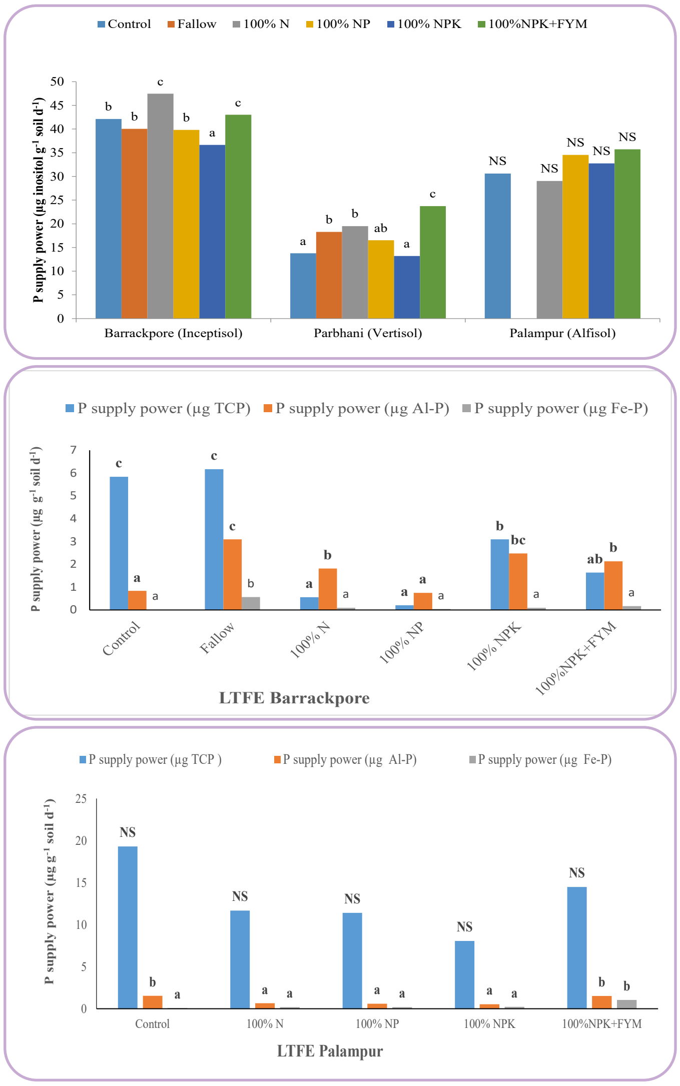


Fig. 2.1.17 Biological P supply power of soil

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

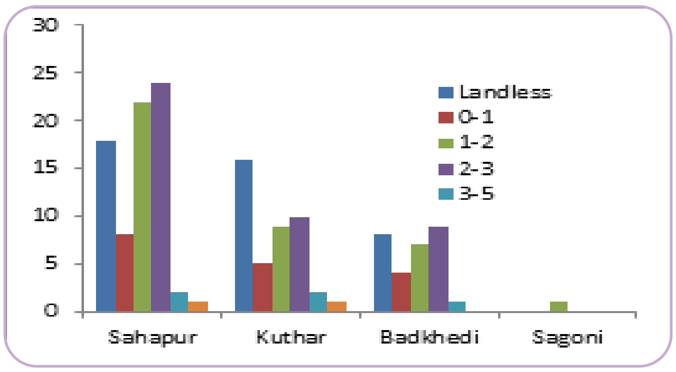
Effect of corrective measures on crop productivity was evaluated. Pruning resulted in heavy fruiting during rainy as well as winter season. Light pruning was followed in kagzi lime by removing old, diseased and unproductive shoots which resulted in bumper lowering and fruiting (Fig.2.1.18a). Fruit weight of lime ranged from 32-40g and 7-10 kg of fruit harvested during July-August from a single plant. Similarly, 8-10 kg of fruits was harvested during winter from a tree. Light pruning in mango also resulted in good flowering and fruiting (Fig. 2.1.18a) and revenue of Rs.13525 generated by selling mango fruit during lock down in 2021. Light pruning where criss-cross and dry twigs in aonla were removed resulted in good fruiting without any input by using natural resources and about 70-100 kg/tree fruits have been harvested from a single tree. Intercropping of gram, wheat, and mustard has been done in the mango, guava, and lime plantations (Fig. 2.1.18b).

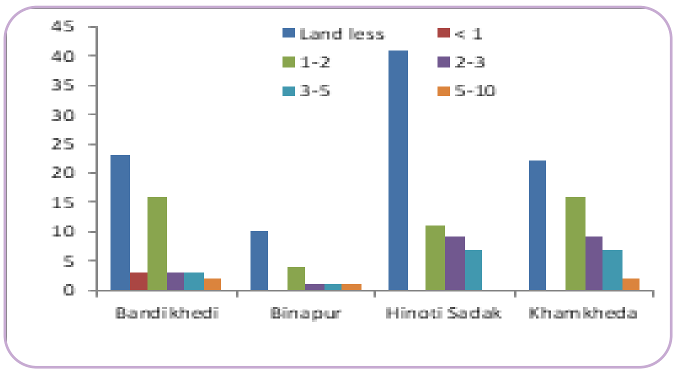
Plate 2.1.18a Fruiting in lime, mango and aonla after pruning

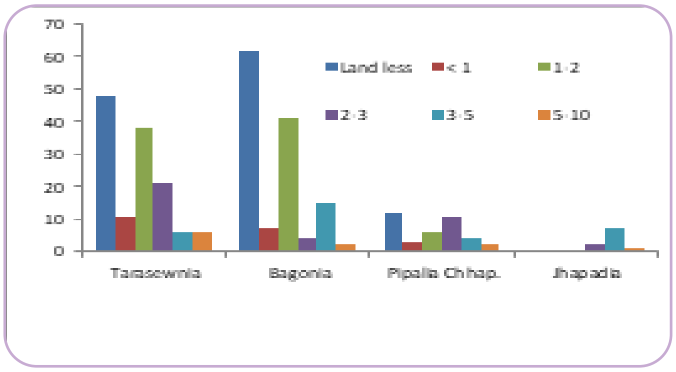
Plate 2.1.18b Intercropping in newly planted mango and guava plantation

2.1.19 Enhancing livelihood security of subsistence farming community through improvement in soil health, crop productivity and capacity building in Madhya Pradesh under SCSP

A study was initiated under SCSP sub plan to enhance the livelihood security of subsistence farming community. Sixteen villages were selected under four clusters.







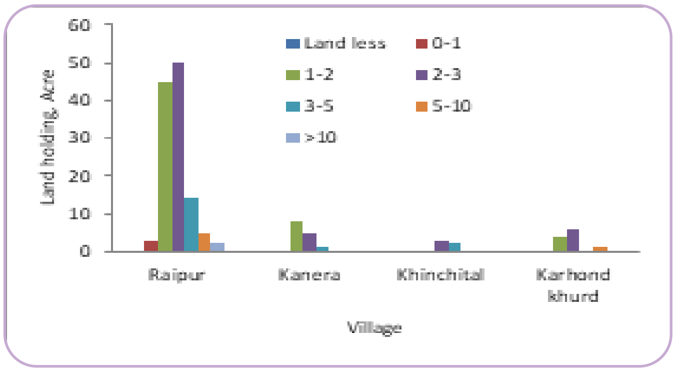


Fig. 2.1.19 Distribution of landholding among farmers in different SCSP villages

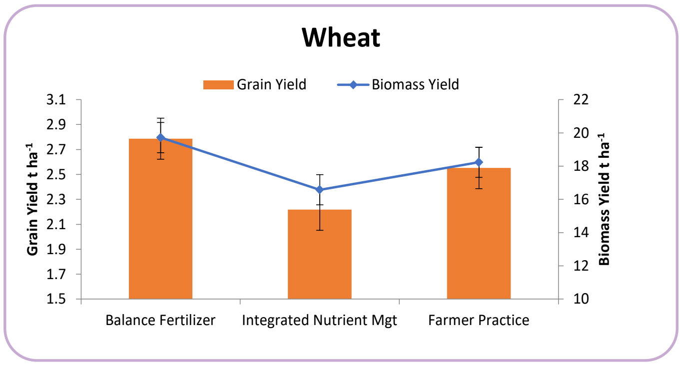
In all about 33 percent landless farmers were recorded in the study area under scheduled caste community (Fig.2.1.19). Most farmers are in marginal category having 2-3 acre land. Balanced and integrated nutrient management treatments were worked out and were applied in 0.5 acre land along with farmers practice.

Maize, soybean, wheat and gram were grown using three nutrient management practices. Seed yield of different crops have been found to be affected by different nutrient management practices. The grain yield of maize was significantly improved under balanced and INM practice in cluster I, II and III. Soybean seed yield ranged between 7.7 and 17.55 q ha^{-1}. Wheat grain yield during 2020-21 varied between 43.45 and 50.34 q ha^{-1} under different nutrient management practices. Cluster III recorded lowest wheat grain yield while other cluster recorded more than 40 q ha^{-1} grain yield. The performance of gram among the three nutrient management practices was the highest in cluster III where it increased from 17.8 to 25.4 q ha^{-1} with integrated nutrient management.

2.1.20 Assessment of different fertilizer management techniques on wheat and chickpea productivity in the farmer's field

In this study, four villages were selected *viz*. Raipur, Kanera, Karnod khurd and Khuichital. Among this four villages 12 progressives (3 from each) farmers were selected for wheat and chick pea crops and imposed 3 treatments viz. balanced fertilizer, integrated nutrient management (INM) farmer practice. The effect of these treatments was studied and results showed that the balanced use of fertilizer gave highest biomass and grain yield of wheat followed by the farmers' practices, which are at par with the balanced use of fertilizers

(Fig. 2.1.20a). Whereas, the lowest biomass and grain yield was found in INM as the major portion of nutrients was applied through the FYM, which take time to supply nutrients to the crop. The highest biomass and grain yield of chick pea was observed in balance use of fertilizers followed by INM (Fig.2.1.20b).



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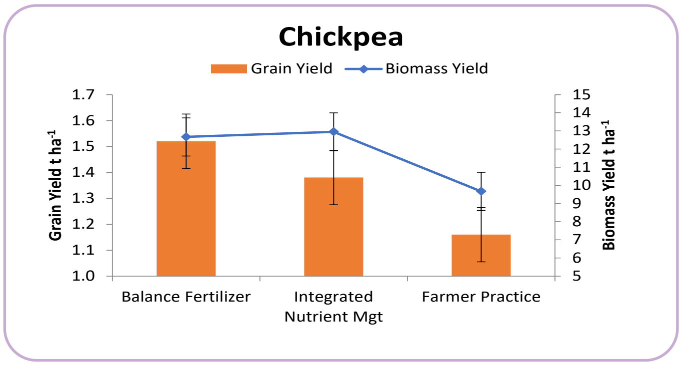


b

Fig.2.1.20 Effect of fertilizer management on yield of wheat (a) and chickpea (b) in the farmer field under SCSP Program

2.1.21 Agro-ecosystem analysis in the tribal inhabited areas of Balaghat district in Madhya Pradesh

Analyses were carried out to assess the quality of soil and water resources of the tribal agro-ecosystem locate inside the south Balaghat forest range of Balaghat district in Madhya Pradesh. Soils collected from eighty locations of twenty-two tribal farmlands identified as rich in organic carbon with moderate availability of nitrogen, phosphorus, potassium, zinc, iron, manganese and copper but, deficient in sulphur and boron. Soil Health Cards were prepared based on the soil test results with nutrient recommendation for their organic-by default rice-fallow systems. Biological analysis of water samples collected from different resources like open well, bore well, ponds and streams near the tribal farmlands showed presence of fecal coliform bacteria in surface water resources. Hence, water from these resources cannot be used for drinking, as there may be possibilities of contamination with other disease causing pathogens (Plate 2.1.21).

Plate 2.1.21 Water sample collection (Kulpa village) and distribution of SHC (Sarra villages) in the Balaghat district

2.1.22 Livelihood survey and ITK survey in the tribal villages of Betul

Two surveys were carried out in tribal dominated villages viz., Charban, Ghisi Bagla and Kanhegon of Betul district in Madhya Pradesh during July-September, 2021. The livelihood survey conveyed that agriculture is the sole livelihood source of tribal population and average size of their farm land is 1-2 hectares. Soils of these farmlands located in the hilly tracts are of shallow red/black type with low-medium fertility status. These low input agriculture systems are challenged with water scarcity, low productivity and low income. Average crop yield for major crops recorded as 28 q ha^{-1} for maize, 10 q ha^{-1} for soybean, 10 q ha^{-1} for groundnut, 23 q ha^{-1} for paddy, 33 q ha^{-1} for wheat and 13 q ha^{-1} for gram crops. Average gross income of farmers is ranged between Rs.40000 and Rs.60000 based on the marketed surplus. Further, major indigenous agricultural technologies of the locality documented in the ITK survey are land preparation using traditional wooden plough (Bakhar), sowing by bamboo pipe, construction of trenches (rain water harvesting) and soil moisture conservation (mulching), dusting wood ash (control of sucking pests), spraying of tobacco decoction (control shoot and fruit borer in brinjal) and use of *Cleistanthus collinus* leaf extract to control yellow stem borer in rice. Tribal farmers use traditional fish trap made up of bamboo splits to catch fish and use extracts of *Terminalia chebula* and *T.bellerica* to control some animal diseases (Plate 2.1.22).

Plate 2.1.22 Indigenous agricultural technologies practiced by tribal farmers of Betul district (M.P.)

2.1.23 Efficacy evaluation of ICAR-CIRCOT Nano-Sulphur as fertilizer formulation for mustard crop

An experiment was conducted at IISS Farm following randomized block design (factorial), where exhaustive crop like maize (*Zea mays* L.) was cultivated during the kharif season (June to October, 2021) and mustard crop (*Brassica nigra* L.) during the rabi season (November 2021 to March 2022). Seven treatments comprised of four levels of sulphur i.e., 0, 30, 45 and 60 kg S ha^{-1} from two different sources viz. elemental sulfur and nano sulfur to find out the appropriate dose of sulphur for higher production. Among the various treatments sulphur dose of 60 kg S ha^{-1} significantly influenced the plant height, number of branches plant^{-1}, leaf area index, number of siliqua plant^{-1}, length of siliqua, number of seeds plant^{-1} and dry matter plant^{-1}, which was at par with 45 kg S ha^{-1} and significantly superior over rest levels of sulphur. Whereas, effect of sulphur on harvest index and 1000 grain weight (g), were found non-significant. Seed yield, Stover yield and sulphur content in seed and stover was significantly increased with increasing dose of sulphur up to 60 kg ha^{-1} superior over control, and 30 kg S ha^{-1} and on par with 45 kg S ha^{-1} (Plate 2.1.23).

Plate 2.1.23 Mustard crop growth under different S doses (A) No Sulfur (B) 100% RDF(S) Elemental S (C) 75% RDF (S) CIRCOT-NANO S (D) 100% RDF(S) CIRCOT-

NANOS

2.1.24 Percent new carbon and old carbon under different nutrient management under long-term soybean-wheat cropping system (Ranchi, Alfisol, 47 years)

The natural abundance of ^{13}C stable isotope estimation proved that INM significantly improved the proportion new carbon at all depths compared to inorganic and control treatments. Approximately 18 to 40% of total soil organic carbon is new carbon under INM and 100% NPK.

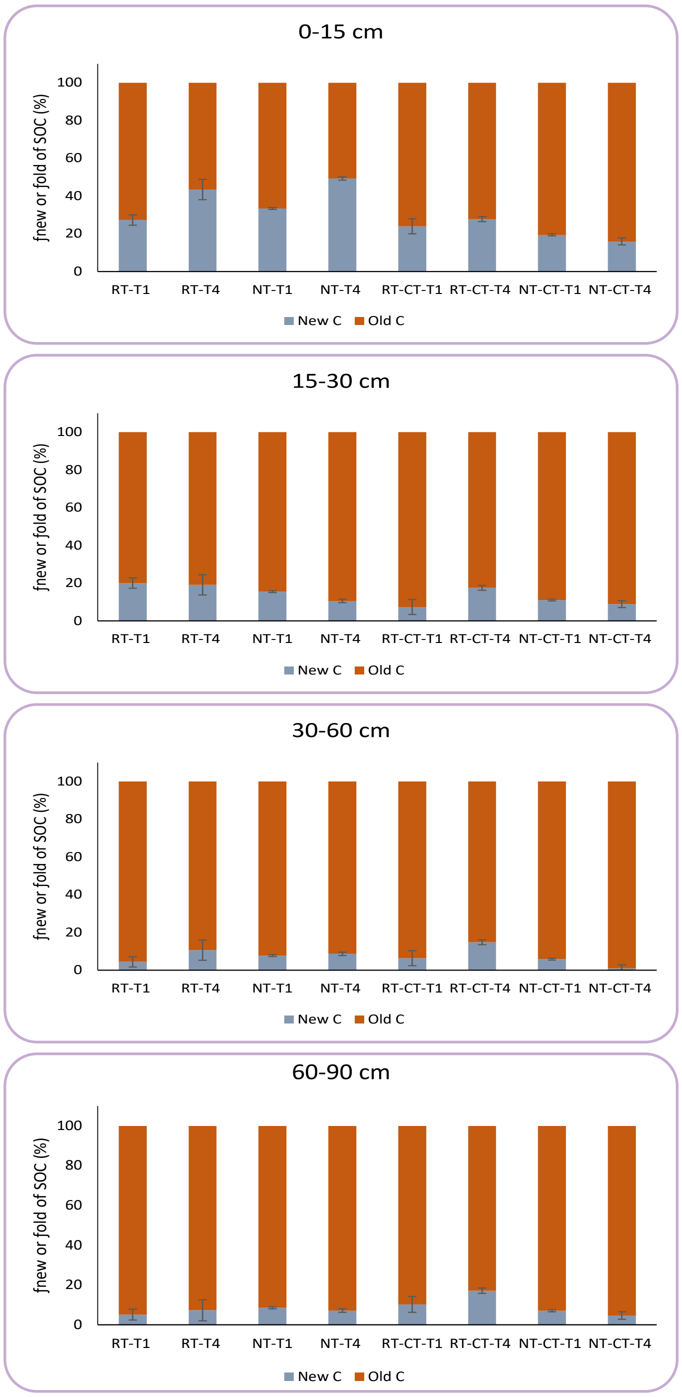
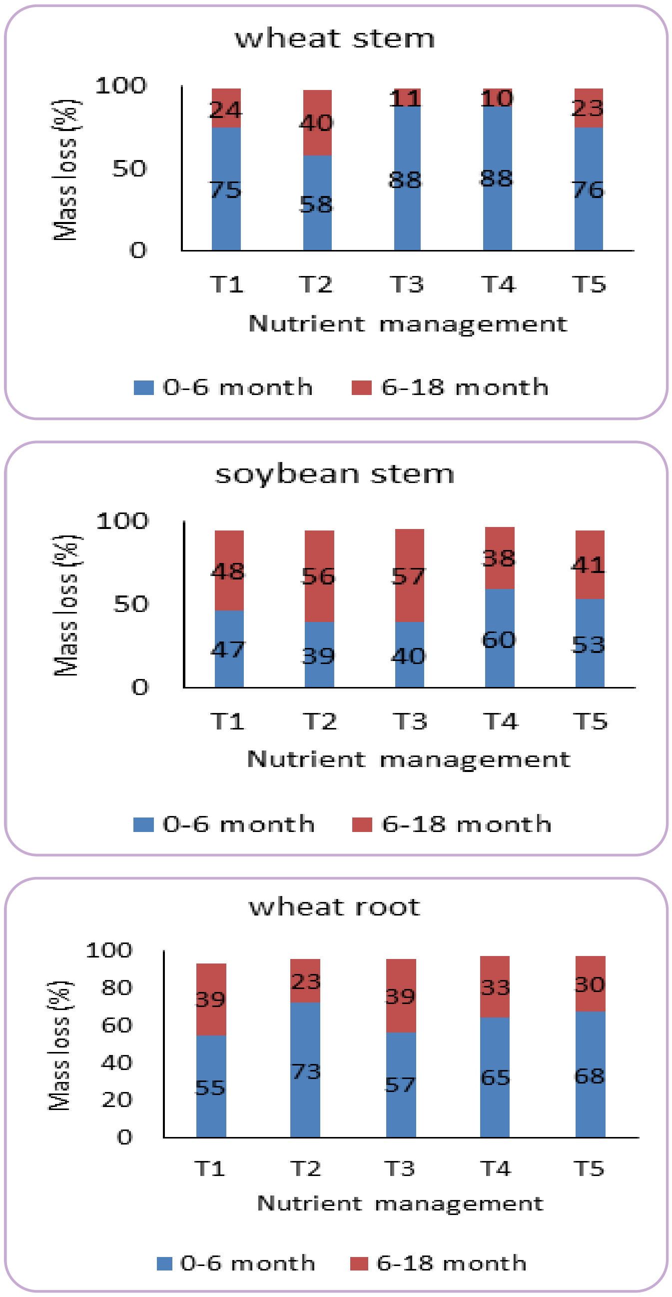


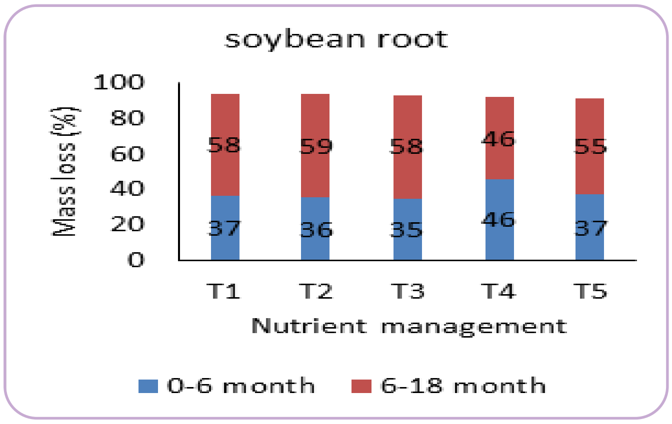
Fig. 2.1.24 Percent new carbon and old carbon under different nutrient management under long-term soybean-wheat cropping system (Ranchi, Alfisol, 47 years).

2.1.25 Residue decomposition in different cropping system and nutrient management

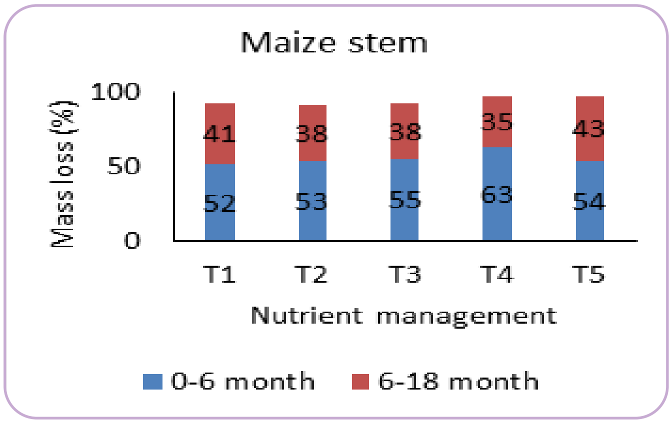
Aboveground and below ground residue decomposition in different cropping system and nutrient management was investigated. The results indicated that during 0-6 months percent mass loss was greater in wheat>soybean, chickpea>maize. Decomposition was greater in stem than root irrespective of crop type. Integrated use of nutrients (100%NPK + FYM @5t ha^{-1}) had the highest percent mass loss of biomass (decomposition) in all crops except chickpea (Fig.2.1.25).Therefore, residue quality other than C:N ratio would drive residue decomposition.

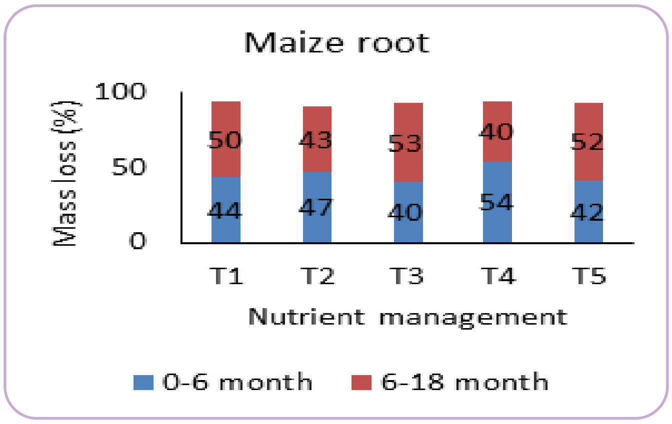
Soybean-Wheat cropping system

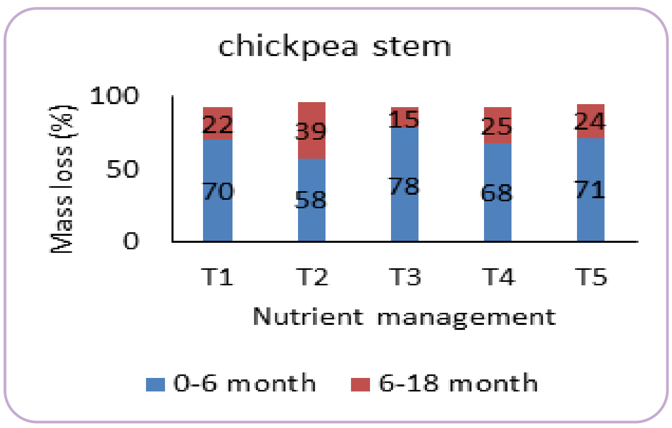


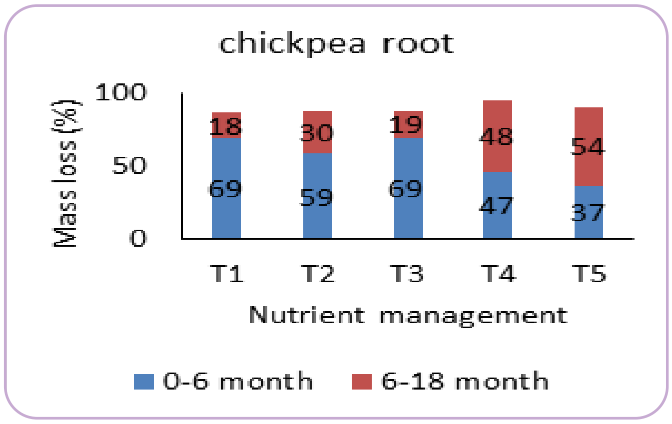


Maize-chickpea cropping system









Note:T1: Fallow; T2: N_0PK; T3: N100PK; T4: N_{100}PK + FYM (@5t/ha); T5: N_{150}PK

Fig. 2.1.25 Variation in percent litter mass loss during decomposition by crop types and nutrient managements

2.1.26 Development of nano sensor and its application through cloud based network for real time irrigation to soil and plant

An IoT based smart irrigation system was developed and tested which helps farmers irrigate their agricultural field from anywhere and anytime using pc or smartphone. The system has composed of a soil moisture sensor, soil temperature and humidity sensors that measure and send it to the Thing Speak web via Wi-Fi module and to monitor the environmental parameters condition. An algorithm has been developed with soil moisture thresholds that have been programmed into a microcontroller to decide to irrigate or not, therefore based on soil moisture thresholds, which opens the solenoid values and thus provides water to irrigate the soil. The lower set point was set by considering the field capacity as 30.5%, permanent wilting point 15.2% and 15.35% available moisture content. Further, the 50% depletion of available moisture content about 22.85% was considered to start the system. To stop the system, the highest set point was determined using the field capacity of 30.55%. The prototype has successfully read the soil moisture value and can properly irrigate according to the specified functional requirements. The performance of the results shows the effectiveness of the system principle in maximizing the water use efficiency. The present study is a state of art nano wireless sensor technology in agriculture, which can replace some of the traditional techniques to the rural farming community. In this reporting period SRF and daily paid workers has been hired for preparation, design and characterization of existing soil moisture sensors using PANI to make nano sensors. Purchase of chemical for preparation of nano material are completed. A set-up is developed for surface modification of MP 406 soil moisture sensor using nano particles of PANI material. Development of nano sensors cloud based network in CIAE farm and standardization and calibration of nano sensor for soil moisture stress measurement is being undertaken. Experimental planning and layout of the sensors in the field is shown in Fig. 2.1.26 and Plate 2.1.26.

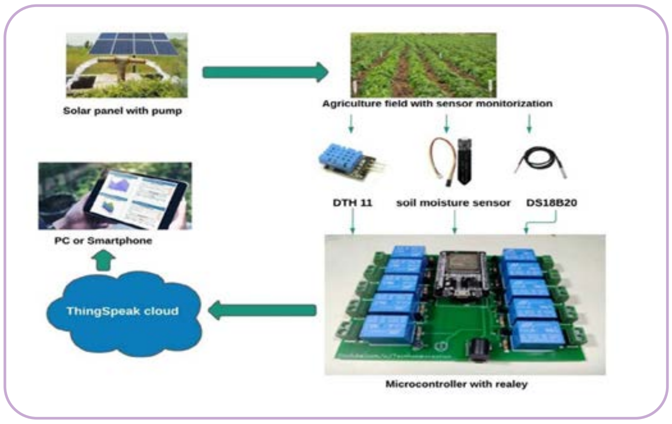


Fig 2.1.26 Overall description of the IoT and cloud based irrigation system: (a) Proposed design, (b) Field view

Plate 2.1.26 IoT and cloud based irrigation system in CIAE Farm (a) Normal photograph (b) Drone view

2.2 AICRP on Long-Term Fertilizer Experiments to Study Changes in Soil Quality, Crop Productivity and Sustainability

2.2.1 Impact of long term fertilizer and manure application on crop yield, nutrient uptake and sustainability in Alfisols

Crop Productivity

Application of 100% NPK+FYM recorded significantly higher productivity of maize, wheat, soybean and finger millet compared to 100% NPK across Alfisols. Application of 100% NPK+lime recorded yields at par with 100% NPK+FYM. Thus, soil amendment with lime is essential to maintain soil quality and crop yields in particular. Application of 150% NPK recorded marginally more yield over 100% NPK and with higher magnitude compared to 50% NPK. Plots with hand weeding had recorded comparatively higher yield than plots with chemical weed control measures under similar nutrient management practices. Imbalanced fertilizer application resulted in significant decline in crop productivity. Continuous application of 100% N alone over the years had resulted in deleterious effect on crop productivity as yield of crops declined even to zero at Palampur (Table 2.2.1a).

Table 2.2.1a Impact of long term manuring and fertilizer application crop yield (kg ha^{-1}) in LTFEs under Alfisols

Treatment	Palampur		Ranchi		Bangalore	
	Maize	Wheat	Soybean	Wheat	Finger millet	Maize
Control	807	375	552	715	780	907
100% N	0	0	438	855	833	887
100% NP	1702	885	673	3419	743	1247
50% NPK	3657	1678	1268	2305	2393	4320
100% NPK	3719	1863	1426	3259	2747	5427
150% NPK	3340	1542	1653	3403	3377	5933
100% NPK +HW	4076	2100	1335	3380	2783	5560
100% NPK + Lime	5203	2557	2081	4218	2967	5597
100% NPK + FYM	5517	2707	2053	4302	3263	6150

Nutrient Uptake

Bangalore

The long-term nutrient options influenced the nutrient uptake pattern in finger millet (Table 2.2.1b). The uptake of N, P and K was maximum with 150% NPK and lowest under control. Similar to major nutrients, secondary nutrients viz. S, Ca, and Mg uptake was highest in 150% NPK application (Fig. 2.2.1a). Reduction in S uptake was noticed in 100% NPK (S-free) where DAP was applied as P source compared to SSP. Micronutrient uptake of Zn, Fe, Cu and Mn was highest in 150% NPK treatment followed by 100% NPK+ FYM + Lime application (Table 2.2.1b). The imbalanced nutrient application has drastically reduced the removal of minerals such as Ca and Mg in finger millet (Fig. 2.2.1a). A similar nutrient uptake pattern was observed in maize also.

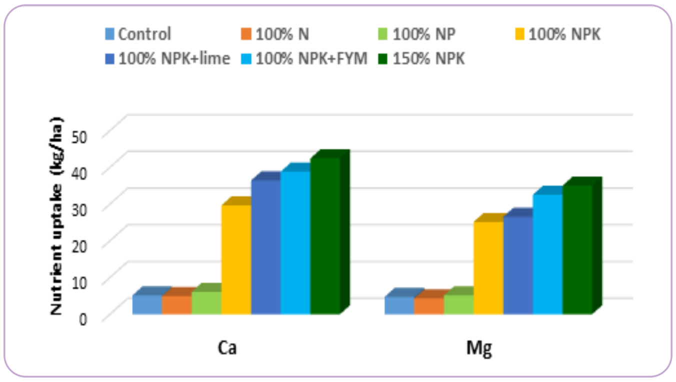


Fig. 2.2.1a Mineral (Ca & Mg) constituent in finger millet as influenced by imbalanced and balanced nutrient use in LTFE at Bangalore

Table 2.2.1b Effect of long term application of fertilizers on primary and micro-nutrients uptake by finger millet in LTFE at Bangalore

Treatments	Nutrient uptake (kg ha^{-1})				Micronutrient uptake (g ha^{-1})			
	N	P	K	S	Zn	Fe	Cu	Mn
Control	13.3	2.9	13.0	1.1	45	158	23	137
100% N	14.0	1.9	9.8	0.8	44	140	22	228
100% NP	15.9	3.6	13.6	1.4	53	185	25	269
50% NPK	46.4	9.0	32.5	3.4	140	499	70	514
100% NPK	78.8	15.8	100.0	6.8	239	772	121	1090
150% NPK	126.8	28.8	164.2	12.4	394	1141	192	1551
100% NPK (S-free)	77.7	19.2	85.7	6.0	222	815	114	1033
100% NPK+HW	84.8	18.8	105.9	7.8	251	767	138	963
100% NPK+lime	76.6	16.7	90.6	7.8	222	691	120	643
100% NPK+FYM	106.0	26.7	115.5	9.6	278	874	155	1113

Palampur

Nutrient uptake (macro, secondary and micronutrients) by maize and wheat followed similar trend to that of yields (Table 2.2.1c). Nutrient uptake was influenced significantly by the long-term application of fertilizers alone or in combination with FYM and lime amendment. Maximum uptake of nutrients was recorded with 100% NPK along with FYM followed by 100% NPK + lime. Nutrients uptake was significantly lower in treatments wherein potassium and sulphur was not in fertilizer schedule. The 100% N alone resulted in no uptake of nutrients, as there was no yield during that period in both the crops. However, the plots in which no fertilizer and manure (control) were supplied little bit nutrient uptake was obtained. Thus, application of N alone adversely affected the crop yield and uptake.

Table 2.2.1c Long-term effect of fertilizers and amendments on nutrient uptake by maize in LTFE at Palampur

Treatment	Nutrient uptake (kg ha^{-1})				Micronutrient uptake (g ha^{-1})			
	N	P	K	S	Zn	Fe	Cu	Mn
Control	12.8	2.0	6.5	1.6	36	122	36	58
100% N	0.0	0.0	0.0	0.0	0	0	0	0
100% NP	34.0	5.4	16.7	7.1	111	390	104	200
50% NPK	72.7	12.9	43.9	12.8	268	900	235	469
100% NPK	80.6	14.9	49.9	17.4	300	980	266	506
150% NPK	73.5	14.9	43.8	15.5	271	922	255	441

100% NPK (-S)	31.3	6.1	18.5	3.8	113	362	93	191
100% NPK + Zn	74.9	12.5	44.4	15.3	367	1187	359	613
100% NPK +HW	96.6	18.1	57.5	20.7	459	862	225	451
100% NPK + FYM	136.2	28.7	84.0	32.9	549	1780	540	895
100% NPK + lime	114.9	23.0	68.1	26.4	447	1364	416	725
CD (0.05)	8.3	1.7	5.9	2.5	50.1	120.6	34.4	56.9

Ranchi

The nutrient (N, P and K) uptake by the crops under soybean-wheat cropping system indicated the highest N uptake for both the crops under integrated use of organics along with balanced fertilizer use (Table 2.2.1d). The lowest N uptake was recorded in the treatment where N alone was applied through urea only over the years for both soybean (Fig. 2.2.1b) and wheat, which was even lower than control. Application of higher dose of NPK i.e. 150% NPK although could utilize nitrogen similar that of optimal dose of NPK as there was no significant difference for grain yield of crops between optimal and super optimal dose of the recommended fertilizers.

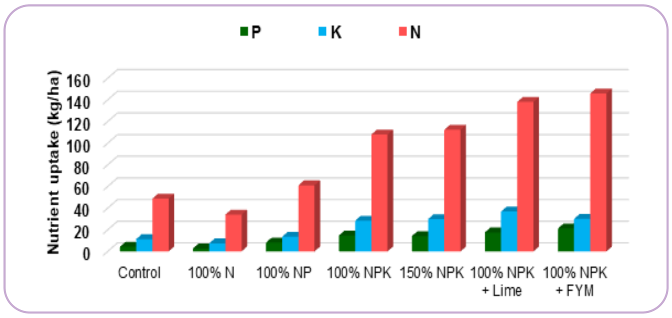


Fig. 2.2.1b Impact of imbalanced and balanced and INM on nutrient removal by soybean in LTFE at Ranchi

Table 2.2.1d Nutrient uptake by soybean and wheat in LTFE at Ranchi

Treatment	Soybean			Wheat		
	Nutrient uptake (kg ha^{-1})					
	N	P	K	N	P	K
Control	48.7	4.3	11.3	8.8	3.5	7.7
100% N	34.0	2.7	7.4	18.4	5.0	13.9
100% NP	61.0	8.1	13.5	53.5	15.6	47.6
50% NPK	78.0	8.2	19.0	36.9	11.6	35.9
100% NPK	107.9	14.7	28.3	54.8	14.6	51.6
100% NPK+HW	92.9	11.5	25.3	52.6	17.3	48.5
150% NPK	112.3	14.1	29.8	59.4	21.3	50.9
100% N (S) PK	123.8	11.7	29.6	56.9	18.3	46.4
100% NPK + Lime	138.1	17.5	36.8	61.0	20.6	60.5
100% NPK + FYM	145.9	21.1	30.0	63.8	23.1	58.9
CD (0.05)	19.4	2.9	5.3	9.5	6.4	7.3

Pattambi

The nutrient uptake data of both kharif and rabi rice revealed that the N, P and K uptake was highest under 100% NPK+FYM @ 5 Mg ha^{-1} followed by 100% NPK+green manuring (Fig. 2.2.1c). The application of imbalanced nutrient adversely affected the major nutrient uptake by the rice.

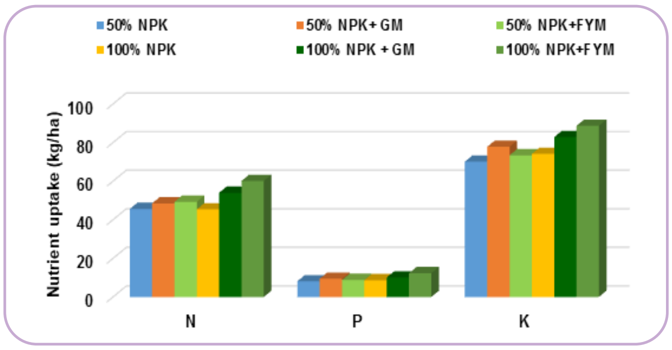


Fig. 2.2.1c Impact of green manuring and FYM on nutrient withdrawal by rice in LTFE at Pattambi

Sustainable Yield Index in Alfisols

The sustainable yield index (SYI) is one of the indices to evaluate soil quality. More SYI value implies better sustainability of crop yield over the years. The estimates SYI in long term fertilizer experiments across Alfisols, data indicated that balanced application of nutrient resulted in higher SYI irrespective of crop (Table 2.2.1e). It means management of nutrients is responsible for sustainability and soil quality as well.

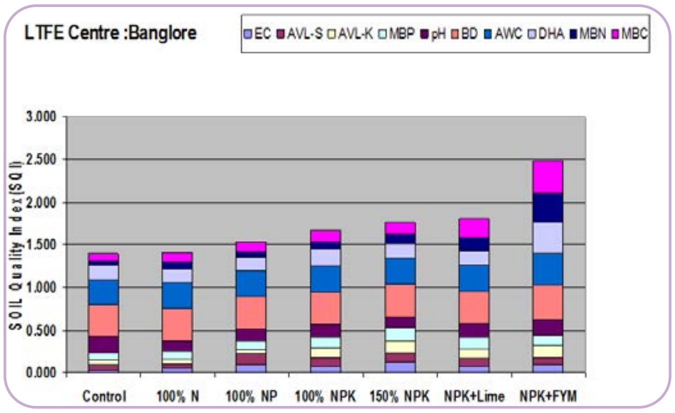
Table 2.2.1e Sustainability yield index (SYI) for crops at different AICRP LTFE Centers in Alfisols

Centre	Crop	Control	100% N	100% NP	100% NPK	150% NPK	100% NPK+ FYM	100% NPK + Lime
Bangalore	Finger millet	-0.26	-0.23	-0.19	0.45	0.61	0.56	0.43
	Maize	-0.20	-0.18	-0.11	0.49	0.60	0.63	0.52

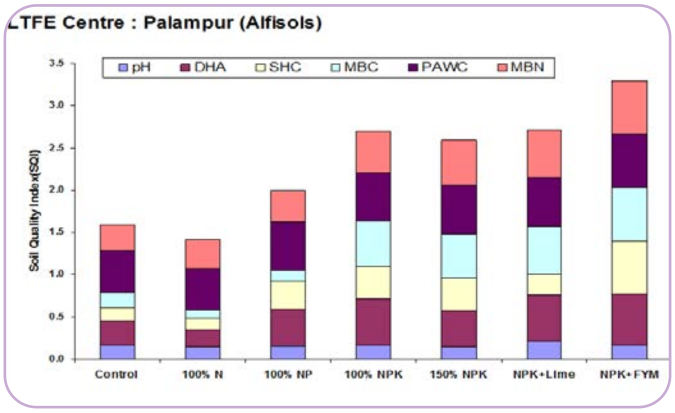
Ranchi	Soybean	0.10	0.01	0.21	0.49	0.47	0.62	0.60
	Wheat	0.03	0.02	0.29	0.35	0.36	0.43	0.41
Palampur	Maize	0.01	0.07	0.15	0.35	0.36	0.53	0.47
	Wheat	0.04	0.05	0.15	0.28	0.28	0.42	0.40
Pattambi	Rice (Kharif)	0.33	0.44	0.46	0.48	0.50	0.61	0.49
	Rice (Rabi)	0.47	0.58	0.62	0.68	0.69	0.82	0.67

4. Soil Quality Index

In a study soil quality index in Alfisols at LTFE sites was determined based on 25-30 attributes. These attributes were subjected to principal component analysis (PCA) to find out soil quality indicators and soil quality index. The key indicators are available K, dehydrogenase activity (DHA), microbial biomass C (MBC), N (MBN) and P (MBP), pH, EC, available S, bulk density and available water content for Alfisols of Bangalore (Fig. 2.2.1d). Similarly, the key indicators for Palampur are dehydrogenase activity (DHA), microbial biomass C (MBC), and N (MBN), pH, saturated hydraulic conductivity and plant available water content.



Bangalore



Palampur

Fig. 2.2.1d Soil Quality Index in Alfisols of Bangalore and Palampur

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

2.3.1 Spatial distribution of available micronutrients and sulphur in surface soils and their management zones in Indo-Gangetic Plain

Assessing multi-micronutrients deficiency in agricultural soils of India

Altogether 242827 surface (0 to 15 cm depth) soil samples from 615 districts of 28 states of India were analyzed for assessing Sulphur (S) and multi-micronutrient (Zn, B, Fe, Cu, Mn) deficiencies. Variable and widespread deficiencies of S and micronutrients in soils were observed in different states. The deficiencies of S, Zn and B were higher compared to the deficiencies of Fe, Cu and Mn. There were occurrences of 2-nutrients (namely S+Zn, Zn+B, S+B, Zn+Fe, Zn+Mn, S+Fe, Zn+Cu and Fe+B), 3-nutrients (namely S+Zn+B, S+Zn+B and Zn+Fe+B), 4-nutrients (namely Zn+Fe+Cu+Mn) and 5-nutrients (namely Zn+Fe+Cu+Mn+B) deficiencies in 0.10 to 9.30% of sampled sites. The average percent of samples showing multi-nutrients deficiencies followed the order S+Zn > Zn+B > S+B > Zn+Fe > Zn+Mn > S+Fe > Zn+Cu > Fe+B > S+Zn+B > S+Zn+Fe > Zn+Fe+B > Zn+Fe+Cu+Mn > Zn+Fe+Cu+Mn+B. The mean deficiency of S+Zn was in 9.30% of the sampled sites (varying from 0.10 to 29.9% of the sampled sites for different states). It was predominantly prevalent in different districts of Bihar, Gujarat, Karnataka, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh and Maharashtra (Fig. 2.3.1). This information could be used by various stakeholders for production, supply and application of right kind of fertilizers in different districts, states and agro-ecological regions of India for better crop production, crop nutritional quality, nutrient use efficiency, soil and environmental health. This will also help in a greater way to address the issue of malnutrition in human/animal.

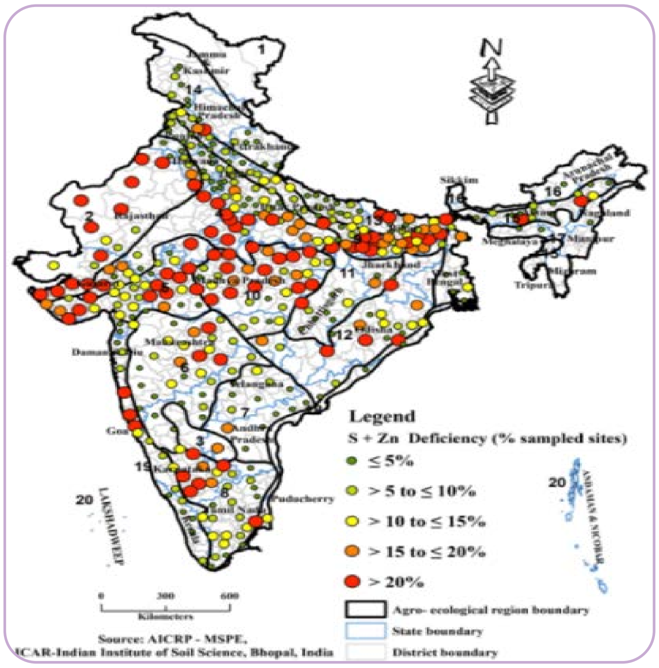


Fig. 2.3.1 Distribution of S+ Zn deficiency in soils (% of sampled sites) of different parts of India

2.3.2 Analyzing spatial variability of available sulphur and micronutrients and associated properties in soils of coastal area of India

Spatial variability in availability of S and micronutrients in soils of coastal area of India was assessed (Fig.2.3.2). Altogether 39097 surface soil samples from the farm lands of 68 coastal districts of India were analyzed. Semivariogram model and parameters like nugget, sill and range were obtained for each soil parameter through geostatistical analysis. Soil parameters had stable, exponential, K-Bessel and spherical semivariogram models with moderate to strong spatial dependence. Available S, Zn, Cu, Fe, Cu, Mn and B were differently correlated among themselves and with soil pH, EC and SOC. Spatial distribution maps for various soil parameters revealed different distribution patterns. The study area had deficiency (including acute deficient, deficient and latent deficient) of available S, Zn, Fe, Cu, Mn and B in 54, 49, 17, 6, 6 and 46% area, respectively.

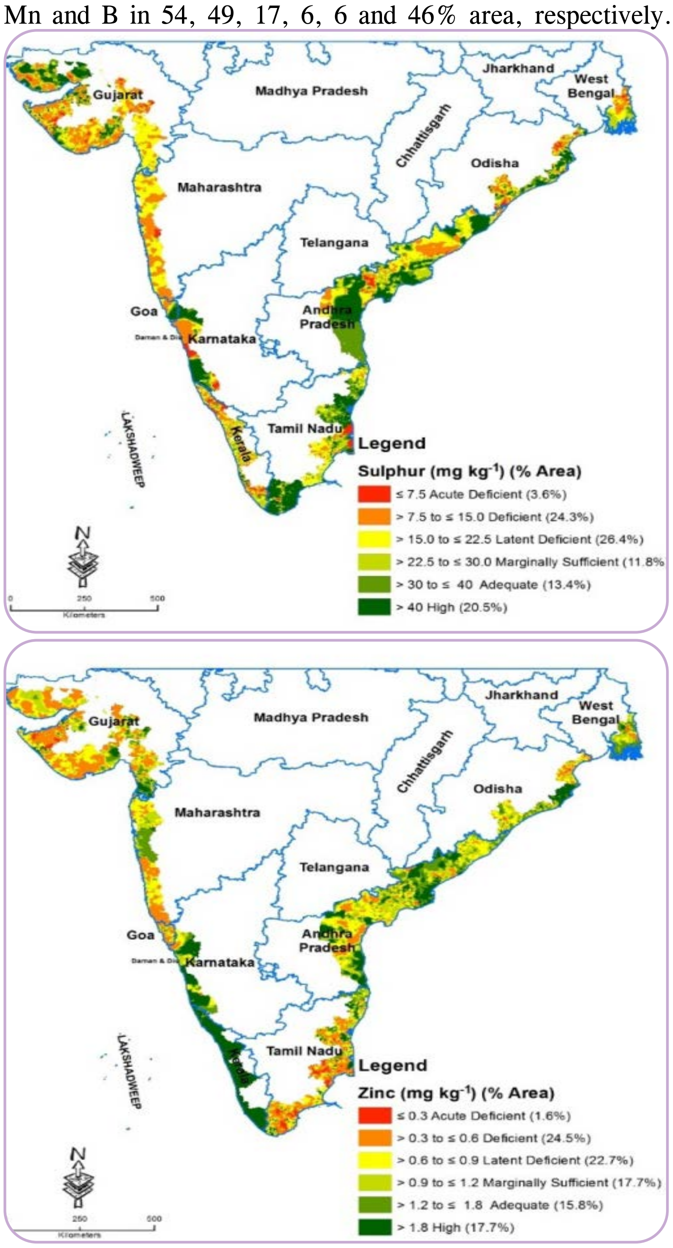
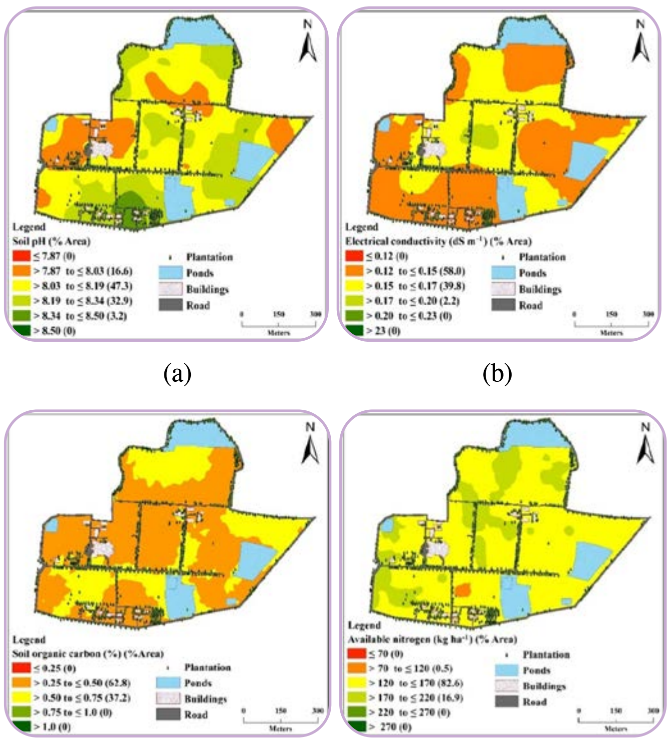


Fig. 2.3.2 Distribution maps of available S and available Zn in coastal soils of India

2.3.3 Assessing farm-scale spatial variability of soil nutrients in central India for site-specific nutrient management

A study was carried out to evaluate spatial variability of phyto-available nutrients (available nitrogen (AN), available phosphorus (AP), available potassium (AK), exchangeable Ca (Ex. Ca), exchangeable Mg (Ex. Mg), available sulphur (AS), available zinc (AZn), available copper (ACu), available iron (AFe), available manganese (AMn) and available boron (AB)) and associated soil properties (soil pH, EC and SOC) of the research farm of ICAR-Indian Institute of Soil Science using ordinary kriging (OK) method for prediction mapping. The experimental semivariograms were obtained and used for generating maps. Soil pH (7.22-8.66), EC (0.10-0.26 dS m^{-1}) and SOC (0.19-0.98%) and concentrations of phyto-available nutrients (AN 76.8-224 kg ha^{-1}, AP 8.20-61.0 kg ha^{-1}, AK 140-693 kg ha^{-1}, Ex. Ca 6779-9803 mg kg^{-1}, Ex. Mg 365-1596 mg kg^{-1}, AS 1.12-37.0 mg kg^{-1}, AZn 0.27-1.64 mg kg^{-1}, ACu 0.69-1.88 mg kg^{-1}, AFe 4.64-19.8 mg kg^{-1}, AMn 3.31-27.2 mg kg^{-1}, AB 0.20-5.00 mg kg^{-1}) in farm soils varied widely with CV values of 2.38-47.3%. Pearson's correlation coefficient analysis revealed positive and negative significant correlations among the studied soil parameters. The principal component analysis resulted in five principal components (PC), with eigenvalue >1, which accounted for >59% of variability. Geostatistical analysis with OK interpolation revealed strong (AN, Ex. Ca, Ex. Mg, AS, AZn and AB), moderate (pH, EC, AP, AK, ACu, AFe and AMn) and weak (SOC) spatial dependence for soil parameters. The generated spatial distribution maps (Fig. 2.3.3) of soil properties and phyto-available nutrients could be used for location-specific nutrients management strategies and finding the appropriate locations for initiating nutrient experiments in the farm.



(a) (b)

(c) (d)

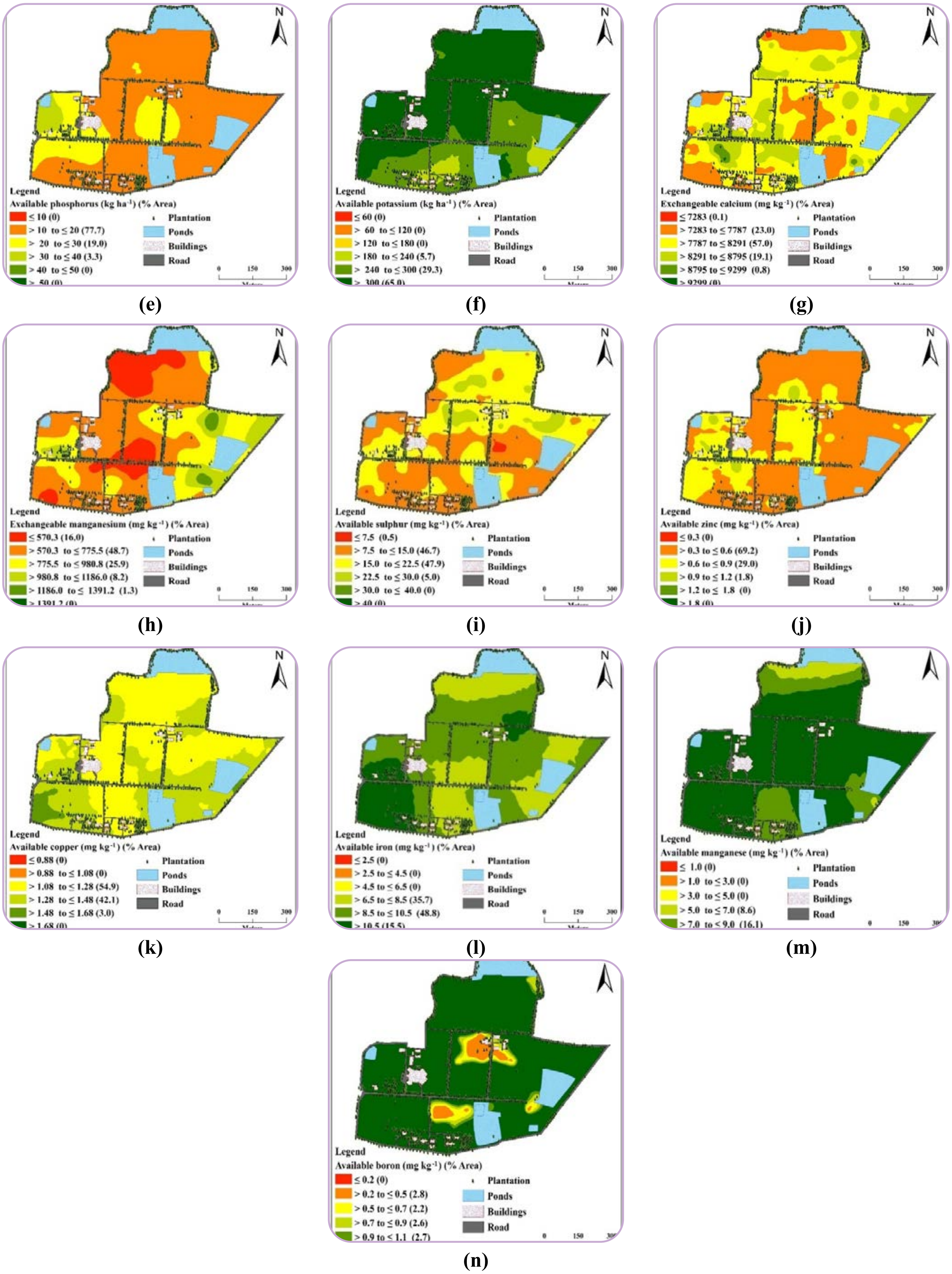


Fig. 2.3.3 Distribution maps of soil parameters

2.4 AICRP on Soil Test Crop Response (STCR)

2.4.1 Development of fertilizer prescription equations under integrated plant nutrient supply systems

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 2.4.1 and Fig. 2.4.1

Table 2.4.1 Basic data and targeted yield equation of different crop varieties developed by various centers of STCR

Crop (variety)	Basic Data					Targeted Yield Equations
	Nutrient	NR (kg q^{-1})	CS (%)	CF (%)	CO (%)	
IGKV, Raipur						
Safflower	N	3.99	15.81	29.12	9.86	FN=13.7T– 0.54SN-0.34ON
(Chhattisgarh	P_2O_5	0.98	52.76	18.57	4.26	FP_2O=5.25T–2.84SP-0.23OP
Kusum-1)	K_2O	6.55	11.36	131.56	8.79	FK_2O=4.98T–0.09SK-0.0OK
Sweet corn	N	0.27	11.10	24.44	12.86	FN=1.09T– 0.45SN- 0.53ON
(Sugar-75)	P_2O_5	0.07	45.84	17.31	2.45	FP_2O=0.39T–2.6 SP-0.14OP
	K_2O	0.30	5.21	84.71	6.34	FK_2O=0.36T–0.06SK-0.07OK
IARI, New Delhi						
Pearl millet	N	3.79	35.36	50.92	6.90	FN=7.44 T–0.69 SN- 0.14 ON
(PusaHybrid 1201)	P_2O_5	0.67	55.71	28.24	8.61	FP_2O_5=2.38T–1.97SP-0.30OP
	K_2O	3.70	32.38	119.57	2.73	FK_2O=3.10T–0.27SK-0.02OK
MPKV, Rahuri						
Turmeric	N	0.45	5.94	48.3	15.5	FN = 0.92T–0.12S –1.61ON
	P_2O_5	0.11	38.37	21.9	3.8	FP_2O_5=0.50T–1.75SP–0.52OP
	K_2O	0.64	10.18	82.5	29.9	FK_2O=0.77T–0.12SK–2.17OK
Pigeonpea	N	3.06	14.18	56.87	40.75	FN=5.38T–0.25SN–3.58ON
(Rajeshewari)	P_2O_5	0.81	37.71	8.86	2.13	FP_2O_5=9.12T–4.26SP–0.72OP
	K_2O	2.30	3.69	59.49	6.37	FK_2O=3.87T–0.06SK–0.96OK
PJNCARI, Karaikal						
Chilli	N	0.72	23.66	56.99	37.84	FN=1.25T-0.42SN–0.65ON
	P_2O_5	0.24	59.74	27.57	10.51	FP_2O_5=0.84T–4.82SP-0.84OP
	K_2O	0.62	19.08	80.66	47.95	FK_2O=0.72T-0.29 SK-0.77OK
Brinjal	N	0.33	27.21	43.83	32.58	FN=0.74T- 0.61 SN – 0.74 ON
(Palur -2)	P_2O_5	0.24	32.20	73.79	22.95	FP_2O_5=0.33T–0.97SP- 0.71OP
	K_2O	0.32	24.69	90.31	36.90	FK_2O=0.35T-0.33SK-0.49OK
GBPUAT, Pantnagar						
Brinjal	N	0.50	31.63	50.41	59.58	FN=1.00T- 0.63 SN-0.59ON
(Pant Samrat)	P_2O_5	0.14	29.16	47.43	94.60	FP_2O_5=0.68T-1.43SP-3.17OP
	K_2O	0.25	13.82	65.12	81.10	FK_2O=0.47T-0.26SK-0.75OK
Mustard	N	8.03	113.61	15.16	26.88	FN=52.96T–7.49SN–1.77ON
(PR20)	P_2O_5	1.29	26.87	28.21	36.45	FP_2O_5=10.54T–2.18SP–0.95OP
	K_2O	3.49	22.91	60.88	7.4	FK_2O=6.93T–0.46SK–0.12OK
CSKHPKV, Palampur						
Pea	N	1.08	33.38	64.27	12.21	FN = 3.44T- 1.06 SN- 0.38 ON
(PalamTriloki)	P_2O_5	0.06	20.17	9.67	4.93	FP_2O_5=1.56T-5.36SP-1.22OP

	K_2O	0.63	24.47	73.43	19.2	FK_2O=1.72T-0.67SK-0.49 OK
CRIJAF, Barrackpore						
Mesta	N	3.29	22.45	31.62	12.26	FN=10.42T-0.71SN-0.39ON
	P_2O_5	1.10	33.75	43.92	14.60	FP_2O_5=2.50T-0.77SP-0.33OP
	K_2O	7.10	53.28	118.89	8.39	FK_2O=5.98T-0.45SK-0.07OK
BHU, Varanasi						
Linseed	N	4.09	16.04	47.44	6.91	FN =8.63T-0.34SN-0.15ON
(Neelam B 67)	P_2O_5	1.11	49.22	36.66	3.75	FP_2O_5=3.03T-1.34SP-0.10OP
	K_2O	4.25	22.21	108.06	23.54	FK_2O=3.94T-0.21SK-0.22OK
KAU, Vellanikkara						
Cluster bean	N	0.68	9.84	90.90	7.17	FN=0.74T–0.11SN – 0.08ON
(Pusanoubahar)	P_2O_5	0.05	2.29	3.29	1.92	FP_2O_5=1.47T–1.59SP–1.34OP
	K_2O	0.22	1.99	10.82	2.96	FK_2O=2.05T–0.22SK–0.33OK
Cabbage	N	3.36	10.18	291.63	10.86	FN=1.15T–0.03SN – 0.04ON
(N-166)	P_2O_5	0.75	19.02	74.05	3.74	FP_2O_5=1.01T–0.59SP–0.12OP
	K_2O	10.35	168.59	514.37	83.06	FK_2O=2.01T–0.40SK–0.20OK
TNAU, Coimbatore						
	N	2.50	15.02	38.19	25.96	FN=6.53T-0.39SN-0.68ON
Foxtail millet	P_2O_5	1.47	22.92	43.51	14.85	FP_2O_5=3.37T-1.21SP-0.78 OP
	K_2O	2.80	5.76	55.74	22.88	FK_2O=5.03T-0.12SK-0.50OK
Dr RPCAU, Pusa						
Mangraila	N	9.90	190.02	20.93	25.50	FN = 5.21T– 0.11 SN–0.13ON
(RajendraShyama)	P_2O_5	1.38	57.19	38.44	9.84	FP_2O_5= 2.41T – 0.67SP–0.17OP
	K_2O	5.09	190.32	36.23	33.64	FK_2O = 2.68T– 0.19 SK-0.18OK
UAS, GKVK, Bangalore						
Bhendi	N	0.445	12.75	38.90	0.67	FN=1.44T–0.33SN-0.67 ON
(Arka Nikita)	P_2O_5	0.352	8.01	67.52	0.62	FP_2O_5=0.52T–0.12SP-0.62OP
	K_2O	0.698	28.03	124.00	0.86	FK_2O=0.56T–0.23SK-0.86OK
Kodomillet	N	2.23	11.50	55.77	0.32	FN=4.00T–0.21SN-0.32ON
(TANU86)	P_2O_5	1.63	24.36	68.22	0.19	FP_2O_5=2.39T–0.36SP-0.19OP
	K_2O	4.07	35.46	226.24	0.77	FK_2O=1.80T–0.16SK-0.77OK
AAU, Jorhat						
Hybrid Maize	N	2.74	43.74	52.82	48.32	FN=5.20T–0.83SN-0.91 ON
(DKC-9144)	P_2O_5	0.73	65.87	48.65	33.03	FP_2O_5=1.49T–1.35SP-0.68OP
	K_2O	2.01	52.07	56.46	38.01	FK_2O=3.55T–0.92SK-0.67OK
Winter Rice	N	2.07	50.78	40.05	25.68	FN=5.17T–1.27SN-0.64 ON
(Ranjit Sub-1)	P_2O_5	0.27	50.20	26.50	5.75	FP_2O_5=1.03T–1.89SP-0.22OP
	K_2O	1.41	53.05	50.60	14.28	FK_2O=2.78T–1.05SK-0.28OK
PJTSAU, Hyderabad						
Chilli (Teja)	N	3.82	70.85	44.12	7.01	FN=21.41T-0.32SN-0.64ON
	P_2O_5	0.36	36.18	46.18	3.33	FP=4.40T-0.52SP-0.2OP
	K_2O	3.06	66.43	75.48	10.02	FK=5.25T-0.07SK-0.25OK
Sesamum	N	9.14	13.56	42.67	24.51	FN=21.41T-0.32SN-0.64ON
(YML66)	P_2O_5	1.87	22.24	32.58	8.71	FP=4.40T-0.52SP-0.2OP
	K_2O	4.20	5.73	60.07	40.40	FK=5.25T-0.07SK-0.25OK
Groundnut	N	4.40	49.65	182.44	67.27	FN=2.41T-0.27SN-0.36ON

(K-6)	P_2O_5	0.47	35.68	46.92	16.60	FP2O5=0.99T-0.76SP-0.35OP
	K_2O	2.75	20.51	108.98	73.67	FK2O=2.52T-0.19SK-0.67OK
			BAU, Ranchi			
Linseed	N	3.16	7.40	68.01	N	FN = 4.16 T – 0.11 SN
(Priyam)	P_2O_5	1.08	12.41	35.28	P_2O_5	FP_2O_5 = 3.06 T – 0.35 SP
	K_2O	3.16	12.82	56.25	K_2O	FK_2O = 5.62 T – 0.23 SK
			JNKVV, Jabalpur			
Pigeon Pea	N	8.19	37.90	117.06	47.67	FN=6.93T–0.32SN-0.44 ON
(TJT-501)	P_2O_5	2.20	46.88	19.75	7.21	FP_2O_5=11.00T–5.41SP-0.90OP
	K_2O	9.48	32.01	121.39	30.57	FK_2O=7.76T–0.31SK-0.31OK

Where, F = Fertilizer dose of N, P_2O_5 or K_2O in kg ha^{-1}; T = Yield target in q ha^{-1}; NR = Nutrient requirement of N, P_2O_5 (P x 2.29) or K_2O (K x 1.21) for 100 kg economic produce; CS = Contribution from soil nutrients in fraction; CF = Contribution from fertilizer nutrients in fraction; CO = Contribution from organic nutrients in fraction; SN, SP, SK = Soil available nutrients N, P_2O_5 (P x 2.29) or K_2O (K x 1.21) determined through soil analysis; ON, OP, OK = Nutrient content in organic matter N, P_2O_5 (P x 2.29) or K_2O (K x 1.21) determined through organic matter analysis.

Fig. 2.4.1 Development of target yield equation for brinjal (Pant Samrat) at GBPUAT, Pantnagar

Research Achievements in Professional Attachment Training

Effect of long term conservation agriculture on potassium quantity intensity parameters in soil under cereal based system in North West India

The effect of conservation agriculture (CA) based management practices on soil K dynamics and quantity-intensity relationship in soil under cereal-based systems of North-West India was assessed as a part of professional attachment training research at ICAR-CSSRI, Karnal. Different pools of K were analyzed after 11 years of an experimental setup consisting of six scenarios i.e. Scenario 1 (Sc1) : (CT-CT) conventional till rice-wheat cropping system; Scenario 2 (Sc2) : (CT-ZT-ZT); partial CA based rice wheat-mungbean system; Scenario 3 (Sc3) : (ZT-ZT-ZT); full CA based rice-wheat-mungbean system; Scenario 4 (Sc4) : (ZT-ZT-ZT) CA based maize-wheat-mungbean system ; Scenario 5 (Sc5) : (ZT-ZT-ZT) same as scenario 3 with sub surface drip; Scenario 6 (ZT-ZT-ZT) same as scenario 4 with sub surface drip. Available K as well as quantity-intensity (Q/I) parameters were evaluated. Results revealed that available K, water-soluble K and exchangeable-K pools were highest in the uppermost layer of soil (0-5 cm). Available K varied between 111 (Sc1) to 191mg kg^{-1} soil (Sc5) in 0-5 cm depth and were significantly higher in CA based scenarios (1.5 times) over Sc1. The equilibrium activity ratio of K^+ (ARe0K) varied between 1.55×10^{-3} in Sc1 to 3.71×10^{-3} $(mol\ L^{-1})^{1/2}$ in Sc6. Though Sc2 maintained higher labile K and ARe0K, it had lower PBCK showing that this practice is not sustainable over long term. However, all full CA based scenarios maintained higher PBCK over the farmers practice (Sc1). The study provided useful information for understanding potassium dynamics in soils following CA and could make significant contribution to operational potassium management.

Potassium Q/I parameters in soil under cereal based CA system in North West India

Scenario	Q/I parameters					
	K_0	K_X	K_L	ARe^{0K} $[(molL^{-1})^{1/2} \times 10^{-3}]$	PBC^K $[cmolkg^{-1}(mol\ L^{-1})^{-1/2}]$	K potential
SC1	0.0248	0.1194	0.1663	1.55	35.3	0.96
SC2	0.0440	0.3517	0.3679	2.85	39.0	1.55
SC3	0.0431	0.0783	0.3122	1.57	59.9	2.58
SC4	0.0626	0.2600	0.2889	2.46	43.0	2.69
SC5	0.0571	0.2095	0.2643	1.87	61.2	3.49
SC6	0.1335	0.1749	0.3249	3.71	45.0	6.00

Evaluation of phosphorus extraction methods and performance of maize in three major soil orders of acid soils of Meghalaya

Phosphorus deficiency is widely common in acid soil of North East Region Meghalaya and P is mainly fixed by Al and Fe. Understanding the relationship and extractability of P among various soil P-tests and their uptake and crop response will provide better yield of Maize in this region. A study was conducted to evaluate the relationship and extractability of P in major soil orders of strongly acid soils of Meghalaya and find out the best correlation of P methods with crop performance and maize is the test crop. The respective methods are Bray 1, Olsen, Mehlich 3, Water and $CaCl_2$ with three common soil orders available in Meghalaya i.e. Entisol, Inceptisol and Ultisol. The basic soil properties of soil orders. In each method three P_2O_5 doses (75%, 100% and 125%) were selected from the initial soil P analysis with their respective soil orders. Performance of maize under different treatment and soil orders are shown. Among the five different soil extraction methods, Olsen P was the highest soil available P and the lowest was in $CaCl_2$ P extractant. However, the response of maize in terms of plant growth parameters and nutrient uptake by plant, Mehlich 3 was superior to other methods. The significantly difference soil available P among the treatments and soil orders. The comparison of soil available P by five P extratants under three different soil orders. Our result suggest that the Mehlich 3 extractant can be used as an index of available phosphorus for Maize grown acid soils of Meghalaya. Among the soil orders Inceptisol reserve more soil available P as compare to Entisol and Ultisol.

Basic characterization of studied soil from the three selected sites

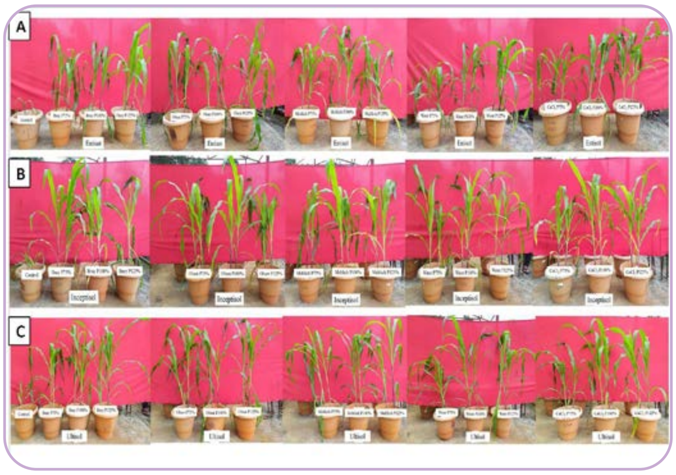
Soil type	Sand (%)	Silt (%)	Clay (%)	pH	SOC (%)	Ca+Mg (meq/100g soil)	Sum of bases (meq/100g soil)	CEC (meq/100g soil)	Base saturation (%)	Av N (kg ha^{-1})	Av P (kg ha^{-1})	Av K (kg ha^{-1})
Entisol	25.16 b	25.72 a	49.12 b	4.87 c	2.45 a	0.80 c	0.93 c	14.75 a	6.27 b	309.4 a	0.80 b	159.6 b
Inceptisol	35.72 a	19.0 b	45.28 c	5.15 b	2.01 c	1.63 b	1.75 b	13.28 a	13.21 a	234.2 b	1.89 a	121.1 c
Ultisol	23.16 b	25.72 a	51.12 a	5.23 a	2.15 b	2.03 a	2.19 a	14.08 a	15.58 a	259.2 ab	0.62 c	290.8 a

Mean values in the column followed by different letters (a-c) are significantly different at $p < 0.05$

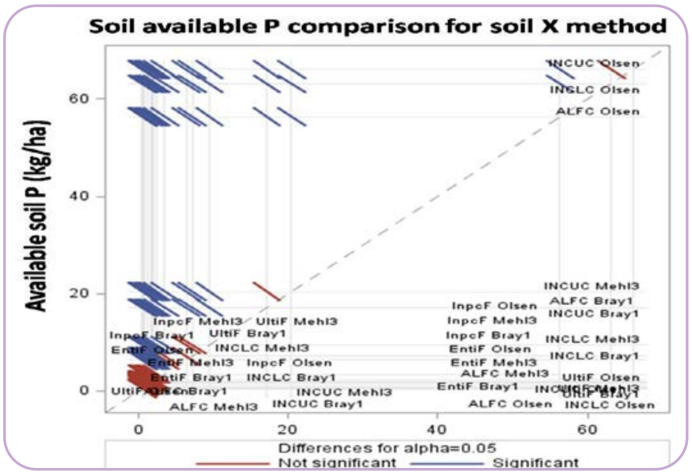
Soil P extracted by five different methods in Entisol, Inceptisol and Ultisol

Soil type	Bray 1	Olsen	Mehlich 3	Water	$CaCl_2$	Mean
Entisol	0.803 (± 0.05)b/B	1.926 (± 0.36)b/A	0.472 (± 0.05)b/C	0.394 (± 0.05)b/D	0.073 (±0.03)b/E	0.734 b
Inceptisol	1.88 (± 0.03)a/B	2.406 (± 0.43)a/A	1.262 (± 0.10) a/C	0.473 (± 0.05)a/D	0.162 (± 0.03)a/E	1.238 a
Ultisol	0.617(± 0.14)c/B	1.542 (± 0.15) c/A	0.447 (± 0.05)b/C	0.342 (± 0.05)b/D	0.037 (± 0.0)c/E	0.597 b
Mean	1.102 B	1.958 A	0.727 C	0.403 D	0.091 E	0.853
Soil x method interaction = p <0.001						

Mean values followed by different letter in the column (small letter: a-c) and row (capital: A-C) are significantly different at $p<0.05$



Comparison of Maize under three different soil orders (A) Entisol (B) Inceptisol and (C) Ultisol

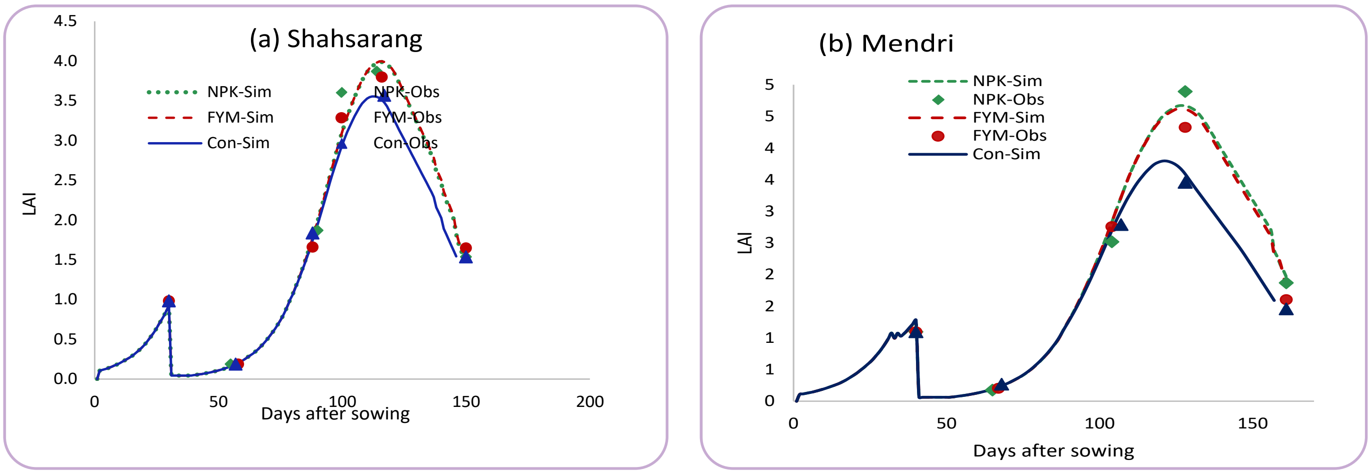


Comparison of soil Av P interaction by five P extraction methods with three soil

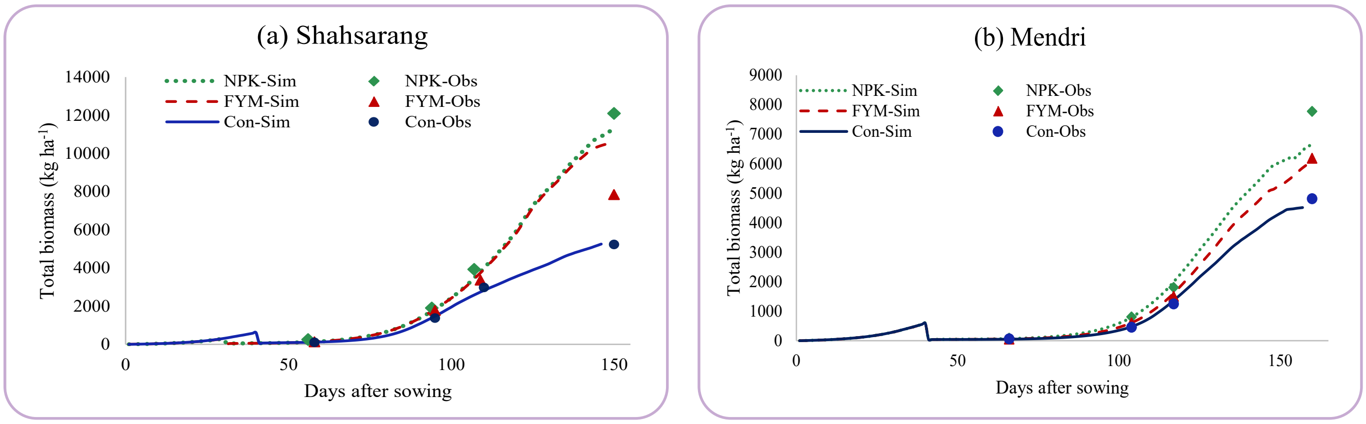
Calibration and evaluation of APSIM–ORYZA for selected rice varieties under hill agriculture of Mid-altitude Meghalaya

APSIM – Oryza model was calibrated and validated for two lowland rice varieties (Shahsarang and Mendri) under hill agriculture of Mid-altitude Meghalaya using data from three years field experiments involving three nutrient managements practices (organic, inorganic and farmers practices i.e. without manures and fertilizers).Datasets of 2017 when used to calibrate gave good agreements were obtained between the predicted and observed values of crop biomass at different phenological stages and leaf area index. Genetic coefficients generated from the model for different phenological stages of lowland rice cultivar Shahsarang and Mendriwas use to validate the model from data generated from 2018 and 2019.

In Shahsarang, inorganic nutrient management improved biomass and grain yield by 49.7 and 153.1%, respectively over control, and the increase over organic nutrient management (FYM) was 54.3% in biomass and 33.1% in grain yield. In Mendri, biomass yield in inorganic nutrient management was 61.7% higher than control and grain yield was 39.5% higher than control. The model underestimated the biomass and grain yield of Shahsarang by 9.12 and 4.15%, respectively and grain yield of Mendri by 16.3% but overestimated biomass yield by 9.72%, and these deviations are well within acceptable range. Thus APSIM – Oryza model can be use to simulate nutrient management strategies for lowland rice varieties under hill agriculture of Mid-altitude Meghalaya.



Simulated and observed biomass of (a) Shahsarang and (b) Mendri at different phenological crop stages



Simulated and observed leaf area index (LAI) of (a) Shahsarang and (b) Mendri at different phenological crop stages

Observed and simulated shoot biomass and grain yield at harvest of rice crop

Treatment		Biomass		LAI	
		Shahsarang	Mendri	Shahsarang	Mendri
NPK	RMSEa	470	94.3	0.090	0.191
	RMSEn (%)	10.4	3.6	5.3	9.0
FYM	RMSEa	390	55.5	0.093	0.161
	RMSEn (%)	11.9	2.7	5.5	8.0
Control	RMSEa	157	61.6	0.065	0.209
	RMSEn (%)	6.5	3.8	4.0	11.2

Theme II. Conservation Agriculture, Carbon Sequestration and Climate Change

2.5.1 Impact of crop residue levels and nutrients levels on crop productivity and soil health in soybean–wheat cropping system under conservation agriculture.

Four levles of residue retention with four levels of nutrients comprising of RDF and 25% reduced doses of N, P_2O_5 and K_2O respectively comprising 16 combinations of treatments were evaluated under soybean–wheat cropping system under conservation agriculture (Table 2.5.1a).

Response of different residue and nutrient levels on grain yield of wheat

Grain yield: The grain yield of wheat crop shows significant differences in grain yield because of different levels of crop residue retention. The maximum yield (6775 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 6366, 5811, 5727 kg ha^{-1} respectively and the lowest grain yield (5727 kg ha^{-1}) was observed in without residue. In case of various levels of nutrient applications, there was non-significant effect of nutrient doses on grain yield and the grain yield varied between (6088 to 6338 kg ha^{-1}). The interaction effect between residue levels and nutrient doses not show any significant difference effect on grain yield (Table 2.5.1b). The highest grain yield (7022 kg ha^{-1}) obtained from 90% crop residue and treatment with 100% RDF that was statistically at par with other residue levels. The lowest grain yield (5578 kg ha^{-1}) was observed in without residue with 75% N, 100% P, K doses. (Plate 2.5.1a)

Table 2.5.1a Crop residue levels and nutrients level treatment combinations

Factor. A↓/ Factor B→	Nutrient level treatment	
Residue levels	Soybean	Wheat
A_1 (90%) Crop residue	B_1. 25:60:40 kg ha^{-1} N, P_2O_5, K_2O	B_1. 120:60:40 kg ha^{-1} N, P_2O_5, K_2O
A_2 (60%) Crop residue	B_2. 15:60:40 kg ha^{-1} N, P_2O_5, K_2O	B_2. 90:60:40 kg ha^{-1} N, P_2O_5, K_2O
A_3 (30%) Crop residue	B_3. 25:45:40 kg ha^{-1} N, P_2O_5, K_2O	B_3. 120:45:40 kg ha^{-1} N, P_2O_5, K_2O
A_4 (0%) Crop residue	B_4. 25:60:30 kg ha^{1} N, P_2O_5, K_2O	B_4. 120:60:30 kg ha^{1} N, P_2O_5, K_2O

Table 2.5.1b Effect of different crop residue and nutrients levels on grain yield (kg ha^{-1}) of wheat

Residue levels	100% RDF (120:60:40)	75% N, 100% P, K	75% P, 100% N, K	75% K, 100% N, P	Mean
90%	7022	6667	6667	6744	6775.00
60%	6411	6544	6278	6233	6366.67
30%	6000	5689	5778	5778	5811.11
0%	5922	5578	5633	5728	5727.78
Mean	6338	6119	6088	6133	
CD 0.05					
Residue	357.984	** 1%			
Nutrient	357.984	NS			
Residue x Nutrient	715.968	NS			

Straw yield: The straw yield of wheat crop shows significant differences in because of different levels of crop residue retention. The maximum stove yield (11104 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 9604, 9460, 9060 kg ha^{-1} respectively and the lowest stover yield (9060 kg ha^{-1}) was observed in without residue. In case of various levels of nutrient applications, there was non-significant effect of nutrient doses on stover yield and the stover yield varied between (8984 to 10688 kg ha^{-1}). The interaction effect between residue levels and nutrient doses did not show any significant difference. (Table 2.5.1c). The highest stover yield (12608 kg ha^{-1}) recorded from 90% crop residue and treatment with 100% RDF which was at par with other residue levels. The lowest grain yield (7648 kg ha^{-1}) was observed in treatment without residue with 75% N, 100% P, K doses.

Plate 2.5.1a Wheat crop performance under different crop residue retention

Table 2.5.1c Effect of different levels of crop residue and nutrient doses on straw yield (kg ha^{-1}) of wheat

Residue levels	100% RDF (120:60:40)	75% N, 100% P, K	75% P, 100% N, K	75% K, 100% N, P	Mean
90%	12608	9520	10800	11488	11104.00
60%	9568	9760	9552	9536	9604.00
30%	9776	9008	9328	9728	9460.00
0%	10800	7648	8896	8896	9060.00
Mean	10688	8984	9644	9912	
CD 0.05					
Residue	1348.722	* 5%			
Nutrient	1348.722	NS			
Residue x Nutrient	2697.445	NS			

Response of different residue and nutrients levels on growth and yield attributes of Soybean crop

Seed yield: The grain yield of soybean crop shows significant differences as a result of different levels of crop residue retention. The maximum yield (1175 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 843, 676, 591 kg ha^{-1} respectively and he lowest grain yield (591 kg ha^{-1}) was observed in without residue. In case of various levels of nutrient applications, there was non-significant effect of nutrient doses on grain yield and the grain yield varied between (781 to 870 kg ha^{-1}). The interaction effect between residue levels and nutrient doses not show any significant difference effect on grain yield as a result of different residue levels and nutrient doses (Table 2.5.1d). The highest grain yield (1225 kg ha^{-1}) obtains from 90% crop residue and treatment with 100% RDF which was statistically at par with other residue levels. The lowest grain yield (580 kg ha^{-1}) was observed in without residue with 75% P, 100% N, K doses. (Plate 2.5.1b)

Table 2.5.1d Effect of different levels of crop residue retention and nutrient doses on grain yield of soybean (kg ha^{-1})

Residue levels	100% RDF (25:60:40)	75% N, 100% P, K	75% P, 100% N, K	75% K, 100% N, P	Mean
90%	1225	1059	1212	1208	1175.83
60%	963	803	848	768	845.42
30%	691	672	658	688	676.96
0%	603	590	580	593	591.75
Mean	870.42	781.04	824.25	814.25	
CD 0.05					
Residue	113.164	** 1%			
Nutrient	113.164	NS			
Residue x Nutrient	226.327	NS			

Straw yield : The straw yield of soybean crop shows no significant differences because of different levels of crop residue retention. The maximum stove yield (3171 kg ha^{-1}) was recorded in 90 % residue retention treatment, which was at par with rest of the residue levels and he lowest stover yield (2331 kg ha^{-1}) was observed in without residue. In case of various levels of nutrient applications, there was also non-significant effect of nutrient doses on Stover yield and the Stover yield varied between (2590 to 3096 kg ha^{-1}). The interaction effect between residue levels and nutrient doses not show any significant difference effect on Stover yield as a result of different residue levels and nutrient doses (Table 2.5.1e). The highest Stover yield (3801 kg ha^{-1}) recorded from 90% crop residue and treatment with 100% RDF that was statistically at par with other residue levels. The lowest grain yield (2113 kg ha^{-1}) was observed in 60% crop residue retention with 75% N, 100% P, K doses.

Table 2.5.1e Effect of different levels of crop residue retention and nutrient doses on straw yield of soybean (kg ha^{-1})

Residue levels	100% RDF (25:60:40)	75% N, 100% P, K	75% P, 100% N, K	75% K, 100% N, P	Mean
90%	3801	2877	3325	2683	3171.25
60%	3538	2113	2995	2449	2773.75

30%	2370	2791	2416	3034	2652.71
0%	2677	2582	2706	2562	2631.46
Mean	3096.25	2590.63	2860.42	2681.88	
CD 0.05					
Residue	499.134	NS			
Nutrient	499.134	NS			
Residue x Nutrient	998.267	NS			

Plate 2.5.1b Soybean crop performance under different crop residue retention

2.5.2 Effect of crop residue levels and herbicidal weed control on crop growth, productivity and soil health in zero-till chickpea-maize cropping system.

The experiment is ongoing under CRP on CA. Four levles of residue retention with four herbicide application based weed control treatments respectively comprising 16 combinations of treatments in each replications and replicated thrice were evaluated under maize–chickpea cropping system under conservation agriculture. (Table 2.5.2a)

Table 2.5.2a Crop residue levels and different herbicide treatments combinations

Factor. A↓/ Factor B→ Residue levels	Herbicide treatment	
A_1(90%)Crop residue	B_1. Imazethapyr @ 50 g a.i. ha^{-1} (as pre-emergence)	B_1.Tembotrione@120g a.i. ha^{-1}+Atrazin @ 1 kg a.i. ha^{-1} (as pre-emergence)
A_2(60%)Crop residue	B_2. Imazethapyr @ 50 g a.i. ha^{-1} (as pre-em) fb HW (50 DAS)	B_2.Tembotrione@120g a.i. ha^{-1}+Atrazin @ 625 g a.i. ha^{-1} (30 DAS)
A_3(30%)Crop residue	B_3. Imazethapyr @ 25 g a.i. ha^{-1}+Clodinafop @ 60 g a.i. ha^{-1} (30 DAS)	B_3.Tembotrione@180g a.i. ha^{-1}+Atrazin @1kg a.i. ha^{-1} (30 DAS)
A_4(0%)Crop residue	B_4. Imazethapyr @ 25g a.i. ha^{-1}+ Clodinafop @ 60g a.i. ha^{-1} (30 DAS) fb HW (50 DAS)	B_4.Tembotrione@120g a.i. ha^{1}+Atrazin @ 625g a.i. ha^{-1} (30 DAS) fb HW (50 DAS)

Response of different crop residue levels and herbicide treatments on grain yield of Chickpea crop

Grain yield: The grain yield (Table 2.5.2b) depicts significant effect as a result of different levels of crop residue retention. The maximum grain yield (1112.75 kg ha^{-1}) was recorded in 90% crop residue retention levels, which was at par with 60% crop residue retention (1108.84 kg ha^{-1}) and 30% crop residue retention (1063.64 kg ha^{-1}) and significantly superior over without residue retention treatment (970.01 kg ha^{-1}). In case of different herbicidal weed control treatments shows non-significant effect on the grain yield. The grain yield because of interaction effect between residue levels and herbicidal weed control treatments varied but could not attain the level of significance (Plate 2.5.2a).

Table 2.5.2b Response of different crop residue levels and herbicide treatments on grain yield of chickpea (kg ha^{-1})

	B1	B2	B3	B4	Mean of A
A1	1124.1	1414.5	1068.7	1216.0	1112.75
A2	1118.4	1335.5	1005.2	1001.0	1108.84
A3	1000.2	1193.3	999.3	1006.4	1063.64

A4	920.1	961.1	903.4	956.8	970.01
MEAN OF B	1040.69	1226.09	994.13	1045.07	
CD 0.05					
A	181.609	* 5%			
B	181.609	NS			
AB	363.218	NS			

Straw yield: The straw yield (Table 2.5.2c) shows non-significant difference because of different levels of crop residue retention. In case of different herbicidal weed control treatments shows non-significant effect on straw yield.

The straw yield because of interaction effect between residue levels and herbicidal weed control treatments varied but could not attain the level of significance.

Table 2.5.2c : Response of different residue levels and herbicide treatments on straw yield of chickpea crop (kg ha^{-1})

	B1	B2	B3	B4	Mean of A
A1	1641.4	2023.3	1574.4	1763.8	1750.70
A2	1649.5	1914.6	1461.0	1443.2	1617.06
A3	1461.1	1707.6	1493.7	1468.7	1532.77
A4	1374.6	1410.5	1387.1	1450.4	1405.67
MEAN OF B	1531.64	1763.98	1479.05	1531.54	
CD 0.05					
A	256.785	NS			
B	256.785	NS			
AB	513.571	NS			

Weed density : The data pertaining to weed density at harvest presented in Table 2.5.2d depicts significant effect on weed density because of different levels of crop residue retention. The maximum weed density (70.50 m^{-2}) was recorded in without residue retention level and significantly higher over 30% crop residue retention (50.67 m^{-2}), 60% crop residue retention (36.33 m^{-2}) and 90% crop residue retention treatment (30.83 m^{-2}).The different herbicidal weed control treatments have significant influence on weed density and maximum weed density (97.50 m^{-2}) was recorded under treatment Imazethapyr @ 50 g a.i. ha^{-1} (as pre-em) and significantly higher weed density over post-emergence application of treatment Imazethapyr @ 25 g a.i. ha^{-1} + Clodinafop @ 60 g a.i. ha^{-1} (44.67 m^{-2}), pre-emergence application of Imazethapyr @ 50 g a.i.ha^{-1} followed by one hand weeding at 50 days after sowing (23.00 m^{-2}) and post-emergence application of Imazethapyr @ 25 g a.i. ha^{-1} +Clodinafop @ 60 g a.i. ha^{-1} as post-emergence followed by one hand weeding at 50 days after sowing has lowest weed density (23.17 m^{-2}). The weed density because of interaction effect between residue levels and herbicidal weed control treatments varied but could not attain the level of significance.

Table 2.5.2d Effect of different levels of crop residue retention and herbicidal weed control treatments on weed density under chickpea at harvest (Nos. m^{-2})

	B1	B2	B3	B4	Mean of A
A1	66.7	15.3	27.3	14.0	30.83
A2	81.3	16.7	31.3	16.0	36.33
A3	100.7	25.3	50.7	26.0	50.67
A4	141.3	34.7	69.3	36.7	70.50
MEAN OF B	97.50	23.00	44.67	23.17	
CD 0.05					
A	6.846	** 1%			
B	6.846	** 1%			
AB	13.692	** 1%			

Plate 2.5.2a Chickpea crop performance under different crop residue retention

Response of different crop residue levels and herbicide treatments on growth and yield of maize crop

Grain yield: The grain yield (Table 2.5.2e) depicts significant effect as a result of different levels of crop residue retention. The maximum grain yield (7028.08 kg ha^{-1}) was recorded in 90% crop residue retention level and significantly superior over 60% crop residue retention (6469.83 kg ha^{-1}), 30% crop residue retention (5851.25 kg ha^{-1}) and without residue retention treatment (5220.75 kg ha^{-1}). The different herbicidal weed control treatments has significant influence on grain yield and maximum grain yield (6353 kg ha^{-1}) was recorded under treatment post-emergence application of Tembotrione @ 120g a.i.ha^{-1} +Atrazin @ 625g a.i.ha^{-1} followed by one hand weeding at 50 days after sowing which was at par with post-emergence application of Tembotrione@180g a.i.ha^{-1}+Atrazin @ 1000g a.i.ha^{-1} (6249 kg ha^{-1}) and significantly superior over Tembotrione @ 120g a.i.ha^{-1}+Atrazin@1000g a.i.ha^{-1} as a pre-emergence (6016 kg ha^{-1}) and Tembotrione@120g a.i.ha^{-1}+Atrazin@625g a.i.ha^{-1} without hand weeding (5952 kg ha^{-1}). The grain yield because of interaction effect between residue levels and herbicidal weed control treatments varied but could not attain the level of significance.

Table 2.5.2e Response of different residue levels and herbicide treatments on grain yield of maize crop (kg ha^{-1})

	B1	B2	B3	B4	Mean of A
A1	6996.7	6916.3	7096.0	7103.3	7028.08
A2	6421.3	6318.7	6446.3	6693.0	6469.83
A3	5494.7	5479.3	6215.3	6215.7	5851.25
A4	5150.0	5091.7	5237.7	5403.7	5220.75
MEAN OF B	6015.67	5951.50	6248.83	6353.92	
CD 0.05					
A	300.428	** 1%			
B	300.428	* 5%			
AB	600.856	NS			

Straw yield : The straw yield (Table 2.5.2f) depicts significant effect because of different levels of crop residue retention. The maximum straw yield (10252 kg ha^{-1}) was recorded in 90% crop residue retention level and significantly superior over 60% crop residue retention (9836 kg ha^{-1}), 30% crop residue retention (9223 kg ha^{-1}) and without residue retention treatment (8702 kg ha^{-1}). The different herbicidal weed control treatments has significant influence on straw yield and maximum straw yield (9743 kg ha^{-1}) was recorded under treatment post-emergence application of Tembotrione @ 120 g a.i. ha^{-1} + Atrazin @ 625 g a.i. ha^{-1} followed by one hand weeding at 50 days after sowing which was at par with post-emergence application of Tembotrione @ 180 g a.i. ha^{-1} + Atrazin @ 1000 g a.i. ha^{-1} (9570 kg ha^{-1}) and significantly superior over Tembotrione @ 120 g a.i. ha^{-1} + Atrazin @ 1000 g a.i. ha^{-1} as a pre-emergence (9349 kg ha^{-1}) and Tembotrione @ 120 g a.i. ha^{-1} + Atrazin @ 625 g a.i. ha^{-1} without hand weeding (9351 kg ha^{-1}). The straw yield because of interaction effect between residue levels and herbicidal weed control treatments varied but could not attain the level of significance.

Table 2.5.2f Response of different residue levels and herbicide treatments on straw yield of maize crop (kg ha^{-1})

	B1	B2	B3	B4	Mean of A
A1	10189.7	10187.3	10213.3	10418.7	10252.25
A2	9562.0	9527.3	10117.0	10139.3	9836.42
A3	8896.3	9025.0	9338.7	9630.0	9222.50
A4	8746.0	8664.7	8610.7	8785.0	8701.58
MEAN OF B	9348.50	9351.08	9569.92	9743.25	
CD 0.05					
A	308.854	** 1%			
B	308.854	* 5%			
AB	617.708	NS			

Weed biomass: The weed biomass (Table 2.5.2g) depicts significant effect because of different levels of crop residue retention. The maximum weed biomass (700.8 kg ha^{-1}) was recorded in without residue retention level and significantly higher over 30% crop residue retention (595.0 kg ha^{-1}), 60% crop residue retention (433.3 kg ha^{-1}) and 90% crop residue retention treatment (380.0 kg ha^{-1}). The different herbicidal weed control treatments has significant influence on weed biomass and maximum weed biomass (755.0 kg ha^{-1}) was recorded under treatment Tembotrione @ 120 g a.i. ha^{-1} + Atrazin @ 1000 g a.i. ha^{-1} as a pre-emergence and significantly higher weed biomass over post-emergence application of Tembotrione @ 120 g a.i. ha^{-1} + Atrazin @ 625 g a.i.ha^{-1} without hand weeding (635.8 kg ha^{-1}), post-emergence application of Tembotrione @ 180 g a.i. ha^{-1} + Atrazin @ 1000 g a.i. ha^{-1} (498.3 kg ha^{-1}) and post-emergence application of Tembotrione @ 120 g a.i. ha^{-1} + Atrazin @ 625 g a.i. ha^{-1} followed by one hand weeding at 50 days after sowing has lowest weed biomass (220.0 kg ha^{-1}). The weed biomass because of interaction effect between residue levels and herbicidal weed control treatments varied but could not attain the level of significance.

Plate 2.5.2b Maize crop performance under different crop residue retention

Table 2.5.2g Response of different residue crop levels and herbicide treatments on weed biomass at harvest under maize crop (kg ha^{-1})

	B1	B2	B3	B4	Mean of A
A1	547	487	373	113	380.0
A2	600	580	380	173	433.3

A3	820	700	600	260	595.0
A4	1053	777	640	333	700.8
MEAN OF B	755.0	635.8	498.3	220.0	
CD 0.05					
A	92.78	** 1%			
B	92.78	** 1%			
AB	185.57	NS			

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

Two cropping systems namely soybean-wheat and maize-chickpea were evaluated for various parameters under various tillage and 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. The soil Bulk density at 0-5 cm. & 5-10 cm. in all the treatments under both the cropping system was recorded without any variation. Soil pH and EC values were also observed without any variation among various treatments under both the cropping system. The runoff losses were observed higher with maize, these losses varied from 12.43 to 27.69 percent under various tillage and crop residue treatments. However, these were 12.46 to 23.76% with soybean crop. The soil loss was varied from 0.41 to 3.5 t ha^{-1} with soybean crop under various tillage and residue levels, while it was 0.46 to 3.73 t ha^{-1} with maize crop. The runoff loss and soil loss were highest with conventional tillage treatment under both the cropping system. The mean weight diameter (mm) of aggregate varied from 0.83 to 0.91 among the treatments under soybean-wheat system however, under maize –chickpea system it was 0.82 to 0.88. The average mean weight diameter was recorded comparatively higher with no tillage with 60% residue treatment (Table 2.5.3, Plate 2.5.3 a & b).

Table 2.5.3 Micro-nutrients concentration in runoff soil

Treatment	Concentration (ppm)			
	Soybean-Wheat			
	Cu	Zn	Mn	Fe
1-Conventional tillage	2.08	4.78	26.78	11.78
2-Reduced tillage with 30% residue	1.08	6.98	27.30	7.06
3- Reduced tillage with 60% residue	1.32	6.86	28.12	7.34
4- No tillage with 30% residue	1.28	7.27	26.32	6.90
5- No tillage with 60% residue	1.20	6.95	19.12	7.44
	Maize- Chickpea			
1-Conventional tillage	1.50	3.93	25.64	8.18
2-Reduced tillage with 30% residue	1.56	4.28	23.12	9.34
3- Reduced tillage with 60% residue	2.02	4.92	28.14	11.64
4- No tillage with 30% residue	0.84	9.27	25.58	8.08
5- No tillage with 60% residue	1.72	2.78	20.98	14.86

Plate 2.5.3a Soybean crop during Kharif

Plate 2.5.3b Maize Crop during Kharif

2.5.4 Development of Efficient Water and Nutrient Management Practices for Soybean-Wheat System under Conservation Agriculture

To evaluate the performance of different irrigation, tillage and nutrient management packages and to identify the most suitable irrigation and nutrient management package for soybean-wheat cropping system under conservation agriculture in Vertisols of central India, field experiments on soybean-wheat cropping system was conducted since 2018. During the rainy season soybean was grown with three fertilizer management treatments *viz*. 100% RDF, 75% RDF, STCR and three tillage treatments *viz*. CT- Conventional tillage, RT-Reduced tillage and NT- No tillage.

Wheat 2020-2021

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). Measured amount of irrigation water was applied in each of the irrigation treatment plots. Flood irrigated plots in wheat received 5 post sowing irrigations and a seasonal total of 314 mm water was applied. In sprinkler irrigation plots a measured total amount of 251 mm water (about 80% of the flood irrigation) was applied through micro sprinklers at twice a week interval, while in drip irrigation treatment a seasonal total of 188 mm of irrigation water (about 60% of the flood irrigation water) was applied through drip system at alternate day interval throughout the season. Better temporal distribution of irrigation water and consequently better profile moisture distribution could be attained in sprinkler and drip systems with less but more frequent irrigation water application to wheat. Perusal of data showed that, the plant height, plant tiller number, root weight per tiller, grain yield, and straw yield of wheat did not vary significantly among the irrigation, tillage and fertilizer treatments. However, leaf area index measured at 45 DAS was found to be significantly higher in sprinkler and drip irrigations compared to that in flood irrigation. Similarly, water use efficiency (WUE) was significantly higher under drip irrigation than the sprinkler and flood irrigation. The WUE was lowest under flood irrigation, which was significantly lower than that under sprinkler irrigation (Table 2.5.4a). The soil temperature in both soil depth (0-5 and 5-15 cm) at 7 AM and 2 PM were also non-significant among the irrigation methods, tillage system and different nutrient doses and interaction of irrigation methods, tillage system and nutrient doses (Table 2.5.4b). Thus, higher water productivity was attained under drip and sprinkler system of irrigation compared to that under flood irrigation where losses of water through surface evaporation, deep drainage was higher. Conservation agricultural system-maintained yield level on par with the conventional agricultural practices with concomitant savings of time, labour and input cost and improvement in soil health parameters and sustainability of yield (Plate 2.5.4a).

Table 2.5.4a Effect of irrigation methods, tillage systems and nutrients doses on grain yield, straw yield and water use efficiency of wheat crop

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
Irrigation methods			
Flood	5026	5786	12.3
Sprinkler	4893	5731	13.7
Drip	4964	5849	16.8
LSD (0.05)	NS	NS	0.72
Tillage systems			
CT	5054	5799	14.6
RT	4903	5720	14.1
NT	4927	5848	14.2
LSD (0.05)	NS	NS	NS
Nutrients Doses			
100% RDF	5091	5628	13.9
75% RDF	4921	5857	14.3
STCR Dose	4854	5861	14.6
LCC	4977	5811	14.2
LSD (0.05)	NS	NS	NS

Table 2.5.4b Effect of irrigation methods, tillage systems and nutrients doses on diurnal variation of soil temperature in 0-5 and 5-15 cm soil depth

Treatment	Soil temperature (⁰C) (30 DAS)			
	7 AM		2 PM	
	Surface (0-5 cm)	Sub-Surface (5-15 cm)	Surface (0-5 cm)	Sub-Surface (5-15 cm)
Irrigation methods				
Flood	17.4	18.4	24.1	23.0
Sprinkler	17.5	18.6	23.2	22.0
Drip	17.5	18.5	23.1	22.0
LSD (0.05)	NS	NS	NS	NS
Tillage systems				
CT	17.4	18.4	23.7	22.5
RT	17.3	18.4	23.5	22.5
NT	17.7	18.7	23.1	21.9
LSD (0.05)	NS	NS	NS	NS
Nutrients Doses				
100% RDF	17.5	18.4	23.4	22.4
75% RDF	17.4	18.6	23.5	22.3
STCR Dose	17.4	18.4	23.5	22.4
LCC Dose	17.5	18.6	23.4	22.2
LSD (0.05)	NS	NS	NS	NS

Plate 2.5.4a Wheat crop grown under flood, sprinkler and drip irrigation systems

Soybean Crop 2021

During 2021, the field experiment conducted on soybean crop in kharif season. There were three levels of fertilizer treatments (F1=100 % RDF, F2=75% DRF, F3=STCR and three levels of tillage treatment (CT-Conventional tillage, RT-Reduced tillage and NT- No tillage) were tested in kharif season. The soybean variety of JS-2029 was sown in month of June 28, 2021 and harvested in the month of October, 2021. The observations on growth and crop yield were recorded under the tillage systems and nutrient doses treatments. All the tillage systems treatments were significantly similar. The grain and straw yield of soybean (657 and 3292 kg ha^{-1}) was slightly higher under reduced tillage system as compared conventional tillage. The lowest grain and straw yield were recorded under no tillage (594 and 2747 kg ha^{-1}) but all the tillage systems were significantly at par. Similarly, in case of fertilizer treatments, the STCR dose recorder slightly higher grain yield of soybean (636 and 3136 kg ha^{-1}) followed by 100% RDF and less yield was in 75% RDF (609 and 2883 kg ha^{-1}). However, all the fertilizer treatments were also significantly at par. The interaction effect of tillage systems and different nutrient doses was found non- significant difference (Table 2.5.4c). Other growth parameters were also found non-significant among tillage systems and different nutrient doses. The soil temperature of both soil depth (0-5 and 5-15 cm) at 7 AM and 2 PM were also found non - significant differences under tillage systems and different nutrient doses as well as interaction effect of tillage system and nutrient doses were no significance differences (Table 2.5.4d). Conservation agricultural system-maintained yield level on par with the conventional agricultural practices with concomitant savings of time, labour and input cost and improvement in soil health parameters and sustainability of yield.(Plate 2.5.4b)

Table 2.5.4c Effect of tillage systems and nutrients doses on grain and straw yield of soybean

	Soybean grain yield (kg ha^{-1})				**Soybean straw yield (kg ha^{-1})**			
	F1	F2	F3	Mean	F1	F2	F3	Mean
CT	604	643	657	635	3016	2979	2954	2983
RT	654	618	653	642	3221	3055	3599	3292
NT	620	565	598	594	2771	2615	2854	2747
Mean	626	609	636		3002	2883	3136	
	Tillage: NS, Nutrient Dose: NS, Tillage x Fertilizer dose: NS				Tillage: NS, Nutrient Dose: NS, Tillage x Fertilizer dose: NS			

Table 2.5.4d Effect of tillage systems and nutrients doses on soil temperature in soil depths

	Soil temperature (^{0}C) (0-5 cm)							
	7 AM				2 PM			
	F1	F2	F3	Mean	F1	F2	F3	Mean
CT	18.2	18.9	17.9	18.3	37.8	37.3	37.9	37.7
RT	19.5	20.3	20.2	20.0	38.1	37.0	35.9	37.0
NT	19.8	20.6	19.8	20.0	36.8	33.0	36.3	35.3
Mean	19.1	19.9	19.3		37.6	35.8	36.7	
	Tillage: NS, Nutrient Dose: NS, Tillage x Fertilizer dose: NS				Tillage: NS, Nutrient Dose: NS, Tillage x Fertilizer dose: NS			

	Soil temperature (^{0}C) (5-15 cm)							
	7 AM				2 PM			
	F1	F2	F3	Mean	F1	F2	F3	Mean
CT	19.4	20.3	21.3	20.3	27.2	27.5	27.6	27.4
RT	20.8	21.4	21.6	21.3	27.4	27.5	26.8	27.3
NT	21.2	21.3	21.1	21.2	27.0	26.5	26.8	26.8
Mean	20.4	21.0	21.3		27.2	27.2	27.1	
	Tillage: NS, Nutrient Dose: NS, Tillage x Fertilizer dose: NS				Tillage: NS, Nutrient Dose: NS, Tillage x Fertilizer dose: NS			

Plate 2.5.4b Establishment of soybean under conservation tillage system

2.5.5 Soil moisture estimation through remote sensing for agricultural drought monitorint and early warming

Evaluation of different satellite-derived soil moisture products

The satellite-derived daily volumetric soil moisture content data for the year 2020 was acquired from Soil Moisture Active Passive (SMAP), European Space Agency Climate Change Initiative Soil Moisture (ESA CCI SM), and Advanced Microwave Scanning Radiometer 2 (AMSR-2). The surface and root zone soil moisture product layer from SMAP L4_SM, surface soil moisture at both AM and PM pass from SMAP L3_SM_P_E, both active and passive combined surface soil moisture from ESA CCI SM, surface soil moisture content from C1 (6.9GHz), C2 (7.3GHz) and X (10.7GHz) bands from both ascending and descending pass of AMSR2 was downloaded and processed to derive the soil moisture for Bhopal, Shajapur and Sehore districts of Madhya Pradesh. The temporal variation of the SMAP L4 product shows that the root zone soil moisture content is comparatively higher than surface soil moisture content for all these three districts with lesser variation (Fig. 2.5.5a). The temporal variation of surface soil moisture derived from all these satellite products shows that soil moisture data from C1 and X bands of AMSR-2 are of poor quality as their values don't fall within the acceptable soil moisture range whereas the data from ESA CCI, SMAP L3 and C2 band of AMSR-2 appears to be fine and within the acceptable range (Fig. 2.5.5b). The correlation coefficient among all these products was computed for each district. There was a good correlation among SMAP L4 surface and root zone soil moisture, SMAP L3 SMPE AM pass, SMAP L3 SMPE PM pass, and ESA CCI soil moisture, but a comparatively weak correlation with AMSR-2 products (Fig. 2.5.5c). These products need to be evaluated with the observed soil moisture data for getting their accuracy and robustness.

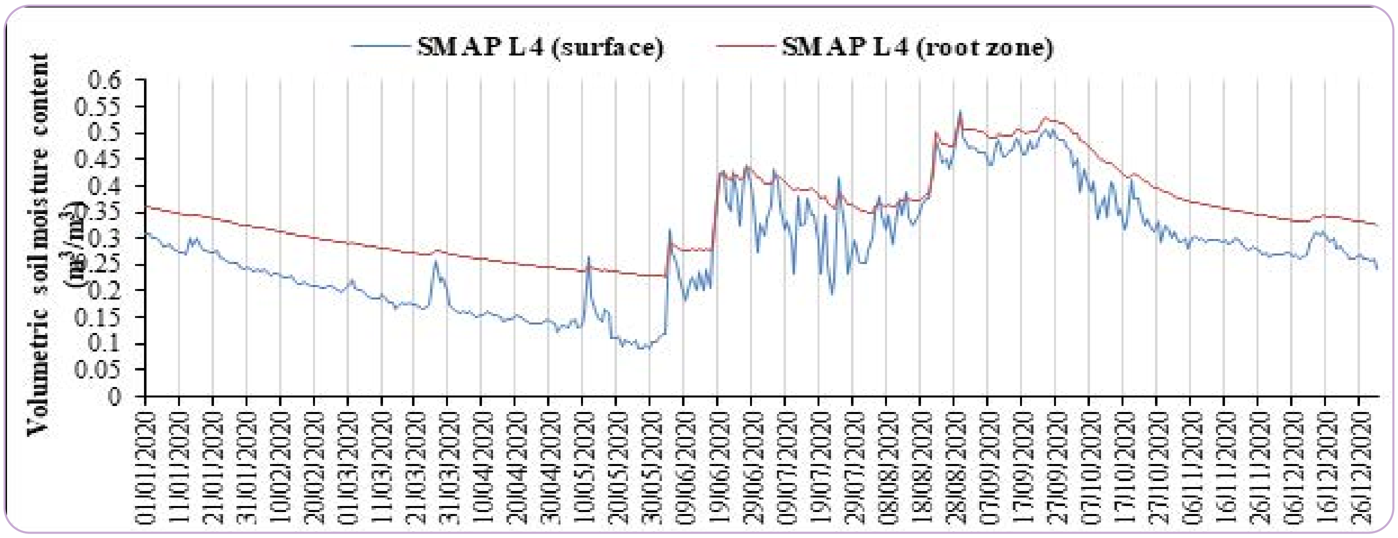


Fig.2.5.5a Temporal variation of surface and root zone volumetric soil moisture content derived from SMAP L4 product of Bhopal district for the year 2020

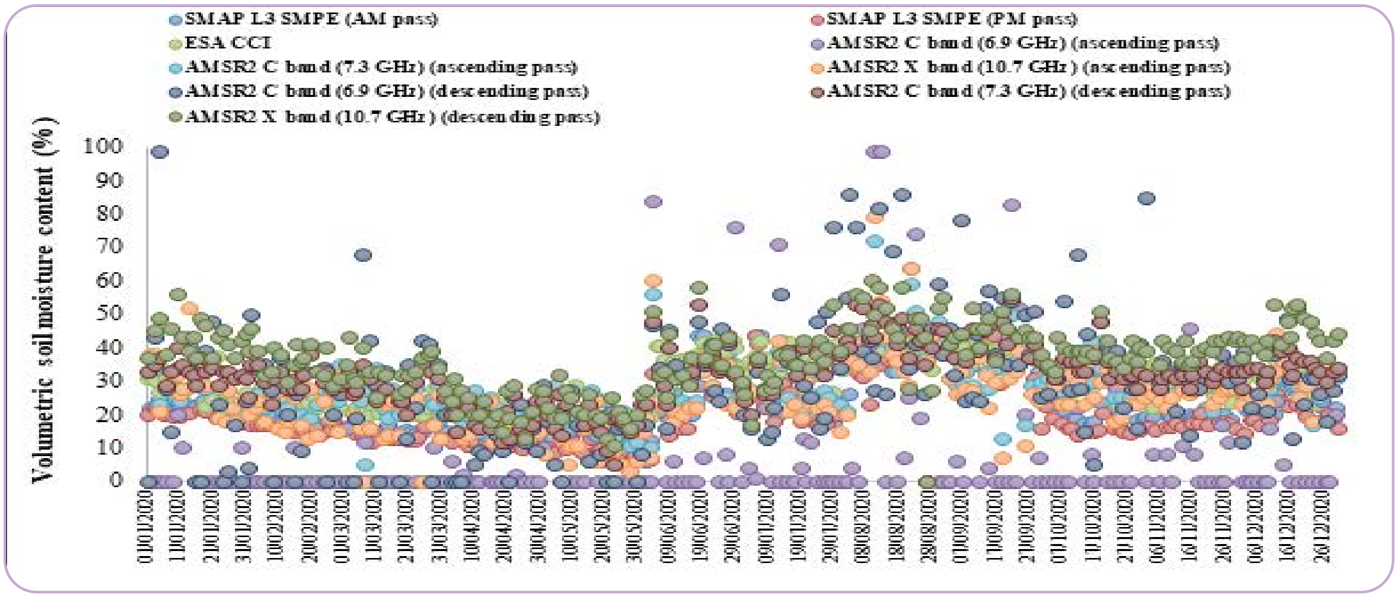


Fig. 2.5.5b Temporal variation of near-surface soil moisture content from different satellites of Bhopal district for the year 2020

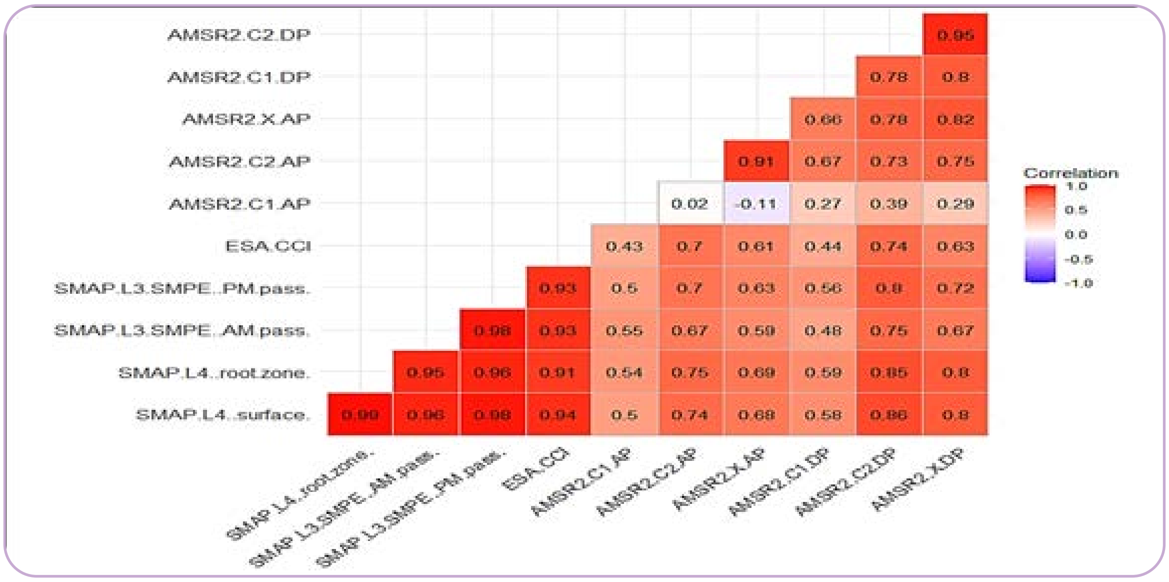


Fig. 2.5.5c Correlation between different satellite-derived soil moisture products for Bhopal

Spatio-temporal variation in near-surface soil moisture content of Madhya Pradesh

In this study, the 40 years (1980 to 2019) data of ESA CCI near-surface volumetric soil moisture content was downloaded and processed to study its spatio-temporal variation across different agro-climatic regions of Madhya Pradesh. The monthly mean soil moisture content was computed, of which trend analysis was carried out using the Mann-Kendall trend test and Sen's slope estimation. It was found that the volumetric soil moisture content during kharif season ranged from 0.25 to 0.34 m^3 m^3 whereas, for rabi season, it ranged from 0.15 to 0.24 m^3 m^3. The monthly pattern of soil moisture variation matches well with the seasonal pattern of water availability i.e. more soil moisture during monsoon while less during summer season. The highest and lowest soil moisture was found in the Chhattisgarh plains and Bundelkhand zone, respectively during both kharif and rabi cropping seasons. Kharif cropping season shows positive while rabicropping season shows a negative trend in soil moisture content.

The positive trend was found during April, May, June, July, September, October, November and December, while the negative trend was during January, February, March and August. This information can be useful for climate change studies and the management of water resources for agriculture in Central India (Fig 2.5.5d)

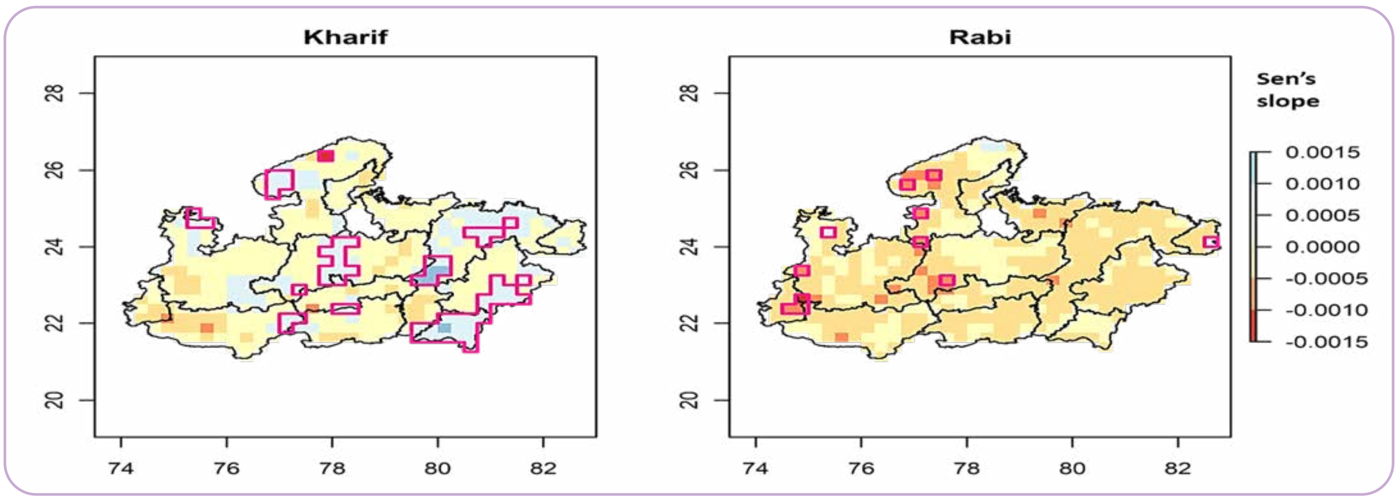
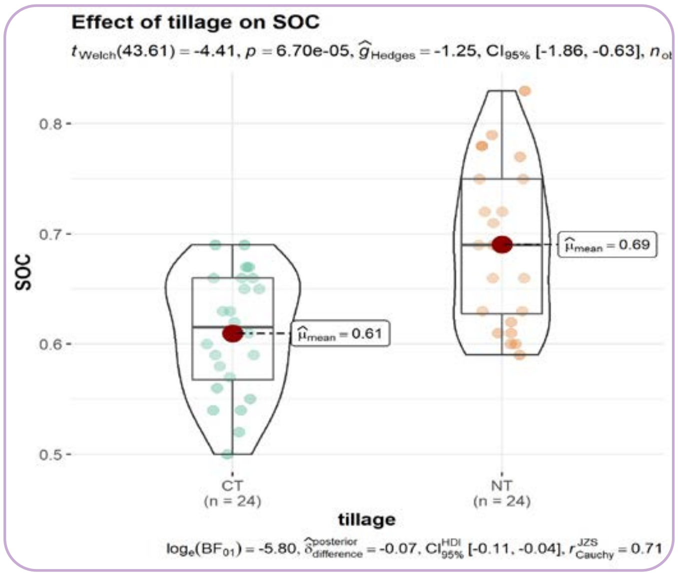


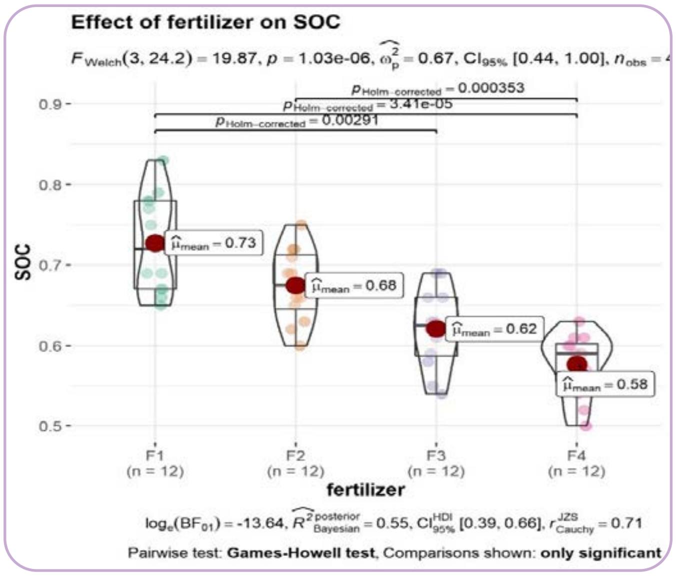
Fig. 2.5.5d The near-surface soil moisture trend during kharif and rabi cropping seasons of Madhya Pradesh across different agro-climatic zones as derived from 40 years data of ESA CCI soil moisture product. The pixels within pink boxes show a significant trend.

2.5.6 Modelling soil carbon staroge and dynamics in different agro ecosystem of India under the changing climate scenario

Tillage, Cropping System and Nitrogen Management Effect on Soil Quality and Crop Productivity in a Medium-deep Vertisol

Maintaining soil health is vital for sustainable agriculture and ecosystem services, which is a challenging task in the semi-arid region. This study aimed to generate information on the effect of long-term tillage and nitrogen management practices on soil properties and soil quality under the maize–wheat (CS1) and maize–chickpea (CS2) systems in a Vertisol. Treatments consist of two types of tillage (no-tillage, NT; conventional tillage, CT) and CS and four nitrogen (N) levels (F1-150%N, F2-100%N, F3-50%N and F4-0%N) were conducted. Composite soil samples were collected at 0–5 cm and 5–15 cm depth after six crop cycles, analyzed, and assessed soil quality (SQ)using the multivariate statistical approach. The SOC concentration increased by 13% and 21% at surface soil in NT than CT (Fig.2.5.6a). The SOC content is significantly affected by the tillage, cropping system and nitrogen management affect. The higher available N, P, K and enzyme activities were recorded under NT in maize–wheat than CT. The principal component analysis clearly separated the treatments in the space defined by the first two principal components (Fig 2.5.6b). The SOC is identified as the most important indicator for SQ evaluation. Results highlighted that long–term NT with 100% N application in maize–wheat system could be a viable option for improving SQ, crop yield, and C– storage in Vertisol of semi-arid regions.





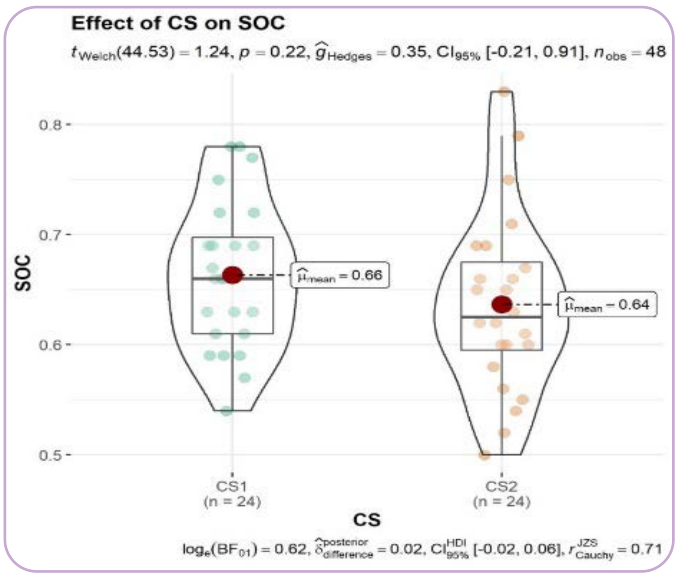
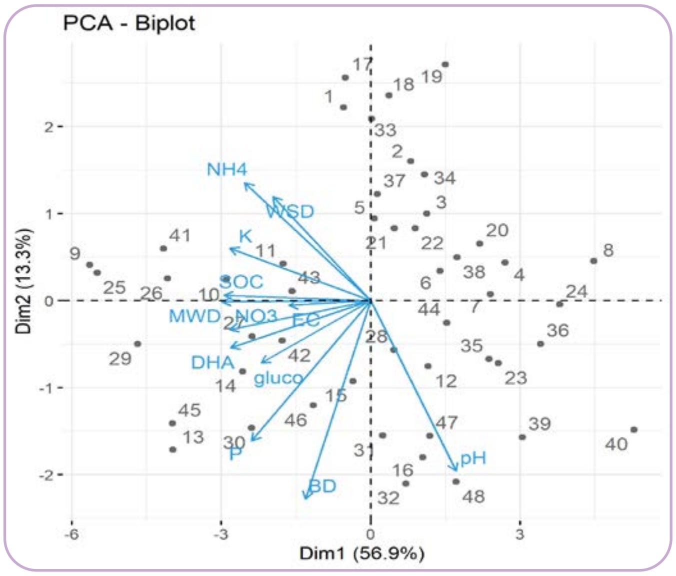


Fig. 2.5.6a Effect of tillage, cropping system and fertilizer on soil organic carbon



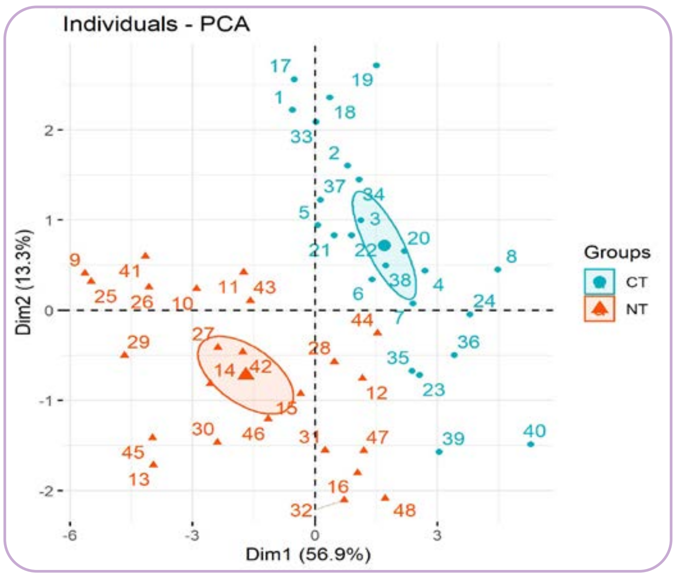
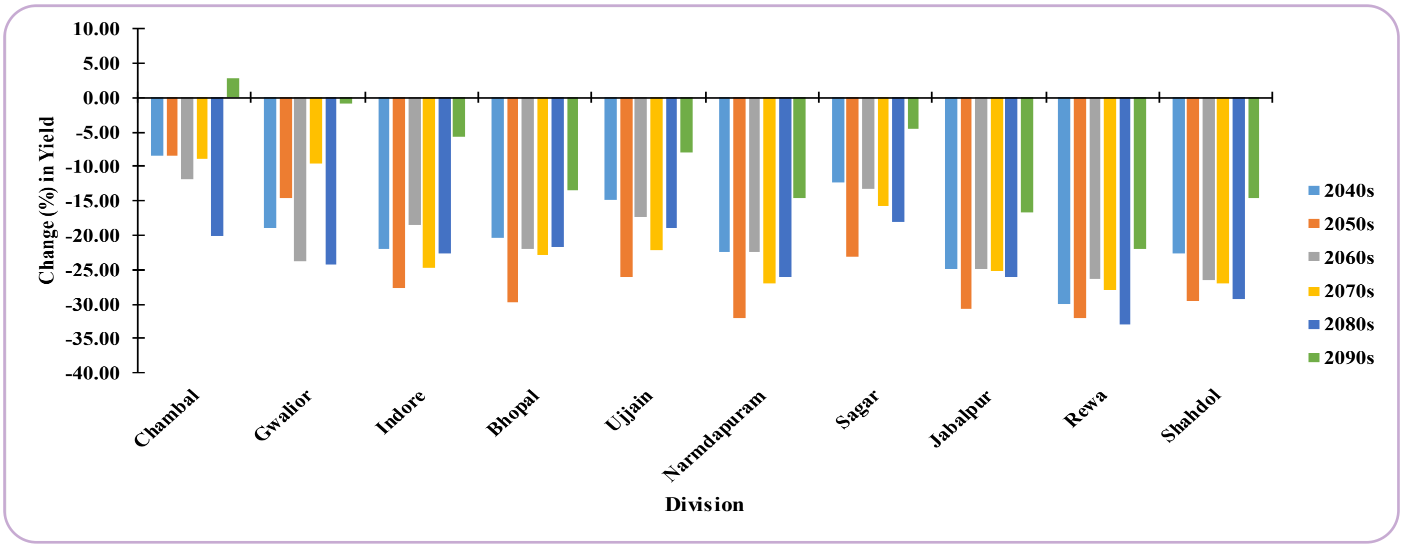


Fig. 2.5.6b Principal component (PC) analysis of the studied variables after 6 years of experimentation

2.5.7 Climate change impacts on water productivity of major crops in Central India

Decadal analysis of impact of future climate on soybean and maize production in Central India

The decadal impact of climate change on soybean and maize productivity (Fig. 2.5.7a) was performed using a well calibrated and tested APSIM model in central India using the ensemble global climate models (GCM). The GCMs, namely BCC-CSM1-1, BCC-CSM1-1-M, GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, GISS-E2-H, and GISS-E2-R, were ensembled to generate future climate data (2040–2090) for central India, under scenarios RCP4.5 and RCP8.5. The trend of decrease in soybean yield was followed as Rewa > Shahdol > Jabalpur > Narmadapuram >Bhopal division; however, for the maize, the trend followed as Chambal>Gwalior>Jabalpur>Rewa>Sagar.Overall, a decrease of up to 45% of wheat grain yield and 27% of chickpea yield were reported in varying decades under the RCPs studies. However, the chickpea yield was seen an increasing trend in Chambal division.



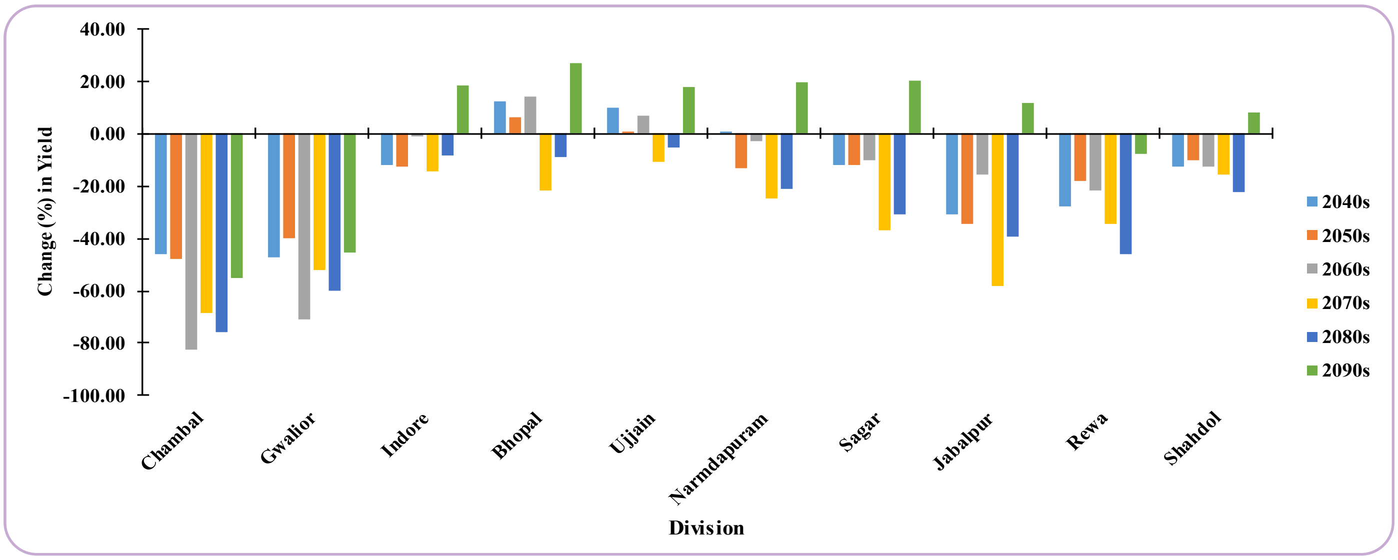


Fig. 2.5.7a Decadal change in soybean and maize yield in different division of Madhya Pradesh under the influence of climate change

Assessing yield gap of pigeon pea crop: A Pan India Analysis

Pigeon pea [*Cajanus cajan* (L.) Millspaugh] is an important pulse crop primarily grown in Asia, Africa, and Latin America. India is considered the primary center of origin of pigeon pea and accounts for approximately 90% of the world's total production. However, the national productivity of pigeon pea is as low as 700 kg ha^{-1}. Within the genetic limits, crop yield determines by environment x management interaction. Understanding the weather and yield relationship will determine the best time to apply specific management practices to maximize crop yield. Therefore, a yield gap (Yg) analysis is a foundation for identifying the soil and management factors limiting current farm yields and improved practices to close the gap. The APSIM-Pigeon pea module was used to analyze the yield potential under irrigated conditions in 63 pigeon pea growing locations in the country. These locations are classified into primary, secondary, and tertiary production zones based on the area and production of pigeon peas. The results from primary districts revealed that yield potential (Yp) was (2328 kg ha^{-1}) compared to water-limited yield potential (Yw) (1749 kg ha^{-1}). The actual yield recorded in the primary district was 734 kg ha^{-1} (Ya). In secondary and tertiary zones, Yp were 2299 and 2411 kg ha^{-1} compared to 1779 and 1579 kg ha^{-1} under Yw, respectively. However, the Ya for secondary and tertiary zones were 759 and 642 kg ha^{-1}, respectively. In primary, secondary, and tertiary production, the Yg was reported 1594, 1539 and 1768 kg ha^{-1}, respectively (Fig.2.5.7b).

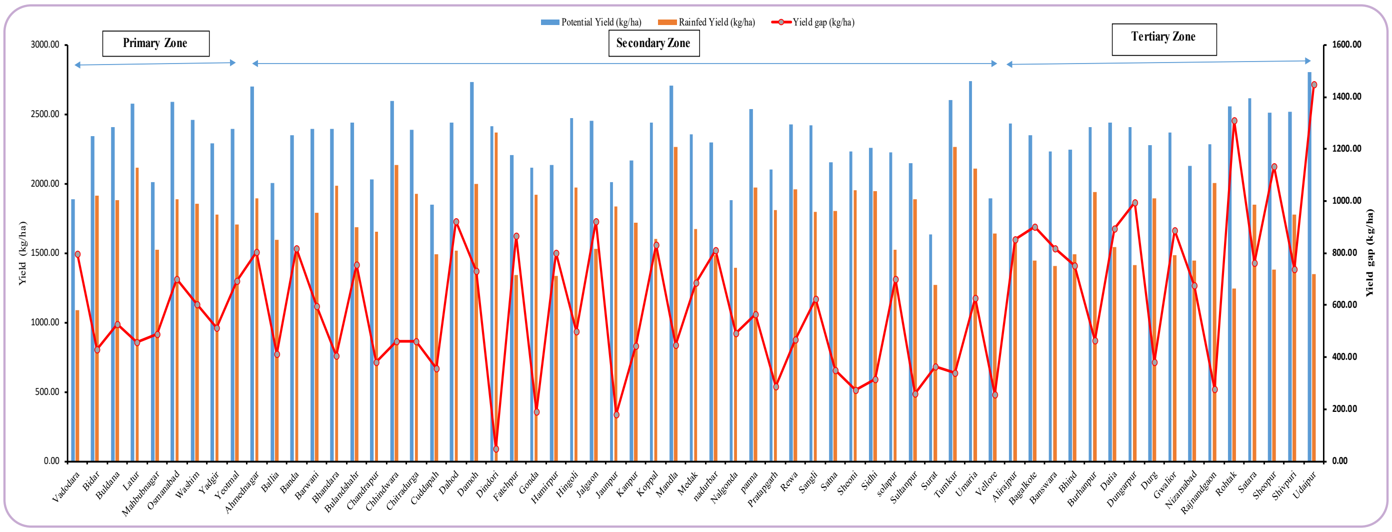
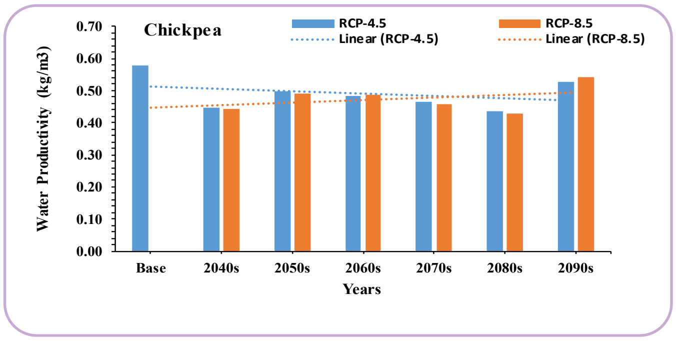
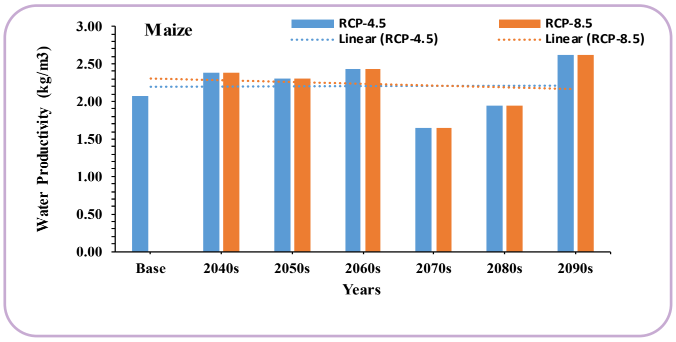


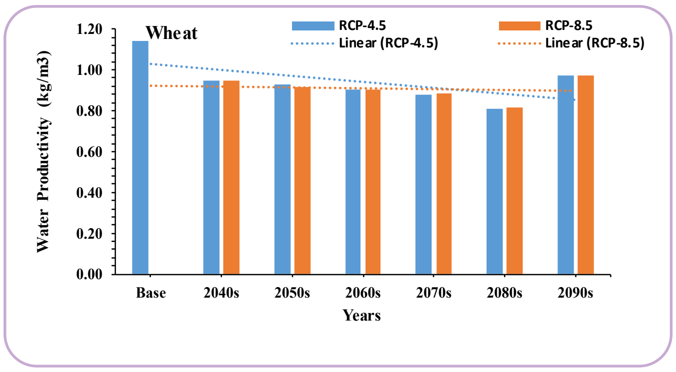
Fig. 2.5.7b Yield gap in pigeon pea growing districts of India

Assessing climate change impact on crop water productivity in central India.

Climate change is a real threat to agriculture and food security. Impact assessments on climate change are essential for the evaluation vis a vis development of the adaptation strategies. This study evaluated climate change impacts on chickpea, wheat, maize, and soybean water productivity in central India. The Agricultural Production Systems sIMulator (APSIM) coupled with GCM data were used to assess the climate change impact on water productivity. The average water productivity of chickpea, wheat, maize, and soybean was recorded at 0.58, 1.10, 0.36, and 2.00 kg m^{-3}, respectively, for the base time (1980-2010). Overall, a decrease in water productivity is reported for chickpea, wheat, and soybean crop; however, an increase in water productivity was reported for maize crops under the future climate scenarios. The decrease in water productivity for chickpea, wheat, and soybean was reported at 19%, 21%, and 16%, respectively; however, an increase of 7% in water productivity was reported for the different RCPs and time slices (Fig.2.5.7c).







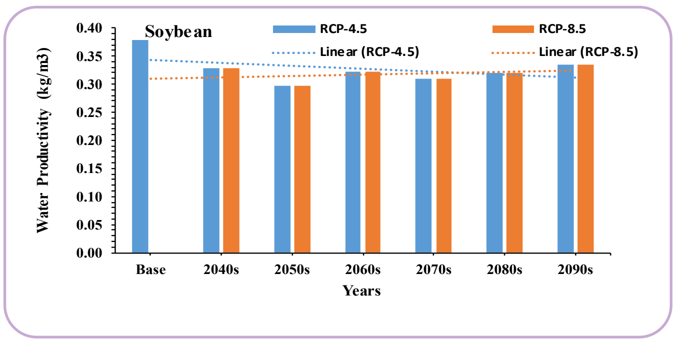
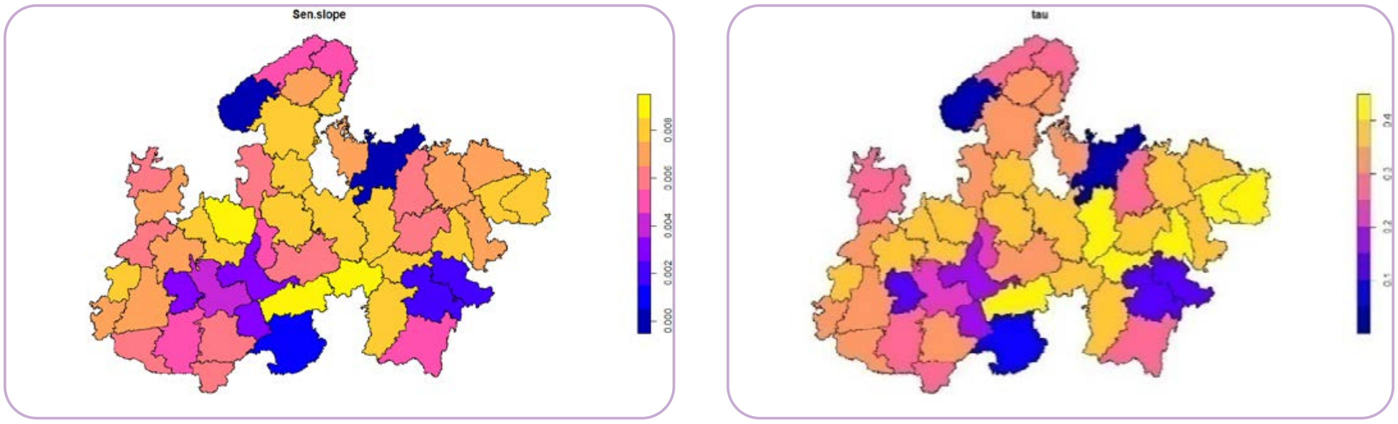


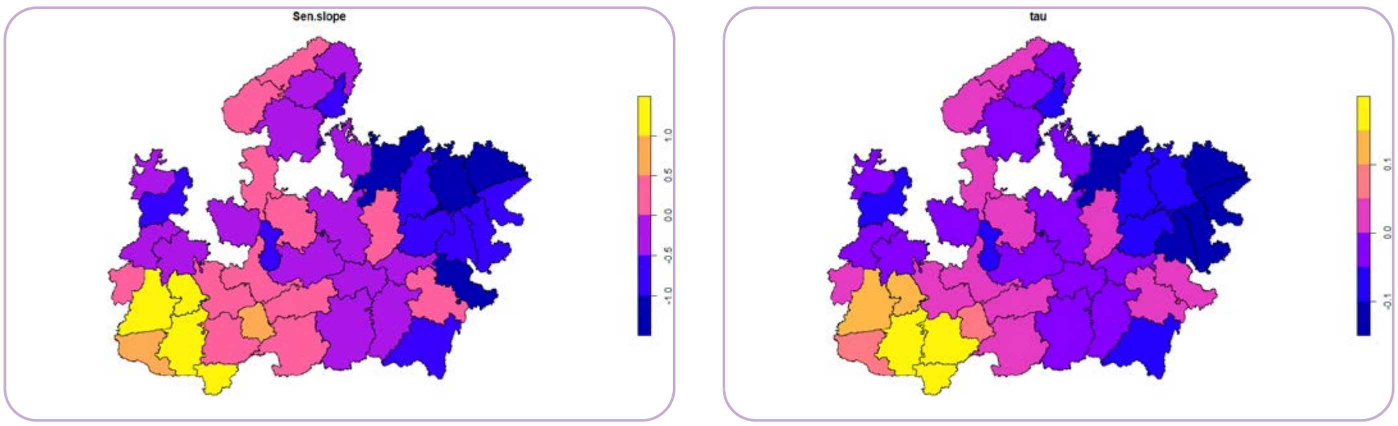
Fig. 2.5.7c Water productivity of different crops under the climate change scenario

Trend analysis of rainfall and temperature pattern in central India

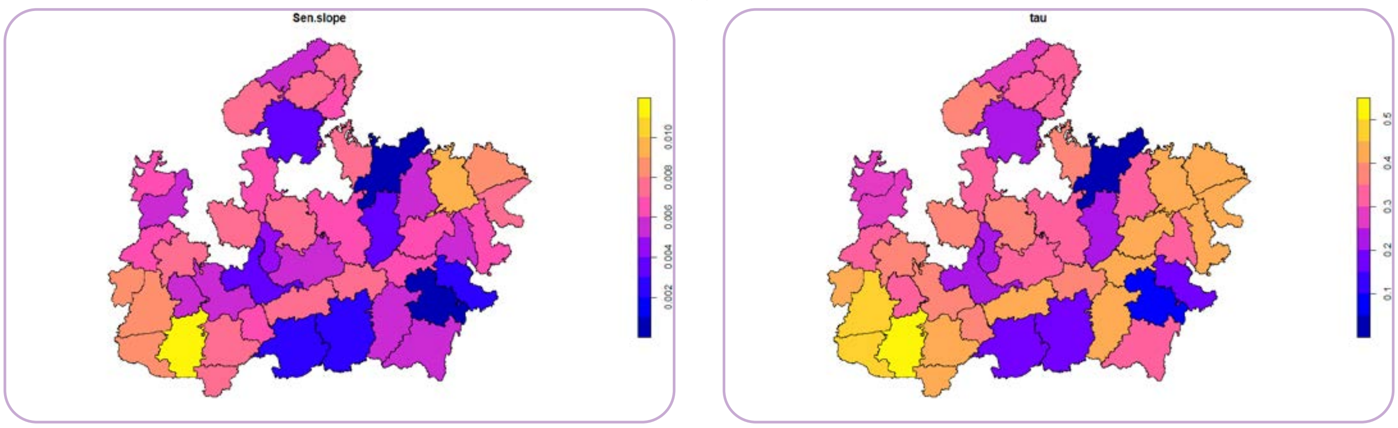
Climate variability, particularly the annual air temperature and rainfall, has received great attention worldwide. The magnitude of the fluctuations of the factors varies with location. Therefore, examining the spatiotemporal dynamics of meteorological variables in the context of changing climate is vital to assess climate-induced changes and suggest feasible adaptation strategies. The present study examines long-term changes (1900-2016) inrainfall and maximum and minimum temperature over central India. The monthly rainfall and temperature data were used in this study. Statistical trend analysis techniques, namely Mann–Kendall test and Sen's slope estimator, were used to examine the trend in monthly temperature and rainfall data. The tau value indicates the change direction in climatic variables, whereas the sen's slope quantifies the changes. The increase in maximum temperature is significant over Madhya Pradesh except for Betul, chindwarra, Chhatarpur, and Sehoni districts. The minimum temperature increased significantly over the state except for the Chindwarra and Mandla districts. However, increasing and decreasing trends for rainfall were observed for the different districts, but the rainfall changes over time are non-significant (Fig. 2.5.7d).



(a)



(b)



(c)

Fig. 2.5.7d Kendall's tau and Sen slope of (a) MaxT, (b) MinT and (c) Rainfall for the trend analysis over central India.

2.5.8 Impact of Climate change on soil tropical process in maize based cropping system in Vertisol of Central India

Controlled increased temperature of Soil on water retention and structure in the Vertisols of Central India

A laboratory study was undertaken to evaluate the effect of controlled increased temperature on soil physical processes such as water-stable aggregates and water content at 0.33 bar and 15 bars. For this brought the soil sample and subjected to gradually increasing temperature *viz*. 42, 44, 48, 54 and 60°C for 8 days in the incubator. It was found that the effect is significant however the water content at field capacity (0.33 bar) was 4-5% higher than the mean average of lower temperature at 60°C while the water content at Permanent wilting point (15 bar) was slightly decreased from the mean average of lower temperature (Fig.2.5.8a). The effect of this increased temperature was also studied on the water-stable aggregates and it was found that the effect was not significant however 3-4% decrease in the aggregate stability at 60°C.

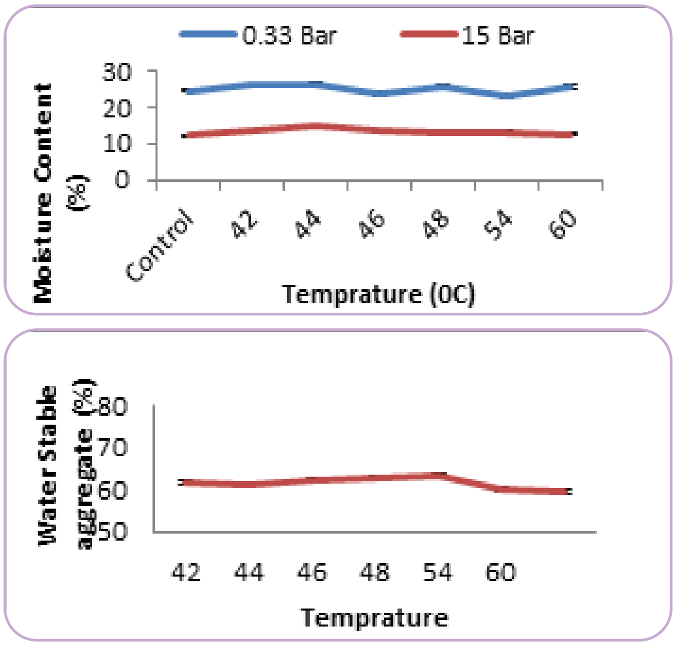


Fig. 2.5.8a Effect of tillage on moisture content and aggregate

Impact of tillage on soil temperature maize based cropping systems in vertisols of Central India

A study was undertaken to evaluate the effect of tillage and N management on soil temperature the result revealed during the initial phase of the rabi season from the December to February when the temperature is very low the tillage and N management does not show any significant effect while during the march and onwards when the temperature has increased beyond the 25°C the tillage had shown a moderating effect of approximately 2°C at both the soil layer (Fig.2.5.8b).

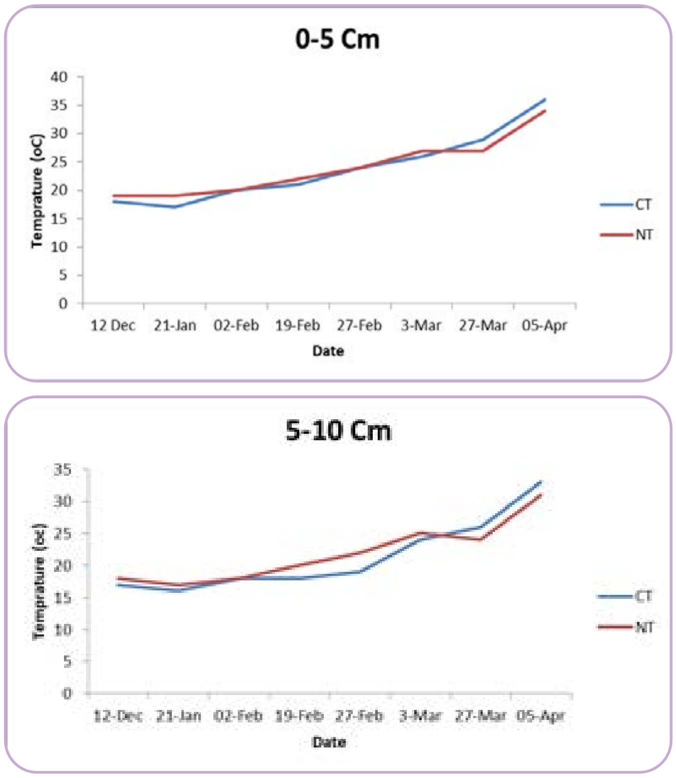


Fig. 2.5.8b Effect of tillage on soil temperature

Soil nitrous oxide fluxes and mineral nitrogen influenced by short term tillage of long-term conservation till soil in Vertisols

After four growing seasons of tillage reversal, in twelve years conservation tillage and nutrient management experiment, the results demonstrated tillage reversal was associated with higher N_2O emissions but was significantly higher only in no tillage converted to conventional tillage (NT-CT) with 100% NPK + FYM @ 2.0 Mg-C ha^{-1} than no tillage (NT) and reduced tillage (RT). Regardless of tillage, integrated use of nutrients was associated with higher growing season soil N_2O emissions and higher levels of soil mineral N. The Nitrous oxide emission factors ranged from 0.75 to 1.20 (Fig. 2.5.8c). Reversal of tillage NT-CT and reduced tillage converted to conventional tillage (RT-CT) was found to have higher NH_4^+-N content in surface soil up to 30 cm depth. Integrated use of inorganic and organic fertilizer (T4) registered a significant increase in NH_4^+-N concentration up to 60 cm soil depth. Measurements in profile nitrate in RT-CT-T4 were significantly higher than NT-CT-T1 before sowing and just after sowing. However, afterward (grand growth, dough, and harvest stage), NT-T1 had significantly higher soil profile nitrate than other treatments, especially RT-CT-T1. The results suggested that the likely increase in soil nitrous oxide emission on tillage reversal in no-till plots (NT-CT) could offset the increased carbon sequestration in surface soil layers of no-till treatment but not in reduced till the soil

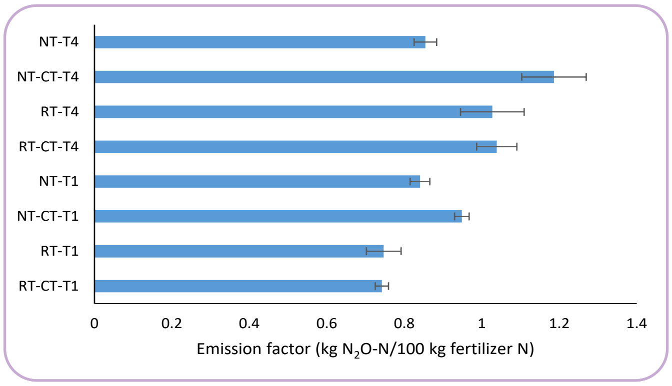
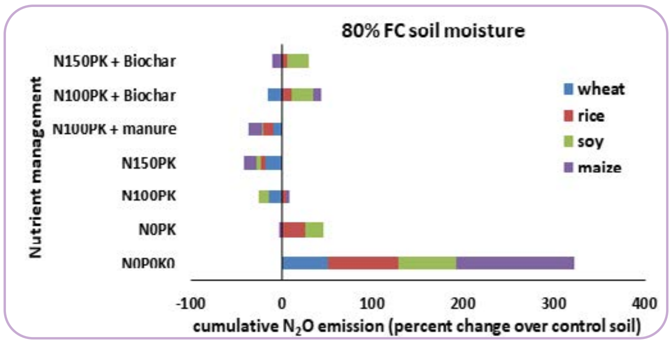


Fig. 2.5.8c The emission factor for each applied nutrient and tillage combination

Nutrient management drives the direction and magnitude of nitrous oxide flux in crop residue returned soil under different soil moisture

We used a laboratory-based soil incubation to test the response of nitrous oxide (N_2O) emission to crop residue type, soil moisture, and how nutrient management modulates these responses. In this study, we incorporated crop residues with different qualities (wheat, rice, soybean, and maize) at two soil moisture {80% field capacity (FC) and 60% FC} and under seven nutrient levels: $N_0P_0K_0$ (no nutrients), N_0PK, $N_{100}PK$, N150PK, $N_{100}PK$+manure@ 5 Mg ha^{-1}, $N_{100}PK$ + biochar@ 5 Mg ha^{-1}, $N_{150}PK$+ biochar@ 5 Mg ha^{-1}. The results demonstrated significant ($p<0.01$) differences in the magnitude of N_2O emissions among treatments. $N_{100}PK$ and $N_{150}PK$ at 80% FC mitigated N_2O emission by approximately 20% in wheat residue amended soil (cf. control soil without residue). In contrast, maize residue amendment (cf. control soil) increased N_2O emission by 130% under $N_0P_0K_0$ and 80% FC. Residue effects were negatively correlated with C: N ratio, and a strong positive correlation ($p<0.01$) was obtained between N_2O emission and CO_2 respiration, labile carbon, mineral N and residue total nitrogen (TN). The addition of residues (cf. control soil) without nutrients significantly increased N_2O emissions. However, cumulative fluxes of N_2O decreased by 6 to 17% when maize and wheat residues (cf. control soil) were applied with nutrients (Fig. 2.5.8d). Negative fluxes of N_2O indicating consumption were observed in every treatment after 57 days of incubation and were most pronounced in control soil without residue and nutrients. Decreasing the soil moisture from 80% FC to 60% FC, the N_2O consumption rate increased by 6.6 times across residue types and nutrient management.



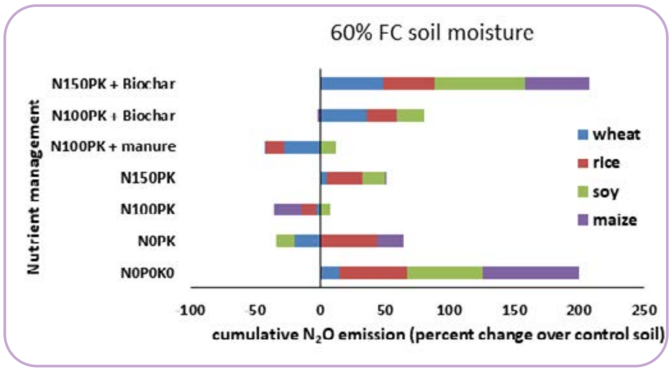


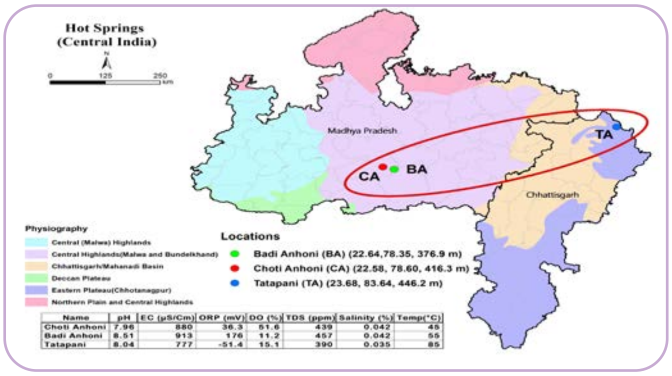
Fig. 2.5.8d The comparative change in cumulative soil nitrous oxide flux in residue-returned soil over residue-control soil under different residue, nutrients, and soil moisture levels after 87 days of incubation.

Theme -III: Microbial Diversity and Genomics

2.6 Microbial Diversity and Genomics

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

Water, mat and soil samples were collected from three hotsprings of Central India viz. Choti Anhoni (CA), Badi Anhoni (BA) and Tatapani (TA) Hotsprings (Fig. 2.6.1).



Name	pH	EC (µS/Cm)	ORP (mV)	DO (%)	TDS (ppm)	Salinity (%)	Temp(°C)
Choti Anhoni	7.96	880	36.3	51.6	439	0.042	45
Badi Anhoni	8.51	913	176	11.2	457	0.042	55
Tatapani	8.04	777	-51.4	15.1	390	0.035	85

Fig.2.6.1 Spatial distribution of three hotsprings (sampling sites) of Central India and water chemical characteristics

From Tatapani hot spring, 8 morphologically distinct bacterial isolates were obtained of which, 5 were found to be Gram-positive and 3 isolates were Gram- negative. These isolates are being screened for lignocellulolytic activities for preparation of microbial consortia for composting of agri-residues.

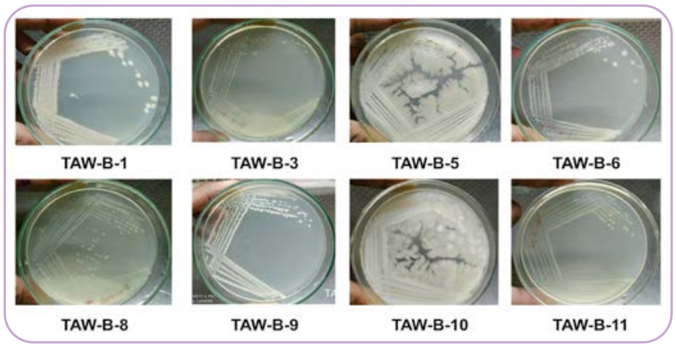


Plate 2.6.1a Bacterial isolates form Tatapani Hot spring on Nutrient Agar (NA) medium

The isolates from Anhoni Hotsprings of Central India were also evaluated for Plant Growth Promoting (PGP) properties coupled with heat tolerance to find efficient bioinoculum for improving plant growth under stress conditions.

Inoculation of thermophilic bacterial strain to Redgram could improve the root and shoot growth under controlled growth chamber experiment (Plate 2.6.1a and b).

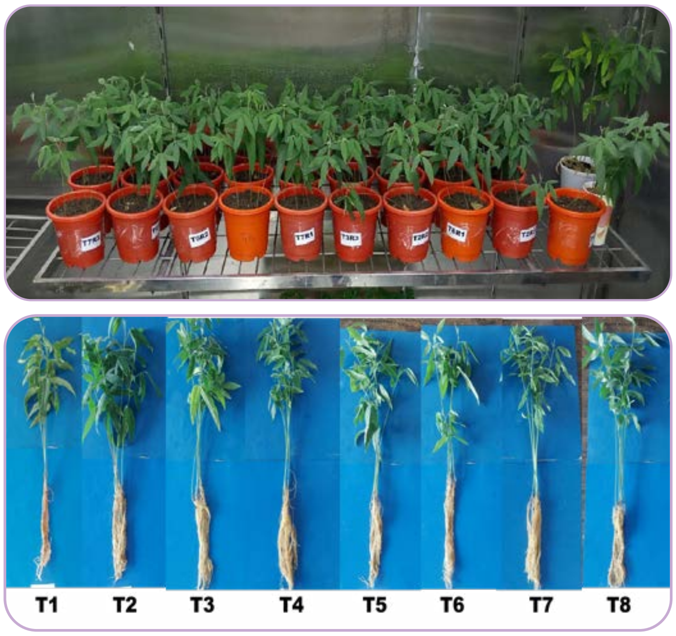


Plate 2.6.1b Plant growth promoting potential of the thermophilic bacteria isolated from Anhoni hotsprings of central India in Pigeon Pea (*Cajanus Cajan*)

2.6.2 Importance of carbon dioxide as an essential component for methane consumption in soil ecosystem

To know the role of CO_2 on methanotrophy, CH_4 consumption was evaluated under different initial concentration of CO_2 (ambient to 50000 ppm) and CH_4(1000 ppm or 10000 ppm). In general CO_2 stimulated CH_4 consumption. The rate of CH_4 consumption (ng CH_4 consumed g^{-1} soil d^{-1}) varied from 0.283 to 0.481 at 1000 ppm of CH_4 and 2.958 to 4.994 at 10000 ppm of CH_4. CO_2 production from CH_4 consumption (ng CO_2 produced g^{-1} soil) varied from 194 to 331 at 1000 ppm CH_4 and 139 to 272 in 10000 ppm of CH_4. However, CO_2 production was lower at higher CH4 concentration, indicated that CO_2 was used up by methanotrophs. Abundance of methanotrophs (pmoA gene copies g^{-1} soil) ranged from 4.5 x 10^5 to 10^7 x 10^5 g^{-1} soil. Linear regression models predicted CH_4 consumption potential ($P \leq 0.05$) under the influence of different CO_2 concentrations. A follow up experiment carried out to evaluate CH_4 consumption under presence or absence of CO_2, which proved that CO_2 is essential for CH_4 consumption. Results indicated that CO_2 is a precursor molecule for CH_4 consumption as it is essential for serine pathway and this pathway is key to overall CH_4 consumption (Fig. 2.6.2). Study defined that methanotrophs carry out mitigation of both greenhouse gases, CH_4 and CO_2

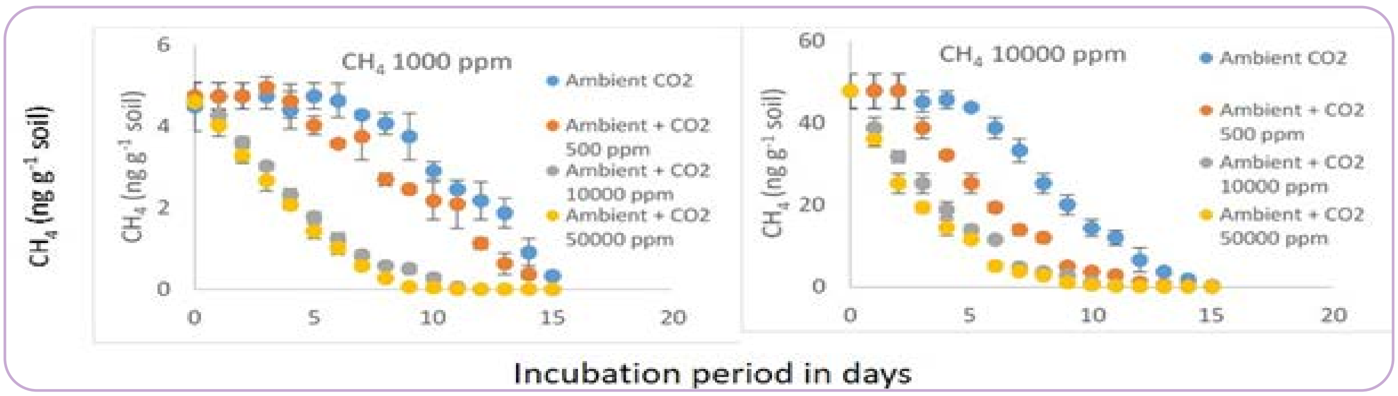


Fig. 2.6.2 CO_2 production from CH_4 consumption (ng CO_2 produced g^{-1} soil) at 1000 ppm CH_4 10000 ppm of CH_4

2.6.3 Methane in rhizosphere influences legume-rhizobia interaction

Experiments were conducted to evaluate the effect of CH_4 on the legume-rhizobia symbiosis in soybean and pigeon pea at rhizospheric CH_4 concentrations 0 ppm (control), 50 ppm and 200 ppm. Soil's CH_4 consumption potential or rate increased due to CH_4 enrichment. CH_4 consumption rate (ng CH_4 consumed g^{-1} soil d^{-1}) increased from 3.50 at 0 days after sowing (DAS) to 7.27 at 45 DAS in case of soybean (Table 2.6.3a). Shoot biomass, root biomass, and nodule number of soybean decreased by 35%, 54% and 55% respectively at 200 ppm of CH_4 than control. Similarly, in case of pigeon pea shoot biomass, root biomass, and nodule number of pigeon pea decreased by 40%, 48% and 45% respectively at 200 ppm of CH_4 than control Acetylene reduction activity (ARA) of nodules was inhibited by 30% in soybean and 35% in pigeon pea at 200 ppm CH_4. Abundance of pmoa gene copies increased by 2.37 folds (Table 2.6.3b) while nifH gene copies decreased by 0.53 folds under 200 ppm CH_4. Follow up experiments with pure cultures of rhizobia indicated that CH_4 did not affect multiplication of rhizobial cells. Further the effect of CH_4 on nodulation efficiency of rhizobia showed reduced nodulation of rhizobial cells by 25% in pigeon pea and 52% in soybean due to CH_4. Study highlight that occurrence of CH_4 in soil ecosystem can inhibit the productivity of legumes by affecting nodulation and N_2fixation (Fig. 2.6.3).

Table 2.6.3a CH_4 consumption rate (k) of rhizospheric soil of soybean and pigeon pea enriched with CH_4

Crop	CH_4 (ppm)	CH_4 consumption rate k (ng CH_4 consumed g^{-1} soil d^{-1})			
		0DAS	15DAS	30DAS	45DAS
Soybean	0	3.50±0.10a	4.01±0.31e	4.63±0.19e	5.20±0.25e
	50	3.50±0.10a	4.65±0.09b	5.44±0.12b	5.98±0.25c
	200	3.50±0.10a	5.25±0.07a	6.51±0.25a	7.27±0.30a
Pigeon pea	0	3.50±0.10a	3.90±0.14f	4.32±0.17f	4.81±0.26f
	50	3.50±0.10a	4.23±0.15d	4.89±0.12d	5.37±0.15d
	200	3.50±0.10a	4.30±0.16c	5.15±0.13c	6.10±0.16b

Table 2.6.3b Abundance of methanotrophs and nitrogen fixers in the rhizospheric soil of soybean and pigeon pea enriched with CH_4.

Crop	CH_4 (ppm)	pmoA (x 10^5 gene copies g^{-1} soil)		nifH (x 10^5 gene copies g^{-1} soil)	
		0 DAS	30 DAS	0 DAS	30 DAS
Soybean	0	11±1.258a	25±2.500e	48±2.449a	86±4.546a
	50	11±1.258a	40 ±3.916c	48±2.449a	31±1.732d
	200	11±1.258a	80±5.944a	48±2.449a	15±2.449f
Pigeon pea	0	11±1.258a	19±1.002f	48±2.449a	67±3.594b
	50	11±1.258a	33±3.317d	48±2.449a	46±4.796c
	200	11±1.258a	57±4.655b	48±2.449a	26±3.873e

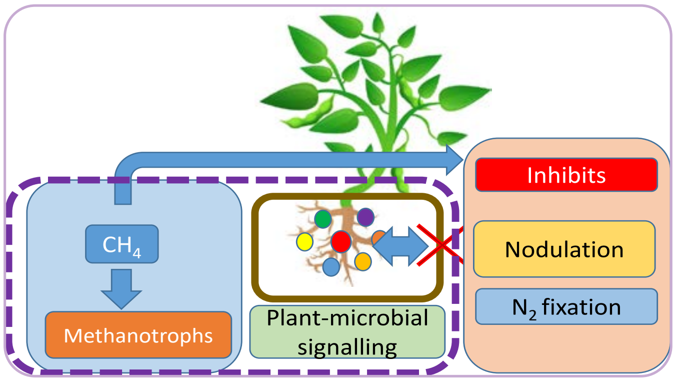


Fig. 2.6.3 Possible mechanism of reduced nodulation in legumes in presence of CH_4

CH_4 can affect symbiosis by two means. First, by inhibiting multiplication of N_2 fixers and second, by affecting association of N_2 fixers with plant roots for nodulation. CH_4 may affect growth of N_2 fixers by interfering the interaction process between cell surface bound enzymes and N_2, affecting nitrogen fixation. CH_4 can also affect the plant-microbial signaling process and inhibit nodulation.

2.6.4 Effect of soil types on plant growth promoting endophytic and rhizoplane bacterial diversity of wheat

Experiments were carried out to evaluate the change in rhizoplane and endophytic microflora of same host when grown on three different soils *viz.* Vertisols (Table 2.6.4), Inceptisols and Alfisols, using Amplified Ribosomal DNA Restriction Analysis (ARDRA) fingerprinting technique with HaeIII restriction endonuclease and BOX PCR technique. Total 27 morphologically distinct isolates were obtained from rhizoplane and root tissue of wheat which was accommodated in nine clusters based on the restriction profile analysis (Fig. 2.6.4). There was similarity in band pattern from rhizoplane and endophyte isolates indicating ability of strongly rhizoplane colonizing isolate to establish as endophyte. Difference occurred in the endophytic flora of same host grown in different soil types with few of the common organisms in host of all the soil types. The isolates were also evaluated for their plant growth promoting attributes and six isolate could grow on nitrogen free medium, fifteen isolate solubilized P from tricalcium phosphate, nine isolate solubilized potassium from glauconite and five had zinc solubilizing ability (Plate 2.6.4).

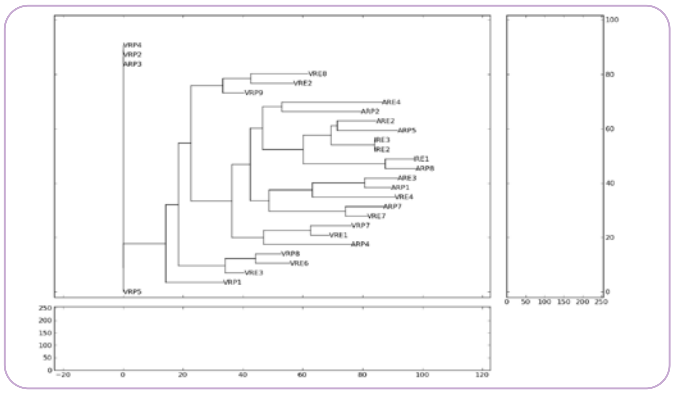


Fig. 2.6.4 Molecular diversity of root associated microbes of wheat grown on different soil types using ARDRA

Plate 2.6.4 Solubilization of Zn from ZnO by wheat root colonizing bacteria

Table 2.6.4 Details of PGPR attributes of root associated bacteria isolated from wheat grown in different soil types

Soil types	No. of Isolates	N-Fixation	Growth on Fe-P	Growth on Al-P	Growth on Ca-P	K -Solubilization from Glauconite	Zn-Solubilization from ZnO
Vertisols	14	5	12	0	10	3	2
Alfisols	10	0	5	0	3	5	3
Inceptisols	3	1	2	1	2	1	0

2.6.5 Low cost Media for Mass Multiplication of Fungal Bioinoculum

A low cost media is developed for mass multiplication of fungal cultures screened and used for enhancing composting of organic wastes by Soil Biology Division. The new media supported the growth and sporulation of fungal cultures such as *Trichoderma asperellum* isolate IISS-F1, *Aspergillus niger* isolate IISS-F2, *Rhizopus oryzae* isolate IISS-F3 and *Aspergillus flavus* isolate IISS-F4 (Plate 2.6.5). It is being evaluated for more fungal species used in agriculture. The new medium (IISS-mycoF) contains locally available materials such as jaggery and wheat bran, thus the formulation will reduce the cost of bioformulation and mass multiplication of fungal inoculums can be done at local level with minimum dependence on costly chemicals ensuring multiplication and supply of bioinoculum at even remote places.

a. *Trichoderma asperellum* isolate IISS-F1

b. *Aspergillus niger* isolate IISS-F2

c. *Rhizopus oryzae* isolate IISS-F3

d. *Aspergillus flavus* isolate IISS-F4

Plate 2.6.5a, b, c and d Growth of fungal cultures in Potato Dextrose Broth (PDB) and new media formulation from IISS (IISS-mF)

2.6.6 Development of microbial decomposer capsules for *in situ* decomposition of rice wheat residue

Decomposer capsule is a microbial consortia consist of four fungi (each capsule contain one fungal species) having ability to decompose the crop residue rapidly in pit as well as in the field (Plate 2.6.6). The capsule is activated in jaggery and wheat bran solution (Bran-Sugar solution) and can be sprayed in field containing residue or in compost pits to enhance decomposition process.

Plate 2.6.6 Microbial decomposer capsule for recycling of farm waste and crop residues

2.6.7 Exploring endophytic fungi for bioremediation of heavy metals

A study was conducted to explore the potential of endophytic fungi isolates belong to genera; Fusarium (EAca-1, ECgi-2 and ECto-4), Curvularia sp. (ECzi-1) and *Aspergillus lavus* (Esac-1) (Fig. 2.6.7) against different haeavy metals and showed tolerance and its growth in the presence of Pb, Cd, Cr and Hg (Table 2.6.7). The fungi isolated also characterized for plant growth promoting potential. The fungal isolates, EDst-1, EAca-1 and ECto-4 showed 56.06,48.67 and 43.58 µg/ml of IAA production respectively. In terms of siderophore production, fungal isolates, EDst-1, ECzi-1, ECzi-2, EPhy-1 and EXst-1 shows formation of orange zone. Fungal isolates, EDst-1, EXst-1 and ECzi-2 showed phosphate solubilizing potential. But most promising one was EDst-1 which shows clear visible halo zone around the colony (Plate 2.6.7 a & b).

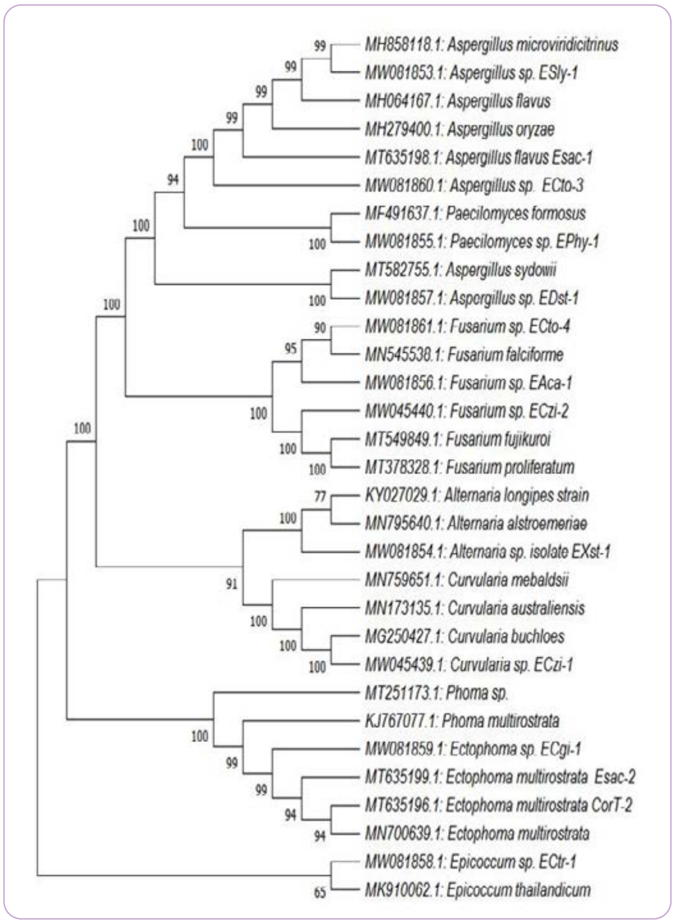


Fig. 2.6.7 Phylogenetic tree showing the relation between endophytic fungal isolates and other closely related species

Table 2.6.7 Heavy metal tolerance index (TI) of fungal isolates

Name of Fungal endophytes	% of Tolerance index			
	Pb (%)	Cr (%)	Hg (%)	Cd (%)
Paecilomyces sp. EPhy-1	150^{a} 36.33_{b}	150^{a} 62.4_{b}	50^{a} 88.06_{b}	50^{a} 60.6_{b}
Alternaria sp. EXst-1	150^{a} 70.79_{b}	100^{a} 53.14_{b}	50^{a} 58.42_{b}	25^{a} 86.8_{b}
Fusarium sp. EAca-1	150^{a} 120.83_{b}	100^{a} 159.32_{b}	50^{a} 124.74_{b}	50^{a} 173.1_{b}
Aspergillus sp. ESly-1	150^{a} 58.04_{b}	150^{a} 106.75_{b}	50^{a} 87.76_{b}	25^{a} 57.9_{b}
Curvularia sp. ECzi-1	150^{a} 120.09_{b}	150^{a} 92.5_{b}	25^{a} 104.55_{b}	50^{a} 108.9_{b}
Fusarium sp. ECzi-2	200^{a} 133.36_{b}	100^{a} 103.07_{b}	25^{a} 83.57_{b}	50^{a} 111.1_{b}
Aspergillus flavus Esac-1	200^{a} 83.41_{b}	200^{a} 96.18_{b}	100^{a} 84.53_{b}	100^{a} 74.7_{b}
E. multirostrata Esac-2	200^{a} 85.93_{b}	100^{a} 25.71_{b}	25^{a} 30.93_{b}	25^{a} 62.5_{b}
Epicoccum sp. ECtr-1	200^{a} 98.51_{b}	200^{a} 68.56_{b}	25^{a} 101.92_{b}	50^{a} 51.5_{b}

E. multirostrata CorT-2	100^{a} 61.55_{b}	100^{a} 105.57_{b}	50^{a} 87.82_{b}	50^{a} 46.6_{b}
Aspergillus sp. ECto-3	200^{a} 92.96_{b}	200^{a} 89.11_{b}	75^{a} 66.03_{b}	75^{a} 48.2_{b}
Fusarium sp. ECto-4	150^{a} 117.11_{b}	50^{a} 121.76_{b}	50^{a} 76.53_{b}	25^{a} 95.7_{b}
Aspergillus sp. EDst-1	200^{a} 90.79_{b}	50^{a} 88.87_{b}	50^{a} 76.59_{b}	25^{a} 86.9_{b}
Ectophoma sp. ECgi-1	150^{a} 105.03_{b}	50^{a} 66.19_{b}	25^{a} 32.73_{b}	25^{a} 34.7_{b}

The concentration of heavy metal (ppm) represented in superscript letter (a); Heat map color scale is given to TI value, represented in lower subscript letter (b) and gradient change from green to red represents the increasing in % of TI.

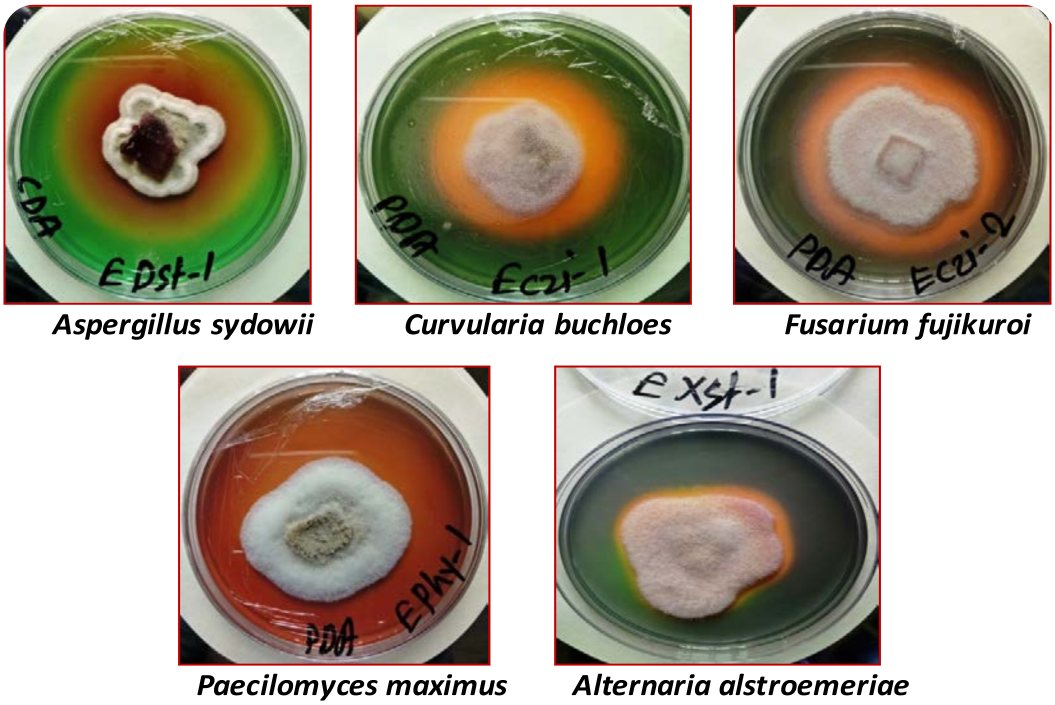


Plate 2.6.7a Siderophore production by potential endophytic fungal isolates

Plate 2.6.7b Phosphate solubilizing potential of endophytic fungal isolates

The inoculation effect of endophytic fungal isolates on maize and wheat plant growth (root and shoot length) was examined and also to what extent endophytic fungal strains influences the host plant growthwere compared with control group.

The inoculation experiment revealed that the presence of selected fungal isolates had no pathogenic effect on wheat and maize seeds or even in its presence promotes the plant growth. In our preliminary study, the root and shoot length was significantly increased in all inoculated pots of maize and wheat. Further, significant differences were observed when compared to control pot (Plate 2.6.7 c & d).

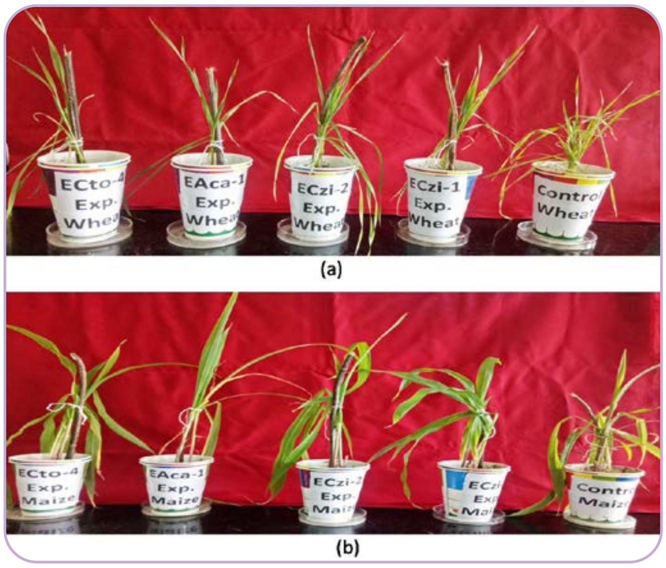


Plate 2.6.7c Plant growth promoting effect of endophytic fungal isolates on (a) wheat and (b) maize

Plate 2.3.6d Pot experiment with selected heavy metals on maize plant under different metal concentration

2.6.8 Evaluating the effect of Bio.Soilz product on nutrient availability and soil microbial activity under Maize-Wheat cropping system

A field experiment was conducted at ICAR-IISS farm with wheat crop (Variety: HD 1544) to evaluate the effect of Bio. Soilz (M/s. Blu Soils Agro Pvt. Ltd) on available soil nutrients, changes in soil microbial activity and crop productivity. Variation in crop growth was observed across the different treatments having Bio.Soilz application with and without recommended dose of fertilizer.

2.7 AINP on Soil Biodiversity and Biofertilizer

Low-cost bacterium based "eco-friendly" efficient synthesis of ZnO nanoparticles by using the bacterium Serratia nematodiphila was done. The physicochemical characterization of ZnO nanoparticles was performed by employing UV-vis spectroscopy, XRD, TEM, DLS, Zeta potential, and Raman spectroscopy and proved the nano size of the particles (10-50 nm). Serratia nematodiphila strain ZTB15 was inoculated and cultured in Luria Bertani medium with 0.1 M zinc sulfate, ZnO nanoparticles. Nano particles were purified by washing through multiple centrifugations at 14,000 rpm for 10 min and dried at 120°C. ZnO nanoparticles disc contacting 100 μg ml^{-1} concentration exhibited antibacterial activity against *Xanthomonas oryzae* pv. oryzae. The nanoparticles also exhibited antifungal activity against the phytopathogenic fungi Alternaria sp. About 85.93% inhibition in mycelia growth was observed at 250 μg ml^{-1} of ZnO nanoparticles.

Developed four microbial inoculants technologies including 1- Rhizobium biofertilizers for pulses cultivation in Andhra Pradesh, 2- Biofertilizer technology for apple, 3- Biofertilizer technology for vegetable crops, 4-Biofertilizer technology for vegetable crops of temperate Himalayas.

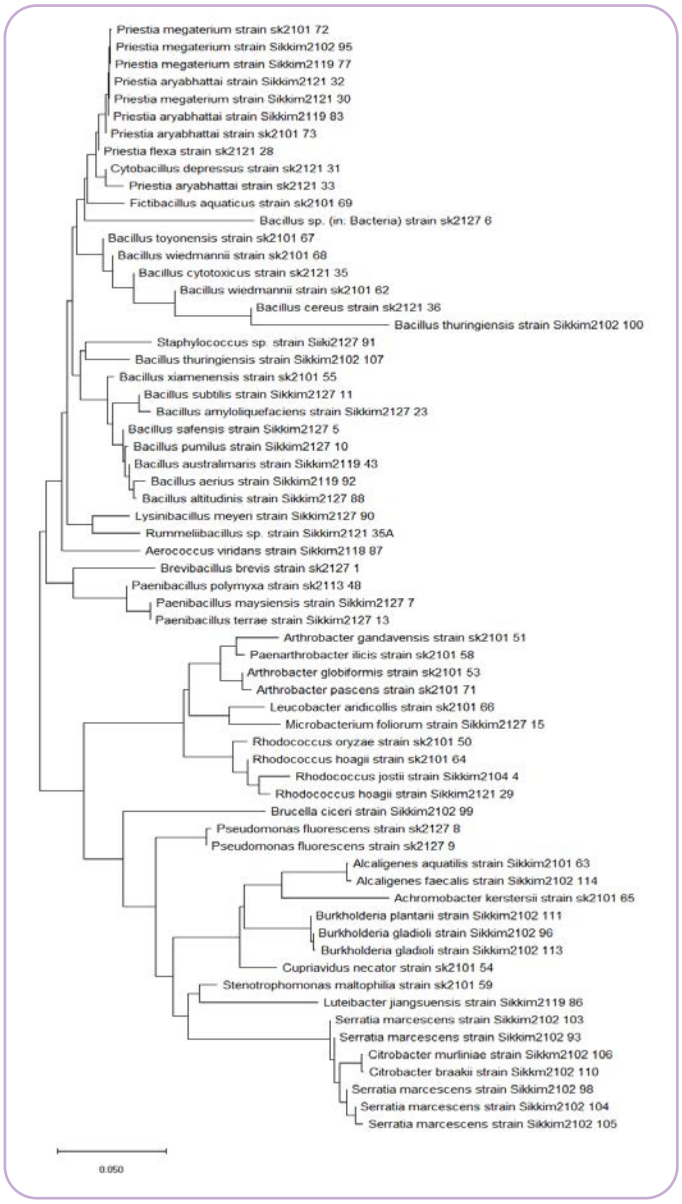
Revenue generated from biofertilizer commercialization is about Rs 320.00 lakhs during 2021-22.

Developed soil biological health kit based on substrate induced respiration. The kit contains assemblies to incubate soil with a defined substrate along with an indicator "Gel probe" which changes its color based on the amount of CO_2 evolved from soil. The color-change of the gel exhibits positive correlation with actual measure of CO_2 and soil biological quality index. The kit is a simple, quick and cost effective to monitor soil biological health without much scientific skill and equipment.

Professional Attachedment Training

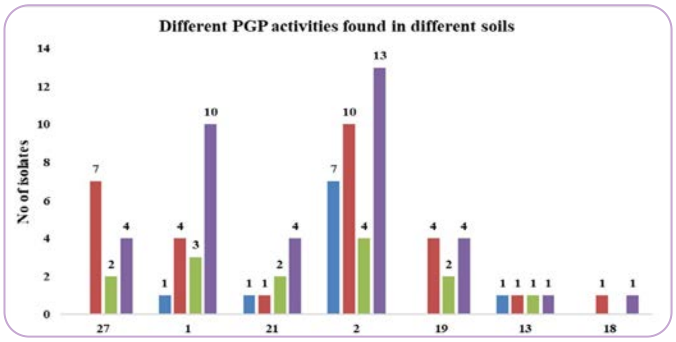
Microbial diversity of Sikkim Soils

In Sikkim, the entire agriculture is under organic farming for so many years and it is assumed that the rich soil microbial diversity must be playing critical role in plant growth amd nutrient supplementation. Keeping that in view this study was conducted to identify the culturable bacterial diversity and distribution of Sikkim soils based on the 16S rRNA approach along with their plant growth promoting (PGP) characteristics. A total of 63 bacteria were selected on the basis of 16S rRNA sequence analysis. Sequence analysis using BLAST showed that majority of the isolates were Gram-positive bacteria. Based on similarity criteria of at least 97% for the 16S rRNA gene sequence, 63 isolates distributed within four different phyla/165 classes: Firmicutes (33 isolates), Proteobacteria (17 isolates), Actinobacteria (10 isolates), and Gamma proteobacteria (2 isolates). A phylogenetic tree of all the bacterial isolates is shown in following figure.



Phylogenetic tree of Sikkim soil isolates. Neighbor-joining trees showing the phylogenetic relationships of bacteria 16S rRNA gene sequences from Sikkim soils to closely related sequences from the NCBI GenBank database

There were six different soils coded as soil no. 27, 1, 21, 2, 19, 13 and 18. Sample no. 2 had highest no. of functionally important microorganisms with respect to PGP attributes followed by sample no. 1 and least functionally diverse groups were found in sampleno. 18. Again sample no.2 had highest no. of microbes with multiple PGP attributes followed bysample no. 1. Overall, Bacillus was the most dominant genus and was distributed all along the samplingtopography and soil no. 2 supported better soil microbes in terms of quality and quantity.



Soil wise distribution of bacterial isolates showing PGP activities

Theme - IV: Soil Pollution, Remediation and Environmental Pollution

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

Total thirteen treatment combinations (T1: Control or only RDF to every crop; T2: FYM @ 5 t ha^{-1} every year + RDF every crop; T3: fly ash @ 10 t ha^{-1} every year + T2; T4: fly ash @ 20 t ha^{-1} every year + T2; T5: fly ash @ 40 t ha^{-1} every year + T2; T6: fly ash @ 20 t ha^{-1} every alternate year + T2; T7: fly ash @ 40 t ha^{-1} every alternate year + T2; T8: fly ash @ 80 t ha^{-1} every alternate year + T2; T9: fly ash @ 100 t ha^{-1} at once + T2; T10: fly ash @ 200 t ha^{-1} at once + T2; T11: fly ash @ 400 t ha^{-1} at once + T2; T12: fly ash @ 20 t ha^{-1} every year + T1; T13: fly ash @ 20 t ha^{-1} every year) were implemented to assess the long-term impact on soil physical and chemical properties (Plate 2.8.1). Soybean (variety RVS-2001-41) plant height increased significantly particularly with application of pond ash at the rate 200 t ha^{-1} or more. Leaf area per plant was maximum in T11 and minimum in T1 indicating the beneficial effect of ash application particularly at highest dose. Total chlorophyll content in soybean leaves was significantly higher in ash treated plots as compared to T1 and T2 plots. This indicates nitrogen availability to plants significantly increased in ash treated plots, probably due to increase in the activities of nitrogen fixing bacteria. However, nodule numbers per plant were not significantly changed due to ash application (Table 2.8.1).There was no significant change in soil pH due to ash or manure treatments. Electrical conductivity (EC) values of the soils were low (non-saline) and no significant change in EC values were observed due to application of ash even at highest rate (T11). Application of ash had decreasing effect on the $CaCO_3$ content in soil due to its lower content in ash as compared to experimental soil. Soil of the experimental area contains medium level of organic C.

Application of ash did not have significant effect on soil organic C content. The average bulk density (BD) values of surface soil decreased with increasing rate of ash application and minimum with highest rate of ash application. Steady state infiltration rate was minimum in T13 and was maximum in T2. There is a decreasing trend in infiltration rate with increasing rate of ash application. Results indicate that application of only ash decreases infiltration capacity of soil, while application of FYM increases it. Cone penetration resistance (CPR) values were minimum in 0-10 cm layer and increased with depth. Variation in CPR values due to treatments was more in 0-5 cm layer as compared to lower layers. There was a decreasing trend of CPR values in 0-10 cm layer with increasing rates of ash application. In general, water holding capacity of soil decreased due to ash application in soil and was minimum at highest application rate (T11).

Table 2.8.1 Growth parameters and biomass yield of soybean

Treatment	Plant height (cm) at 60 DAS	Leaf area plant^{-1} (cm^2)	Total chlorophyll in leaves (mg g^{-1}) at 60 DAS	Nodule no. plant^{-1} at 65 DAS	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T1	66.6	418.0	8.57	103.0	730.0	3650.0
T2	66.8	447.3	11.5	103.6	816.6	3690.0
T3	71.4	453.0	19.1	122.3	908.0	4055.3
T4	71.4	493.4	18.9	98.6	942.0	3921.3
T5	69.5	511.4	18.5	118.8	984.6	4045.3
T6	69.3	546.6	19.4	105.0	1101.3	4272.0
T7	69.0	519.2	17.6	105.0	1069.3	4100.6
T8	69.1	516.5	19.1	125.3	1039.3	4267.3
T9	69.4	524.5	19.4	103.0	1108.6	4458.0
T10	77.2	587.2	18.8	122.8	1071.3	4645.3
T11	79.6	610.7	19.9	144.6	1063.3	4553.3
T12	68.4	515.4	19.2	96.0	872.0	3991.3
T13	66.6	439.8	18.9	97.1	792.6	3877.3
LSD (5%)	5.31	86.37	4.38	NS	215.21	501.87

Plate 2.8.1 Fly ash application at field and soybean growth at ICAR-IISS, Research Farm

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

Municipal solid waste (MSW) contains considerable amounts of toxic metals, which may pose risk to plants, animals, and human beings through contamination of the food chain. Among the possible methods of waste disposal and utilization, mixing of different raw materials during the process of composting, which is known as co-composting, is regarded as the most economical way for the treatment and final disposal of solid waste. In the present study, the use of soft wood (pigeon pea) biochar as an additive during the process of co-composting with MSW improved the quality of the co-composted product, MSWBC. Application of MSWBC-10% PPB in soil significantly reduced the DTPA-extractable heavy metal content by 14.7% (Ni) to 62.5% (Cd) and reduced heavy metal mobility (transfer coefficient values) from the soil to the plant system. Application of municipal solid waste biochar compost (MSWBC) significantly ($P < 0.05$) reduced the heavy metal content in spinach leaves and roots compared to MSW amended soil. The percent decrease in spinach leaf following the application of MSWBC-10% PPB compared to MSW was 20.62, 28.95, 36.02, 41.88, 41.50, and 41.23% for Cu, Cd, Pb, Cr, Ni, and Zn, respectively. The average per cent reduction in DTPA extractable Cd, Pb and Ni was highest in soil amended with co-composed product of MSW with Zeolite additives, MSWZC (33, 27 and 20%) followed by co-composed product of MSW with biochar additives, MSWBC (21, 12 and 10%) and co-composed product of MSW with lime additives, MSWLC (9, 6 and 10%), respectively. The study concludes that co-composted product, MSWBC, stabilized heavy metals in MSW, reduced their uptake by spinach and thus making it a viable option for safe disposal of MSW (Plate 2.8.2).

Plate 2.8.2 Municipal solid waste (MSW); co-composted products; impact on soil and crop quality

2.8.3 Assessment of acid mine drainage affected areas in Madhya Pradesh

Geo-referenced soil and water samples were collected from the Singrauli open cast coal mine viz. Jhingurda and Jayant areas as well as from agricultural fields of mine site villages *viz*. Madhauli, Marwani, Banauli, Bindhanagar and Gharauli of Madhya Pradesh (Plate 2.8.3). The soil samples were analysed to measure organic carbon, available P, K and water samples were analysed for heavy metals of the mine areas. Jhingurda coal mine area soil was high in organic carbon, low to medium in available P and medium in available K, whereas Jayant coal mine area soil was high in organic carbon, low to medium in available P but high in available K. In nearby agricultural soils, high organic carbon, low available P and medium to high available K were found (Table 2.8.3). Cu (< 0.1 ppm), Ni (< 0.12 ppm), Fe (< 2 ppm), Co (< 0.05 ppm), Pb (< 0.06 ppm) and Zn (0.06 ppm) were within a safe limit in mine drainage water, whereas Mn concentration was up to 2 ppm which is far beyond the safe limit (≤ 0.2 ppm).

Table 2.8.3 Soil parameters of Singrauli coal mine areas

Places	Parameters	Org. C (%)	Avail.P (mg kg^{-1})	Avail. K (mg kg^{-1})
Jhingurda mine site	Range	2.51 - 2.97	14.50 - 21.10	78.88 – 113.23
	Mean	2.79	16.78	97.10
Jayant mine site	Range	3.75 – 3.90	14.80 – 16.80	129.67 – 170.79
	Mean	3.81	15.73	145.15
Agricultural and forest land	Range	0.71 – 1.44	8.20 – 13.50	111.29 – 228.35
	Mean	1.06	11.35	151.33
Reference point	Mean	0.59	25.4	244.31

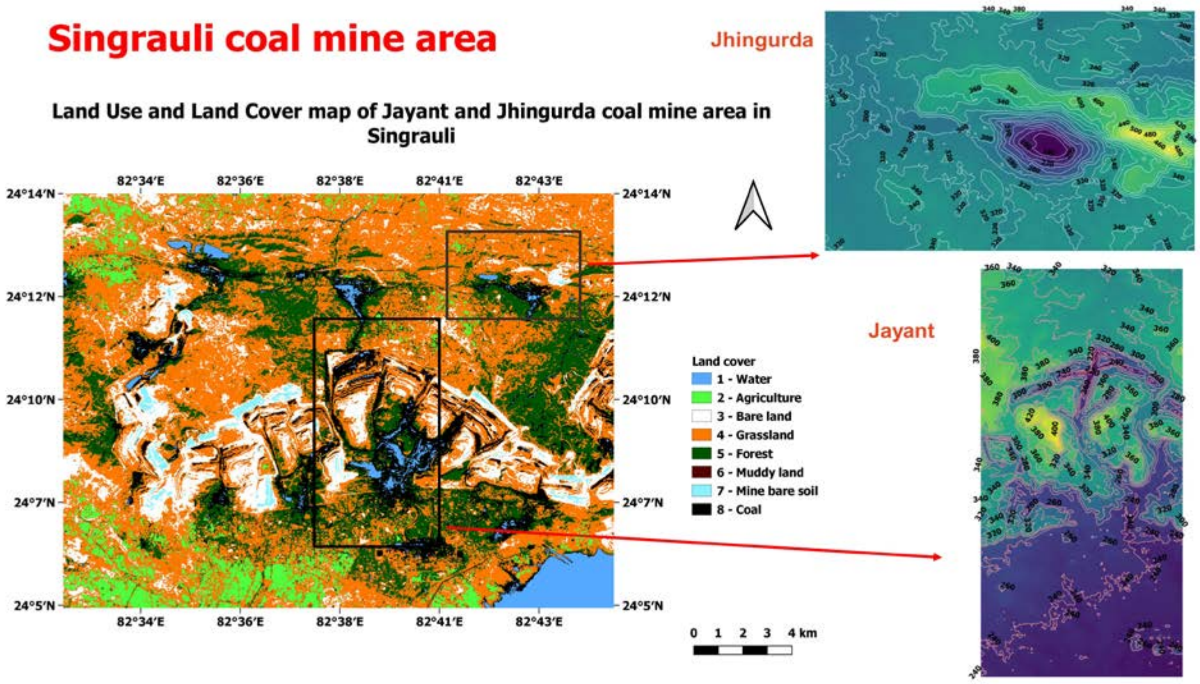


Plate 2.8.3 Land use classifications and digital elevation model (DEM) of Jayant and Jhingurda coal mine area of Singrauli

2.8.4 Assessment of soil heavy metals using VNIR spectroscopy of Jajmau Industrial area, Kanpur

Jajmau has more than 400 tanning industries and considered to be severe chromic polluted area, located on the left bank of Ganga River.It is the oldest city and has the biggest leather tanneries which generate revenue of 15000 cr every year and accounting for 30% of Indian Export. The effluent discharge from these tannery industries is about 29 million litres per day (MLD) but only 50% is treated. The untreated waste is directly drained into the agricultural soils of nearby villages. These tanneries specialize in processing hides into heavy leather and are the only location in India where saddlery products are manufactured. 99% of industries are performing chrome tanning process. The area where discharge waste is collected and the dumping site of Jajmau tannery industry are highly polluted with chromium.

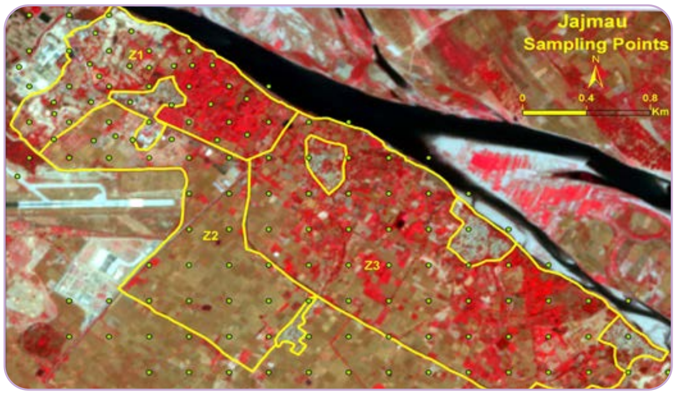


Plate 2.8.4 Location of soil sampling points overlaid Sentinal-2A satellite imagery and collection of soil samples from Jajmau, Kanpur

The study area was divided into three zones (Z1=Dumping sites close to CETP (Central Effluent Treatment Plant) and CLRI (Central Leather Research Institute), Z2=Close to Kanpur Airport and Z3= Southern part includes Motipur and Kishanpur villages) using freely available satellite imagery Sentinal-2A data downloaded from USGS Earth Explorerdated-3 April, 2021, Tile Number-T44RMQ by visual interpretation technique. 120 geo-referenced surface soil samples were collected gridwise at an interval of 250 m (Plate 2.8.4).

2.8.5 Arsenic profiling of water, soil and vegetable crops in some selected contaminated districts of West Bengal

Five blocks from each three districts viz., Malda, Murshidabad and South 24-Parganas of West Bengal were selected for profiling of the arsenic (As) under TSP programme of the project. Soil, irrigation water and plant samples were collected from 10 sites of each block for the study. Plant samples were collected mainly from vegetable crops like potato, onion, garlic, amaranths, brinjal, tomato, cabbage, cauliflower and spinach. Arsenic concentration in soils of Malda, Murshidabad and South 24-Parganas district varied from 0.24 to 2.99, 0.10 to 2.12 and from 0.11 to 3.65 ppm with mean value of 1.11, 0.78 and 1.23 ppm, respectively (Table 2.8.5). The mean value of arsenic concentration in irrigation water were 0.46 ppm for Malda, 0.37 ppm for Murshidabad and 0.60 for South 24-Parganas. Arsenic concentration in plant samples of Malda, Murshidabad and South 24-Parganas district varied from 0.02 to 0.82, 0.06 to 0.83 and from 0.08 to 0.99 ppm with mean value of 0.31, 0.28 and 0.31 ppm, respectively.

Table 2.8.5 Arsenic concentration (ppm) in soil, irrigation water and plant samples of different districts of West Bengal

District	Soil		Irrigation water		Plant	
	Range	Mean	Range	Mean	Range	Mean
Malda	0.24 – 2.99	1.11	0.06 – 1.46	0.46	0.02 – 0.82	0.31
Murshidabad	0.10 – 2.12	0.78	0.05 – 0.90	0.37	0.06 – 0.83	0.28
South 24-Parganas	0.11 – 3.65	1.23	0.10- 2.03	0.60	0.08 – 0.99	0.31

2.8.6 Monitoring heavy metal pollution in textile industry area of Siricilla district of Telangana state

Survey was carried out in Siricilla district which is famous for textile industry for monitoring the pollution status. Soil, plant and water samples were collected from seventeen farmers' fields all along the channel which is 2 km in length before joining with Manair River which are polluted with the effluent discharged from the textile small scale industry (Plate 2.8.6). The samples collected were analysed for pH, EC, micronutrients (Zn, Cu, Fe and Mn) and heavy metals (Cd, Cr, Ni, Pb and Co). Water samples collected have recorded mean Cd, Cr, Ni, Pb and Co contents of 0.016, 0.015, 0.025, 0.116 and 0.026 mg kg^{-1}, respectively.

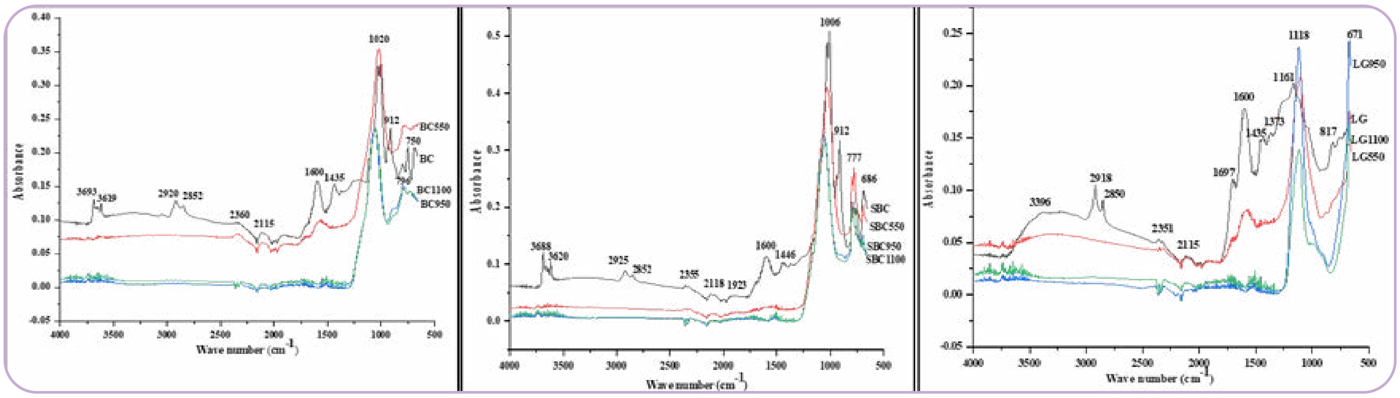
Plate 2.8.6 Soil, plant and water sampling area in Siricilla district, Telangana

Cadmium (slightly) and lead (2 to 3 times) content in the soils are more than permissible limits. Paddy plant samples (n=17) collected were found to be more than the permissible limits in case of lead (1.25 times) and cobalt (3 times). Rest of the heavy metals were within the permissible limits.

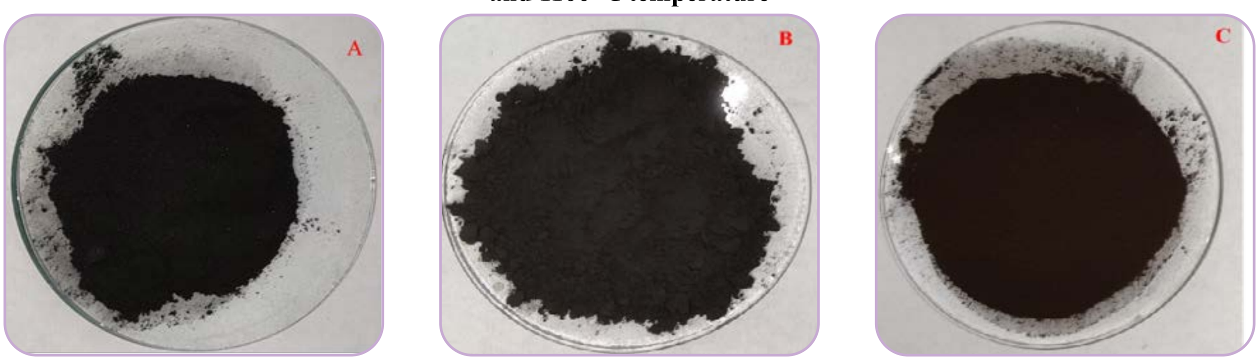
Professional Attachment Training (PAT)

Effect of ashing temperature on types of mineral and functional group present in coal and ash samples

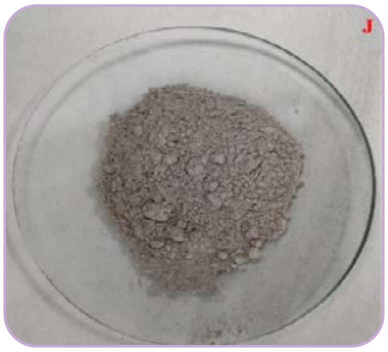
Two coal sample from Talcher coalfield, Odisha (bituminous and sub-bituminous coal), and lignite sample from Neyveli (Tamil Nadu) were used for this study. The samples were heated in muffle furnace at 550°C for 2 hours, 950°C for 2 hours, and at 1100°C for 1 hour. The ash obtained at different temperature were used for analysis. Different types of functional groups present in coal, as well as ash samples, were analysed in FTIR. Types of minerals present in coal and prepared ash samples at different temperature (550°C, 950 °C and 1100°C) were determined by X- Ray diffractometer. Results revealed that diffraction pattern suggest the presence of amorphous and crystalline phase of minerals in coals and respective ash. Results of XRD revealed that in bituminous, sub-bituminous coals, quartz, kaolinite siderite and anatase were dominant minerals while gypsum, kaolinite and quartz were prominent in lignite. In prepared ash from all the coals and lignite at the temperature (550, 950 and 1100 °C) predominate minerals were quartz, hematite, anhydrite, mullite, rutile, anatase, illite, magnetite and siderite, however, kaolinite present in coal converted into amorphous phase due to heating above 500°C. The FTIR absorption spectra of coal ashes were significantly differ from coal to coal, suggesting that organic and mineral components in coals changed after burning at 950°C. Moreover, the spectra of coal ashes show the absence of organic functional groups, indicating the burn out of organic components. The sharp doublet at 3693 and 3619 cm^{-1} was easily recognized as kaolinite from the spectra in bituminous and sub-bituminous coal whereas, these peaks are blunt in lignite coals. The coals in this study, however, only show the bands at 3693 and 3619 cm^{-1} but the bands at 3669 and 3652 cm^{-1} were absent, indicating the poor crystalline structure of kaolinite. The absorption bands at 1091, 1031, 1010 cm^{-1} correspond to ash in the coal.



FTIR spectra of (a) bituminous (BC) (b) sub-bituminous (SBC) (c) lignite (LG) and respective ash prepared at 550, 950 and 1100 ℃ temperature



A = Bituminous, B = Sub-bituminous, C = Lignite



J = $Ash_{1100°C}$ (Bituminous), K = $Ash_{1100°C}$ (Sub-bituminous), L = $Ash_{1100°C}$ (Lignite)

Different coal and ash images

Assessment of Polycyclic aromatic hydrocarbons (PAHs) in diverse agricultural soils of central India, Bhopal

Polycyclic aromatic hydrocarbons (PAHs) are a class of organic compounds found ubiquitously in the environment and pose serious threat to environment and humans. Because of their carcinogenic characteristics, these pollutants have received considerable attention. in this study, the 16 EPA priority PAHs were measured in agricultural surface soils (0-5 cm) from diverse agricultural land use systems in central India. ∑ 16 PAHs of different agricultural soil samples ranged from ND–122.52 μg kg^{-1}. Total concentration of 7 carcinogenic PAHs ranged from ND-101.64 μg kg^{-1}. The levels of PAHs in different agricultural soil samples varied widely. In general, we observed that ∑ 16 PAHs concentrations in agricultural soils have followed the order: fly ash treated agricultural soil samples ≥ sewage irrigated soil horticulture land use soil and conservation agriculture soil organic farming soil. PAH levels in fly ash-treated soils were 2-5 times higher than that in sewage-irrigated soils. PAHs containing four to five rings were the most common. In addition, it was found that agricultural soils treated with fly ash and sewage irrigated soils have a higher carcinogenic potential based on B[a]Peq TEQs. PAHs with higher carcinogenic potency in these contaminated soils indicate a higher level of health risk for humans.

Percentage composition of different PAHs rings [6-ring (IP and B[ghi]P); 5-ring PAHs (B[a]P, B[k]F, DB [ah]A and B[b] F; 4-ring (CHR, PYR, FLA and B[a]A; 3-ring (ANT, ACE, ACY, FLO, and PHE); 2-ring (NAP)] in diverse agricultural soil samples of central India, Bhopal.

3. Transfer of Technology

3.1 Capacity Building Programmme

3.1.1 Farmer Scientist interaction and field visit was conducted at IISS farm.

Under soil health awareness week, a farmer-Scientist interaction was organized at IISS Farm Bhopal during December 1-7, 2021. A total of 30 farmers participated from adopted villages (Raipur and Kanera and Karond Khurd) of the Bhopal district. Scientists interacted with farmers to create awareness about maintaining healthy ecosystems and human well-being by addressing the growing challenges in soil management, reducing soil salinization to improve soil health.

Popularizing vermicomposting technology among the farmers

Under the SCSP program, popularized vermicomposting technology by distributing 36 portable vermicompost beds and also conducted a field day.

3.2 Demonstrations/FLDs

3.2.1 ICAR-IISS, Bhopal

Demonstration of agricultural technology for conversion of Waste to Wealth

The technology such as sprinkler irrigation, no-tillage, residue incorporation in the field, vermicomposting and nutrient management were demonstrated to the farmers of the villages adopted under the SCSP program during Swachhta Pakhwada (December 16-31, 2021). A field day on vermicomposting and nutrient management for safe disposal of the waste was also conducted in the Raipur in which approximately 20 farmers participated.

Vishesh Sawachtha Abhiyan conducted in Raipur village

Demonstration of vermicompost technology

Demonstration of microbial culture for accelerating composting process

Field demonstrations for microbial mediated compost preparation for enhancing decomposition of organic wastes were conducted. Mass multiplied culture of fungi and bacteria was demonstrated for use in composting process to reduce the composting period in Ratibad village. The farmers were also explained about importance of organic manure in soil health and composting for human health and environmental security.

Application of microbial culture

Heap preparation

Special assignment to demonstrate safe disposal of food damaged farm produce

A team of scientists from ICAR-IISS, Bhopal visited KVK, Sheopur, Madhya Pradesh on August 13, 2021 to demonstrate the methods for safe disposal of damaged grain using composting techniques employing microbes and earthworms. An online training programme was organized in collaboration with KVK Sheopur, about 100 farmers besides officials from KVK, ZPD Jabalpur and officials from State departments joined this online demonstration. The theoretical aspects of composting / vermicomposting technology to be adopted for safe disposal of spoiled grains were explained by the team followed by an online demonstration of the whole process of composting and vermicomposting to the farmers and other state government officials.

Demonstration of microbial mediated composting

Demonstration of Best-Bet Conservation Agriculture Practices on Farmers' Fields in Vertisols of Central India

Farmer field experiments were conducted in a participatory mode in villages Khamkheda, Rasla Khedi, Raipur and Karod Khurd. Data for various growth and yield attributes were recorded under no till, reduced tillage and compared with conventional tillage farmers practice.

Crop – Wheat

Twelve demonstrations with wheat crop were conducted during rabi season 2020-21. A perusal of the data revealed that reduced tillage recorded higher seed yield of Wheat (47.90 q ha^{-1}) as compared to conventional tillage (47.61 q ha^{-1}) and zero tillage (47.31 q ha^{-1}), however the differences in grain yield could not attain the level of significance.

Crop – Chickpea

Eight demonstrations with wheat crop were conducted during rabi season 2020-21. A perusal of the data revealed that conventional tillage recorded higher seed yield of chickpea (10.83 q ha^{-1}) as compared to zero tillage (10.11q ha^{-1}) and reduced tillage (10.04 q ha^{-1}), however the differences in grain yield could not attain the level of significance.

Soybean 2021 (Kharif)

Twenty field demonstrations under zero tillage and reduced tillage were conducted during kharif season 2021 with soybean crop. A perusal of the data revealed that zero tillage recorded higher seed yield of soybean (11.14 q ha^{-1}) as compared to reduced tillage (10.38 q ha^{-1}) and conventional tillage (10.60 q ha^{-1}), however the differences in seed yield could not attain the level of significance.

Technology Assemblage, Application and Feedback

Crop based Module- Kharif season 2021-22

Conservation agriculture based 50 participatory demonstrations were conducted during Kharif season 2021-22 (40 Soybean and 10 Rice). Soybean productivity ranged between 13.50 to 17.85 q ha^{-1} in different villages with an average of 15.50 q ha^{-1}. Similarly Rice crop also recorded seed yield varied between 36.25 to 43.55 q ha^{-1} with an average of 40.85 q ha^{-1} under farmers field condition in the selected villages.

Intervention	Villages covered	Name of crop	Number of Households covered	Area covered (ha)	Yield (q ha^{-1})
Conservation agriculture based low cost, energy saving sustainable management for improving crop productivity and improving soil health.	Bhairopur	Rice	4	1.62	42.75
		Soybean	8	3.24	15.06
	Kanchvabli	Rice	---	---	---
		Soybean	2	0.81	13.50
	Khamkheda	Rice	5	2.02	43.55
		Soybean	28	11.33	17.85
	Kalyanpur	Rice	1	0.40	36.25
		Soybean	2	0.81	15.60
Total/Average		Rice	10	4.04	40.85
		Soybean	40	16.19	15.50

Soybean

Technical Observation	Farmers practice	Intervention
Grain yield (q ha^{-1})	13.80	15.50
Straw yield (q ha^{-1})	20.70	24.80
Cost of cultivation (Rs.ha^{-1})	33970	29840
Net income (Rs.ha^{-1})	21230	32156
B:C ratio	1.62	2.07

View of soybean crop in farmers field under demonstrations

Paddy

Technical Observation	Farmers practice	Intervention
Grain yield (q ha^{-1})	49.50	40.85
Straw yield (q ha^{-1})	79.20	64.95
Cost of cultivation (Rs.ha^{-1})	63920	40542

Net income (Rs. ha^{-1})	52405	55455
B:C ratio	1.81	2.36
Farmers reaction	Conservation agriculture practices are profitable but weed management is major problem under DSR. Moreover, availability of machine for large scale adoption is required.	

View of rice crop in farmers field under demonstrations

Horticulture based module

Under horticulture based modules, improved package of practices for better vegetables yield is demonstrated in thirty farmer's field. In summer season, the vegetables of Brinjal Sponge gourd, Bottle gourd and Okra were grown under the demonstration trail. The balanced nutrient application and need based pesticide was applied for better growth and production of vegetable. Due to balanced nutrient application, control of weed and insect-pest, the crop yield was increased under demonstrations as compare to farmer's practices. Brinjal, Sponge gourd, Bottle gourd and Okra productivity ranged between 35.50 to 44.20 t ha^{-1}, 12.70 to 16.60 t ha^{-1}, 16.80 to 21.50 t ha^{-1}, 10.50 to 15.20 t ha^{-1} in different villages with an average of 39.50 t ha^{-1}, 14.60 t ha^{-1}, 19.10 t ha^{-1}, 12.80 t ha^{-1} respectively.

Brinjal

Technical Observation	Farmers practice	Intervention
Yield (q ha^{-1})	320	395
Cost of cultivation (Rs.ha^{-1})	78000	86000
Net income (Rs.ha^{-1})	146000	190500
B:C ratio	2.87	3.21

Sponge gourd

Technical Observation	Farmers practice	Intervention
Yield (q ha^{-1})	108	146
Cost of cultivation (Rs.ha^{-1})	58000	65000
Net income (Rs.ha^{-1})	71600	110200
B:C ratio	2.23	2.69

Bottle gourd

Technical Observation	Farmers practice	Intervention
Yield (q ha^{-1})	155	191
Cost of cultivation (Rs.ha^{-1})	65000	75000
Net income (Rs.ha^{-1})	90000	116000
B:C ratio	2.38	2.54

Okra

Technical Observation	Farmers practice	Intervention
Okra Yield (q ha^{-1})	80	128
Cost of cultivation (Rs.ha^{-1})	66000	62000
Net income (Rs.ha^{-1})	30000	91600
B:C ratio	1.45	2.47

New plantation/ Orchards

Growth of new orchards plants

Plant Type (Fruit)	Age	Average plant height (cm)	Average girth in cm (circumference)
Crop 1 Guava	9 Months	210 cm	20.50 cm
Crop 2 Mango	12 months	100.30 cm	18.23 cm
Crop 2 Drumstick	10 months	115.15 cm	12.25 cm

Survival of new orchards plant

S.No.	Name of Farmer	Village	Crop 1 Mango		Crop 2 Guava	
			Plantation	Survival	Plantation	Survival
1.	Shri Doulat Singh Rajput	Khamkheda	100	50	50	30
2.	Shri Gabbar Singh Ahirwar	Khamkheda	50	30	50	35
3.	Shri Mahesh Silawat	Khamkheda	50	40	---	---
4.	Shri Naresh Rajak	Khamkheda	50	32	50	28
5.	Shri Kamal Singh Meena	Bhairopur	25	20	25	22
6.	Shri Narayan Singh Rajak	Khamkheda	50	35	---	---
7.	Shri Bullu Singh Ahirwar	Khamkheda	50	25	---	---
8.	Shri Ramsingh Rajput	Khamkheda	50	20	50	30
9.	Shri Singh Dangi	Khamkheda	---	---	100	80
10.	Shri Devee Singh Dangi	Khamkheda	---	---	75	50
11.	Shri Sushila Bai	Khamkheda	50	40	---	---
12.	Shri Gajraj Singh Meena	Khamkheda	25	20	---	---
	Total		500	332	400	275

Old plantation/Orchards

Technical Observation	Farmers practice	Intervention
Guava yield (q ha^{-1})	140	180
Cost of cultivation (Rs.ha^{-1})	98000	110000
Net income (Rs.ha^{-1})	112000	160000

NRM based module

Wheat- HI- 1544

Technical Observation	Farmers practice	Intervention
Grain Yield (q ha^{-1})	47.60	51.75
Straw Yield (q ha^{-1})	71.80	82.80
Cost of cultivation (Rs.ha^{-1})	44000	39150
Net income (Rs.ha^{-1})	51914	65126.25
B:C ratio	2.17	2.66

Gram- RVG-202

Technical Observation	Farmers practice	Intervention
Grain yield (q ha^{-1})	14.82	16.95
Straw yield (q ha^{-1})	22.97	27.96
Cost of cultivation (Rs.ha^{-1})	25800	20700
Net income (Rs.ha^{-1})	51264	67440
B:C ratio	2.98	4.25

Livestock based module

Technical Observation	Farmers practice N=25	Intervention N= 25
Average body weight (kg)	1.20	1.45
No. of fingerlings/ Average egg production /month/ Average milk yield/day	9 egg production /month (108*20=2160 egg per year + 5 Cock)	11 egg production /month (132*20=2640 egg per year + 5 cock)
Cost of rearing (Rs.)	4450	7000
Net income (Rs.)	10510	23400
B:C ratio	3.36	4.34

Vermicomposting

Technical Observation	Before	After
Yield (q/unit)/	---	20 /year
Cost of cultivation (Rs.)	---	2650
Net income (Rs.)	---	9000
B:C ratio	---	3.39

Microbial-based agricultural waste management using vermicomposting (SAP)

A. Training Programme (SAP)				
S.No.	**No. of Participants**	**Location**	**Date**	**Remarks**
1	40	Beenapur	22.02.22	Practical Training on vermicomposting was imparted to farmers in the institute and at village level.
2	20	IISS BHOPAL	28.02.22	
3	70	IISS BHOPAL	24.03.22	
4	50	Bhairopur	29.03.22	

Radio Talk/TV Programme

Dr. A. B. Singh delivered talk on "खेती में मृदा स्वास्थ्य के लिए जैविक खेती" dated July 17, 2021 at Doordarshan Bhopal.

Dr. A. B. Singh delivered talk on "Hello grama sabha-live phone in" dated October 17, 2021 at Prasar Bharati, All India Radio Bhopal.

Dr. A. B. Singh delivered talk on "जैविक खेती मे पोषक तत्व प्रबंधन" dated December 22, 21 at Doordarshan Bhopal.

Dr Sanjay Srivastava delivered talk on " रबी फसलों हेतु एकीकृत पोषक तत्व प्रबंधन" dated October 16, 2021 at Doordarshan Bhopal.

3.3 Tribal Sub-Plan/Scheduled Tribe Component

3.3.1 ICAR-IISS, Bhopal

Enhancement of Soil Health and Livelihood of Tribals in Chattisgarh

On Field Demonstration on Soil health management and summer moong production

During rabi season of 2020-21, training on soil health management cum summer moong seed distribution programme was conducted at village Gidhali village, Ambagarh chowki block of Rajnandgaon district. Padamshri Phulvasahan Devi Yadav, President Maa Bamleshwari Janhit Karya Samiti, graced the occasion and motivated the farmers to maintain soil health. In this training programme, 6 q seed of summer moong variety IPM 410-3 was demonstrated in the fields of tribal ladies farmers.

On Field Demonstration on Soil health management and production of HYV of paddy

During Kharif season 2021, ICAR IISS in collaboration with KVK Rajnandgaon conducted on field demonstration of HYV of rice Indira Dhan) at village Ghidhali, Ambagarh Chowki Block of Rajnandgaon district.

Demonstration/ exhibition/ field day/farmers fair

The on-field demonstrations on chickpea were conducted in Mogra village, Ambagarh Chowki, Rajnandgaon District and a field day was conducted on March 3, 2021 at the village to educate the farmers about importance of soil testing, soil health and crop management. There after a scientist –farmers interactive meeting was conducted at the village and issues of farmers were addressed.

Inputs supplied: Seed packets of 30 quintals of HYVs of rice (Rajeshwari), 6 quintals of green gram and 100 portable vermibeds were distributed to 75 tribal farmers of Ambagarh Chowki block in Rajnandgaon district, Chhattisgarh to improve the seed replacement ratio with high yielding rice varieties and balanced nutrient management for maintaining soil health.

Enhancement of Soil Health and Livelihood of Tribals of Barwani District in Madhya Pradesh

During 2020-21, the agricultural inputs like seeds and planting material were distributed to the tribal farmers in different blocks of Barwani district Under STC project. The field demonstration trials were conducted in different at 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.

कृषि विज्ञान केंद्र के वैज्ञानिकों ने तैयार किया मिर्च का पौधा

किसानों को अच्छी पैदावार के लिए बताई जा रही पौधा रोपने की तकनीक, वायरस अटैक से बचाने के तरीके

भास्कर संवाददाता | [illegible]

तलून के पास स्थित कृषि विज्ञान केंद्र के वैज्ञानिकों ने मिर्च की पौध तैयार की है, जिसे किसानों को बांटा जा रहा है। साथ ही किसानों को मिर्च की फसल को वायरस अटैक से बचाने व अच्छी पैदावार होने की तकनीक भी बताई जा रही। कृषि विज्ञान केंद्र के वैज्ञानिक डॉ. एसके बड़ोदिया के मार्गदर्शन में उन्नत किस्म के बीजों से मिर्च की पौध तैयार की गई है।

उन्होंने बताया आईसीएआर के अंतर्गत भारतीय मृदा विज्ञान संस्थान भोपाल की परियोजना तहत आदिवासी किसानों को मिर्च की पौध का वितरण किया गया। इस दौरान आदिवासी किसानों को केंद्र के उद्यानिकी वैज्ञानिक डॉ. डीके जैन ने मिर्च की फसल की रोपाई से लेकर कटाई तक की तकनीकी जानकारी व कीट-रोग की रोकथाम की जानकारी दी। इससे की आदिवासी किसानों को मिर्च की फसल से अच्छी आय प्राप्त कर सके। केंद्र के वैज्ञानिक दल द्वारा बड़वानी क्षेत्र के मिर्च फसल लेने वाले किसानों के खेतों का भ्रमण किया गया। इस दौरान कहीं-कहीं मिर्च में पर्ण कुंच, कुकड़ा रोग का संक्रमण पाया गया। वैज्ञानिकों ने जानकारी देते हुए बताया कि मिर्च में पर्ण कुंचन,कुकड़ा व विषाणु जनित रोग है। यह बेगोमोवायरस वंश के अंतर्गत आता है। इस रोग के कारण मिर्च की पत्तियां छोटी होकर मुड़ जाती है। पत्तियों की शिराएं मोटी हो जाती है। इससे पत्तियां मोटी दिखाई पड़ती है। पौधों की बढ़वार रुक जाती है व पौधे झाड़ीनुमा दिखाई देने लगते है। इसके साथ-साथ पौधों पर फल लगना कम हो जाते है व फल कुरूप हो जाते है। वर्षा में कमी व तापमान की अधिकता भी इस रोग को बढ़ावा देती है। इस विषाणु जनित रोग को सफेद मक्खी रोग ग्रसित पौधों से दूसरे स्वस्थ पौधों में फैलाती है।

किसानों को मिर्च की पौधे वितरित करते हुए।

वायरस के लिए मिर्च की फसल को बचाने रखें सावधानी

वैज्ञानिकों ने बताया मिर्च की फसल को वायरस अटैक से बचाने के लिए पौधे की रोपाई के दौरान सावधानियां रखें। पौधे की आयु 30-35 दिन होने पर रोपण करें, फसल को रस चूसक कीटों से बचाव के लिए रोपाई के पूर्व पौधे को इमिडाक्लोप्रीड 17.8 फीसदी, एसएल 7 मिली प्रति लीटर पानी के घोल में 20 मिनट तक पौधे की जड़ों को डुबाने के बाद खेत में रोपाई करें, मिर्च के खेतों के चारों ओर मक्का या ज्वार की दो-तीन कतारें कीट अवरोधक के लिए लगावें, खेत में रोग के प्रारंभिक लक्षण दिखने पर पर्णकुंचित पौधों को उखाड़कर मिर्च के खेत से दूर गड्ढे में डालकर दबा देवें। खेत में सफेद मक्खी की निगरानी के लिए पीले प्रपंच(चिपचिपे कार्ड) 10 प्रति एकड़ लगाना चाहिए। साथ ही रोग के प्रसार को रोकने के लिए रोग ग्रस्त पौधों को देखते ही खेत से उखाड़कर नष्ट करें। नीम तेल 3000 पीपीएम 3 मिली प्रति लीटर पानी में घोलकर 10 दिन के अंतराल पर दो बार छिड़काव करें।

Frontline demonstrations trial in Year 2021 under TSP project

Crop	District	Blocks	No of FLDs	Crop Yield		Increase Yield (%)
				Farmers' practices	Improved Practices	
Soybean	Barwani	4	66	1150 kg ha^{-1}	1640 kg ha^{-1}	41.80
Gram	Barwani	3	66	970 kg ha^{-1}	1334 kg ha^{-1}	37.50
Wheat	Barwani	3	50	2680 kg ha^{-1}	3760 kg ha^{-1}	40.20
Chilli	Barwani	2	50	2450 kg ha^{-1}	3430 kg ha^{-1}	40.02
Tomato	Barwani	3	50	110 t ha^{-1}	154 t ha^{-1}	40.40

Field Day

A Field day was organized at Kaweli village of Balaghat district on October 11, 2021 and Sarra village on October 12, 2021 where scientists of ICAR-IISS visited the tribal farm fields to observe the performance of their traditionally grown rice crop. Scientists showed them nutrient deficiency symptoms, pest infestations, and major weeds detected and explained the reasons of those problems and remedies.

Farmers' field visit at Sarra village of Balaghat district of Madhya Pradesh

Farmer Scientist Interface Meeting

Farmer-scientist interface meeting organized for the tribal farmers of the Kaweli, Kulpa and Sarra villages on October 13, 2021 to understand about possible hurdles in adopting the soil health card based nutrient recommendation given by ICAR-IISS Bhopal. During the event, soil health cards were distributed to tribal framers along with cuttings of Gliricidia and winter vegetable seeds.

Farmer-scientist interface meeting and distribution of vegetable seeds

Farmer-scientist interface meeting organized on October 21, 2021 at ICAR-IISS Bhopal to understand various issues associated with tribal farming in Betul district of Madhya Pradesh.

Farmer-scientist interface meeting

Frontline Demonstration of Bio formulations in tribal farm fields of Madhya Pradesh

Frontline demonstrations (FLD) on bio formulations were carried out in 200 tribal farm fields of Betul district (MP) during the Kharif season of 2021 for three crops *viz*., soybean (40), maize (130) and paddy (30). Under the nutrient management intervention a combination of farmyard manure (FYM), chemical fertilizers (CF) and different bioformulations (biofertilizers, biopesticides, and biofungicides) were used. The yield advantage of the intervention over the farmers' practice (FYM+CF) observed was 27.5% in soybean, 21.5% in maize and 25.7 in paddy.

FLDs on bioformulations for paddy and soybean in the tribal fields of Betul district (M.P.)

Training for Tribal Farmers at ICAR-IISS Bhopal

A five days training-cum-exposure visit on "Resource Conservation Technologies for the Tribal Farmlands of Madhya Pradesh" was organized for the tribal farmers of Betul district (M.P.) during October 25-29, 2021 under the STC/TSP project of the institute "Enhancement of soil health and livelihood of tribal's in Central India".

Enhancing Livelihood Security of Subsistence Farming Community through Improvement in Soil Health, Crop Productivity and Capacity Building in Madhya Pradesh under SCSP

A study was initiated under SCSP sub plan to enhance the livelihood security of subsistence farming community. Sixteen villages were selected under four clusters. In all about 33 percent landless farmers were recorded in the study area under scheduled caste community. Most farmers are in marginal category having 2-3 acre land. Balanced and integrated nutrient management treatments were worked out and were applied in 0.5 acre land along with farmers practice.

Distribution of agri-inputs to the farmers under the SCSP project

Under this program, soybean seed Var-JS-29-34 (1500kg), Maize seed (250 kg) Urea 100 Bag, Wheat seed var Tejas and Hi 1544 130 bags (40 kg of each bag), Chickpea seed 46 bags (30 kg of each bag) Sickle 150 Spade 220 pickaxe 150 Growmore 198 Bag (50 kg of each bag) 36 sprayer Imazithyper (25 liter) and Thiamethoxam (12.5 kg) Mineral mixture 400kg were distributed to 140 farmers of Raipur, Kanera, Karond Khurd and Khichital of Bhopal district.

Maize and soybean and wheat and gram were grown using three nutrient management practices. The grain yield of maize was significantly improved under balanced and INM practice in cluster I, II and III. Soybean seed yield ranged between 7.7 and 17.55 q ha^{-1}. Wheat grain yield during 2020-21 varued betweeb 43.45 and 50.34 q ha^{-1} under different nutrient management practices. Cluster III recorded lowest wheat grain yield while other cluster recorded more than 40 q ha^{-1} grain yield. The performance of gram among the three nutrient management practices was the highest in cluster III where it increased from 17.8 to 25.4 q ha^{-1} with integrated nutrient management.

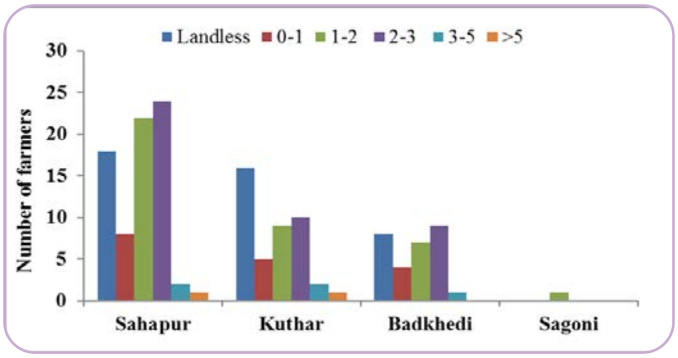
Distribution of inputs under SCSP sub-plan

Various inputs have been provided to farmers of the community for easing out their agricultural expenses as per direction from government. A brief detail is given in the following table.

Item	Qty
Thiomethoxam kg	50
Imazithyper, litre	100
Soybean, kg	5910
Maize, kg	1000
Wheat Seed, kg (HI 1544)	20000
Gram Seed (JG 12 and RVG 201), kg	5520
Urea, kg	16200
12:32:16 (NPK), kg	14400

Land holding capacity of the farmers selected under SCSP project (Cluster I)

148 farmers were selected from the villages viz. Sahapur, Kuthar, Badkhedi and Sagoni In field demonstration, balance fertilizer, Integrated nutrient management and farmer practices in wheat and soybean crop are evaluated. On farmer field, Integrated nutrient management practices perform better where all the yield attribute are higher than balance fertilization and farmers practices. The wheat yield obtained in balance fertilizer, Integrated nutrient management and farmer practices in all the farmer's field are 45.5, 47.8 and 41.5 q ha^{-1}, respectively. The corresponding value for soybean is 16.3, 17.6 and 14.8 q ha^{-1}, respectively.



Land holding capacity

Yield of wheat and soybean crop under different management system in field demonstration

Farmer's	Wheat (Yield q ha^{-1})			Soybean (Yield q ha^{-1})		
	Balance fertilizer	INM	Farmers practice	Balance fertilizer	INM	Farmers practice
1	44.0	46.0	41.0	17.0	18.0	15.5
2	47.1	51.5	45.0	18.0	19.0	16.4
3	46.3	49.5	43.5	16.0	18.0	13.9
4	44.5	46.5	41.0	17.0	18.0	15.4
5	44.1	47.0	40.0	16.0	17.0	14.6
6	43.5	46.0	39.0	18.0	19.1	14.5
7	47.5	49.2	43.0	16.0	18.0	14.5
8	45.5	47.4	41.0	16.5	18.0	16.5
9	41.5	44.0	36.0	15.0	17.0	15.0
10	44.5	46.6	40.0	18.0	19.0	16.2
11	49.9	51.0	44.5	16.0	17.0	14.5
12	44.1	46.2	40.0	15.0	16.0	13.5
13	52.0	54.0	47.0	12.5	13.2	11.3
14	43.0	45.0	39.0	16.0	17.0	14.5
15	45.6	47.0	42.6	18.0	19.0	16.0
Mean	**45.5**	**47.8**	**41.5**	**16.3**	**17.6**	**14.8**

Field demonstration in soybean and wheat crops

Seed (wheat, chickpea) and fertilizer (NPK:12:32:16) and portable vermibeds were distributed to 21 SC farmers from different villages i.e.Tarasewania, Pipalia Chhaparband, Bagoniya and Jhapadia of Bhopal district for front line demonstration (FLD) in SCSP adopted villages for demonstration of Integrated Nutrient Management and Balanced ferilizatio for improvement of soil health and crop productivity. Seeds (Wheat and Chickpea) and fertilizer (Grow More) were distributed to approximately 100 farmers from villages Sahapur, Kuthar, Kachibadkhedi, Sagoni during month of November 2021.

Distribution of agri-inputs to the SC farmers for front line demonstration

Front line demonstration of vermicomposting of agrowastes

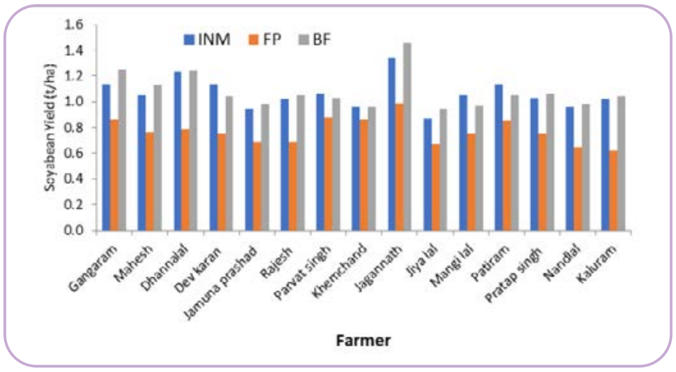
Farmers seminar on "Climate Smart Technologies" and "Soil Health Card"

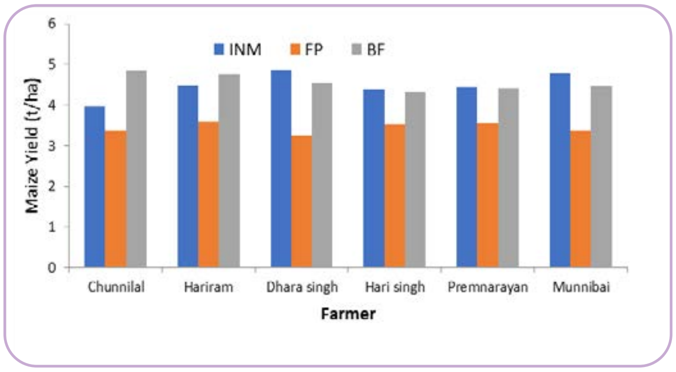
Dr. Sangeeta Lenka and EPCO project team organized Farmers seminar on "Climate Smart Technologies" and "Soil Health Card" to sensitize the farm men and women on adaptation and mitigation strategies in agriculture for climate change and site-specific nutrient management based on soil health assessment for the forty adopted villages of Climatically vulnerable district of Rajgarh and Sehore in Madhya Pradesh from October 26-30, 2021 and November 16-19, 2021. Total of 120 farmers trained in each district.

Demonstration of Nutriment management technology in Adopted Villages under MGMG by the Institute

the farmer's field under SCSP

Balanced use of fertilizers and integrated nutrient management were demonstrated in soyabean and maize crops during Kharif season 2021 at farmers' fields of Raipur, Kanera, Khichital and karond khurd village. The highest yield (1.46 t ha^{-1}) was obtained in the Balance use of fertilizer by the Sh Jagarnath of the Raipur village. While the lowest was obtained in the farmer's practice (0.62 t ha^{-1}) by Kaluram of Kchital in the soybean. In Maize, the highest yield (4.85 t ha^{-1}) was obtained by Chunnilal of Kanera village whereas the lowest was recorded in the field of Munnibai (3.36 t ha^{-1})





MGMG Activities

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

Group	Members	Name of five villages adopted by Group Leader
1	Dr. A.K. Patra, Director, ICAR-IISS Dr. A.B. Singh, PS, & Nodal Officer, MGMG Dr. A.O. Shirale, Scientist, SC&F Dr. Sudeshna Bhattacharjya, Scientist, SBD Dr. Narayan Lal, Scientist, SC&F	Dobra, Khejra, Perwalia Sadak, BadarkhaS adak, Mubarakpur
2	Dr. P. Tripathi PS & Co-Nodal officer Dr. N.K. Sinha, Scientist, SPD Dr. Dolamani Amat Scientist, SBD 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. K. Bharati, PS, SBD Mrs. Seema Bhardwaj, Scientist, SPD (Study leave) Dr. Dhiraj Kumar, Scientist, PC (LTFE)	Choupdakala, Ghatkheri, Sayyaid Semara, Emaliya Chopra and Amoni

4	Dr. J.K. Saha, HOD, ESS Dr. Hiranmoy Das, Scientist (STCR) Dr. Madhumounti Saha, Scientist, ESS Dr. Dinesh Kumar Yadav, Scientist, ESS Dr. Khushboo Rani, Scientist, SCF	Islam Nagar, Dewalkhedi, Bharonpura, Kalyanpura, Puraman Bhavan
5	Dr. K.M. Hati, PS, SPD Dr. Sanjay Srivastava, PS, SC &F Dr. Sanjib Kumar Behera, SS, MSN Dr. K.C. Shinogi, Scientist, ITMU Dr Gurav Priya Pandurang, Scientist SC & F	Bankhedi, Baroda, Sojna, Amaravadi and Kuravadi
6	Dr. A.K. Shukla, PC, MSN Dr. R. Elanchezhian, PS, SC&F Dr. R.K. Singh, PS, SPD Dr. J.K. Thakur, Scientist, SBD Dr. Nisha Sahu, Scientist, ESS	Sagoni, Munirgarh, Gudawal, Chhattarpura, Chiklodkhurd
7	Dr. A. K. Biswas, HOD, SC&F Dr. Brij Lal Lakaria, PS, SC&F Dr. Asha Sahu, Scientist, SBD Dr. Bharat P. Meena, Scientist, SC&F Ms Alka Rani, Scientist, SPD	Golkhedi, Binapur, Kanchbavli, Khamkheda and Raslakhedi
8	Dr. R.S. Choudhary, HOD, SPD Dr. P. Jha, PS, SC&F Dr. A.K. Vishwakarma, PS, SPD Dr. K. Bharati, PS, SBD Dr. Abhijit Sarkar, Scientist, ESS	Raipur, Kanera, Momanpur, Kadhaiya and Karodkhurd
9	Dr. P. Dey, PC, STCR Dr. N.K. Lenka, PS, SC&F Dr. M. Mohanty, PS, SPD Dr. M. VassandaCoumar, 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 Dr. Asit Mandal, Scientist, SBD Mr. Rahul Mishra, Scientist, ESS Dr. M. 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. Jitendra Kumar, Scientist, SPD	Shahpur, Devpur, Kasi Barkeda, Sagoni, and Barkedi Hajam

Some of activities are given below:

Special Swachhta Campaign Organized by Mera Gaon Mera Gaurav (MGMG)

The Mera Gaon Mera Gaurav team of ICAR-Indian Institute of Soil Science, Nabibagh, Bhopal organized a special Swachhta campaign at Sukhi Sevaniya village on October 20, 2021.

FLD on Effect of foliar application of Zn-B formulation on rice crop in Uttarakhand

AICRP on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants

Frontline demonstration trials were conducted to examine the effect of foliar application of Zn-B formulation once (at 30 days after transplanting (DAT)) and twice (at 30 and 60 DAT) to rice (cv. HKR47) on farmer's fields (3 sites) in Pindari village of District U.S. Nagar. The details of soil chemical properties and grain and straw yields, Zn and B concentrations in grain and straw in rice crop are presented in Table. Single foliar spray of Zn-B formulation at 30 DAT increased the grain yield of rice by 23.5 to 65.7% and straw yield by 12.4 to 40.4 % over farmer's practice. With two foliar sprays of Zn-B formulation at 30 and 60 d after transplanting increased the grain yield of rice by 27.3 to 67.7 % and straw yield by 14.6

to 39.5% over farmer's practice. Higher response of foliar spray of Zn and B was recorded for Site 3 which had lowest content of DTPA extractable Zn (0.66 mg Zn kg^{-1} soil) and hot water-soluble B (0.33 mg B kg^{-1} soil. Considering the increase in grain yield of rice, foliar application of Zn-B formulation at 30 and 60 DAT in rice appeared to be a profitable practice.

Effect of foliar spray of Zn-B formulation on grain and straw yields and nutrient concentration and uptake of rice (cv. HKR47) on Farmer's fields in Pindari Village, Sitarganj, Distt. Udham Singh Nagar

Site	Soil Properties	Treatments	Rice (cv. HKR47)											
			Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain Zn (mg kg^{-1})	Straw Zn (mg kg^{-1})	Grain B (mg kg^{-1})	Straw B (mg kg^{-1})	Zn uptake by Grain (g ha^{-1})	Zn uptake by Straw (g ha^{-1})	B uptake by Grain (g ha^{-1})	B uptake by Straw (g ha^{-1})	Total Zn uptake (g ha^{-1})	Total B uptake (g ha^{-1})
1	Texture loam , pH 7.73, EC 0.337 dS m^{-1}, OC 5.2 g C kg^{-1} soil, 0.96 mg DTPA Zn and 0.37 mg HCC-B (mg kg^{-1} soil)	Farmer's Practice	5.07	5.62	11.9	11.9	6.8	5.1	60.3	66.8	34.2	28.7	127.2	101.1
		Single spray of Zn-B formulation at 30 DAT	6.46	7.89	10.8	10.5	7.4	7.8	69.8	82.7	48.0	61.6	152.5	130.7
		Double spray of Zn-B formulation at 30 and 60 DAT	6.84	7.84	13.1	10.5	8.8	9.0	89.5	82.5	60.0	70.6	172.0	142.5
2	Texture loam , pH 7.89, EC 0.335 dS m^{-1}, OC 6.4 g C kg^{-1} soil, 1.02 mg DTPA Zn and 0.48 mg HCC-B (mg kg^{-1} soil)	Farmer's Practice	4.59	6.14	10.7	13.4	6.8	9.6	49.2	82.5	31.0	58.9	131.8	113.5
		Single spray of Zn-B formulation at 30 DAT	5.98	7.82	10.9	9.9	8.1	10.8	65.0	77.3	48.4	84.4	142.2	125.7
		Double spray of Zn-B formulation at 30 and 60 DAT	6.19	7.88	12.2	10.5	8.4	10.5	75.2	82.3	52.2	82.7	157.5	134.5
3	Texture loam , pH 7.75, EC 0.304 dS m^{-1}, OC 5.8 g C kg^{-1} soil, 0.66 mg DTPA Zn and 0.33 mg HCC-B (mg kg^{-1} soil)	Farmer's Practice	4.50	6.80	10.4	12.1	6.1	6.0	46.9	82.3	27.4	40.8	129.1	109.6
		Single spray of Zn-B formulation at 30 DAT	7.46	8.72	10.1	8.5	7.4	6.9	75.1	74.1	55.4	60.2	149.2	129.5
		Double spray of Zn-B formulation at 30 and 60 DAT	7.55	9.16	12.7	11.8	8.4	8.7	95.9	108.2	63.7	79.7	204.0	171.9

AICRP on Soil Test Crop Response

Frontline demonstrations (FLDs) on farmers' fields

Trials conducted on farmers' fields to demonstrate the value of soil test based nutrient recommendations. FLDs were conducted for dual purpose, firstly to find out the suitability of different crops in different region and secondly for creating awareness regarding proper use of fertilizers for a particular crop on the basis of soil test and fertilizer recommendation through STCR approach.

Crop (variety)	Village	District	No. of FLDs	Yield (q ha^{-1})		Increased yield (%)
				Farmers' practice	STCR based	
		IGKV, Raipur, Chhattisgarh				
Wheat (HI-8777)	Dumali	Kanker	5	22.8-25.7	27.2-30.3	13.0-20.0
Wheat (CG-04)	Mainpat	Surguja	5	27.5-30.3	36.38.8	25.0-32.7
Chickpea (RVG- 2020)	Patharra	Kawardha	5	14.5-15.5	16.4-17.1	10.0-12.6
Maize (Hyb-DKC9165 & Pioneer)	Babusemra	Bastar	10	59.2-62.7	64.1-68.3	4.4-12.0
Rice (CG Zinc Rice-1)	Pasangi/ Bangaon	Kondagaon	10	33.0-37.0	44.0-48.0	24.3-37.1
Rice (MTU-1156)	Sonwahi, Bishunpur	Surguja (Surajpur)	10	31.0-37.8	45.5-50.0	22.0-34.2
Soybean (CG Soya 1)	Ramhepur	Kabirdham	10	17.1-18.6	20.2-21.0	10.1-20.1
		TNAU, Coimbatore, Tamil Nadu				
Lady's finger	Gopanari	Coimbatore	5	9.33	15.01	60.9
Rice (White Ponni)	Sadivayalpathy	Coimbatore	15	3.91	6.02	53.96
Maize (TNAU Hybrid CO6)	Gopanari	Coimbatore	4	5.94	9.58	61.3
Sugarcane (COC86032)	Kaikkanvalavu	Salem	2	74.3	120.5	62.2

Tomato (Sivam)	Kaikkanvalavu	Salem	23	45.39	78.43	72.8
IARI, New Delhi						
Wheat (HD-2967)	Rajpur	Aligarh (U.P.)	4	40.38	58.55	44.9
PJTSAU, Hyderabad, Telangana						
Rice (KNM 118)	Tagilepally	Nizamabad	6	66.54	70.25	5.57
Groundnut (NithyaHaritha& Dharani)	Mediwada-Ravikamatam	Visakhapatnam (AP)	12	19.66	23.05	18
Chickpea (NBEG -3)	Raiguda	Adilabad	6	16.86	18.17	7.8
Rice (RNR 15048)	Tripuraram Miryalaguda	Nalgonda	3	53.29	56.3	5.64
Groundnut (Lepakshi)	Peddagottili, Levidi, Balleruguda, Gajulaguda	Vijayanagaram, AP	12	9.72	11.5	18
CSKHPKV, Palampur, Himachal Pradesh						
Soybean(Harit Soya)	Masroor	Kangra	6	8.7	18.0	107
CRIJAF, Barrackpore, West Bengal						
Rice (Shatabdi)	Briddhapalla	North 24 Parganas	13	37.5	47.0	25.3
Onion (Sukhsagar)	Anoka and Dhantala	Nadia	6	22.0	28.48	29.4
KAU, Vellanikkara, Kerala						
Tomato (Manuprabha)	Thiruvilwamala	Thrissur	1	266	308	15.78
Turmeric (Kanthi)	Vellanikkara	Thrissur	1	238	380	59.66
AAU, Jorhat, Assam						
Hybrid Maize (DKC-9144)	Danichapari	Golaghat, Assam (2 ha)	2	45.5	56.7	24.57
Winter Rice (Ranjit Sub-1)	Dichaiparia	Golaghat, Assam (2 ha)	2	44.8	62.9	40.40
JNKVV, Jabalpur, Madhya Pradesh						
Rice (JR-206)	Tikaria	Jabalpur	5	33.36	45.13	35
Rice (JR-206)	Magarda	Jabalpur	2	31.25	49.12	58
Wheat(GW-322)	Sahajpuri	Jabalpur	4	34.52	44.46	29
Chickpea(JG-12)	Sahajpuri	Jabalpur	2	8.41	12.79	52

Trainings cum field days

The capacity building programmes cum field days were organized by the different centers of AICRP on STCR to create awareness about soil testing and soil health for sustainable crop production.

District	Village	Date	Total participants	No. of women farmers
IGKV, Raipur, Chhattisgarh				
Bastar	Babusemra	15.03.2021	25	02
Uttar Bastar, Kanker	Babusemra	16.03.2021	35	07
Mainpat, Sarguja	Dumali	17.03.2021	25	-
Kabirdham	Bargaon	20.03.2021	25	05
Ambikapur, (Sarguja)	Sonwahi	24.11.2021	25	03
Kondagaon	Pasangi	16.11.2021	31	02
Kabirdham	Ramhepur	16.10.2021	50	10
KAU, Vellanikkara, Kerala				
Thrissur	Adatt	15.02.2022	25	04
Thrissur	Kuzhalmandam	14.03.2022	30	06
AAU, Jorhat, Assam				
Jorhat	Garumora Gaon	05.12.2022	102	45
PJTSAU, Hyderabad, Telangana				
Adilabad	Ankapur	20.2.2021	35	6

Nagarkurnool	Kanapur	28.3.2021	45	11
YSR	CK Dinne	03.01.2021	40	4
Rangareddy	Sherguda	19.02.2021	52	14
Rangareddy	Sherguda & Bhadraipalli	19.02.2021	52	14
Rangareddy	Maddur village	4.12.2021	22	5
Adilabad	Sakinapur	09.08.2021	67	35
Nagarkurnool	Appajipalli	17.12.2021	30	4
Nagarkurnool	Venkatapur	11.10.2021	20	4
JNKVV, Jabalpur, Madhya Pradesh				
Jabalpur	Takaria	25.07.2021	30	9
Jabalpur	Sahajpuri	5.12.2021	100	35

4. Training and Capacity Building

4.1. Training Attended by Staff

A. Participation in Training (Category-wise)

S. No.	Category	No. of employees undergone training during 2021
1	Scientist	19
2	Technical	1
3	Administrative & Finance	0
4	Skilled Supporting Staff	0
Total		**20**

B. HRD fund allocation and utilization (Rs. in Lakhs April 2021 to March 2022)

S. No.	RE for HRD	Actual Expenditure for HRD
1.	2.00	1.85

C. Training attended during January to December 2021

C1 Category: Scientific staff				
S.No	**Name of employee**	**Title**	**Organizer**	**Duration**
1	Mr. Rahul Mishra	Restoration of post-mining sites	Charles University, Environment Centre, Prague, Czechia (Online)	June 8-12, 2021
2	Dr. AB Singh	Online Certification Course on Organic Farming	University of Agricultural Sciences Dharwad	July 26-28, 2021
3	Drs JK Saha, Sanjay Srivastava, R Elanchezhian and M Mohanty	NABL Assessors Training Course on ISO/IEC 17025: 2017 (Level1)	NABL Gurugram (Online)	August 25-27, 2021
4	Dr. JK Thakur	Applications of Bioinformatics Tools in Agricultural Research	UBKV, West Bengal & ICAR-IASRI, New Delhi (Online)	September 20-30, 2021
5	Dr. Nisha Sahu	Strategies for climate risk management and resilient farming	ICAR-CRIDA & NIAEM, Hyderabad	September 20-24, 2021
6	Drs JK Saha, Sanjay Srivastava, R Elanchezhian and M Mohanty	NABL Assessors' Training Course on ISO/IEC 17025: 2017 (Level 2)	NABL Gurugramat Hotel Hilton, Gurugram	Septeber 23-25, 2021
7	Drs. MV Coumar, Abhijit Sarkar	Basics of Geographical Information System	IIRS-ISRO, Deharadun (Online)	September 27 - October 22, 2021
8	Drs Sudeshna Bhattacharjya and Asha Sahu	Analysis of Multi-Location Experiments	ICAR-NAARM Hyderabad	October 28-30, 2021
9	Drs. M. Homeshwari Devi, Immanuel C Haokip, Khushboo Rani and Dinesh Kumar Yadav	Statistical Designs and Analytical Methods for Multifactor Experiments	ICAR- CMFRI, Kochi	December 08-17, 2021
C2 Category: Technical staff				
S.No.	**Name of employee**	**Title**	**Organizer**	**Duration**
1	Mr. Sanjay Kumar Parihar	E-governance applications in ICAR under HRM Unit	ICAR-IASRI, New Delhi	September 6 to September 10, 2021
2	Mr. Sanjay Kumar Parihar	Soft skill and personality development for T1-T4 Staff	ICAR-NAARM, Hyderabad	September 20 to September 25, 2021

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	Dr. Khushboo Rani	ICAR- CSSRI, Karnal	February 17 to May 17, 2021	Dr. Ashim Datta
2	Mr. Rahul Mishra	CSIR-Central Institute of Mining and Fuel Research, Dhanbad	February 23 to May 31, 2021	Dr. R E Masto
3	Dr. Dinesh Kumar Yadav	CSIR-NEERI, Nagpur	March-June, 2021	Dr. A Ramesh Kumar
4	Mr. Abinash Das	ICAR-NBAIM, Mau	February 17 to May 17, 2021	Dr. Alok Kumar Shrivastava

4.3. Research Guidance for Degree Students

S. No.	Name of the Student	Name of the College/Institute/University	Degree	Name of the Co-Guide
1	Mr. Shubham Singh	College of Agriculture, RVSKVV Gwalior, MP	Ph.D. Soil Science	Dr. A. B. Singh
2	Ms. Surubhi Kaner	College of Agriculture, RVSKVV Gwalior, MP	M.Sc. (Ag.) Soil Science	Dr. A. B. Singh
3	Ms. Nazmeen Khanam	College of Agriculture, RVSKVV Gwalior, MP	M.Sc. (Ag) Soil Science	Dr. Asit Mandal
5	Ms. Ashi Shroti	Carrier College Bhopal	M.Sc. (Ag) Soil Science	Dr. Asit Mandal
6	Mr. Rupesh Yadav	College of Agriculture, RVSKVV Gwalior, MP	M.Sc. (Ag) Soil Science	Dr. Pramod Jha
7	Mr. Pramod Sharma	College of Agriculture, RLBCAU, Jhansi	M.Sc. (Ag) Soil Science	Dr. A.K. Biswas
8	Mr. Rakesh Raghuvanshi	College of Agriculture, RVSKVV Gwalior, MP	M.Sc. (Ag) Soil Science	Dr. N.K. Lenka
9	Mr. Raghavendra Narwaria	College of Agriculture, RVSKVV Gwalior, MP	M.Sc. (Ag) Soil Science	Dr R Elanchezhian
10	Mr. Chandrapal Rajput	College of Agriculture, RVSKVV Gwalior, MP	M.Sc.(Ag) Soil Science	Dr R.K. Singh
11	Ms. Mamta Chaudhary	College of Agriculture, RLBCAU, Jhansi	M.Sc.(Ag) Soil Science	Dr K.M. Hati
12	Ms. Kanchan Panthi	College of Agriculture, RVSKVV Gwalior, MP	M.Sc. (Ag) Soil Science	Dr. S.R. Mohanty
13	Ms.Kajal Kakaria	Career college, Bhopal	M.Sc. Biotechnology	Dr. S.R. Mohanty
14	Ms Deeksha	College of Agriculture, RLBCAU, Jhansi	M.Sc. (Ag) Soil Science	Dr M.V. Coumar
15	Mr Ganesh Malgaya	College of Agriculture, RVSKVV Gwalior, MP	Ph.D. Agronomy	Dr. R.H. Wanjari
16	Ms. Nita Mahawar	College of Agriculture, RVSKVV Gwalior, MP	Ph.D. Soil Science	Dr. Sanjay Srivastava

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

Name of Scientist	Topic	Date	Venue	Remarks
Dr R Elanchezhian	Soil Health Management	December 3, 2021	ICAR IISS Bhopal	Students from Govt. Motilal Vigyan Mahavidyalaya, Bhopal

Capacity building

Particulars	No. of training & Date	No. of villages covered	No. of farmers benefited
Awareness cum training programme	1 (December 4, 2021)	4	100
Training Programme	1 (December 16, 2021)	4	120
One day workshop on pulses for soil health and nutritional security	1 (February 10, 2022)	4	45
Organized one day training programme on “Resource Conservation Technologies for Sustainable Agriculture”	1 (March 24, 2022)	4	75

5. Awards, Honours and Recognitions

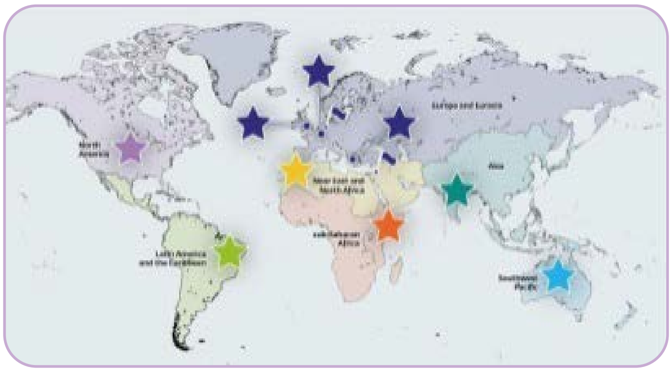
5.1 Awards

- Dr. A.B. Singh, Dr. B. L. Lakaria, Dr. B. P. Meena, Dr, S. Ramana and Dr. J. K. Thakur received Best AI-NPOF Centre award for the year 2020-21.
- Dr. Asha Sahu awarded Young Scientist Award 2021 by National Environmental Science Academy during the International Conference on "Promoting Environmental Technologies for Waste Management and Sustainable Development (WMSD-2021)" during December 12-13, 2021 at Kalinga Institute of Industrial Technology, Bhubaneswar, Odisha.
- Dr. J.K. Thakur received distinguished Scientist Award from Green Agri Professional Society, in 3rd international conference on Food, Agriculture and Innovations (ICFAI) held during December 24-26, 2021 at Ranchi, Jharkhand.
- Dr. Priya Gurav received Best Young Scientist Award, EET CRS 10th Science and Technology Awards -2021, Bangalore.
- Dr. Priya Gurav received NESA Young Scientist of the Year Award 2021, National Environmental Science Academy, New Delhi.
- Dr. Priya Gurav received Best Ph.D. thesis presentation award in 23rd Annual Convention and National Conference on "Application of Clay and Allied Sciences in Agriculture, Environment and Industry" held during December 22-23, 2021 at ICAR-IARI, New Delhi 110012.
- Dr. Nishant K Sinha received the distinguished scientist award during the 3rd International conference on Food, Agriculture, and innovations (3rd ICFAI), December 24-26, 2021 at Ranchi.
- Dr. S.R. Mohanty awarded Fellow of NAAS.

- Dr. D.K. Yadav received "Seth Lachhiram Chudiwal Award-2020" for Best Ph.D. Thesis in the field of Agricultural Chemicals by ICAR-IARI, New Delhi during 59th convocation of the institute held on February 12, 2021.
- Dr. Dinesh K Yadav received "SPS India Best Ph.D. Thesis Award-2021" by Society of Pesticide Science India, ICAR-IARI, New Delhi (December 2021).
- Dr. Abhijit Sarkar received FAI Award for Outstanding Doctoral Research in Fertilizer Usage 2021 from the Fertilizer Association of India, New Delhi.
- Dr. Abhijit Sarkar received Augmenting Writing Skills for Articulating Research (AWSAR) award from Department of Science and Technology (DST) and selected among top 100 Ph.D. research story (popular article) in India for the academic year 2020-21.
- Dr. Abhijit Sarkar received ISSS Best Doctoral Research Presentation Award at 85th Annual Convention of the Society on November 18, 2021 Visva-Bharati (Central University), Sriniketan, West Bengal.
- ICAR-IISS received a copyright (Copy Rights No. SW-14175/2021) for Soil Quality Indices calculation software (SQI CAL) for assessment of soil health under different management practices in a very short time with minimum data sets.

Copyright Office

Extracts from the Register of Copyrights



- Soil Spectroscopy laboratory of ICAR-IISS, Bhopal identified as Regional Champion Laboratory on soil Spectroscopy for the Asian region.
- Dr. Sangeeta Lenka received Science and Engineering Research Board-POWER- fellow in the year 2021.
- Dr. Somasundaram Jayaraman and Dr Nishant K. Sinha received the ISSS- Dr. J. S. P. Yadav memorial award for Excellence in Soil Science during the 85th Annual convention of Indian Society of Soil Science, November 16- 19, 2021 at Visva-Bharati (Central University), Sriniketan, West Bengal.

Honours and Recognitions

- Dr. J.K. Thakur received best oral presentation awards in 3rd international conference on Food, Agriculture and Innovations (ICFAI) held during December 24-26, 2021 at Holiday Home, Ranchi, Jharkhand.
- Dr. Narayan Lal received Innovative Article Award from Agriculture and Food – newsletter, Balurghat, Beltalapark, Dakshin Dinajpur, West Bengal, India.
- Dr. Khushboo Rani received best paper award in Oral presentation at 9th Annual Convention and National Webinar, 2022 during February 25-26, 2021 organized by Society for Fertilizers and Environment.
- Dr. R. Elanchezhian and Dr S. Srivastava are empanelled as Assessors for National Accreditation Board for Testing and Calibration Laboratories (NABL).
- Ms. Alka Rani received 3rd best paper presentation award for oral presentation in the National Symposium on i-GEOMATICS: An integrated technology to empower citizens towards self-reliant nation on a virtual platform hosted by Indian Society of Geomatics, Ahmedabad and Indian Society of Remote Sensing, Dehradun from December 15-17, 2021.
- Dr. Nishant K Sinha received the best oral presentation award during the 3rd International conference on Food, Agriculture, and innovations (3rd ICFAI), December 24-26, 2021 at Ranchi.
- Dr. Dhiraj Kumar got best oral presentation Award in the Virtual National Seminar on "Advances in Sustainable Management of Natural Resources for Food and Nutritional Security" from August 26-27, 2021.
- Dr. Nisha Sahu received Best Oral Presentation Award in 3rd International Conference (Hybrid Mode) on Food, Agriculture and Innovations (3rd ICFAI), Ranchi, Jharkhand during December 24-26, 2021.
- Dr. Sangeeta Lenka received the best oral presentation award from Centre for Climate Change & Disease Management, Department of Environmental Soil Science, GITAM University in association with Society for Science of Climate Change and Sustainable Environment, New Delhi, India.
- Dr. A. B. Singh recognized as Key note Speaker in webinar "How to Handle the waste Generated Nearby Us" during May 17-21, 2021 organised by SAGE University Bhopal.
- Dr. A.B. Singh recognized as Key note speaker in webinar on Organic farming: Basic principles and good practices jointly organized by ICAR-IISS, Bhopal & ICAR-IIFSR, Modipuram on August 6, 2021.
- Dr. A.B. Singh as Chief Guest, given lecture on Organic farming and Soil health, invited by Head, IES University Bhopal on December 6, 2021.
- Dr. J. K. Thakur delivered invited lecture under Swachhta abhiyan organized by State dept. of Agril on November 26, 2021 at CIAE, Bhopal.
- Dr. K. Bharati recognized as the Key note speaker at Techno-scientific Challenges and Sustainable Solutions for Living beings during Changing Environment (TCSE-2021) organized by: National Environmental Science Academy (NESA), New Delhi ICAR-Indian Agricultural Statistics Research Institute (IASRI).
- Dr. Sudeshna Bhattacharjya was honored as invited speaker by Swantree Environmental Foundation on the occasion of World Soil Day 2021.
- Dr. Sudeshna Bhattacharjya received expert lecture recognition by VIT School of Agricultural Innovations and Advanced Learning (VAIAL), Vellore on November 9, 2021.
- Dr. Sudeshna Bhattacharjya received reviewer recognition from SERB, DST for Core Research Grant proposals.
- Dr. Brij Lal Lakaria recognized as member of Editorial Board of the Indian Journal of Soil Conservation by the Indian Association of Soil and Water Conservationists, Uttranchal, Dehradun.
- Dr. Brij Lal Lakaria recognized as Key speaker in Workshop on "Sustainable Biochar Production through Agro-forestry Systems and its Application in Odisha" during October 27-28, 2021 at Balangir, Odisha.
- Dr. N.K. Lenka recognized as Chief Guest in the Training programme on "Advances of soil moisture measurements and its Estimation and related studies" organized by KSCSTE – CWRDM during October 27-30, 2021 for the Department of Soil Survey & Soil Conservation, Kerala.
- Dr. N.K. Lenka recognized as expert reviewer by DST-SERB for examination of research proposals.
- Dr. N.K. Lenka acted as Editor, Frontiers in Plant Sciences (Theme : Abiotic stress).
- Dr. N.K. Lenka acted as External Examiner for two M.Sc. (Soil Science) scholoars of RVSKVV, Gwalior.
- Dr. A.K. Biswas acted as external examiner for Ph.D. viva-voce at TNAU, Coimbatore.
- Dr. A.K. Biswas acted as thesis Evaluation of Ph.D. scholars of University of Calcutta, Kolkata and Maharana Pratap University of Agriculture & Technology, Udaipur.
- Dr. Priya Gurav acted as rapporteur in National Webinar on "Nanotechnology in Agriculture: Opportunities and Challenges" held on June 21, 2021.

- Dr. R. Elanchezhian acted as Lead Speaker at the National Conference of Plant Physiology on "Frontiers of Plant Physiology for Climate Smart Agriculture" during December 9-11, 2021 at ICAR-NIASM Baramati.
- Dr. R. Elanchezhian awarded Best oral paper in International Plant Physiology Virtual Symposium on "Physiological interventions for climate smart agriculture" during March 11-12, 2021 organized by ISPP New Delhi & ICAR-SBI Coimbatore.
- Dr. R S Chaudhary: Nominated as Member, State level Advisory Board for New Generation Watershed Projects, 2021.
- Dr. R.S. Chaudhary nominated as Nodal Officer, State Level Green Platform – Decision Supply System for MP on June 11, 2021.
- Dr. R.S. Chaudhary acted as Member standing committee on Policy and Bye-laws of ISSS 2021-22.
- Dr. R.S. Chaudhary acted as Guest of Honor in the DST Training Program on "Integrated Nutrient Budgeting Through Advanced Models to Improve Crop Production" on November 29, 2021.
- Dr. R.S. Chaudhary chaired the session VII on "Soil Physics/Soil Conservation" on November 17, 2021 during 85th Annual Convention of ISSS at Shanti Niketan West Bengal.
- Dr. R.S. Chaudhary acted as member judging committee for ISSS Dr JSP Yadav Memorial Award for excellence in Soil Science, 2021.
- Dr. Dinesh K Yadav selected as member of Technical Committee of 9th International Conference on Environment Pollution and Prevention (ICEPP 2021) from November 19-21, 2021 in Sydney, Australia organized by Hong Kong Chemical, Biological & Environmental Engineering Society (HKCBEES), Hong Kong.
- Dr. Nisha Sahu acted as Organizing Secretary for International Conference on "New Paradigms for Agriculture, Food and Sustainability Concerns (NPAFSC-2021) by Agriculture Letters, Mumbai during February 26-28, 2021.
- Dr. Nisha Sahu delivered an invited lecture in International Webinar on "New Innovative approaches for improving agricultural productivity" organized by Eklavya University, Damoh (MP) on August 10, 2021.
- Dr. Abhijit Sarkar received best Oral Presentation award in 30th National Web Conference on Soil and Water Management Technologies for Climate Resilience, Agricultural and Environmental Sustainability".
- Dr. Nisha Sahu acted as organizing Secretary for International Conference on "New Paradigms for Agriculture, Food and Sustainability Concerns (NPAFSC-2021) by Agriculture Letters, Mumbai during February 26-28, 2021.
- Dr. Nisha Sahu invited as speaker at International Webinar on "New Innovative approaches for improving agricultural productivity" organized by Eklavya University, Damoh (MP) on August 10, 2021.
- Dr. K.M. Hati acted as an external examiner of a M. Sc. (Agriculture) student from RCSM College of Agriculture, Kolhapur, MPKV, Rahuri.
- Dr. Nishant K. Sinha served as member of expert panel of National Seminar cum Workshop on "Application of space technology and artificial intelligence for climate resilient agriculture and disaster management" during October 29-30, 2021 at BIT Mesra, Ranchi.
- Dr. Nishant K. Sinha served as rapporteur of a technical session in the National Seminar on Developments in Soil Science: 2021 at 85th Annual Convention of ISSS during November 16-19, 2021 at Visva-Bharati (Central University), Sriniketan.
- Dr. Nishant K. Sinha served as Co-Chairman of a technical session in 3rd International Conference on Food, Agriculture, and Innovations during December 24-26, 2021 at Ranchi.
- Dr. R.H. Wanjari acted as Member of the National Organizing Committee for the Virtual National Seminar on "Advances in Sustainable Management of Natural Resources for Food and Nutritional Security" organized by NAHEP (ICAR) & NAU Navsari at NAU Navsari (Gujarat) during August 26-27, 2021.
- Dr. A. K. Biswas served as a panelist in the Webinar on 'Future of Science and Technology on Natural Resource Management' organized on National Science Day on February 28, 2021 by Bhopal Chapter of NAAS and ICAR-IISS, Bhopal.
- Dr. A.O. Shirale and Dr. A.K. Biswas as a course-coordinator organized the Skill India Training Programme on 'Soil and Water Testing Lab Analyst (NSQF Level-5) during 15 February to 16 March, 2021 at ICAR-IISS.
- Dr. A. K. Biswas organized the National Science Day webinar on the topic 'Future of Science and Technology on Natural Resource Management' and contributed as a Panelist on February 28, 2021 organized by Bhopal chapter of NASC and ICAR-IISS, Bhopal.
- Dr. Sanjay Srivastava appointed as Member of Expert Committee, SERB, DST, GOI for the National Post-Doctoral Fellowship & SRG under the Earth and Atmospheric Science Scheme during November 10-12, 2021.
- Dr. Sanjay Srivastava acted as adviser to the Chairman of Rajasthan State Public Service Commission during October 25-27, 2021 in recruitment of Agricultural Officers.
- Dr. Sanjay Srivastava acted as reviewer for standard operating procedure for soil available phosphorus, Bray I and Bray II method, FAO (2021) Rome.
- Dr. Somasundaram Jayaraman associate Editor, Soil Research, CSIRO, Australia.
- Dr. Somasundaram Jayaraman associate Editor, Frontiers in Sustainable Food System.

6. Linkages and Collaboration

The Institute has linkages with several ICAR institutes and SAUs located throughout the country. The three AICRPs (LTFE, MSPE & STCR), an AINP on SBB and CRP on CA stationed at ICAR-IISS Bhopal have 94 cooperating centers spread across almost all the SAUs of the country. As lead centre, the Institute is undertaking platform project of CRP on Conservation Agriculture and external funded projects (INDO-UK Nitrogen centre, ICRAF, FAO, ICARDA, CEFIPRA, NASF, DST, DBT, NICRA, MPCOST, EPCO) involving linkage with several ICAR Institutes. Also, efforts have been made to strengthen research collaborative activities with SAUs through guidance of PG students by the Institute scientists. Besides, several private firms, viz., Hindustan Copper Ltd., Malanjkhand, M/s Grasim Industries Limited, Nagda, Ujjain, M.P., UPL Pvt. Ltd, Mumbai, M/s Privi Life Science, Mumbai, M/s Blu Soils Agro Pvt. Ltd, Patna are collaborating with the Institute on various R&D activities. Besides, ICAR-IISS, Bhopal conducted the proficiency testing programme 2021 of GLOSOLAN for the analysis of soil samples.

List of Co-operating Centres under AICRPs/AINP

AICRPs/AINP	**No. of Cooperating Centres**		
	ICAR	**SAUs/SGUs**	**Total**
AICRP on LTFE	**3**	**15**	**18**
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			
AICRP on MSPE	**2**	**19**	**21**
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			
AICRP on STCR	**4**	**21**	**25**
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			
AINP on Soil Biodiversity-Biofertilizers	**3**	**14**	**17**
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			
CRP on CA	**13**	**0**	**13**
PIC New Delhi, PIU Bhopal, 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			

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. Evaluation of glauconite as source of potassium for crops
Investigators: AO Shirale, Gurav Priya Pandurang, Sanjay Srivastava, B.P. Meena and A.K. Biswas
3. Enhancing the productivity of major crops through improving the natural resource base of tribal inhabited areas of central India
Investigators: Shinogi K.C., Sanjay Srivastava, B.P. Meena, N.K. Sinha, K. Bharati, Gurav Priya Pandurang, A.K. Tripathi, Hiranmoy Das, Abhijit Sarkar R.L. Raut (KVK, Balaghat), Rameshwar Ahirwar (KVK, Balaghat), Aparna Jaiswal (COA, Balaghat)
4. Mineralogy of Vertisols in relation K availability in central and western India
Investigators: Gurav Priya Pandurang, A.O. Shirale, B.P. Meena, B.L. Lakaria, Sanjay Srivastava, P. Chandran (ICAR-NBSS&LUP, Nagpur), S. Sandeep
5. Micronutrients distribution in major soil orders of India as influenced by soil properties and land use pattern
Investigators: S.K. Behera, A.K. Shukla, N.K. Sinha, J.K. Thakur, K. Kartikeyan (ICAR-NBSS&LUP, Nagpur)
6. 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, I/c KVK Barwani (MP), I/c KVK Rajnandgaon (Chhattisgarh) and I/c KVK Betul (MP)
7. Assessment of nutrient (N & P) use efficiency in wheat genotypes for improved crop productivity
Investigators:R. Elanchezhian, A.O. Shirale, B.P. Meena, Alka Rani, Sanjay Srivastava, Ajay, S. Ramana, A.K. Biswas, MV Coumar, AB Singh and Renu Pandey (ICAR-IARI, New Delhi).
8. Soil health assessment and input use efficiency 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
9. 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
10. 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 of all divisions

(B) Externally Funded Projects

11. All India Network Programme on Organic Farming (ICAR, New Delhi)
Investigators: AB Singh, BP Meena, Brij Lal Lakaria, R. Elanchezhian,JK Thakur, NK Sinha, Abinash Das
12. 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, Abhay O Shirale, Hiranmoy Das, Narayan Lal
13. Assessing the impact of imbalanced use of chemical fertilizer on soil health using a soil function based quantitative approach (DST, New Delhi)
Investigators: NK Lenka, BP Meena, Sangeeta Lenka, AO Shirale, RH Wanjari,RK Singh
14. Long-term monitoring of soil processing in forests and grasslands (MOEF, GOI)
Investigators: Pramod Jha, Sumanta Bagchi
15. 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, B.P. Meena, Pradip Dey, AK Biswas
16. Sustainable biochar production agroforestry systems and its application: A climate resilient soil management approach funded by ICRAF
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

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

Climate Change

(A) Institute Projects

17. Climate change impact on water productivity of major crops in central India
Investigators: N.K. Sinha, M. Mohanty, J. Somasundaram, Pramod Jha, Alka Rani, Seema Bhardwaj, Hiranmoy Das, K.M. Hati, R.S. Chaudhary
18. Impacts of conservation agriculture on runoff and soil loss under different cropping system in
Vertisols
Investigators: Prabhat Tripathi, R.K. Singh, R.S. Chaudhary, Seema Bhardwaj, J. Somasundaram, M. Mohanty, K.M. Hati, Rahul Mishra.
19. 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. Soil moisture estimation through remote sensing for agriculture drought monitoring and early warning
Investigators: Alka Rani, NK Sinha, M Mohanty, Jitendra Kumar, Seema Bhardwaj, RS Chaudhary, KM Hati and RK Singh
c. Evaluation of deficit irrigation levels and phosphorus nutrition levels for optimizing water productivity rooting behaviour and yield of wheat in semiarid climate of central India
Investigators: Seema Bhardwaj, Alka Rani, Jitendra Kumar, Prabhat Tripathi, J Somasundaram, RS Chaudhary, M Mohanty

(B) External funded projects

20. Assessment of important soil properties of India using mid-infrared spectroscopy (ICAR-ICRAF, Nairobi)
Investigators:K.M. Hati, M. Mohanty, Pramod Jha, R.S. Chaudhary, N.K. Sinha, J.K. Thakur, M. V. Coumar, Pradip Dey, Dhiraj Kumar, A.K. Patra, Javed Rizvi
21. CRP-Conservation Agriculture (LCPC: Dr AK Biswas and DLCPC: Dr RS Chaudhary) (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
c. Fine-tuning of conservation agricultural practices for Vertisols of central India
Investigators: J Somasundaram, S Ramana, BP Meena and Abhay Shirale

d. Development of water and nutrient management practices in conservation agriculture for Vertisols of central India
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, Brij Lal Lakaria, M Mohanty, JK Thakur and K Bharati
22. Cropping systems and soil management effects on soil organic carbon sequestration and greenhouse gas emission in Vertisols of central India under change climate scenarios (NICRA II-Phase, ICAR)
Investigators: M Mohanty, NK Sinha,Pramod Jha, Sangeeta Lenka, J Somasundaram, , AK Vishwakarma, RS Chaudhary, Muneshwar Singhand Seema Bhardwaj
23. Strategies for enhancing yield of soybean (*Glycine Max* L) and pigeonpea (*Cajanus cajan*, L) in India using climate variability information and crop growth simulation models in collaboration with ICAR-IISR, Indore (IITM, Pune)
Investigators: M Mohanty, VS Bhatia, NK Sinha, Prabhat Tripathi, RS Chaudhary, Seema Bhardwaj and AK Patra
24. Sustainable adaptive management of water resources to variable climates of Madhya Pradesh (ICAR-ICARDA, Moracco)
Investigators: M Mohanty, NK Sinha, AK Patra
25. Vulnerability and impact assessment of climate change on soil and crop production in Madhya Pradesh (UNDP-GEF-MoEFCC)
Investigators: Sangeeta Lenka, NK Lenka, M Mohanty, RH Wanjari and AK Patra
26. Assessing the potential impact of climate smart technologies on soil health and nutrient
accounting in selected vulnerable districts of MP (EPCO, Bhopal)
Investigators: Sangeeta Lenka, NK Lenka, MV Coumar, M Mohanty, Dolamani Amat, JK Saha, AK Patra, Dinesh Kumar Yadav
27. Assessing the potential impact of climate change and management on soil carbon and nitrogen storage in selected ecosystems of India (NASF, ICAR)
Investigators: Sangeeta Lenka, NK Lenka, Vasudev Meena, Asit Mandal, Kaushik Batabayal (BCKV, West Bengal)

7.3 Programme III – Soil Microbial Diversity and Biotechnology

(A) Inter-Institute Project

28. Effects of long term use of fertilizer and manure on soil functional diversity and nutrient supplying capacity under different soils and cropping systems(ICAR-IISS, Bhopal and ICAR-IISR, Indore)
Investigators: Sudeshna. Bhattacharjya, Asha Sahu, MC Manna, Muneshwar Singh, RH Wanjari, MP Sharma and AK Patra.

29. 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 Bhattachrjya, 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: J.K. Thakur, Asit Mandal, Dolamani Amat and MC Manna

(B) Externally Funded Projects

30. Enhancing decomposition rate and quality of biowaste through microbial consortia for improving soil health (NASF, ICAR)
Investigators: AB Singh, Asha Sahu, Sudeshna Bhattacharjya,AK Tripathi, JK Thakur, Dolamani Amat, Asit Mandal

31. Ecogenomics of soil microbes involved in global climate mitigation and nitrogen use efficiency in rice-wheat agroecosystem of central India under elevated CO_2 and temperature (DST, New Delhi)
Investigators: SR Mohanty, K Bharati, S Gangil (ICAR-CIAE, Bhopal), AK Vishwakarma

32. 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

33. Methanogenic bio-electrode driven conversion of CO_2 to CH_4 to enhance methanogenesis and mitigation of greenhouse gas from agro-waste basedbioenergy systems" (DST-JSPS programme)
Investigators: S.R. Mohanty, K. Bharati, A.K. Patra, Seiya Tsujimura, Masanori Kaneko

34. Microbial based agricultural waste management using vermicomposting funded by Swachchta Action Plan, ICAR, New Delhi
Investigators: AK Patra (Project leader), AK Vishwakarma (PI), JK Thakur, AB Singh, BL Lakaria, BP Meena, RS Chaudhary, Asha Sahu, Asit Mandal

7.4 Programme IV: Soil Pollution, Remediation and Environmental Security

(A) Institute Project

35. Quantitative assessment of acid mine drainage affected areas in Madhya Pradesh
Investigators: Madhumonti Saha, Ajay, Abhijit Sarkar, JK Saha and Hiranmoy Das.

36. 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, Madhumonti Sah, JK Saha, NK Sinha, H Biswas (ICAR-NBSSLUP Nagpur), Mrunalini Kancheti (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, J. K. Saha , Sunil Kumar Meena (CPCB), Hiranmoy Das, Ajay and Dinesh Kumar Yadav

(B) Externally Funded Projects

37. Reclamation and rehabilitation of copper mining affected land in malanjkhand area of madhya pradesh, (Hindustan Copper Ltd. Malanjkhand)
Investigators: Ajay, Tapan Adhikari, Asit Mandal and JK Saha

38. Use of fly ash in agriculture for sustainable crop protection and environmental protection funded by NTPC, Noida
Investigators:J.K. Saha, M. V. Coumar, A.K. Patra, Tapan Adhikari, Ajay, K.M. Hati, Vasudev Meena, Abhijit Sarkar, Rahul Mishra, Sangeeta Lenka, Asit Mandal, A.K. Vishwakarma, Madhumonti Saha , Hiranmoy Das, S Ramana, Nisha Sahu.

39. Exploring endophytic fungi for the phytoremediation of heavy metal contaminated soils (DST, New Delhi)
Investigators: Asit Mandal

40. 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, C. D. Singh, Samir Kumar Pal, S N Bose

New project approved

New Externally funded Projects (RPP-I)

1. Evaluating the impact of Geoxol.com on soil health and crop productivity funded by M/s Privi Life Science, Mumbai (Contractual project)
Investigators: J Somasundaram, NK Sinha, M Mohanty, RS Chaudhary, KM Hati, AO Shirale, AK Patra

2. 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, C. D. Singh, Samir Kumar Pal, S N Bose

3. 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, B.P. Meena, Pradip Dey, AK Biswas

4. Sustainable biochar production agroforestry systems and its application: A climate resilient soil management approach funded by ICRAF
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, Archana Singh, Jamal Pervez Noor

5. Investigation of potentials of soil as a sink for nitrous oxide and strategies for mitigation nitrous oxide emission

funded by DST SERB –POWER Fellowship
Investigator: Sangeeta Lenka

6. Modelling soil carbon storage and dynamics in different agro-ecosystems of India under the changing climate scenarios funded by NICRA
Investigators: M. Mohanty, N.K. Sinha, Pramod Jha, Dhiraj Kumar, R.H. Wanjari, Prabhat Tripathi, AK Patra
7. 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: M. Mohanty, N.K. Sinha, J. Somasundaram, Pramod Jha, K. Bharati, Jitendra Kumar, Sangeetal Lenka, J.K. Thakur, Abinash Das, KM Hati, RS Chaudhary, AK Patra
8. Evaluating the effect of Bio.soilz on soil nutrient availability and microbial activity under maize-wheat cropping system in vertisols of Central India funded by M/s Blu Soils Agro Pvt. Ltd, Patna (Contractual project)
Investigators: Asit Mandal, JK Thakur, AB Singh, R Elanchezhian, AK Patra
9. UAV based soil moisture measurement and dissemination-IoT based approach for soil moisture monitoring and dissemination (Collaborative project with IIT Delhi)
Investigators: NK Sinha, AK Vishwakarma, J Somasundaram, KM Hati, M Mohanty, Jitendra Kumar Alka Rani, S Sen (IIT Delhi)

New institute projects (RPP-I)

1. Impact of Water and nitrogen management strategies on soil quality /soil health under conservation agriculture in Vertisols
Investigator: J. Somasundaram

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

1. Development and promotion of CA machinery (ICAR-IISS, Bhopal and ICAR-CIAE, Bhopal)
Investigators: Dushyant Singh, NS Chandel, A.K. Vishwakarma
2. System for production of enriched biochar from crop residue (ICAR-IISS, Bhopal and ICAR-CIAE, Bhopal)
Investigators: Sandip Mandal, Chirag Maheswari, A.K. Shukla, S.K. Behera
3. 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

8. Consultancies, Contractual Services, Patents and Technology Commercialization

S. No.	Title	Sponsorer	Project team
1	Evaluating the impact of Geoxol.com on soil health and crop productivity	M/s Privi Life Science, Mumbai	J Somasundaram, NK Sinha, M Mohanty, RS Chaudhary, KM Hati, AO Shirale, AK Patra
2	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

9. Publications

9.1 Papers in Research Journal

9.1.1 International/ National (NAAS rating more than 6)

Adhikari T, Dharmarajan R, Lamb D, Zhang H (2021). Remediation of frogmore mine spoiled soil with nano enhanced materials. *Soil and Sediment Contamination: An International Journal*, DOI: 10.1080/15320383.2021.1950610. (NAAS Rating 7.25)

Adhikari T, Gowda RC, Wanjari RH, Singh M (2021). Impact of continuous fertilization on heavy metals content in soil and food grains under 25 years of long-term fertilizer experiment. *Communication in Soil Science and Plant Analysis* 52(04),389-405. (DOI: https://doi.org/10.1080/00103624.2020.1854290). (NAAS Rating 6.77)

Adhikari T, Dharmarajan R (2021).Nano contaminants in soil: emerging concerns and risks. *International Journal of Environmental Science and Technology* https://doi.org/10.1007/s13762-021-03481-1.(NAAS Rating 8.54)

Aher SB, Lakaria BL, Kaleshananda S, Singh AB (2021). Yield, Nutrient uptake and Economics of Soybean-wheat cropping system under organic nutrient management in Central India. *Journal of Plant Nutrition* 45(6), 904-919. (NAAS Rating: 7.13)

Behera SK, Shukla AK, Prakash C Tripathi A, Kumar A,Trivedi V (2021). Establishing management zones of soil sulphur and micronutrients for sustainable crop production. *Land Degradation & Development* 32(13), 3614-3625. https://doi.org/10.1002/ldr.3698.(NAAS Rating 9.78)

Behera SK, Shukla AK, Singh P, Trivedi V, Patra AK, Rao AS, Singh AK (2021). Zinc application enhances yield and alters micronutrients concentration in pigeonpea (*Cajanus cajan* L. Millsp.). *Nutrient Cycling in Agroecosystems* 119,423-443.https://doi.org/10.1007/s10705-021-10133-w.(NAAS Rating 8.45)

Behera SK, Suresh K, Shukla AK, Kamireddy M, Mathur RK, Majumdar K (2021). Soil and leaf potassium, calcium and magnesium in oil palm (*Elaeis guineensis Jacq.*) plantations grown on three different soils of India: Status, stoichiometry and relations. *Industrial Crops and Products* 168, 113589. https://doi.org/10.1016/j.indcrop.2021.113589.(NAAS Rating 10.24)

Bharati K, Parmar R, Vishwakarma A, Dubey G, Patra A, Chaudhari SK, Mohanty SR (2021). Nitrous oxide production from soybean and maize under the influence of weedicides and zero tillage conservation agriculture. *Journal of Hazardous Materials*, 402, p.123572.(NAAS Rating 15.04)

Bhattacharjya S, Adhikari T, Sahu Asha, Patra AK (2021). Ecotoxicological effect of TiO2 nano particles on different soil enzymes and microbial community. *Ecotoxicology*. https://doi.org/10.1007/s10646-021-02398-2.(NAAS rating: 8.82)

Bhattacharjya S, Sahu A, Phalke DH, Manna MC, Thakur JK, Mandal A, Tripathi AK, Sheoran P, Choudhary M, Bhowmick A, Rahman MM, Naidu R, Patra AK (2021). In situ decomposition of crop residues using lignocellulolytic microbial consortia: a viable alternative to residue burning. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-12611-8. (NAAS Rating: 9.06)

Biswas DR, Ghosh A, Ramachandran R, Basak BB, Bhattacharyya R, Biswas SS, Sarkar A,Moharana PC (2021). Decay kinetics of enzymes as influenced by manuring under varying hydrothermal regimes in a wheat–maize cropping system of subtropical Cambisols in India. *Journal of Soil Science and Plant Nutrition* 21, 908-921.(NAAS Rating: 8.16)

Chitdeshwari TC, Jegadeeswari D, Kumar A, Shukla AK (2021). Boron fertilization improves growth, yield, boron uptake and quality of beetroot (*Beta vulgaris* L.). *Agrochimica* 65, 173-186. (NAAS Rating 6.65)

Coumar MV, Parihar RS, Dwivedi AK, Saha JK, Rajendiran S, Lakaria BL, Patra AK (2021). Effects of Co-composting of Municipal Solid Waste and Pigeon Pea Biochar on Heavy Metal Mobility in Soil and Translocation to Leafy Vegetable Spinach. *Bulletin of Environmental Contamination and Toxicology* 106(12). DOI: 10.1007/s00128-020-03096-1. (NAAS Rating 7.66)

Das S, Bhattacharyya R, Das TK, Sharma AR, Dwivedi BS, Biswas AK, Meena MC (2021). Soil quality indices in a Conservation agriculture-based rice-mustard cropping system in north-western Indo-Gangetic plains. *Soil & Tillage Research* 208,104914.(NASS Rating 10.60)

Dhaliwal SS, Sharma S, Sharma V, Shukla AK, Walia SS, Alhomrani M, Gaber A, Toor AS, Verma V, Randhawa MK, Hossain A (2021). Long-term integrated nutrient management in the maize–wheat cropping system in alluvial soils of north-western India: influence on soil organic carbon, microbial activity and nutrient status. *Agronomy* 11, 2258. https://doi.org/10.3390/agronomy11112258.(NAAS Rating 8.60)

Dhaliwal SS, Sharma S, Shukla AK, Sharma V, Bhullar MS, Dhaliwal TK, Alorabi M, Alotaibi SS, Gaber A, Hossain A (2021). Removal of biomass and nutrients by weeds and direct-seeded rice under conservation agriculture in light-textured soils of north-western India. *Plants* 10, 2431. https://doi.org/10.3390/plants10112431.(NAAS Rating 8.76)

Dhaliwal SS, Sharma V, Shukla AK, Kaur J, Verma V, Singh P, Singh H, Abdel-Hafez SH, Sayed S, Gaber A, Ali R, Hossain A(2021). Enrichment of Zinc and Iron Micronutrients in Lentil (*Lens culinaris* Medik.) through Biofortification. *Molecules* 26,7671. https://doi.org/10.3390/molecules26247671.(NAAS Rating 9.27)

Dhaliwal SS, Sharma V, Shukla AK, Verma V, Behera SK, Sandhu PS, Kaur K, Gaber A, Althobaiti YS, Abdelhadi AA, Hossain A (2021). Assessment of agroeconomic indicators of Sesamum indicum L. as influenced by

application of boron at different levels and plant growth stages. Molecules 26, 6699. https://doi.org/10.3390/molecules26216699.(NAAS Rating 9.27)

Dhaliwal SS, Sharma V, Shukla AK, Verma V, Behera SK, Singh P, Alotaibi SS, Gaber A,Hossain A (2021). Comparative efficiency of mineral, chelated and nano forms of zinc and iron for improvement of zinc and iron in Chickpea (Cicer arietinum L.) through biofortification. *Agronomy* 11, 2436. https://doi.org/10.3390/agronomy11122436.(NAAS Rating 8.60)

Dhaliwal SS, Sharma V, Shukla AK, Verma V, Sandhu PS, Behera SK, Singh P, Kaur J, Singh H, Abdel-Hafez SH, Gaber A, Sayed S, Hossain A (2021). Interactive effects of foliar application of zinc, iron and nitrogen on productivity and nutritional quality of Indian mustard (*Brassicajuncea* L.). *Agronomy* 11(11),2333. https://doi.org/10.3390/agronomy11112333.(NAAS Rating 8.60)

Garg KK, Jain D, Rajpurohit D, Kushwaha HS, Daima HK, Stephen BJ, Singh A, Mohanty SR (2021). Agricultural Significance of Silica Nanoparticles Synthesized from a Silica Solubilizing Bacteria. *Comments on Inorganic Chemistry*, 1-17. (NAAS Rating 10.82)

Ghosh A, Singh AK, Madhab SK, Manna C, Jha P, Bhattacharyya R, Manjanagouda SS, Singh R, Chaudhari SK, Kumar RV (2021). Do moisture conservation practices influence stability of soil organic carbon and structure? *Catena* 119, 105127. (NAAS Rating 10.33)

Giridhar K, Gowda NK S, Pal DT, Krishnamoorthy P, Joseph RF, Dey DK, Shukla AK(2021). Feeding zinc biofortified sorghum stover decreases zinc deficiency in sheep. *Indian Journal of Animal Sciences* 91(4), 299–304.(NAAS Rating 6.28)

Hati KM, Jha P, Dalal RC, Somasundaram J, DangaYP, KopittkePM, Kirchhof G,Menzies NW (2021). 50 years of continuous no-tillage, stubble retention and nitrogen fertilization enhanced macro-aggregate formation and stabilisation in a Vertisol. *Soil & Tillage Research* 214, 105163. (NAAS Rating 10.60)

Jain D, Bhojiya AA, Chauhan S, Rajpurohit D, Mohanty SR (2021). Polyphasic characterization of plant growth promoting cellulose degrading bacteria isolated from organic manures. *Current Microbiology* 78(2), 739-748. (NAAS Rating 7.75)

Jayraman S, Sinha NK, Mohanty M, Hati KM, Biswas AK, Chaudhary RS, Shukla AK (2021). Conservation tillage, residue management, and crop rotation effects on soil major and micro-nutrients in semi-arid vertisols of India. *Journal of Soil Science and Plant Nutrition* 21(1), 523-535.(NAAS Rating 8.16)

Jha P, Lakaria BL, Vishwakarma AK, Wanjari RH, Mohanty M, Biswas AK, Sinha NK (2021). Modeling the organic carbon dynamics in long-term fertilizer experiments of India using the Rathamsted carbon model. *Ecological Modelling* 450,109562. (NAAS Rating 8.50)

Jhanji S, Shukla AK, Dhatt KK, Kumar P (2021). Road to successful floriculture through soil micronutrient mapping of different zones of India. *Indian Journal of Agricultural Sciences* 91 (5), 666–672.(NAAS Rating 6.21)

Jorrin B, Maluk M, Atoliya N, Kumar SC, Chalasani D, Tkacz A, Singh P, Basu A, Pullabhotla SV, Kumar M, Mohanty SR (2021). Genomic diversity of pigeon pea (*Cajanuscajan* L. Millsp.) endosymbionts in India and selection of potential strains for use as agricultural inoculants. *Frontiers in Plant Science*, 1848.(NAAS Rating 10.40)

Khanam R, Hazra GC, Ghosh AB, Kulsum PG, Chatterjee N, Shukla AK (2021). Risk Assessment of Arsenic Toxicity Through Groundwater-Soil-Rice System in Maldah District, Bengal Delta Basin, India. *Archives of Environmental Contamination and Toxicology* 81, 438–448.(NAAS Rating 8.40)

Kumar D, Rizvi RH, Bhatt S, Singh R, Chaturvedi OP (2021). Land use/land cover change and soil fertility mapping using GIS and remote sensing: A case study of Parasai-Sindh watershed in Bundelkhand region of Central India. *Range Management and Agroforestry* 42(1),15-21. (NAAS Rating 6.28)

Kumar P, Sharma M, Butail NP, Yadav S, Kumar P, Shukla AK (2021). Assessing the spatial variability of the soil properties in geologically complex Jawali region of north-west Himalaya,India.*International Journal of Environmental Analytical Chemistry*. https://doi.org/10.1080/03067319.2021.1900146.(NAAS Rating 7.43)

Kumar S, Yadav DK, Sharma K, Yadav S, Vijaykumar L, Deeksha MG (2021). Screening of rice landraces and their morpho-biochemical basis of resistance against Cnaphalocrocismedinalis. *The Indian Journal of Agricultural Sciences* 91(3). (NAAS Rating 6.21) Volume No 91(3): 382-387

Lakshmi PV, Singh SK, Pramanick B, Kumar M, Laik R, Kumari A, Shukla AK, Abdel Latef AA H, Ali OM,Hossain A(2021). Long-term zinc fertilization in calcareous soils improves wheat (*triticum estivum* l.) productivity and soil zinc status in the rice–wheat cropping system. *Agronomy* 11, 1306. https://doi.org/10.3390/agronomy11071306.(NAAS Rating 7.68)

Lal N, Gupta AK, Marboh ES, Kumar A, Nath V(2021). Effect of mode of pollination on fruit set and fruit characteristics in litchi.*Erwerbs-Obstbau* 63,227-23. (NAAS Rating 7.04)

Lal N, Sahu N, Evening Stone Marboh, Gupta AK, Kumar A, Nath V (2021). Effect of Pollen Grain and Pollination Period on Fruit Set in Litchi (Litchi chinensisSonn.). *National Accademy of Sciences Letter* 44(5), 461-464. (NAAs Rating 6.42)

Lenka NK, Lenka S, Yashona DS, Shukla AK, Elanchezhian R, Dey P, Agrawal PK, Biswas AK, Patra AK (2021). Carbon dioxide and/or temperature elevation effect on yield response, nutrient partitioning and use efficiency of applied nitrogen in wheat crop in central India. *Field Crops Research* 264, 108084.(NAAS Rating 10.31)

Lenka NK, Lenka S, Yashona DS, Jat D (2021). Elevated temperature and low nitrogen partially offset the yield, evapotranspiration, and water use efficiency of winter wheat under carbon dioxide enrichment. *Agricultural*

Water Management 250, 106856. (NAAS Rating 10.02)

Mangalasserya S, Nayak MG, Philip PS, Rupa TR, Behera SK, Srinivasan V (2021). Delineating the nutrient constraints and developing nutrient norms for cashew (*Anacardium occidentale* L.) in coastal India. *Journal of Plant Nutrition* 44(17), 2627-2639. https://doi.org/10.1080/01904167.2021.1921198.(NAAS Ratinmg 7.13)

Manorama K, Behera SK, Suresh K (2021). Establishing optimal nutrient norms in leaf and soil for oil palm in India. *Industrial Crops and Products* 174, 114223. https://doi.org/10.1016/j.indcrop.2021.114223.(NAAS Ratinmg 10.24)

Manorama K, Behera SK, Suresh K, Prasad MV, Mathur RK,Harinarayana P (2021). Mulching and technological interventions avoid land degradation in intensive oil palm (*Elaeis guineensis Jacq*.) production system. *Land Degradation & Development* 32(13), 3785-3797. https://doi.org/10.1002/ldr.3886.(NAAS Ratinmg 9.78)

Meena BP, Biswas AK, Singh M, Das H, Chaudhary RS, Singh AB, Shirale AO, Patra AK (2021). Energy budgeting and carbon footprint in long-term integrated nutrient management modules in a cereal- legume (*Zea mays – Cicer arietinum*) cropping system. *Journal of Cleaner Production* 314:1-13, 127900. (NAAS Rating 13.25).

Meena BP, Jha P, Ramesh K, Biswas AK, Elanchezhian R, Das H, Sathyaseelan N, Shirale AO, Patra AK (2021). Agronomic management based on multi-split topdressing increases grain yield and nitrogen use efficiency in rainfed maize in Vertisols of India. *Journal of Plant Nutrition*, DOI:10.1080/01904167.2021.1998529. (NAAS Ratinmg 7.13)

Meena BP, Jha P, Ramesh K, Biswas AK, Elanchezhian R, Neenu S, Das H, Shirale AO, Patra AK (2021). Modified split application of nitrogen with biochar improved grain yield and nitrogen use efficiency in rainfed maize grown in Vertisols of India. *Journal of Plant Nutrition*.https://doi.org/10.1101/2020.07.13.200345.(NAAS Ratinmg 7.13)

Mohanty SR, Kumar A, Parmar R, Dubey G, Patra AK, Kollah B (2021). Do methanotrophs drive phosphorus mineralization in soil ecosystem?. *Canadian Journal of Microbiology,* 67(6), 464-475.(NAAS Rating 7.79)

Moharana PC, Biswas DR, Ghosh A, Sarkar A (2020). Variability of crop residues determines solubilization and availability of phosphorus fractions during composting of rock phosphate enriched compost *vis*-à-vis ordinary compost. *Communications in Soil Science and Plant Analysis* 51(15),2085-2101.(NAAS Rating 6.77)

Nandi R, Mondal K, Singh KC, Saha M, Bandyopadhyay PK,Ghosh PK (2021). Yield-water relationships of lentil grown under different rice establishments in Lower Gangetic Plain of India. *Agricultural Water Management* 246, 106675. https://doi.org/10.1016/j.agwat.2020.106675.(NAAS Rating 10.02)

Pratibha G, Shrinivas I, Biswas AK, Madhavi M, Indoria AK, Murthy K, Reddy S, Ch SR (2021). Weed shift and community diversity in conservation and conventional agriculture systems in pigeonpea-castor system under rainfed semi-arid tropics. *Soil and Tillage Research* 212, 105075.(NAAS Rating 10.60)

Ramana S, Tripathi AK, Ajay, Singh AB, Bharti K, Sahu Asha, Rajput PS,Saha JK, Srivastava S, Dey P, Patra AK (2021). Potential of cotton for remediation of Cdcontaminated soils. *Environmental Monitoring and Assessment*. 193, 186.https://doi.org/10.1007/s10661-021-08976-5. (NAAS rating: 7.90)

Ramana S, Tripathi AK, Bharti K, Singh AB, Ajay, Sahu A, Rajput PS, Dey P, Saha JK, Patra AK (2021). Tolerance of cotton to elevated levels of Pb and its potential for phytoremediation. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-13067-6,. (NAAS rating: 9.06)

Ramana S, Tripathi AK, Kumar A, Dey P, Saha JK, Patra AK (2021). Phytoremediation of Soils Contaminated with Cadmium by *Agave Americana*. *Journal of Natural Fibers*. https://doi.org/10.1080/15440478.2020.1870642.(NAAS Rating 8.62)

Ramana S, Tripathi AK, Kumar Ajay, Dey P, Saha JK, Patra AK (2021). Evaluation of *Furcraeafoetida* (L.) Haw. for phytoremediation of cadmium contaminated soils. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-021-12534-4.(NAAS Rating: 9.06)

Renu S, Sarim KM, Singh DP, Sahu U, Bhoyar MS, Sahu A, Kaur B, Gupta A, Mandal A, Thakur JK, Manna MC, Saxena AK (2021). Deciphering cadmium (Cd) tolerance in newly isolated bacterial strain, *Ochrobactrum intermedium* BB12, and its role in alleviation of Cd stress in Spinach plant (*Spinacia oleracea* L.). *Frontiers in Microbiology* 4156.(NAAS Rating 10.23)

Roy T, Biswas AK, Sarkar AO, Jha P, Sharma NK, Mishra PK, Patra AK (2021). Impact of Varied Levels of N, P, and S Stoichiometry on C Mineralization from three Contrasting Soils with or Without WheatStraw Amendment: a Laboratory Study. *Journal of Soil Science and Plant Nutrition*. https://doi.org/10.1007/s42729-021-00664-0.(NAAS Rating 8.16)
Rating 7.90)

Saha M, Das M, Sarkar A (2021). Distinct nature of soil organic carbon pools and indices under nineteen years of rice-based crop diversification switched over from uncultivated land in eastern plateau region of India. *Soil & Tillage Research* 207, 104856. (NAAS Rating 10.60)

Saha M, Sarkar A, Badyopadhyay PK, Nandi R, Singh KC (2021). Tillage and potassium management for improving yield, physiological, and biochemical responses of rainfed lentil under moisture stressed rice-fallow. *Journal of Soil Science and Plant Nutrition* 20, 2536–2551.(NAAS Rating 8.16)

Sahu A, Singh SK, Sahu N, Manna MC, Patra AK (2021). Phytoextraction of cadmium by African marigold (*Tageteserecta* L.) grown under cadmium contaminated soil inoculated with arbuscular mycorrhizal fungus, *Glomus mosseae*. *International Journal of Environment* *and Pollution*. 68(1/2), 59-71..(NAAS Rating 6.54)

Sahu N, Reddy GP Obi, Das B, Kumar N, Singh SK (2021). Assessment on spatial extent of arid and semi-arid climatic zones of India using GIS. *Journal of Agrometeorology* 23(2), 189-193.(NAAS Rating 6.47)

Sarkar A, Biswas AK, Ghosh A, Jha P, Das M, Patra AK, Roy T, Saha M, Biswas SS, Biswas DR (2021). Moisture sensitivity alteration of soil organic carbon and nitrogen mineralization in Vertisol. *Indian Journal of Agricultural Sciences* 91(10),26-30.(NAAS Rating 6.21)

Sarkar A, Biswas DR, Datta SC, Dwivedi BS, Bhattacharyya R, Kumar R, Bandyopadhyay KK, Saha M, Chawla G, Saha JK and Patra AK (2021). Preparation of novel biodegradable starch/ poly(vinyl alcohol)/bentonite grafted polymeric films for fertilizer encapsulation. *Carbohydrate Polymers* 259, 117679. (NAAS Rating 13.18)

Sarkar A, Biswas DR, Datta SC, Dwivedi BS, Kumar R, Bandyopadhyay KK, Bhattacharyya R, Saha M, Biswas SS, Patra AK (2021). Double-boiled linseed and mustard oil-based formulations to prepare oil-coated controlled release fertilizers. *Indian Journal of Agricultural Sciences* 91(2), 310-4.(NAAS Rating 6.21)

Sarkar A, Saha M, Saha JK, Coumar MV, Mandal A, Patra AK (2021). Comparative assessment of P adsorption, release kinetics, enzymatic activities of weathered fly ash amended texturally different soils. *International Journal of Environmental Sciences and Technology*. https://10.1007/s13762-021-03196-3. (NAAS Rating 8.54)

Shukla AK, Behera SK, Prakash C, Patra AK, Rao CS, Chaudhari SK, Das S, Singh AK, Green A (2021). Assessing multi-micronutrients deficiency in agricultural soils of India. *Sustainability* 13(16), 9136.https://doi.org/10.3390/su13169136. (NAAS Rating 8.58)

Shukla AK, Behera SK, Prakash C, Tripathi AK, Patra AK, Dwivedi BS, Trivedi V, Rao CS, Chaudhari SK, Das S, Singh AK (2021). Deficiency of phyto-available sulphur, zinc, boron, iron, copper and manganese in soils of India. *Scientific Reports* 11, 19760. https://doi.org/10.1038/s41598-021-99040-2. (NAAS Rating 10.00)

Shukla AK, Behera SK, Tripathi R, Prakash C, Nayak AK, Kumar PS, Chitdeshwari T, Kumar D, Nayak RK, Babu PS, Katkar RN, Subbarayappa CT, Moharana KC, Patra AK, Rao CS, Chaudhari SK, Rao AS, Singh AK, Das S (2021). Evaluation of spatial spreading of phyto-available sulphur and micronutrients in cultivated coastal soils. *PLoS ONE* 16(10), e0258166. https://doi.org/10.1371/journal.pone.0258166.(NAAS Rating 8.74)

Singh M, Babanna SK, Kumar D, Ragunandhan P, Dwivedi ID, Kumar A, Tewari RK, Chaturvedi OP,Dagar JC (2021). Valuation of fuelwood from agroforestry systems: a methodological perspective. *Agroforestry Systems* 95, 977-993. (NAAS Rating 7.97)

Sinha NK, Mohanty M, Somasundaram J, Chaudhary RS, Patra H, Hati KM, Singh RP, Thakur JK, Kumar J, Kumar Dhiraj, Rani A, Singh AB, Bal SK, Reddy KS, Prabhakar M (2021). Maize productivity analysis in response to climate change under different nitrogen management strategies. *Journal of Agrometeorology* 23(3), 279-285. (NAAS Rating 6.47)

Suresh K, Behera SK, Manorama K, Mathur RK (2021). Phenological stages and degree days of oil palm crosses grown under irrigation in tropical conditions. *Annals of Applied Biology* 178(1), 121-128.https://doi.org/10.1111/aab.12641.(NAAS Rating 8.04)

Tripathi R, Majhi M, Sahu SG, Mohanty S, Moharana KC, Shahid Md, Swain CK, Lal B, Gautam P, Dash PK, Chatterjee D, Kumar A, Tripathy R, Bhattacharya B, Shukla AK, Nayak AK (2021). Modelling the spatial variation of methane and nitrous oxide emission from rice fields using DNDC model. *Journal of the Indian Society of Remote Sensing*. https://doi.org/10.1007/s12524-021-01433-3.(NAAS Rating 7.00)

Yadav DK, Tripathi KP, Kaushik P, Rana Pankaj,Kamil VS, Khatri DD, Shakil NA (2021). "Microwave assisted synthesis, characterization and biological activities of ferrocenyl chalcones and their QSAR analysis: Part II". *Journal of Environmental Science and Health,* Part B, 56(1), 82-97. DOI:10.1080/03601234.2020.1838828. (NAAS Rating 7.20)

Yadav DK, Tripathi KP, Kaushik P, Rana P, Kamil VS, Khatri D, Shakil NA (2021). Antinemic activity of ferrocenyl chalcones against Meloidogyne incognita infestation in tomato. *Indian Journal of Agricultural Sciences* 91(2), 305-9. (NAAS Rating 6.21)

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

Kumar J, Vashisth A, Sinha NK, Mohanty M, Rani A, Chaudhary RS (2021). Application of Ground-Based Remote Sensing in Identifying Biotic Stress: A Review. *Research Biotica*, 3(1): 28-32.

Lal N, Singh Awtar, Gupta AK, Marboh ES, Kumar A, Nath V (2021). Vivipary in litchi (Litchi chinensis): new report.*Current Horticulture* 9(2): 70.(NAAS Rating 4.53)

Lal N, Pandey SK, Nath V(2021). Assessment of Dwarf Genotypes in Litchi based on Trunk and leaf characteristics. *Journal of AgriSearch*, 8 (4):331-337. (NAAS Rating 4.71)

Mallick P, Basak JS, Dutta A, Das H, Majumder A (2021). Construction of Two Level Balanced and Nearly Balanced Optimal Supersaturated Designs. *Journal of Indian Society Agricultural Statistics* 75(1), 63-73. (NAAS Rating 5.51)

Shukla AK, Behera SK, Singh G (2021). Micronutrient fertilizers in Indian agriculture–product profile, availability, forecast and agronomic effectiveness. *Indian Journal of Fertilisers* 17 (4), 348-360.(NAAS Rating 4.76)

Singh NR, Kumar Dhiraj, Handa AK, N Ram, Kamini MP, Naresh Kumar, Ram A, Devi, Bhatt BP, Chaturvedi

OP, Arunachalam A and Singh LN (2021). Land use effect on soil organic carbon stocks, microbial biomass and basal respiration in Bundelkhand region of central India. *Agricultural Research*.https://doi.org/10.1007/s40003-021-00584-6. (NAAS Rating 5.20)

Basavaraja PK, Mohamed SH, Rajesh NL, Gangamrutha GV,Dey P (2021). Spatial heterogeneity of plant nutrients in soils of Mysuru District, Karnataka. *Journal of Indian Society of Soil Science* 69(4), 369-377. (NAAS Rating 5.31)

Chaudhary RS, Somasundaram J, Sinha NK, Lakaria BL, Mohanty S R, Singh AB, Mohanty M, Hati KM, Singh RK, Patra AK (2021). Participatory Soil Quality Assessment Using Low-Cost Tools under Contrasting Management Practices in a Vertisol. *Agricultural Research* https://doi.org/10.1007/s40003-021-00598-0. (NAAS Rating 5.10)

Chaudhary SK, Jat ML, Chakraborty D, Biswas AK (2021). Conservation Agriculture and Sustainable Development Goals: Potential Opportunities, and Strategies in India. PPMANDTM. *Indian Journal of Agricultural.Physics* 21(1), 1-9. (NAAS Rating 5.10)

Chhokar RS, Das TK, Choudhary VK, Chaudhary A, Raj Rishi, Vishwakarma AK, Biswas AK, Singh GP, Chaudhari SK (2021). Weed Dynamics and Management in Conservation Agriculture. *Journal of Agricultural Physics* 21(1), 222-246. . (NAAS Rating 5.10)

Coumar MV, Sharma M, Jain RC, Saha JK, Gupta SC, Rajendiran S, Patra AK (2021). Effect of Modified Steel Slag Application as Soil Amendment on Soil Quality and Spinach Yield in a Copper Contaminated Vertisol. *Biological Forum* 13(2): 336-344. (NAAS Rating 5.11)

Das H, Dutta A, Nishad D, Majumder A (2021). New D-optimal Covariate Designs in CRD and RCBD set-ups. *Journal of Indian Society of Agricultural Statistics* 75(2), 157-168. (NAAS Rating 5.61)

Dey P, Bhattacharyya K (2021). A pandemic resilient policy for soil research in the backdrop of COVID-19. *Agricultural Research Journal* 58 (1), 159-163. (NAAS Rating 5.44)

Jain D, Kaur G, Bhojiya AA, Chauhan S, Khandelwal SK, Meena RH, Rajpurohit D, Mohanty SR (2021). Phenetic Characterization of Nitrogen Fixing Azotobacter from Rhizospheric Soil of Southern Rajasthan. *Journal of Pure and Applied Microbiology* 15(1), 428-436. (NAAS Rating 5.05)

Jain D, Meena RH, Choudhary J, Sharma SK, Chauhan S, Bhojiya AA, Khandelwal SK, Mohanty SR (2021). Effect of microbial consortia on growth and yield of wheat under typic haplustepts. *Plant Physiology Reports* 26(3), 570-580. (NAAS Rating 5.50)

Kumar R, Makarana G, Biswas AK, Mishra JS, Chaudhary AK, Hans H (2021). Performance of Promising lentil (Lens culanaris) cultivars under zero-till condition for sustanable intensification of rice (*ORYZA SATIVA*)-fallows in eastern India. *Indian Journal of Agronomy* 66 (4), 444-448. (NAAS Rating 5.55)

Pratibha G, Hati KM, Mishra JS, Sharma KL, Srinivas K, Prasad JVNS, Kundu S, Indoria AK, Rao KV, Srinivas I, Rao MS, Desai S, Manjunath M, Reddy KS, Raju MKB, Somasundaram J, Vishwakarma AK, Choudhary RS, Jha P, Singh RK, Mudalagiriyappa, Patode R, Arunakumari H, Biswas AK, Patra AK, Chaudhari SK (2021). India's Consortia Research Platform on Conservation Agriculture: Recent Advancements and Lessons Learnt in Rainfed Semi-arid Ecologies. *Journal of Agricultural Physics* 21(1), 85-112.(NAASRating 5.10).

B. Technical/Popular Articles/Review Articles

Bhattacharjya S, Sahu A and Singh AB (2021). Significance of blue carbon in climate change mitigation. *Harit Dhara*. 4(2):13-16.

Chavan S, Vishnu R, Kumar N, Kumar D, Sirohi C, Handa AK (2021). Melia dubia An indigenous tree species for industrial agroforestry in India. *Indian Farming* 71 (06): 7-11.

Das A, Rani K, Trivedi A, Yadav D, Singh AB (2021). Earthworm: The ecosystem Engineer. *Harit Dhara Volume* 4 (1) PP 16-20.

Gurav PP, Choudhari PL, Shirale AO, Meena BP, Shinogi KC, Biswas AK (2021). Zeolites: The boon for future agriculture. *NESA Newsletter* 24(9):3-4.

Gurav PP, Choudhari PL, Shirale AO, Meena BP, Shinogi KC, Yadav DK, Biswas AK (2021). Zeolite: nature's gift for agriculture production. *Harit Dhara* 4(2): 27-31.

Haokip Immanuel C, Das H, Dey P, Kumar D (2021).Targeted yield approach based fertilizer recommendations for higher productivity and profitability. *Harit Dhara* 4(1): 10-12.

Kumar Dhiraj, Ram Asha, Dev I, Newaj R (2021). Boron status and tackling its widespread deficiency. *Indian Farming* 71(08): 42-44.

Lal N, Biswas AK, Patra AK (2021). Fruitfly: A noxiouspest in guavaorchard. *Agricultural World*. 1(4): 5-9.

Lenka S, Lenka NK, Saha JK (2021). रासायनिक उर्वरकों के उपयोग से उत्पन्न ग्रीन हाऊस गैसों के उत्सर्जन का अल्पीकरण। *Krishisewa*. https://www.krishisewa.com/crop-varieties/1268-elimination-of-emissions-of-greenhouse-gases-generated-by-the-use-of-chemical-fertilizers.html.

Lenka S, Lenka NK, Saha JK and Yadav DK"Potential use of the natural abundance of stable carbon isotope (13C) for soil organic matter turnover". *Harit Dhara*, 4(2): 17-19.

Manorama K, Suresh K, Rao BN, Ramachandrudu K, Behera S.K, Kalidas K, Prasad MV, Mathur R K (2021) Best managment practices for growing irrigated oil palm in India. *Technical Bulletin, ICAR-IIOPR, Pedavegi, A. P., India*. pp. 1-24. (ISBN : 81-87561-61-0).

Meena BP, Shinogi KC, Shirale AO, Gurav Priya, Meena VD, Biswas AK, Patra AK (2021). Gliricidia (Gliricidia sepium) as an aid for enhancing soil health and crop productivity. *Indian Farming* 71(06):12-14 (June).

Meena BP, Shirale AO, Lakaria BL, Shinogi KC, Gurav PP, Meena V, Biswas AK, Patra AK (2021). Hari pathi keliye Gliricidia. *Kheti* 36-37.

Meena BP, Singh AB, Lakaria BL, Thakur JK, Ramana S, Shankar NR, Patra AK (2021). **जैविक खेती मे सोयाबीन उत्पाद**. ICAR-IISS, Bhopal

Mishra R, Das R, Rani A, Patra AK (2021). Soil Health Card: A step towards sustainable agriculture. *Harit Dhara*, 4(1): 26-28.

Sahoo S, Moharana PC, Lenka S, Priydarshani L, Das D, Dash B (2021). Impact of Climate Change on Agriculture: Present and Future Scenario. *Harit Dhara*. 4 (1). 29-32.

Sahu N, Saha JK (2021). Role of VNIR Spectroscopy in Heavy metal Contaminated Soils. *Agriculture Letters*. 2(8):57-60.

Sahu N, Lal N (2021). Remote Sensing: Boom for Horticulture. *Agriculture letters*. 2(8): 54-56.

Sahu N, Saha JK, Mishra R, Sinha N, Kancheti M, H Biswas, Lal N, Sahu Asha (2021). Jajmau industrial area, Kanpur: hub of chromium in the world. *Harit Dhara*. 4(2):10-12..

Sahu N, Sahu A, Lal N (2021). Industrial Pollutants: Hamper or EnhanceSoilBiodiversity. *Marumegh*: Volume 6(3):6-9.

Shinogi KC, Srivastava S, Gurav P, Meena BP, Shirale AO, Kamble AL (2022) Resource Conserving Technologies for the Rainfed Tribal Farmlands of Central India. *The Agriculture Magazine* 1(4) 22-25.

जादौन प्रियंका, लकारिया बृज लाल, सिंह अरविन्द कुमार एवं गेहलोत यशवन्त (2021) भू–जल पुनर्भरण एवं जल भरण । कृषक जगत। 2 अगस्त 2021।

जादौन प्रियंका, लकारिया बृज लाल, सिंह अरविन्द कुमार एवं गेहलोत यशवन्त (2021) बरसात के पानी का संचय जरूरी । कृषक जगत। 16 अगस्त 2021

Vishwakarma AK, Lakaria BL, Shirale AO, Kamble AL, Singh RK, Wanjari RH, Singh AB, Bharti K, Sahu A, Shinogi KC, Biswas AK, Patra AK, Mishra Anupam, Singh SRK, Parmar P, Nagar HR (2021). Resource conservation technologies for enhancing productivity, economics and resource use efficiency under soybean-wheat cropping system. *Harit Dhara* 4(1) January-June, pp 3-6.

Vishwakarma AK, Lakaria BL, Shirale AO, Kamble AL, Singh RK, Singh AB, Shinogi KC, Bharti K, Sahu A, Biswas AK, Patra AK, Parmar P, Nagar HR (2021). Conservation Agriculture for Enhanced Yield and Income from soybean-wheat systems: Efforts of ICAR-IISS, Bhopal. *Harit Dhara*. Volume 4(1) pp 3-6.

आहेर सतीश भागवत राव, लकारिया बृज लाल एवं लाल नारायण (2021)। फलदार फसलों पर जलवायु परिवर्तन का प्रभाव। फल फूल सितम्बर–अक्टूबर 2021 पृ. 4–6 ।

Yadav B, Malav LC, Yadav DK, Nogiya M, Jangir Aand Mina BL (2021). “Sensor-Based Nutrient Management Techniques”, *Food and Scientific Reports*, 2(12): 34-36.

Yadav DK, Yadav B, Mishra R, Rani K, Das A, Sarkar A, Rani A, Saha JK (2021). Effect of pesticide application on nutrient uptake by plant. *Harit Dhara*, 4(1): 21-23.

C. Technical Bulletins

Gurav PP (2021). Potassium in shrink-swell soils of India: An Enigma (Blog). SEGH, Society for Environmental and Geochemistry Health, https://segh.net/blogs/f/potassium-in-shrink-swell-soils-vertisols-of-india-an-enigma (1-7).

Lakaria BL, Jha P, Biswas AK, Patra AK, Chaudhari SK (2021). Protocol for biochar use in Indian Agriculture. IISS, Bhopal 13p.

Lakaria BL, Singh AB, meena BP, Thakur JK, Ravisankar N, Elanchezhian R, Patra AK (2021). जैविक प्रणाली द्वारा मक्का उत्पादन. ICAR IISS Bhopal, 8 pages.

Naik SK, Jha BK, Mali SS, Kumar O, Kumar R, Biswas AK, Mishra JS,Singh AK (2021). Conservation Agriculture for Management of Rice Fallow Areas in Eastern Plateau and Hill Region of India. ICAR-Research Complex for Eastern Region. *Technical Bulletin* NO,29.

Shinogi KC, Srivastava S, Gurav PP, Ahirwar RP, Tripathi AK, Bharati K, Sinha NK, Kamble AL, Meena BP, Das H, Parihar S, Biswas AK, Patra AK (2021). Indigenous Soil and Water Management Practices Prevail in the Tribal Farmlands of Balaghat District in Madhya Pradesh. ICAR-IISS Extension Bulletin 2021, ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh. 31p.

Kaushal R, Chauhan A, Mohanty SR (2021). Biofertilizer Technology for Vegetable Crops of Termperate Himalayaas, published by ICAR-All India Network project on Soil Biodiversity-Biofertilizers India Institute of Soil Science, Bhopal. Department of Soil Science and Water Management Dr. YSP-UEHF, Nami, Solan-173230, Himachal Pradesh. Technical Bulletin No AINP SBB/YSP-UIHF/2021/02

Lakshmipathy R, Trimurtulu N, Prasad PRK, Mohanty SR (2021). Rhizobial biofertilizers for Pulse Cultivation in Andhra Pradesh, published by ICAR-All India Network project on Soil Biodiversity-Biofertilizers India Institute of Soil Science, Bhopal, Agricultural Research Station Acharaya NG Ranga Agricultural University, Amaravathi

Anith KN, Chitra N, Meena Kumari KK, Nyshanth NS, Kumar AS, Subha P, Vigi S, Bindu R, Ajith RP, Mohanty SR (2021). Biofertilizer technology for Vegetable Crops ICAR-All India Network project on Soil Biodiversity-Biofertilizers, Kerala Agricultural University Department of Agricultural Microbiology College of Agriculture, Vellayani, Thiruvananthapuram, Kerala-69522

Kaushal R, Chauhan A, Mohanty SR (2021). Biofertilizer Technology for Apple, published by ICAR-All India Network project on Soil Biodiversity-Biofertilizers India Institute of Soil Science, Bhopal. Department of Soil Science and Water Management Dr. YSP-UEHF, Nami, Solan-173230, Himachal Pradesh. Technical Bulletin No AINP SBB/YSP-UIHF/2021/02.

Nopmanee S, Lauris L, Maria CSM, Rob de Hayr, Sanjay S, Takesure T (2021). Standard operating procedure for soil pH determination. FAO, Rome. Pp:1-19.https://www.fao.org/3/cb3637en/cb3637en.pdf(appendix III).

D. Books, Reports, Souvenir and Manuals

Chitdeshwari T, Stalin P, Muthumanickam D, Jegadeeswari D, Malathi P, Thilagavathi T, Velu V, Malarvizhi P, Santhi R, Behera SK, Prakash C, Tripathi A, Sikaniya Y, Shukla AK (2021). Sulphur and micronutrients: Soil health and fertility maps of Tamil Nadu. All India Co-ordinated Research Project on Micro and Secondary Nutrients and Pollutant elements in Soils and Plants, Department of Soil Science and Agricultural Chemistry, Directorate of Natural Resource Management, TNAU, Coimbatore & ICAR-Indian Institute of Soil Science, Bhopal, India. ISBN: 978-93-91845-15-5.

Dubey SK, Parandiyal AK,Sharma KK, Debey RK, Meena DC, Singh AK, Jha P,Mohaptar KP (2021). 60 Years of Research in Ravine Region 155p. ISBN 978-81-924624-6-2, ICAR-IISWC, RC, Chhalesar, Agra, 282006

Lakaria BL, Aher SB, Jha P, Singh AB, Meena BP, Ramana S, Thakur JK (2021). Prospects of Organic Farming as Resource Conservation Technology. Conservation Agriculture and Climate Change Impact and Adaptations. Editors: Ritesh Saha, Dhananjay Barman, Madhusudan Behera and Gouranga Kar NIPA Genx Electronic Resources & Solutions Pvt. Ltd., New Dehli-110034 (ISBN: 978-93-90591-08-4) pp 496.

Paramanik B, Panda P, Das I, Kundu A, Mandal A, Choudhury A (2021). Basics of Vermicomposting: A Viable Technology for Rural Livelihood. In: Chapter 3. Sustainable farming. P. S. Patra, K. Pradhan, S. Kheroar, A. Tamanag, P. Adhikary (2021). pp 87-106 New India Publishing Agency. New Delhi. p 44-86

Paramanik B, Panda P, Patra PS, Das I, Mahato NK, Choudhury A, Mandal A (2021). A Low Cost Aquatic Green Manure for Agricultural Crops (Azolla). In: Chapter 4. Sustainable farming. P. S. Patra, K. Pradhan, S. Kheroar, A. Tamanag, P. Adhikary (2021). pp 87-106 New India Publishing Agency. New Delhi. p 87-106

Patra AK, Elanchezhian R, Mohanty SR, Tripathi P, Coumar MV, Mandal A, Sinha NK, Meena BP, Das H (2020). Annual Report 2020, ICAR-IISS Bhopal, 133 p.

Rangare NR, Rangare SB, Lal N, Rahangdale HK. (2021). Production Technology of Tropical and Sub-tropical fruit crops. Pp. 138.Scripown Publication, New Delhi.

Singh AB (2021). मृदा स्वास्थ्य आलोक : Hindi Magazine published annually by our institute. Edited the draft manuscript and finally printed in the form of book

Thakur JK, Mandal A, Manna MC, Jayaraman S, Patra AK (2021). Impact of Residue Burning on Soil Biological Properties. In: Conservation Agriculture: A Sustainable Approach for Soil Health and Food Security (pp. 379-389). Springer, Singapore.

E. Book Chapters

Das A, Mishra R, Rani K, Kundu S, Somasundaram J and Rao Srinivasa Ch. (2021). Improving nutrient use efficiency: Research, technology and policy. In: Innovations and Advances in Agricultural Research, Technology and Policy, ICAR-National Academy of Agricultural Research Management, p.191-227

Chaudhary RS, Kumar Jitendra, Rani A, Bhardwaj S (2021). Judicious Soil Management for Having Improved Physical Properties of Soil and Input Use Efficiency. Pp: 269-304. In: R. Bhatt et al. (eds.), Input Use Efficiency for Food and Environmental Security,https://doi.org/10.1007/978-981-16-5199-1_9. Print ISBN: 978-981-16-5198-4; eBook ISBN: 978-981-16-5199-1.

Dasgupta S, Sengupta S, Saha S, Sarkar A, Anantha KC (2021). Approaches in advanced soil elemental extractability: catapulting future soil–plant nutrition research. In Rakshit A, Singh S, Abhilash P, Biswas A (eds) Soil Science: Fundamentals to Recent Advances. Springer, Singapore. pp. 191-236. https://doi.org/10.1007/978-981-16-0917-6_10

Lakaria BL, Aher S, Jha P, Singh AB, Meena BP, Ramana S, Thakur JK (2021). Biodynamic farming and organic farming: Traditional Approach for Resource Conservation. In. Conservation Agriculture and Climate Change: Impacts and Adaptations (Eds RiteshSaha, Dhananjay Barman, Madhusudan Behera and Gouranga Kar), (ISBN: 978-93-90591-08-4, p496) pp 189-210.

Lenka NK, Ana Patricia Fernández-Getino García (2021). Hedges and Buffer strips. In: Recarbonizing global soils: a technical manual of recommended management practices. Food and Agricultural Organization, Rome, Vol.3, pp. 322-336, doi.org/10.4060/cb6595en.

Meena BP, Shirale AO, Biswas AK, Lakria BL, Meena VD, Gurav Priya P, Das H, Patra AK (2021). Recent advances in enhancing nutrient use efficiency for higher crop productivity. In 'Nutrient Use efficiency Through Next Generation Fertilizers' (Eds) Ummed Singh and C.S. Praharaj. Brillion Publishing, New Delhi pp- 175-198.

Rani A, Kumari A, Singh A, RN and Kumari K (2021). Climate-Smart Agriculture: An Integrated Approach for Attaining Agricultural Sustainability. In: Climate Change and Resilient Food Systems (pp. 141-189). Springer, Singapore.

Sarkar A, Saha M, Biswas SS, Roy T (2021). Preface of phytobiome in nutrient recycling, biogeochemistry, and spatial dynamics. In Solanki MK, Kashyap PL, Ansari RA, Kumari B (Eds.): Microbiomes and Plant Health: Panolpy and their applications. Academic Press, Elsevier pp. 243-266. DOI: https://doi.org/10.1016/B978-0-12-819715-8.00008-2.

Sanjay S. (2021). Importance of Soil / water Testing, Soil / water Sampling techniques and Different simple Soil Testing Kits (Soil Testing Fertilizer Recommendation: STFR meter; Medha Parishak), In. Eds. Balasubramani, N. and Vincent A. (2021). Certificate Course on Integrated Nutrient Management (CCINM) for Fertiliser Dealers [E-book]. Hyderabad: National Institute of Agricultural Extension Management (MANAGE). pp

95-103. (ISBN: 978-81-950446-7-2)

Shinogi KC, Srivastava S, Rashmi I, Somasundaram J, Sinha NK, Gurav PP,Kamble AL (2021). Socioeconomic Challenges and Prospects in the Adoption of Conservation Agriculture Practices in India. In: J Somasundaram, Dalal RC, Patra AK and AK. Chaudhary (eds.). Conservation Agriculture: A Sustainable Approach for Soil Health and Food Security. 611-621.

Shirale AO, Meena BP, Biswas AK, Somasundaram J, Gurav PP, Lakaria BL, Jha P, Lal N, Jat RL, Das H, Patra AK (2021). Nutrient management strategies in climate change scenario. In 'Conservation Agriculture: A Sustainable Approach for Soil Health and Food Security' (Eds) J. Somasundaram, RC Dalal, AK Patra and SK Chaudhari, Springer Nature Singapur Pte Ltd, pp- 407-421.

Shirale AO, Meena BP, Gurav PP, Srivastava S, Biswas AK, Elanchezhian R, Meena VD, Das H, Wanjari RH, Patra AK (2021). Rock Phosphate: An emerging source of Phosphorus for higher use efficiency in field crops. In 'Nutrient Use efficiency Through Next Generation Fertilizers' (Eds) Ummed Singh and CSPraharaj. Brillion Publishing, New Delhi pp- 175-198.

Singh M, Wanjari RH, Kumar U (2021). Long-Term Fertilizer Experiments in India: Achievements and Issues for Future Research. In: Rakshit A., Singh S., Abhilash P., Biswas A. (Eds) Soil Science: Fundamentals to Recent Advances. pp. 781-800 (Publisher: Springer, Singapore. https://doi.org/10.1007/978-981-16-0917-6_39; Published online on 31.07.2021).

Singh RK, Badodiya SK, Tiwari DK, Wanjari RH, Elanchezhian R, Coumar MV, Tripathi P, Singh AB, Das H, Mandal A, Somasundaram J, Shirale AO, Patra AK, Shinogi KC, Chaudhary RS,Alwa J (2021). Balanced fertilizer use in chickpea boosts crop yield and nutritional security of tribal farmers of Madhya Pradesh. In "Advances in Sustainable Management of Natural Resources for Food and Nutritional Security" Theme-2, Natural Resources Management for Food and Nutritional Security. (Book of Abstract: B33).

Sinha NK, Mohanty M, Somasundaram J, Kumar J, Kumar D, Rani A (2021). Implication of Different Tillage System on Root System Architecture and Their Environment. In Conservation Agriculture: A Sustainable Approach for Soil Health and Food Security (pp. 451-475). Springer, Singapore

Somasundaram J, Shirale AO, Sinha NK, Meena BP, Hati KM, Mohanty M, Naorem AK, Biswas AK, Patra AK (2021). Conservation Agriculture for Enhancing Soil Health and Crop Production. In Conservation Agriculture, Climate change Impact and Adaptations Eds., RiteshSaha, Dhananjay Barman, Madhusudan Behera and Gouranga Kar, NIPA Publication, New Delhi, pp- 361-372.

Wanjari RH, Singh RK, Badodiya SK, Tiwari DK, Elanchezhian R, MV Coumar, Singh AB, Das H, Mandal A, Somasundaram J, Shirale AO, Patra AK, Tripathi P, Shinogi KC,Alwa J (2021). Agronomical practices in wheat (cv PusaTejas) to enhance crop productivity and nutritional security in tribal areas of Barwani (Madhya Pradesh). In "Advances in Sustainable Management of Natural Resources for Food and Nutritional Security" Theme -1, Current Trends, and Future Prospects of Natural Resources. (Book of Abstract: A53).

Yadav DK, Sarkar R, Laskar N, Sangama SN, Shakil NA, Recent developments in agrochemicals-synthetic and natural. In: Innovations and Advances in Agricultural Research, Technology and Policy. (Eds Ch. S. Rao, M. Balakrishnan, V.V. Sumanth Kumar, P. Krishnan, and S.K. Soam). ICAR-National Academy of Agricultural Research Management, Hyderabad. p. 411-434. (2021).

Folder/ Extension leaflet

Lakaria BL, Singh AB, Meena BP, Thakur JK, Ramana S, Elanchezhian R, Shankar NR, Patra AK (2021). जैविक पद्धति द्वारा मक्का उत्पादन . ICAR-IISS, Bhopal.

Vishwakarma AK, ICAR-IISS, Bhopal (2021). Rapo composting for improving soil fertility and productivity under SAP as part of National special swachhta campaign

Sahu A, Singh AB, Bhattacharjya S, Thakur JK, Mandal A, Amat D, Das A, Bharati K, Tripathi AK, Patra AK. (2021). Family Net Vessel Composting: Low-Cost Technology for Efficient Recycling of Kitchen Waste. ICAR-IISS, Bhopal.

Singh AB, Thakur JK, Sahu A, Mandal Asit, BL Lakaria, Shankar NR and Patra AK (2021). जैविक खेती में पोषक तत्व प्रबंधन के लिए वर्मीकम्पोस्टिंग तकनीक. ICAR-IISS, Bhopal.

Thakur JK, Mandal Asit, Sahu A, Singh AB, Amat D, Bhattacharjya S, Manna MC, Patra AK (2021). EXCEL Decomposer Capsule (English). ICAR-IISS, Bhopal.

Thakur JK, Mandal Asit, Sahu A, Singh AB, Amat D, Bhattacharjya S, Manna MC, Patra AK (2021). EXCEL Decomposer Capsule (Hindi). ICAR-IISS, Bhopal.

Thakur JK, Mandal Asit, Sahu A, Singh AB, Bhattacharjya S, Tripathi AK, Amat D, Manna MC, Patra AK (2021). In-situ decomposition technology for rice-wheat residue. ICAR-IISS, Bhopal.

Thakur JK, Sahu A, Mandal A, Singh AB, Bhattacharjssya S, Tripathi AK, Amat D, Manna MC, Patra AK (2021). धान एवं गेंहूँ यथास्थान विघटन तकनीक . ICAR-IISS, Bhopal.

Thakur JK, Singh AB, Meena BP, Lakaria BL, Ramana S, Shankar NR, Patra AK (2021). फसल सुरक्षा हेतू जैविक विधियाँ ICAR-IISS, Bhopal.

Vishwakarma AK, ICAR-IISS, Bhopal (2021). Vermicomposting for recycling of agricultural waste under SAP as part of National special swachhta campaign

Working/concept papers/ Policy brief

Lakaria BL, Jha P, Biswas AK, Patra AK and Chaudhari SK (2021). Policy Brief on Roadmap for biochar use in India. ICAR-IISS, Bhopal, MP, 4p.

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5	Dr Sangeeta Lenka, Sr. Scientist	Member
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Remote Sensing and GIS Laboratory		
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2	Dr NK Sinha, Scientist	Member
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Central Lab		
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5	Mr Jai Singh, STO	Member
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4	Mr Pramod Chauhan, STO	Member
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2	Dr Dolamani Amat, Scientist	Alternate incharge
HRD (Training)		
1	Dr KM Hati, Pr. Scientist	Nodal Officer
2	Dr Monoranjan Mohanty, Pr. Scientist	Co-Nodal Officer
3	Mr Sanjay Kumar Kori, Steno Gr.-III	Member
Mera Gaon Mera Gaurav		
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2	Dr Prabhat Tripathi, Pr. Scientist	Co-Nodal Officer
Weed Management		
1	Dr AKViswhwakarma, Pr. Scientist	Nodal Officer
2	Dr Vasudev Meena, Scientist	Co-nodal Officer
3	Mr Hukum Singh, TO	Member
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2	Dr RK Singh, Pr. Scientist	Member
3	Dr Asit Mandal, Sr. Scientist	Member
4	Dr Vasudev Meena, Scientist	Member
5	Dr RH Wanjari, Pr. Scientist	Member Secretary & Nodal Officer

6	AAO	Member
4	AF&AO	Member
8	Mr Sanjay Katinga, LDC	Member
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3	Dr AK Vishwakarma, Pr. Scientist, I/c Farm/PI of FF Project	Member
4	Dr Monoranjan Mohanty, Pr. Scientist	Member
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7	Sh Khilan Singh Raghuvanshi, T-5 & IJSC Representative	Member
8	Dr Bharat Prakash Meena, Scientist & I/c Security & I/c Hostel	Member Secretary

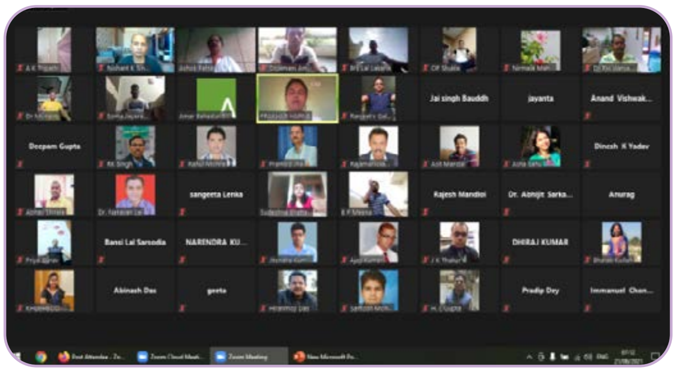
11. Important Meetings/Activities

Republic Day

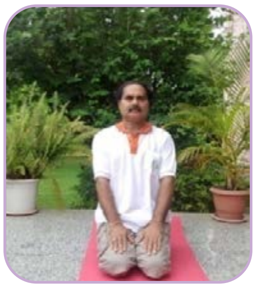
The 72nd Republic Day was celebrated on January 26, 2021 in the Institute premises with great gaiety and fervor. Dr AK Patra Director addressed the gathering and requested all the staff and their family members to work with sincerity for the welfare of the nation.

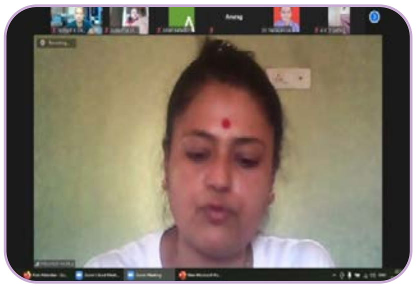
International Yoga Day

The ICAR-IISS, Bhopal celebrated the 7th International Yoga Day on June 21, 2021 with a demonstration cum awareness lecture on yoga. Dr. Ashok K Patra, 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 Mrs Sanisha Harne. 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

An on-field Institute Research Council (IRC) meeting washeld on February 18, 2021 to review the progress of the experimental fields. The Institute IRC was organized during 16-17, 20 & 22 December 2021.Dr. A.K. Patra, Director chaired the session and 52 ongoing projects including external funded and 15 new projects were presented and reviewed.

Independence Day

The 75th Independence Day was celebrated on August 15, 2021 in the Institute premises with great gaiety and fervor.

World Food Day

World Food Day 2021 was celebrated in an online mode at ICAR Indian Institute of Soil Science on October 16, 2021. On this occasion, Dr Ashok K. Patra, Director, ICAR IISS graced the occasion as Chief Guest along with scientists, staff of the institute and progressive farmers. In his address, Dr. Patra has expressed his concerns on Global Hunger Index and emphasized on food security and reducing hunger of the world in general and India in particular. He has elaborated on the importance of safe food for healthier tomorrow. He has augmented scientists, farmers and all other stakeholders to become food heroes and work towards the nutritional and livelihood security of the under privileged sections of the society. He has urged everyone to commit sincerely towards mass awareness on food and nutritional security. Earlier Dr AB Singh, HoD (SB) briefed about the significance of the event and requested everyone to contribute towards better production, better nutrition, better environment and better life to reduce global hunger as well as poverty. Dr AK Biswas, HoD (SCF) elaborated on contribution of agriculture sector in the GDP of the nation and linkage of food-famine-hunger including household nutritional security. Dr JK Saha, HoD (ESS) spoke on nutritional security and its importance in relation to reduced soil pollution. Dr P. Dey, PC (AICRP-STCR) gave an account of ancient agriculture and availability, access, utility and stability issues of the food security system. The role of biofertilizers in management of soil pollution was emphasized by Dr SR Mohanty, NC (AINP-SBB). Progressive farmers Sh Suresh Madhav and Sh Arjun Pipaliya spoke on the occasion and lauded the efforts of the institute towards improving soil health, system productivity and livelihood security. Dr R Elanchezhian, I/c PME Cell, coordinated the event and proposed vote of thanks at the end of the program.

Hindi Pakhwada

Hindi Pakhwada was celebrated in the Institute during September 14-28, 2021. Several competitions such as Debate, Quiz, Hindi vocabulary (Sabda Gyan), Typing test were conducted and the Director, ICAR-IISS distributed prizes to the winners of different competitions.

Vigilance Awareness Week

Vigilance awareness week 2021 was observed at ICAR-IISS, Bhopal during October 16, 2021 to November 1, 2021. On October 26, 2021 very first day integrity pledge was taken by 100 institute employees along with 15 tribal farmers at 11.0 A.M. Thereafter, in the afternoon session on same day one sensitization programme on vigilance awareness was conducted at Shahpur village gram panchayat Kuthar. On October 27, 2021, an essay competition was conducted on topic "Integrity is essential for self Reliance". A total 7 participants had taken part in it. On October 29, 2021 quiz competition was organised at the institute with total 11 participants. During the vigilance week activities corona guideline followed with all preventive measures. On 2nd November 2021 closing ceremony was organised, Init Director Dr. A.K. Patra stressed upon preventive vigilance. The occasion was graced by Director General (Home Guard) M.P. Shri Pawan Kumar Jain as chief Guest.

Prize distribution to competition winners

Integrity pledge

Sensitization programme on vigilance awareness

Soil Health Awareness Week

Soil health awareness week was organized at ICAR-Indian Institute of Soil Science, Bhopal during December 1-7, 2021. This weeklong program included World Soil Day (WSD), which is celebrated every year by Food and Agricultural Organization of the United Nations on December 05. This years' theme of WSD was "Halt Soil Salinization, Boost Soil Productivity". A massive March Pastwas organized by the institute Scientist, Technical and other staff to spread awareness among the public on the importance of soils in human life and protection of this precious resource. On the occasion Dr Ashok K Patra, Director, informed that as per FAO about 9% of the soils of the planet earth are affected by salinity or sodicity. In India there is about 6.73 million hectares of salt affected soils and it is increasing. If this is not corrected this will pose threat on the existence of future generations. He also gave TV and radio talks for mass awareness. On the same day, a farmer-scientist interaction meet was organized at village Khamkheda, Dist Bhopal, (M.P.). The Director of institute, Dr AK Patra, Dr AB Singh, Organizing Secretary, Dr Pradip Dey, Co-Chairman, Dr R Elanchezhian, Convener, Dr AK Vishwakarma Co-Organizing Secretary and scientists of the institute along with staff participated in the program.

On this occasion Sh Ravinder Patil, DGM SBI, and Sanjay Kumar, AGM SBI along with their staff participated in the program. Dr AK Patra emphasized the role of soil for the survival of the human being and requested to create awareness amongst villagers to protect a precious natural resource for the next generation. He reiterated an application of imbalanced and unscientific use of agro-chemicals (including fertilizers) resulted in degradation of soil health and occurrence of multi nutrient deficiencies in soil.The farmers expressed their views and feedback on the various programs undertaken by the institute. On this occasion, soil health cards were distributed to the farmers. During the events, scientists, officials, students and about 200 farmers from nearby villages participated in this awareness program.

An Agricultural Education Day was celebrated on December 03 where more than 100 college students of Bhopal were taught about various aspects of soils including soil salinization. The students were exposed to soil museum and a quiz competition on soil awareness was also organized.

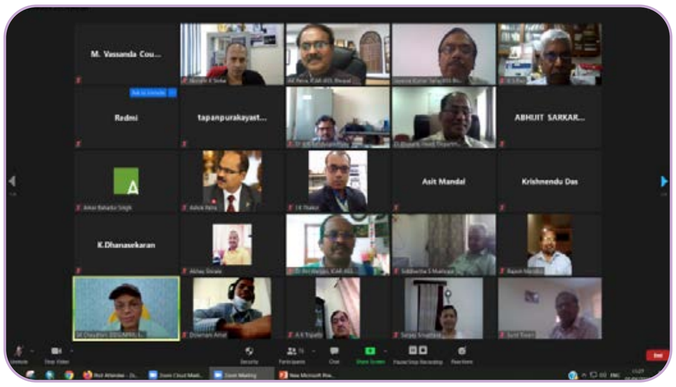
Farmer'-Scientists interaction meet and Field days were organized on December 01 and 02 where more than 200 farmers under the scheme SCSP and Farmers FIRSTwere given training on conservation agriculture and soil health maintenance practices during the Soil Health Awareness Week.

Van Mahotsav Celebration

The Women scientists of ICAR-IISS organized "Vriksha Ropan Karyakram" on July 22, 2021 at IISS Farmars a part of 'Azadi Ka Amrit Mahotsav' India@75 celebration and under "Van Mahotsav".

Celebration of World Environment Day

To commemorate the theme of this year's World Environment Day that marks the beginning of the United Nations Decade on Ecosystem Restoration, ICAR-Indian Institute of Soil Science organized a webinar on "Ecosystem Restoration for Sustainable Food Production and Human Health" on June 5, 2021. Dr. S. K. Chaudhari, DDG (NRM), ICAR in his chief guest address highlighted the environmental impacts of indiscriminate use of industrial effluents, municipal wastes and more importantly electronic wastes. He emphasized on preventing and reducing entry of harmful substances in soil as a key to maintain soil health and soil ecosystem services. Dr. K.S. Rao, Professor and Head, Department of Botany, University of Delhi, as lead speaker delivered the gathering on "Restoration Ecology from Reference Ecosystems to Novel Ecosystems". He emphasized on species diversity to restore ecosystem processes. The guest speaker of webinar, Dr. Pinaki Sar, Professor, Department of Biotechnology, IIT Kharagpur, underpinned the importance of metagenomics for environmental management and biogeochemical mechanisms in restoration of arsenic contaminated environment. The third speaker of the webinar Dr. T.J. Purakayastha, Principal Scientist, Division of Soil Science and Agricultural Chemistry, IARI delivered on "Carbon neutral farming: Key to improvement in soil health and crop production".



Fit India Freedom Run 2.0

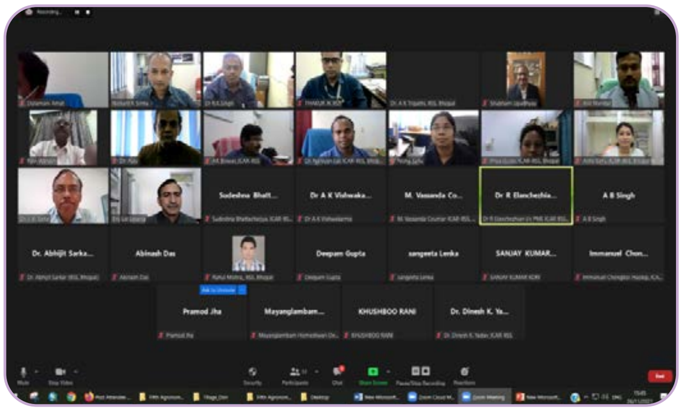
ICAR-IISS Organized Fit India Freedom Run to commemorate the Azadi Ka Amrit Mahotsav during August 13 to October 2, 2021. All the staff of IISS walked daily in their best capacity and covered a distance of about 5800 km. Also a marathon was also organized on September 15, 2022 in which all the staff participated with enthusiasm and showed solidarity to their concern to a sound physical health.

Launch workshop for Project on Biochar

A launch workshop for the project on "Sustainable biochar production in agroforestry systems and its application: A climate resilient soil management approach"was organized in Virtual Mode on July 5, 2021. It was attended by representative from GIZ , IIFOR-ICRAF and ICAR-IISS Bhopal namely Dr. Jonas, Dr. Javed Rizvi, Dr. SK Dhyani, Dr. Aqeel Rizvi and Team members from ICAR-IISS Bhopal.

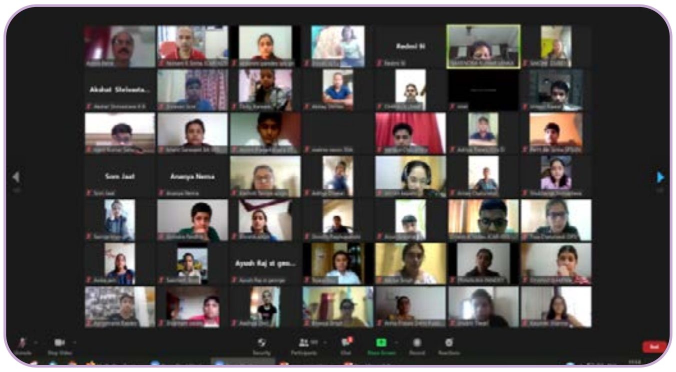
Constitution Day & National Campaign on "Agriculture and Environment: the citizen face"

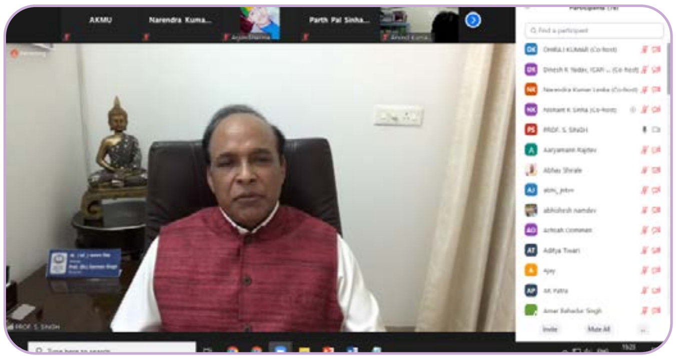
ICAR-Indian Institute of Soil Science celebrated the Constitution Day on November 26, 2021. All the staff of ICAR-IISS and students from Govt. Sardar Patel Senior Secondary School and Brigadier Trivedi Memorial Higher Secondary School, Bhopal attended to the live telecast on DD Sansad TV by the President, Vice President, Prime Minister and the Lok Sabha Speaker. There were more than 100 participants. A quiz competition was conducted for the students. A guest lecture was delivered by Mr. Shubham Upadhyay, Advocate and Co-Founder Judiciary Gold, Bhopal. On the same day the institute organized National Campaign on "Agriculture and Environment: the citizen face" under Azadi ka Amrit Mahotsav, in which students and staff participated.



National Nutrition Week

The National Nutrition Week -2021 was organized by the ICAR-IISS, Bhopal and the NAAS-Bhopal Chapter during the first fortnight of September 2021, with the theme, “Feeding smart right from start”. On this occasion, an online essay competition in Hindi and English was organized among students from leading schools of Bhopal, viz. Delhi Public School, Campion school, Sagar Public School, Fr. Agnelite School and St. George school. The competition was held on 11 September 2021 on the topic “Human Nutrition: Key to A Healthy Nation” in which 100 students participated. Exposure visit of progressive farmers were also organized in which the role of soil management in human nutrition was dealt with. On 25 September 2021, a special lecture by Prof. Sarman Singh, Director (AIIMS), Bhopal was organized on the topic, “Nutrition and Human Health in Pandemic Times”. The winners of the essay competition were distributed the prize money and certificates.



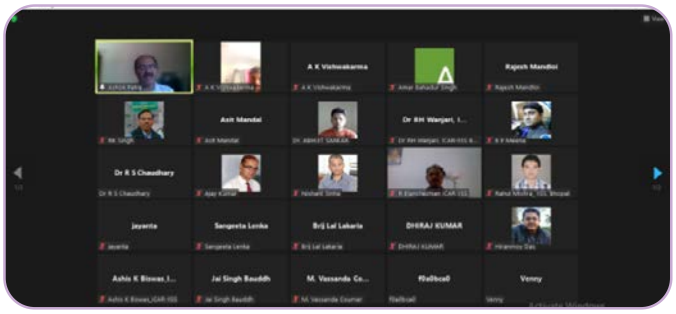


SWACCHTA CAMPAIGN MONTH- October 2021

Special National Swachhta Campaign

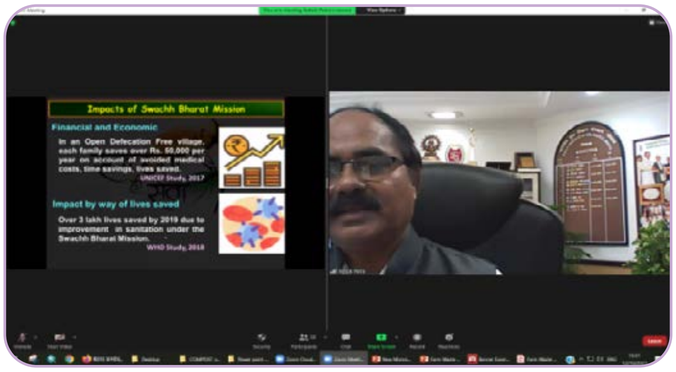
An Outdoor Special National Swachhta Campaign was organized by ICAR-Indian Institute of Soil Science on 12th October 2021, at villages Khamkheda and Arvalia of Bhopal district on the topic “Waste to Wealth” as per the directives of the NRM Division. On this occasion, Dr Ashok K. Patra Director, ICAR IISS graced the occasion as Chief Guest along with scientists, staff of the institute and about 250 farmers. In his remarks, Dr. Patra has emphasized on the need of creating wealth from waste and importance of organizing such campaigns particularly in rural areas. Dr AB Singh, HoD (SB) and PI NPOF, Dr AK Biswas, HoD (SCF) & LCPC of CRP on CA and Dr AK Vishwakarma spoke on the various aspects of crop residue management and their conversion into valuable compost. Dr JK Thakur and Dr Asit Mandal presented various composting techniques to the participants. Literatures on recycling of farm and kitchen wastes as provided by the SMD has been distributed to the farmers and the video films on Waste to Wealth were displayed to the farmers. On this occasion, vermibeds, worm mother culture and certificates were distributed to the farmers who have successfully completed the training on Vermicomposting under ASCI Skill India program. Besides, 100 students of Govt. Secondary School Khamkheda were sensitized on the importance of cleanliness during this Special National Swachhta Campaign. In the afternoon, a special lecture on Swachch Bharat Abhiyan was delivered by Dr. A.K. Patra, which was attended by all the staff of the institute. Dr R Elanchezhian, I/c PME Cell, coordinated the daylong program and Dr NK Sinha proposed vote of thanks at the end of the program. The campaign was also organized at Dewas, Sehore, Ujjain, Shajapur and Agar districts of Madhya Pradesh in collaboration with an NGO, Solidaridad, Bhopal in which 250 farmers actively participated in the special campaign. Faculty of Agriculture of Ram Krishna Dharmarth Foundation University, Gandhi

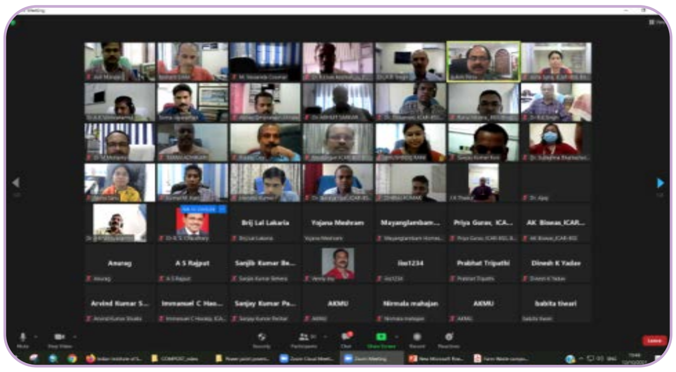
Nagar, Bhopal also organized a large scale demonstration on production of vermicompost in which 200 students including staff members of the university participated and learned the process of vermicomposting through utilization of organic wastages of the campus. Altogether about 500 farmers, 300 students and 100 staff members attended the programme



Online swacchta pledge on October 2, 2021

Outdoor special national swachhta campaign on October 12, 2021





Video films showcased during Special Swachhta Campaign

Video films on composting of farm and household wastes has also been prepared in hindi and English which were streamed via YouTube link to all the ICAR institutes for showing to the farmers all over the India.

Glimpses of Outdoor swachhta campaign during the month

Barkheri village on October 5, 2021 – 40 farmers

Ratibad village on October 18, 2021 – 40 farmers

Pipalia village on October 7, 2021 – 30 farmers

Swachhta Campaign at Sukhi Sevaniya village on October 20, 2021 – 40 farmers and farm womens

Bhairopur village on October 8, 2021 – 50 farmers

Swachhta Campaign at Choprakala village on October 20, 2021 – 40 farmers

Khajuri village on October 14, 2021 – 50 farmers

Disposal of old/obsolete and other scrap materials

Swachhata Pakhwada (December 16-31, 2021)

A Swachhata Pakhwada was organized during December 16-31, 2021 at institute premises and adopted villages.

Swachhata pledge was undertaken by scientists and staffs of the institute on December 16, 2021

Farmers training on Vermicomposting on December 16, 2021

Demonstration for conversion of waste to wealth

Basic maintenance and cleanliness drive in the Institute

Celebration of Kisan Diwas

Creation of Swachhta awareness in public

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

Name	Programme	Venue/ Organizer	Period
Dr Jitendra Kumar	Hyper Spectral Data for Land and Coastal Systems	Online, NASA's Applied Remote Sensing Training Program, USA	January 19, 26 and February 2, 2021
Dr Pradip Dey	National Training Programme on "Integrated Nutrient Management and Nutrient Budgeting through Advanced Models to Improve Crop Productivity"	Virtual, ICAR-IISWC-RC, Ooty, Tamil Nādu (TN)	January 22, 2021
Dr Pradip Dey	Executive Committee Meeting of Society for Fertilizers & Environment (SFE)	Virtual, SFE, Kolkata	January 30, 2021
Dr Pradip Dey	Virtual Meeting to discuss a Research Project between ICAR and CIMMYT	Virtual, ICAR-IISS, Bhopal	February 1, 2021
All Scientists	Workshop on 'Pulses for Soil Health and Nutritional Security'	Virtual, ICAR-IISS, Bhopal	February 10, 2021
Dr S Bhattacharjya and Dr Abhijit Sarkar	First International Conference on Recent Advances for Managing Sustainable Soil Health and Crop Production.	Virtual Mode, GKV Society, Agra, Uttar Pradesh	February 18-22, 2021
Dr Pradip Dey	National Conference on "Advanced Modelling and Innovations in Water Resources Engineering (AMIWRE – 2021)"	Department of Civil Engineering, National Institute of Technology, Jamshedpur	February 20-21, 2021
All Scientists	National Webinar on Future of Science and Technology on Natural Resource Management in Agriculture during "National Science Day"	ICAR-IISS, Bhopal	February 28, 2021
Dr Pradip Dey	Working Group Meeting of Experts for Development of Textbook of Vermicompost Producer for Class 9 & 10	Virtual Mode, PSS CIVE, Shyamla Hills Bhopal	March 3-5, 2021
Dr Pradip Dey	Meeting on Soil Quality Index	Virtual Mode, ICAR-IISS, Bhopal.	March 5, 2021
Dr R Elanchezhian	International Plant Physiology Virtual Symposium on "Physiological Interventions for Climate Smart Agriculture"	ISPP New Delhi & ICAR-SBI Coimbatore	March 11-12, 2021
All PCs	XXVI Meetings of ICAR Regional Committee–VI ICAR-CSWRI, Avikanagar also attend Inaugural and Technical Sessions	Virtual Mode, Krishi Bhawan, New Delhi	March 13, 2021
All scientists	World Water Day	ICAR-IISS, Bhopal	March 22, 2021
Dr Pradip Dey	Stakeholder Workshop on "Prioritization of CSA Technologies for Development of State Adaptation Plan to Climate Change"	Virtual, European Soil Pertnership	March 23, 2021
Dr Pramod Jha	National Conference on "Carbon Sequestration in Agricultural Soils: Current Trend and Future Strategies"	ICAR-NBSSLUP, Nagpur	March 24-26, 2022
All PCs	Review Meeting of ICAR Regional Committee No. VII	Virtual, ICAR, New Delhi	March 25, 2021

Dr BP Meena	Global Symposium on Soil Biodiversity	Virtual - FAO	April 10-12, 2021
Dr Khushboo Rani	International Webinar on World Earth Day, 2021 "Restore Our Earth"	SKNRAU, Jobner (Rajasthan)	April 22, 2021
Dr AB Singh	Webinar on Organic Farming	ICAR-Indian Institute of Soybean Research, Indore	May 13, 2021
Drs BL Lakaria, Sangeeta Lenka	National E Seminar on "Ecosystem Restoration" Centre for Climate Change & Disease Management,	Department of Environmental Soil Science, GITAM University, New Delhi, India	June 4-5, 2021
All Scientists	World Environment Day on "Ecosystem Restoration for Sustainable Food Production and Human Health"	ICAR-IISS Bhopal	June 5, 2021
Dr AK Biswas	NAAS Fellowship Presentation	NAAS, New Delhi	June 17-18, 2021
All Scientists	Webinar on Balanced Use of Fertilizers	ICAR- IISS Bhopal	June 18, 2021
Dr Pradip Dey	Council Meeting of Indian Society of Soil Science	Virtual, New Delhi	June 19, 2021
Drs Pradip Dey, AK Biswas, Sanjay Srivastava, BL Lakaria, R. Elanchezhian, NK Lenka, RH Wanjari, Sangeeta Lenka, MV Coumar, BP Meena, Dhiraj Kumar, Narayan Lal, AO Shirale, Priya Gurav, Khushboo Rani	National Webinar on "Nanotechnology in Agriculture: Opportunities and Challenges"	Bhopal Chapter of NAAS, ICAR-IISS, Bhopal	June 21, 2021
All staff	International Yoga Day	ICAR-IISS Bhopal	June 21, 2021
Dr Pradip Dey	ESP Plenary Meeting	Virtual, NRM ICAR, New Delhi	June 24, 2021
Drs AB Singh, Pradip Dey, AK Biswas, Sanjay Srivastava, R Elanchezhian, NK Lenka, BL Lakaria, RH Wanjari, JK Thakur, Priya Gurva, Abhijit Sarkar, Khushboo Rani	Brain Storming Session on Regenerative Agriculture for Soil Health, Food and Environmental Security	ICAR, New Delhi	June 26, 2021
Dr AK Patra, All PCs	ICAR- Director's Conference on the Chairmanship of Secretary, DARE & DG, ICAR	Virtual, ICAR, New Delhi	July 2, 2021
Drs AK Biswas, BL Lakaria	Project Launch Meeting between ICRAF-IISS-GIZ on Biochar	ICRAF, New Delhi	July 5, 2021
Dr Sanjay Srivastava	नवीन मिट्‌टी परीक्षण प्रयोगशालाओं के लिए आवश्यक प्रयोगशाला यंत्रों के उपार्जन हेतु तकनीकी मापदण्ड निर्धारण बाबत्	State Department of Agriculture, Madhya Pradesh	July 6, 2021 and November 17, 2021
Dr SR Mohanty	Annual Review Meeting of AMAAS	Virtual, ICAR-NBAIM, Mau	July 8, 2021
Dr Jitendra Kumar	E-Gosthi on Resource Conservation Technology for Sustainable Soil Health Management under Azadi Ka Amrut Mahotsav	ICAR-IISS, Bhopal	July 13, 2021

All Scientists	Van Mahotsav Week Program	ICAR-IISS, Bhopal	July 10-16, 2021
Drs RH Wanjari, Dhiraj Kumar	Brain Storming Session on 'Safe Use of Chemical Fertilizers and other Agro Chemicals'	NRM Division, ICAR, New Delhi	July 19, 2021
Drs RH Wanjari, Dhiraj Kumar	Role of Agricultural Engineering on Economic Development and Self-sufficiency due to situation emerged due to COVID-19 in our Country	ICAR-CIAE, Bhopal	July 27-30, 2021
All PCs	Mid-Term Review Meeting of the XXVI Meeting of ICAR-Regional Committee No. V	Virtual, ICAR, New Delhi	July 27, 2021
All scientists	Virtual Launching Workshop of ICAR-NASF Project "Development of Nano Sensor and its Application through Cloud based network for Real Time Irrigation to Soil and Plant"	ICAR-IISS, Bhopal	July 30, 2021
Drs Pradip Dey, AB Singh, Prabhat Tripathi, Ajay, SK Behera, RH Wanjari, K Bharati, R Elanchezhian	Meeting at Singhodi village, pipariya, Hoshangabad FPO initiation and formation at Pipariya	Pipariya, Hoshangabad	August 4, 2021
Dr RH Wanjari	National Webinar on 'Weed Management'	AICRP on Weed Management, BCKV Mohanpur (West Bengal)	August 6, 2021
All Scientists	Mass Awareness Campaign Programme on Organic Farming	ICAR- IISS, Bhopal	August 6, 2021
Drs Pradip Dey, AK Biswas, JK Saha, Sanjay Srivastava, R Elanchezhian, NK Lenka, RH Wanjari, BP Meena, Dhiraj Kumar, Nisha Sahu, AO Shirale, Abhijit Sarkar	Webinar on "Finalization of Protocol for Analysis of Soil, Water and Ash Samples" under the NTPC sponsored Research Project 'Use of Fly Ash in Agriculture for Sustainable Crop Production and Environmental Protection'	ICAR-IISS, Bhopal	August 9-10, 2021
Drs Nisha Sahu, Narayan Lal	International Webinar on "New Innovative Approaches for Improving Agriculture Productivity".	Eklavya University, Damoh, MP	August 10, 2021
Dr Pradip Dey	Awareness cum sensitization programme on the use of Nano urea fertilizer – prospects and challenges	Virtual, AICRP on STCR & ICAR- KVK, Imphal West	August 12, 2021
Dr RH Wanjari	Webinar on "The Parthenium Weed Problem and its Management"	Virtual, Indian Society of Weed Science & ICAR - DWSR, Jabalpur	August 16, 2021
Dr Sanjay Srivastava	Technical Committee Meeting for Soil Testing Laboratory Instrument	State Department of Agriculture, Madhya Pradesh	August 17, 2021
Dr AK Biswas	Post - COVID Reforms by Dr. K.V. Subramaniam, Chief Economic Advisor, Govt. of India	NAAS, New Delhi	August 19, 2021
Dr Nisha Sahu	Webinar on "Conquering Intricacies on Citations and References"	Virtual, WILEY	August 24, 2021

Dr Pradip Dey	EUROSOIL 2021 Workshop "Regulatory Systems of Soil Protection in Europe – What works, what doesn't"	Virtual, NRM ICAR, New Delhi	August 24, 2021
Dr Pradip Dey	Fourth Sectional Committee Meeting of Environmental Services, SSD 07	Virtual, New Delhi	August 24, 2021
All PCs	XXVI Meeting of ICAR Regional Committee No. VII, (comprising the states of Madhya Pradesh, Maharashtra, Chhattisgarh and Goa)	Virtual, ICAR, New Delhi	August 25, 2021
Drs RK Singh, RH Wanjari, K Bharati, Shinogi KC, Dhiraj Kumar	National Seminar on "Advances in Sustainable Management of Natural Resources for Food and National Security"	Virtual, Navsari Agricultural University, Navsari, Gujarat	August 26-27, 2021
Drs AB Singh, AK Biswas, RH Wanjari, Dhiraj Kumar, Nisha Sahu	Farmer's Training on "Food and Nutrition for Farmers"	ICAR-IISS, Bhopal	August 26, 2021
Drs AK Biswas, Khushboo Rani	National Seminar on "Rice-Fallow Management in Eastern India"	Virtual, ICAR-RCER, Patna	August 26, 2021
Dr Nisha Sahu	Webinar on "Agricultural Residues Conversion to Biofuels through Solar Powered Microwave Pyrolysis"	Virtual, ICAR-RCER, Patna, Bihar	August 27, 2021
Dr Pradip Dey	International Webinar on "Natural Resource Management for Agriculture - Potentials and Prospects"	Virtual, TNAU, Coimbatore	August 27, 2021
Dr Pradip Dey	Meeting under Precision Agriculture	Virtual, ICAR-IIVR, Varanasi under the Project	September 7, 2021
Dr Pradip Dey	Inauguration of ICAR-Network Project on Precision Agriculture (NePPA)	Virtual, ICAR, New Delhi	September 8, 2021
Dr Pradip Dey	Ninth Global Soil Partnership (FAO) Plenary Assembly	Virtual, FAO, Rome	September 8-10, 2021
Dr Pradip Dey	Member of the SAS&SSM working group of INSAS (FAO)	Virtual, NRM ICAR, New Delhi	September 13, 2021
All PCs	XXVII Meeting of ICAR Regional committee No. VIII comprising the States of Karnataka, Kerala, Tamil Nadu and UTs of Lakshadweep and Puducherry	Virtual, ICAR, New Delhi	September 14, 2021
All Staff	Azadi Ka Amruth MahotsavFit India Freedom Run 2.0.	ICAR-IISS, Bhopal	September 15, 2021
All Scientists	Poshan Vatika Mahaabhiyan Evam Vraksharopan under '"International Year of Millets 2023"	ICAR- IISS, Bhopal	September 17, 2021
Dr RH Wanjari	International Conference on "Reorienting Agronomic Research & Education to Combat Current and Future Challenges in Agriculture"	RPCAU, Pusa, Bihar	September 20-22, 2021
Dr Hiranmoy Das	International Workshop on Advance Statistical Data Analysis Using SPSS	Science Tech Institute, Lucknow (online)	September 21-27, 2021
Dr AB Singh	ISAE Webinar – Automation in Agriculture	Indian Society of Agricultural Engineers	September 25, 2021
All Staff	Special Lecture by Director, AIIMS, Bhopal on "Nutrition and Human Health"	ICAR-IISS, Bhopal	September 25, 2021

All Scientists	Inaugural function of the new campus of "National Institute of Biotic Stress Management, Raipur"	ICAR-NIBSM Raipur	September 28, 2021
Drs AB Singh, Asha Sahu, AK Biswas, BP Meena, Sudeshana Bhattachajya, Narayan Lal, Nisha Sahu, Jitendra Kumar, AO Shirale, Dhiraj Kumar, DK Yadav, Khushboo Rani, Mr Rahul Mishra	International Webinar Conference on Alternate Cropping Systems for Climate Change and Resource Conservation	ICAR-IIFSR, Modipuram	September 29-October 1 2021
Drs DK Yadav, Khushboo Rani	International Virtual Workshop on "Soil Carbon for Sustainable Crop Production and Soil Health Management"	SKNRAU, Jobner, Rajasthan	October 4 and 5, 2021
Dr Sanjay Srivastava	Review cum Sensitization Workshop of ZTMUs/ ITMUs and PMEs of ICAR Institutes	Virtual, ICAR, New Delhi	October 5-11, 2021
Dr Narayan Lal	National Conference (Virtual Mode) on "Integrated Farming Systems: A Tool for Enhancing Income and Nutritional Security"	ICAR-RCER, Patna	October 5-7, 2021
All Scientists	Special National Swachhta Campaign on "Waste to Wealth"	Virtual mode NRM Division of ICAR	October 12, 2021
Dr AK Biswas	Regional Expert Consultation on Agroforestry for environmental resilience and sustainable livelihood of Farmers in Asia - Pacific	ICRAF-GIZ, New Delhi	October 13-14, 2021
Dr Pradip Dey	GLOSOLAN Soil Spectroscopy Webinar #5 and #6	Virtual, FAO, Rome	October 14 and 28, 2021
All the Scientists	An evening with World Food Laureate, Dr Rattan Lal: Discussion on Global Food and Nutritional Security to meet the SDGs during and after COVID -19 Pandemic	ICAR New Delhi	October 16, 2021
Drs K Bharati, Shinogi KC	3rd International Conference on Global Initiative in Agricultural, Forestry and Applied Sciences,	Shri Guru Ram Rai University, Dehradun, Uttarakhand	October 17-18, 2021
Dr AB Singh	National level Stakeholder Consultation for a new global initiative of one CGIAR on Nature-Positive Solutions (NPS): Enhancing productivity and resilience, while safeguarding the environment, and promoting inclusive growth within communities	Alliance of Biodiversity International and CIAT Region- Asia, India Office, New Delhi	October 19, 2021
Drs AK Biswas, Pramod Jha	5th Meeting of Asian Soil Laboratory Network in the Framework of GLOSOLAN	Online Mode, FAO, Rome	October 20, 2021
Drs Asha Sahu, Sudeshna Bhattacharjya, Nisha Sahu, BP Meena, NK Sinha, AO Shirale, Jitendra Kumar, Priya Gurav, Madhumonti Saha, Abhijit Sarkar, DK Yadav, Khushboo Rani	Global Symposium on Salt-Affected Soils (GSAS21)	FAO, Rome	October 20- 22, 2021
Dr Sanjay Srivastava	Meeting of South East Asia Laboratory Network (SEALNET)	Virtual, FAO, Rome	October 21, 2021

All Scientists	Webinar on "Agricultural Research Management System (ARMS)" for Scientists of Ag. Edn, Ag Engg and NRM SMDs	Virtual, ICAR- New Delhi	October 22, 2021
Dr Abhijit Sarkar, Mr Rahul Mishra	Nature Conference on "Waste Management and Valorization for a sustainable Future"	Nature, Seoul, Korea	October 26- 28, 2021
Dr Nisha Sahu, Immanuel Chongboi Haokip, Mr Rahul Mishra	International webinar on "Fighting the Hunger using Smart Technology"	ICAR- IIPOR, Pedavegi, Andhra Pradesh	October 26, 2021
Dr Nisha Sahu	Webinar on "Crop Diversification: A way towards Nutritional Security"	ICAR-Research Complex for Eastern Region, Patna	October 26, 2021
Dr BL Lakaria	Biochar Workshop	Balangir, Odisha	October 27-28, 2021
All Scientists	Interaction Meeting of ICAR Scientists with Secretary DARE & DG, ICAR	Virtual, ICAR- New Delhi	October 28, 2021
Dr BL Lakaria	Webinar on "Climate Resilient Varieties, Technologies and Practice"	Virtual, ICAR-CIBA, Chennai	September 28, 2021
Dr NK Sinha	Application of Space Technology and Artificial Intelligence for Climate Resilient Agriculture and Disaster Management	Leads Connect and BIT Mesra, Ranchi	October 29-30,2021
All staff	Rastriya Ekta Diwas (National Unity Day)	ICAR-IISS, Bhopal	October 31, 2021
Dr Immanuel Chongboi Haokip	Webinar on "Planning & Decision making for Efficient water Management"	Virtual; ICAR RCER, Patna	November 1, 2021
Drs Pradip Dey, RS Chaudhary, KM Hati, NK Sinha	2nd Plenary session of soil spectroscopy	Virtual, GLOSOLAN, FAO Rome	November 2-4,2021
Drs AK Biswas, BL Lakaria, R Elanchezhian, Pramod Jha, AO Shirale, Narayan Lal	National Webinar on Nutrient Management in Dominant Cropping Systems under Different Agro-climatic Zones of India	Virtual, ICAR-IISS, Bhopal	November 11, 2021
Drs NK Sinha, Jitendra Kumar	XV Agricultural Science Congress and ASC Expo 2021	BHU, Varanasi	November 13-16, 2021
Drs Pradip Dey, AB Singh, AK Biswas, RS Chaudhary, KM Hat, RK Singh, Prabhat Tripathi, Pramod Jha, J Somasundaram, RH Wanjari, Sangeeta Lenka, Asha Sahu, Asit Mandal, NK Sinha, BP Meena, Dhiraj Kumar, AO Shirale, Jitendra Kumar, Abhijit Sarkar, Madhumonti Saha, Nisha Sahu, MV Coumar	85th Annual Convention of the Indian Society of Soil Science (ISSS)	Palli Siksha Bhavana, Institute of Agriculture, Visva-Bharti, Sriniketan, Birbhum District, West Bengal	November 16-19, 2021

Dr Pradip Dey	Panel Meeting FAD, BIS,	Virtual, New Delhi	November 16, 2021
Dr RS Chaudhary	National Seminar on "Developments in Soil Science 2021 Special Symposium on "Achieving Land Degradation Neutrality by 2030	Shanti Niketan, West Bengal	November 17,2021
Drs RH Wanjari, Immanuel Chongboi Haokip	Fifth International Agronomy Congress Agri Innovations to Combat Food and Nutrition Challenges	PJTSAU, Hyderabad	November 23-27, 2021
Dr Sanjay Srivastava	5th Global Soil Laboratory Network Meeting (GLOSOLAN)	Virtual, FAO,Rome	November, 23-25, 2021
Drs Pradip Dey, RH Wanjari, BP Meena, Dhiraj Kumar	Webinar on 'The Relevance of Constitution in our life by Shri Buddy Rangnathan, Advocate, Supreme Court	Virtual, ICAR, New Delhi	November 25, 2021
All Scientists	Agricultural Education Day	ICAR-IISS, Bhopal	December 3, 2021
Dr Pradip Dey	Meeting under the Chairmanship of Joint Secretary (INM) to share success stories of Village Level Soil Testing Labs on the occasion of Azadi Ka Amrit Mahotsav	Virtual, ICAR, New Delhi	December 3, 2021
All scientists	World Soil Day-2021 with the theme; Halt Soil Salinization, Boost Soil Productivity"	ICAR-IISS, Bhopal	December 4, 2021
All scientists	Workshop on 'Rapid Composting for Sustainable Soil Health'	Virtual, IISS, Bhopal	December 4, 2021
Dr Pradip Dey	SOC Divisional Meeting under the Chairmanship of Dr. S.K. Chaudhari, DDG (NRM & Engg)	Virtual, ICAR, New Delhi	December 6, 2021
Dr AB Singh	World Soil Day 2021	IES University, Bhopal	December 6, 2021
Drs NK Sinha, Jitendra Kumar	Modeling Soil Physical Processes for Improving resource use Efficiency in Agriculture	ICAR-IISS Bhopal	December 8, 2021
Drs R Elanchezhian, Sangeeta Lenka	National Conference of Plant Physiology on "Frontiers of Plant Physiology for climate smart agriculture"	CSAU & T, Kanpur	December 9-11, 2021
All PCs	XXV Meeting of ICAR Regional Committee-III	Virtual, ICAR,New Delhi	December 11, 2021
Dr Asha Sahu	International Conference on "Promoting Environmental Technologies for Waste Management and Sustainable Development (WMSD-2021)"	Kalinga Institute of Industrial Technology, Bhubaneswar	December 12-13, 2021
Dr Abhijit Sarkar	30th National Web Conference on Soil and Water Management Technologies for Climate Resilience, Agricultural and Environmental Sustainability	Soil Conservation Society of India, New Delhi; Collaborator: Odisha University of Agriculture & Technology, Bhubaneswar	December 14-16, 2021
Dr KM Hati	First Meeting of the Working Groups Soil Spectroscopy	GLOSOLAN, GSP, FAO-UN, Rome	December 16-18, 2021
All Scientists	Natural Farming Awareness address by Hon'ble PM in Vibrant Gujarat Conclave	Auditorium ICAR-IISS, Bhopal	December 16, 2021

Dr Priya Gurav	23rd Annual Convention of the and Conference of Clay Mineral Society of India	ICAR-IARI, New Delhi	December 22-23, 2021
Dr Nishant K Sinha	5th Meeting of Global Soil Laboratory Network	Global soil laboratory network (GLOSOLAN)	December 23-25, 2021
Dr Pradip Dey	Executive Committee Meeting of the Society for Fertilizers & Environment	Virtual, BCKV, West Bengal	December 24, 2021
Drs JK Thakur, Nisha Sahu, NK Sinha	3rd International Conference on Food, Agriculture and Innovations (3rd ICFAI)	Virtual, Holiday Home, Ranchi, Jharkhand	December 24-26, 2021
Dr Nisha Sahu	Virtual Workshop on Science Communication	ICAR-IIHR, Bengaluru	December 29, 2021

13. Workshops, Seminars and Trainings Organized

Training

Programme	Course Directors/Coordinators	Duration	Sponsored by
Integrated Nutrient Management	Drs Pradip Dey, RH Wanjari, M Vassanda Coumar and Madhuri Wankhede	January 5-7, 2021	ICAR-IISS & SIAET, Bhopal
Soil Health Management	Drs J Somasundaram, Nishant K Sinha and Jitendra Kumar	January 19-22, 2021	ICAR- IISS & SIAET, Bhopal
Integrated Nutrient Management	Drs AB Singh, AK Tripathi, Pradip Dey and Sudeshna Bhattacharjya (ICAR-IISS, Bhopal) and Mrs. Deepika Dixit (SIAET, Bhopal)	February 23-25, 2021	ICAR-IISS & SIAET, Bhopal
Training on Residue Management in Organic Farming for Sustainable Management of Soil health	Drs AB Singh, JK Thakur and NK Sinha	June 3, 2021	ICAR-IISS and PJTSAU, Hyderabad
Soil Testing and Nutritional Recommendation for Agricultural Crops under Azadi ka Amrit Mahotsav	Drs Pradip Dey, RH Wanjari, AK Vishwakarma, M Vassanda Coumar and Smt Deepika Dixit	July 27-30, 2021	ICAR-IISS & SIAET Bhopal
Soil Health Management" under Azadi Ka Amrit Mahotsav	Drs Pradip Dey, RH Wanjari, Hiranmoy Das and Dhiraj Kumar (ICAR-IISS, Bhopal) and Mr. Sitaram Thakur (SIAET, Bhopal)	July 27-30, 2021	ICAR-IISS & SIAET Bhopal
Training on Organic Farming: Basic Principles and good practices under Mass Awareness Campaign on Organic Farming	Dr AB Singh	August 6, 2021	ICAR-IISS and ICAR-IIFSR, Modipuram
Capacity building programme "Soil Testing and Soil Health Management"	Dr Pradip Dey	August 9, 2021	ICAR-IISS, Bhopal & PJTSAU, Hyderabad

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

Title	Course Directors/Coordinators	Duration	Sponsored by
Workshop on Pulses for soil health and nutritional security organized on the occasion of world pulses day	Drs AB Singh, BL Lakaria, R Elanchezhian, AK Vishwakarma, RH Wanjari, NK Sinha	February 10, 2021	ICAR-IISS, Bhopal
National Science Day webinar on "Future of Science & Technology on Natural Resources Management in Agriculture"	Dr AK Biswas	February 28, 2021	ICAR-IISS, Bhopal
World Water Day	Dr RS Chaudhary	March 22, 2021	ICAR-IISS, Bhopal
National webinar on Nanotechnology in Agriculture: Opportunities and Challenges	Drs NK Lenka, Tapan Adhikari	June 21, 2021	NAAS-Bhopal Chapter and ICAR-IISS, Bhopal
National Nutrition Week	Dr NK Lenka	September 1-15, 2021	NAAS-Bhopal Chapter
Poshan Vatika Mahabhiyanevam Vraksharopan" under "International Year of Millets 2023"	Drs AB Singh, AK Patra, RS Chaudhary & NK Sinha	September 17, 2021	ICAR-IISS, Bhopal
Farmers Scientists Interface on "Climate Resilient Varieties, Technologies and Practices"	Drs AB Singh, BL Lakaria, RH Wanjari, AK Vishwakarma	September 28, 2021	ICAR-IISS, Bhopal

Special Swachhta Campaign	Drs AK Vishwakarma, SK Behera, Jitendra Kumar, Dolamani & Mr Abinash Das and Mr Hukum Singh	October 2-31,2021	ICAR-IISS, Bhopal
Outdoor Special National Swachhta Campaign at villages Khamkheda and Arvalia of Bhopal district on the topic "Waste to Wealth"	Drs Pradip Dey, Hiranmoy Das	October 12, 2021	ICAR-IISS, Bhopal
World Food Day 2021	Drs Pradip Dey, R Elanchezhian, AK Biswas, JK Saha, SR Mohanty	October 16, 2021	ICAR-IISS, Bhopal
National Webinar on "Nutrient management in dominant cropping systems under different agroclimatic zones of India"	Drs Pradip Dey, Pramod Jha, BL Lakaria	November 11, 2021	ICAR-IISS, Bhopal
National Campaign on "Agriculture and Environment: the citizen face"	Drs Ajay, R Elanchezhian, Asha Sahu and Priya Gurav	November 26, 2021	ICAR-IISS, Bhopal
Soil Health Awareness Week	Drs AK Patra, Pradip Dey, R Elanchezhian, RS Chaudhary, AK Biswas, JK Saha, AK Shukla, SR Mohanty, Ajay, Sanjay Srivastava, BL Lakaria, J Somasundaram, Prabhat Tripathi, NK Lenka, RH Wanjari, AK Vishwakarma, M Mohanty, AB Singh	December 1-7, 2021	ICAR-IISS, Bhopal
Agricultural Education Day	Drs R Elanchezhian, AB Singh, P Dey, Ajay, R H Wanjari, J Somasundaram, K Bharati Asha Sahu, M Mohanty, NK Sinha	December 3, 2021	ICAR-IISS, Bhopal
Workshop on "Rapid Composting for Sustainable Soil Health"	Dr AB Singh	December 4, 2021	ICAR-IISS, Bhopal .
World Soil Day on Farmer-Scientist Interaction Meet	Drs AK Patra, All HoDs/PCs, Drs AK Vishwakarma,R. Elanchezhian,M Mohanty, Sanjay Srivastava, NK Lenka, Ajay, J Somasundaram, P. Tripathi	December 4, 2021	Khamkheda, Bhopal
World Soil Day	Drs AK Patra, All HoDs/PCs, Drs. R. Elanchezhian, AK Vishwakarma, M Mohanty, Sanjay Srivastava, NK Lenka, Ajay, J Somasundaram, P. Tripathi	December 4, 2021	ICAR-IISS, Bhopal

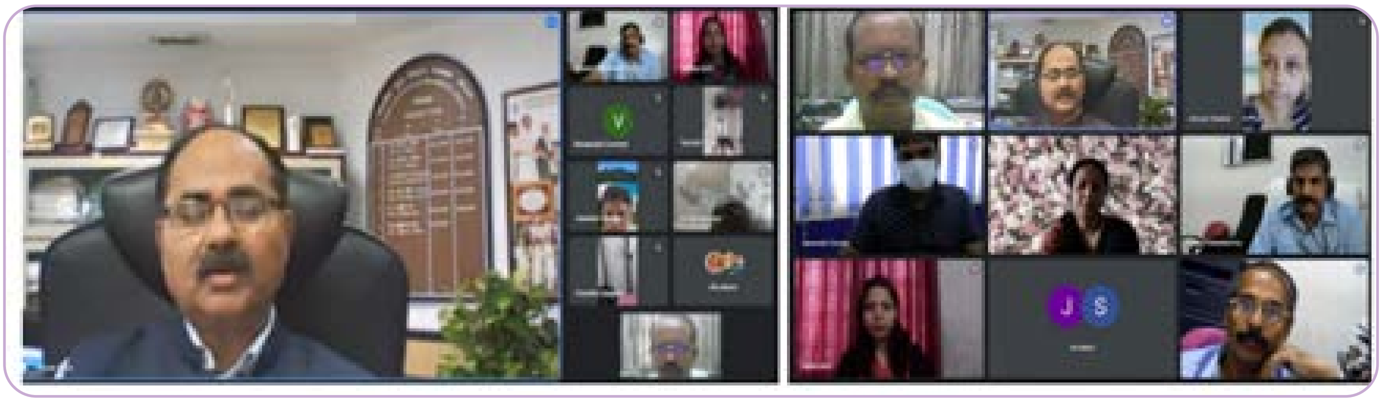
Farmers' training/Student training

Programme	Course Directors/ Coordinators	Duration	Sponsored by
Skill development training programme for 'Soil and water lab analyst'	Drs AO Shirale, BP Meena, Priya Gurav and AK Biswas	February 15 – March 16, 2021	Agriculture Extension Division, ICAR, New Delhi
Skill development training programme on "Vermicompost Producer" for Farmers [National Skills Qualifications Framework (NSQF) Level-4]	Drs AK Tripathi, AB Singh, Asit Mandal, JK Thakur, Dolamani Amat	February 17 - March 16, 2021	Agriculture Extension Division, ICAR, New Delhi
Farmer's Awareness Campaign on "Balanced use of Fertilizer" through virtual mode	Drs AB Singh, Pradip Dey, AK Vishwakarma	June 18, 2021	ICAR-IISS, Bhopal
E-Goshthi on "Resource conservation technology for sustainable health management"	Dr R S Chaudhary	July 13, 2021	ICAR-IISS, Bhopal
Soil Test & Yield target based fertilization for sustainable soil health"	Dr Pradip Dey	August 13, 2021	ICAR-IISS, Bhopal & TNAU, Coimbatore

Food and Nutrition for Farmers	Drs AB Singh, AK Vishwakarma	August 26, 2021	ICAR-IISS, Bhopal
Curtain Raiser of "International Year of Millets 2023"	Dr AK Vishwakarma	September 17, 2021	ICAR-IISS, Bhopal
Farmers- scientist interaction meet for Awareness campaign on "Balanced use of Fertilizer"	Dr Nishant K Sinha	December 7, 2021	ICAR-IISS, Bhopal

Online Training on "Integrated Nutrient Management"

Virtual Training Programme on "Soil Health Management"

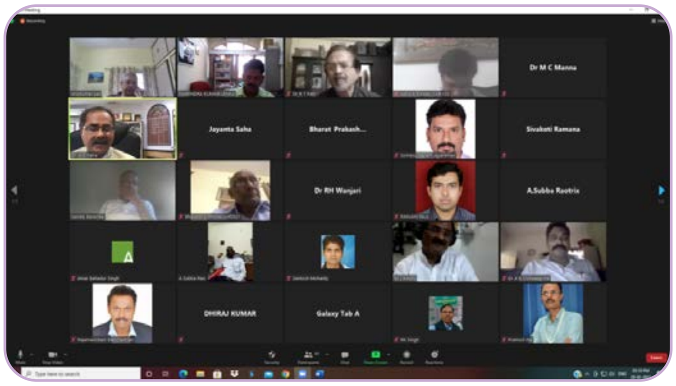


Webinar on "Climate Resilient Varieties, Technologies and Practices" on September 28, 2021

National Science Day webinar on "Future of Science & Technology on Natural Resources Management in Agriculture"

The ICAR-Indian Institute of Soil Science, Bhopal in collaboration with Bhopal Chapter of the National Academy of Agricultural Sciences organized a webinar on the theme "Future of Science & Technology on Natural Resources Management in Agriculture" on February 28, 2021. The webinar included presentations by two lead speakers, Dr. RT Patil, former Director, ICAR-CIPHET, Ludhiana and Dr. DK

Pal, former Visiting Scientist, ICRISAT, followed by a panel discussion on the theme. In the panel discussion, eminent researchers including Dr. A. Subba Rao, former Director, ICAR-IISS; Dr. DLN Rao, former Emeritus Scientist, Dr. BN Johri, Chairman, NASI Regional Chapter; Dr. AK Biswas, Head, ICAR-IISS and Dr. ML Khan, Professor, HS Gaur Central University, Sagar discussed on various aspects of Natural Resource Management (NRM) and called for minimizing fragmented and isolated research, i.e., the need to integrate different aspects of NRM under one umbrella. Scientists from ICAR Institutes, Fellows and Associates of NAAS from Madhya Pradesh, Chhattisgarh and Vidarbha region of Maharashtra participated in the program.



National Webinar on "Nanotechnology in Agriculture: Opportunities and Challenges"under the aegis of NAAS-Bhopal Chapter and Indian Institute of Soil Science

The National Academy of Agricultural Sciences-Bhopal Chapter in collaboration with ICAR-Indian Institute of Soil Science, Bhopal organized a National Webinar on the theme"Nanotechnology in Agriculture: Opportunities and Challenges"on June 21, 2021 in virtual mode. The webinar consisted of a technical session followed by a panel discussion. Dr Anil Kumar Singh, Vice-President of the NAAS chaired the technical session. The webinar was attented by participation of about 350 delegates including present and former Directors and researchers from several ICAR Institutes and SAUs, and former Vice-Chancellors of SAUs.

Van Mahotsav week

Van Mahotsav Week was organized during July 10-16, 2021 and 250 mango, 350 guava, 300 papaya and 250 lime plants have been distributed to the farmers under FFP. Women scientists of ICAR-IISS organized "Vriksharopan Karyakram" on July 22, 2021, at IISS Farm. Besides, one day training program has been organized on "Planting and caring of horticultural crops" on June 17, 2021 in Kalyanpur Village.

Campaign on waste to wealth

National Swachhta Campaign was organized in the adopted villages under MGMG on Waste to Wealth on October 12, 2021.

National Swachhta Campaign at adopted village

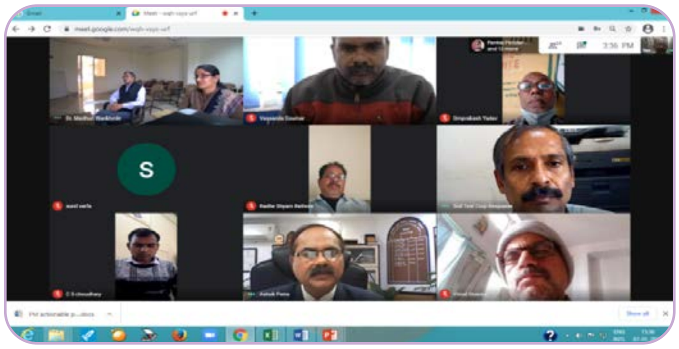
Training conducted under TSP

Krishi Mela cum Krishak Sangosthi on Soil health management for improved agricultural productivity

A "Krishi Mela cum Krishak Sangosthi" was organised at Gidhali Village of block Mohla, Rajnandgaon district Chhattisgarh on March 2, 2021 in association with AICRP on MULLaRP, Raipur and KVK Rajnandgaon. Padma Shri, Smt. Phoolbasan Bai Yadav, President of Maa Bamleshwari Janhit Karya Samiti graced the function and emphasized on the importance of organic farming practices for soil health improvement. distributed the 30 quintals of HYVs of rice (Rajeshwari), 6 quintals of green gram and 100 portable vermibeds were distributed among tribal farmars during the occasion. The team of scientists from the ICAR-IISS including Drs. R. Elanchezhian, Prabhat Tripathi, M. Vassanda Coumar gave lectures on Soil health management for improving crop productivity. In this Krishi Mela, an animal health camp was also organized and 75 animals were vaccinated for Foot and Mouth disease. Altogether 350 tribal farmers attended the Krishi Mela and Krishak Sangoshthi.

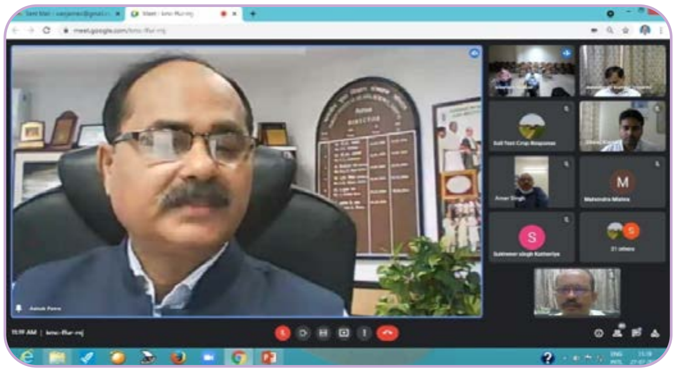
Online Training on 'Integrated Nutrient Management'

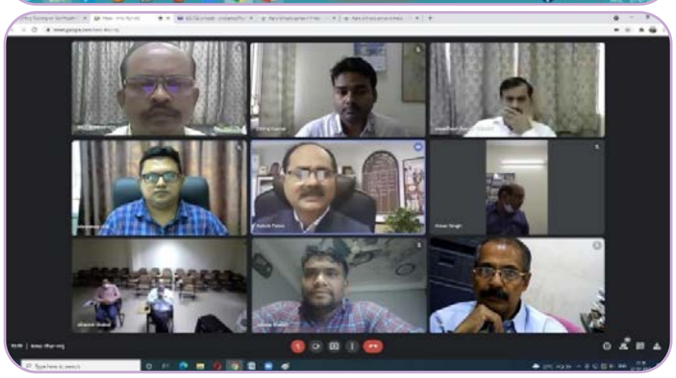
An online 3-day Training on "Integrated Nutrient Management" was organized jointly by ICAR-Indian Institute of Soil Science (IISS), Bhopal & State Institute of Agricultural Extension & Training (SIAET), Bhopal during January 5-7, 2021. The focus of this training was on importance of INM, role and dynamics of soil nutrients, residue management, micronutrients and their management, INM in long-term fertilizer experiments, uses of biofertilizers, INM in problem soils, ITK under organic farming etc. Apart from this, a social issue such as gender sensitization and gender budgeting was also well addressed during the programme. In this training, 30 State Govt Officials from different parts of Madhya Pradesh participated. These participants include Sub-Divisional Officer (SDO), Senior Agriculture Development Officer (SADO), Agriculture Development Officer (ADO), Block Technology Officer (BTM), Assistant Technology Manager (ATM), District Consultant (DC) & Technical Assistant (TA). Dr Ashok K Patra, Director, ICAR-IISS, Bhopal and Shri GP Prajapati, Director, SIAET, Bhopal graced the valedictory session on January 7, 2021 and addressed the participants online. Dr Patra in his address to participants expressed his views on significance, scope and importance of integrated nutrient management from soil as well as human health point of view. Training programme which was coordinated by Dr Pradip Dey, Dr RH Wanjari, Dr M Vassanda Coumar (ICAR-IISS, Bhopal) and Dr Madhuri Wankhede (SIAET, Bhopal).



Training on "Soil Health Management"

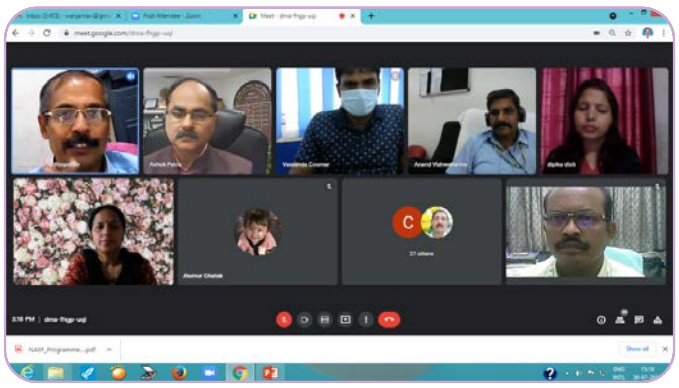
An online 4-day Training on "Soil Health Management" was orgnised jointly by ICAR-Indian Institute of Soil Science (IISS), Bhopal & State Institute of Agricultural Extension & Training (SIAET), Bhopal during July 27-30, 2021 via Google Meet. The focus of this training was on soil sampling, soil testing, concepts on plant nutrition, soil testing kit (Mridaparikshak), role of fertilizer and manure in crop production, balance and integrated nutrient management, organic farming, crop residue management, conservation agriculture, importance of macro/ micronutrients in agriculture, Soil Health Card Scheme, gender sensitization and gender budgeting etc. In this training, 40 officials from different parts of Madhya Pradesh participated online. Dr Ashok K Patra, Director, ICAR-IISS, Bhopal and Shri KP Ahirwar, Director, SIAET, Bhopal graced the inaugural session and addressed the participants online. Dr Patra emphasized upon significance of soil for crop production, animal & human health and overall sustainability of ecosystem. He further emphasized that soil health is key component to enhance crop productivity for doubling farmers' income. This training programme was coordinated by Dr Pradip Dey, Dr RH Wanjari, Dr Hiranmoy Das, Dr Dhiraj Kumar and Shri Sitaram Thakur.

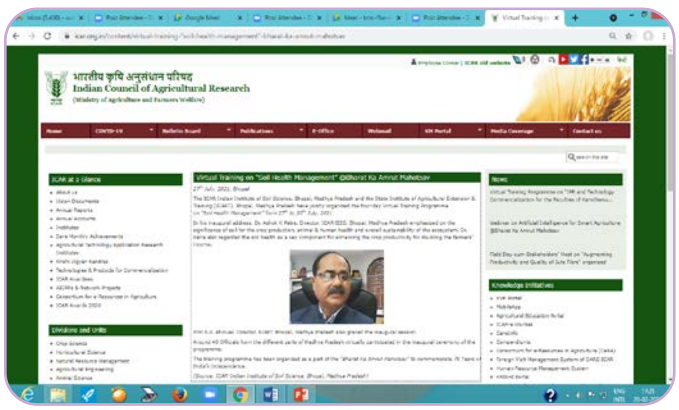




Training on "Soil Testing and Nutritional Recommendation for Agricultural Crops"

The Institute has organized Online 4-day Training on "Soil Testing and Nutritional Recommendation for Agricultural Crops" jointly by ICAR- IISS, Bhopal & State Institute of Agricultural Extension & Training (SIAET), Bhopal during July 27-30, 2021 via Google Meet. The focus of this training was on soil sampling, soil testing, concepts on plant nutrition, soil testing kit (Mridaparikshak), role of fertilizer and manure in crop production, balance and integrated nutrient management, organic farming, crop residue management, conservation agriculture, importance of macro/ micronutrients in agriculture, Soil Health Card Scheme, gender sensitization and gender budgeting etc. In this training, 30 officials as Assistant Soil Testing Officers and Assistant Soil Survey Officers from different parts of Madhya Pradesh participated online. Dr Ashok K Patra, Director, ICAR-IISS, Bhopal graced the valedictory session and addressed the participants online. He emphasized upon importance of soil testing in maximizing crop yield, soil health, animal health and human health by using 4 R (Right source of fertilizer at the right rate, at the right time, in the right place in the right amount) nutrient management concept. He further stated that soil testing vis-à-vis best management practices (BMPs) are need to be adopted by the farmers for doubling farmers income. Through this platform, Dr Patra appealed the participants to transfer the techniques of soil health management and BMPs for updating the skills of the farmers to optimize the yield and overall economics. Mrs Pooja Singh addressed the trainees on gender sensitization and gender budgeting and appealed the participants to follow gender equality. The training programme was coordinated by Drs Pradip Dey, RH Wanjari, AK Vishwakarma, M Vassanda Coumar and Smt Deepika Dixit.





Drs. AK Biswas, RH Wanjari, Shinoji KC, NK Sinha, JK Thakur, Abhijit Sarkar, AB Singh, AK Tripathi, Sanjay Shrivastava, Asha Sahu, BP Meena, K Bharati, AK Vishwakarma, MV Coumar, H Das and Priya Gurav and Pandurang organized a five day Training-cum-Exposure visit on "Resource Conservation Technologies for the Tribal Farmlands of Madhya Pradesh" for the tribal farmers of Betul district (M.P.) at ICAR- Indian Institute of Soil Science, Bhopal during October 25-29, 2021.

RH Wanjari and Dhiraj Kumar Organized (04) Kissan Pathsala, three (03) day each as member of the organizing committee on "climate resilient agriculture" under NICRA project at nearby villages during February to March, 2021.

SR Mohanty, RH Wanjari, Kollah Bharati and Dhiraj Kumar organized a Special Swachhta Campaign in MGMG Group-3 villages namely Choprakala and SukhiSewania on October 20th, 2021.

Important Meetings/Activities

Drs AK Patra, AB Singh, AK Biswas, R Elanchezhian, AK Vishwakarma, Asit Mandal and JK Thakur participated and organized nation wise Special National Swachhta campaign on "Waste to Wealth" conducted by NRM Division of ICAR on October 12, 2021 in Physical and Virtual mode through video film, publication.

Drs Asha Sahu, BP Meena and AK Biswas organized Special National Swachchta Campaign on "Waste to Wealth" on October 22, 2021 at Village Golkhedi.

14. Distinguished Visitors


Dr SK Dhyani, Dr. Aqeel Rizvi and Dr. Mrs Archana Singh from ICRAF visited ICAR-IISS Bhopal

Dr SK Senapati, Member of RAC visited on October 6, 2021

Dr. M.H. Mehta
Ex-Vice Chancellor – Gujarat Agricultural University)
visited on September 30, 2021

15. Infrastructure Development

Instrument/Equipment Purchased

During the year 2021, Non Refrigerated Centrifuge, Kjeleahi N Distillation Unit, Water Purification Systems (5 No.), Reciprocating Shaker, Deep Freezer, UV Spectrophotometer, Microwave Digestion System (6 No.), IRGA, IR Temperature Sensor, Refrigerator (02 No.), Laboratory Incubator, Visible Spectrophotometer, IoT System, TDR, Flame Photometer were purchased.

New Equipment

The Division of Soil Chemistry and Fertility was gifted Rotary Sample Divider from Food and Agricultural Organization of the United Nations for showing very good performance in the Proficiency Testing organized by Global Soil Laboratory Network of the FAO, UN. The team that conducted analysis of soil samples for proficiency testing comprised Drs. Sanjay Srivastava, Pramod Jha, Abhay Shirale and Mr. Deepak Kaul The equipment is worth Rs. 1000000/ (Rupees ten lakh)

Library

The library maintains book, journals, bulletins and annual report etc. It provides lending, referencing and reprographic services etc. The library also exchanges publications of the institute with other ICAR institutes and SAUs. During the period under report, the library has acquired total documents as mentioned below:

Documents	Addition during 2021	Total
Books	3	2596
Bound Journals	Nil	3180
Annual Reports	55	2685
Foreign and Indian Journals	Nil	Nil

Farm Activities

During the reported period farm section arranged various inputs such as seed and fertilizers etc. for field experiments. Apart from input arrangement rain water harvesting also managed by the section so that round the year irrigation water can be provided to all the field experiments as well as general farm area for producing various crops during rabi , kharif and in summer season. The main crops raised at farm during the year were maize, pigeon pea soybean during the kharif season, however chick pea, wheat, linseed and mustard during rabi season, moong was also raised during the summer season. The total revenue generated during the period was Rs.18,15,444/-

Chickpea Field

Pigeon Pea 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 Ashok Kumar Patra	Director	Soil Chemistry/Fertility/ Microbiology	05.10.1989	01.05.2014
Mr Thomas Joseph	Private Secretary	Office Staff	18.09.1989	18.09.1989
Mr Sunny Kumar	Stenographer Grade III	Office Staff	21.12.2011	21.12.2011
Mr Sukhram Sen	Senior Technical Assistant	Driver	25.01.1991	25.01.1991
Mr Bhoi Lal Uikey	Skilled Supporting Staff	Lab Attendant	13.11.1995	13.11.1995
Mr Darashram	Skilled Supporting Staff	Lab Attendant	15.03.1990	15.03.1990
		DIVISION OF SOIL PHYSICS		
Dr RS Chaudhary	Pr. Scientist& I/c Head	Soil Physics/Soil & Water Conservation	10.11.1993	09.12.1999
Dr Kuntal Mouli Hati	Pr. Scientist	Soil Physics/Soil & Water Conservation	27.12.1996	27.12.1996
Dr Rakesh Kumar Singh	Pr. Scientist	Soil Physics/Soil & Water Conservation	25.01.1993	16.10.2002
Dr Prabhat Tripathi	Pr. Scientist	Agronomy	19.09.1998	28.06.2017
Dr J Somasundaram	Pr. Scientist	Soil Physics/Soil & Water Conservation	12.11.2001	22.12.2008
Dr Monoranjan Mohanty	Pr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1999	10.11.1999
Mrs Seema Bhardwaj	Scientist	Soil Science/Pedology	07.01.2008	07.07.2018
Dr Nishant Kumar Sinha	Scientist	Agricultural Physics	20.04.2010	27.08.2010
Dr Jitendra Kumar	Scientist	Soil Science/Soil Physics	15.09.2011	02.01.2020
Ms Alka Rani	Scientist	Soil Science	04.01.2019	12.04.2019
Mr Rajesh Kumar Mandloi	Chief Technical Officer	T-9	19.06.1989	19.06.1989
Mr Pramod Kumar Chouhan	Technical Officer	T-5	15.02.1993	15.02.1993
Mr Janak Singh Mehra	Skilled Supporting Staff	Khalasi	08.09.1997	08.09.1997
		DIVISION OF SOIL CHEMISTRY AND FERTILITY		
Dr Ashish 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 Brij Lal Lakaria	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	01.10.1997	15.01.2007
Dr R Elanchezhian	Pr. Scientist	Plant Physiology	09.11.1998	17.2.2012
Dr Narendra Kumar Lenka	Pr. Scientist	Soil Physics/Soil & Water Conservation	30.11.2000	09.10.2009
Dr AK Vishwakarma	Pr. Scientist	Agronomy	16.04.2003	01.08.2013
Dr Pramod Jha	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	16.04.2003	17.07.2009
Dr Shinogi KC	Scientist	Agricultural Extension	27.04.2011	05.09.2011
Dr Bharat Prakash Meena	Scientist	Agronomy	15.09.2011	22.12.2011
Dr Shirale AO	Scientist	Soil Science	01.01.2015	10.04.2015
Dr Gurav Priya Pandurang	Scientist	Soil Science	01.01.2016	11.04.2016
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 Jai Singh	Sr Technical Officer	T-6	22.05.1990	22.05.1990
Mr Harish Kumar	Skilled Supporting Staff	Lab attendant	14.03.1990	14.03.1990
DIVISION OF SOIL BIOLOGY				
Dr Amar Bahadur Singh	Pr. Scientist	Biochemistry	22.03.1999	22.03.1999
Dr AK Tripathi	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	05.08.1991	25.07.1992
Dr Santosh Ranjan Mohanty	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
Dr Kollah Bharati	Pr. Scientist	Microbiology - Plant Science	29.10.2009	05.04.2011
Dr Asit Mandal	Sr. Scientist	Soil Chemistry/Fertility	23.06.2009	30.10.2009
Dr Jyoti Kumar Thakur	Scientist	Agricultural Microbiology	20.04.2010	27.08.2010
Dr Asha Sahu	Scientist	Soil Chemistry/Fertility/Microbiology	03.05.2010	03.05.2010
Dr Sudeshna Bhattacharjya	Scientist	Soil Science	01.01.2015	10.04.2015
Dr Dolamani Amat	Scientist	Agricultural Microbiology	05.01.2017	15.04.2017
Mr Abinash Das	Scientist	Soil Science	05.10.2020	13.01.2021
Mrs Seema Sahu	Asstt. Chief Technical Officer	T 7-8	14.04.1987	24.01.1989
Mr Sant Kumar Rai	Technical Asstt	T-3	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 Jayant Kumar Saha	Pr. Scientist & I/c Head	Soil Chemistry/Fertility/ Microbiology	21.01.1992	02.01.1993
Dr Ajay	Pr. Scientist	Plant Physiology	12.04.1993	31.08.1999
Dr Tapan Adhikari	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	22.03.1996	07.11.1996
Dr Sivkoti Ramana	Pr. Scientist	Plant Physiology	06.02.1997	06.02.1997
Dr Sangeeta Lenka	Sr. Scientist	Soil Physics/Soil & Water Conservation	08.01.2007	18.05.2007
Dr M Vassanda Coumar	Sr. Scientist	Soil Chemistry/Fertility/ Microbiology	04.11.2009	15.03.2010
Dr Vasudev Meena	Scientist	Agronomy	15.09.2011	23.12.2011
Dr Abhijit Sarkar	Scientist	Soil Science	05.07.2016	29.06.2018
Mrs Madhumonti Saha	Scientist	Soil Science	05.07.2017	29.06.2018
Dr Nisha Sahu	Scientist	Soil Chemistry/Fertility/ Microbiology	23.01.2012	30.11.2019
Dr Dinesh Kumar Yadav	Scientist	Agricultural Chemicals	05.10.2020	12.01.2021
Mr Rahul Mishra	Scientist	Soil Science	05.10.2020	11.01.2021
Mr Vinod Choudhary	Sr. Tech. Assistant	T-4	14.06.1989	14.06.1989
Mr Ram Bharose	Skilled Supporting Staff	Lab attendant	20.03.1990	20.03.1990
AICRP-LTFE				
Dr RH Wanjari	Pr. Scientist	Agronomy	07.01.1999	07.01.1999
Dr Dhiraj Kumar	Scientist	Soil Chemistry/Fertility/ Microbiology	01.01.2015	13.08.2020
Mrs Geeta Yadav	Private Secretary	Office Staff	26.12.1995	26.12.1995
Mr Jagannath Gour	Skilled Supporting Staff	Lab Attendant	20.07.1992	20.07.1992
AICRP-MSPE				
Dr Arvind Kumar Shukla	Pr. Scientist & I/c PC (MSPE)	Soil Chemistry/Fertility/ Microbiology	05.07.1996	31.03.2011
Dr Sanjib Kumar Behera	Pr. Scientist	Soil Science & Agricultural Chemistry	08.01.2007	27.06.2017
Mr Shahab Siddiqui	Asstt. Chief Technical Officer	T-7-8	05.10.1992	05.10.1992

Mr Venny Joy	Personal Assistant	Office Staff	14.02.1991	23.03.1998
Mr KS Raghuvanshi	Technical Officer	T-5	29.12.1988	29.12.1988
Mr Bhamar Singh Yadav	Skilled Supporting Staff	Messenger	01.09.1993	23.01.1999
		AICRP-STCR		
Dr Pradip dey	Pr. Scientist & I/c PC (STCR)	Soil Chemistry/Fertility/ Microbiology	03.06.1993	01.02.2012
Dr Hiranmoy Das	Scientist	Agricultural Statistics	15.09.2011	23.12.2011
Dr I Chongboi Haokip	Scientist	Soil Science	07.01.2020	04.04.2020
Mrs Yojana Meshram	Personal Assistant	Office Staff	12.05.1997	12.05.1997
Mrs Kavita Bai	Skilled Supporting Staff	Safaiwala	20.12.1988	20.12.1988
		AINP-BIOFERTILIZER AND BIODIVERSITY		
Dr Santosh Ranjan Mohanty	Pr. Scientist & 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	Plant Physiology	09.11.1998	17.02.2012
Mr Sanjay Kumar Kori	Steno. Grade-III	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
Mr Sanjay Kumar Parihar	Technical Assistant	T-3	29.06.2019	29.06.2019
		AKMU		
Dr J Somasundaram	Pr. Scientist	Officer In-Charge Remot Sensing & GIS Laboratory	12.11.2001	22.12.2008
		REMOTE SENSING & GIS LABORATORY		
Dr Monoranjan Mohanty	Pr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1999	10.11.1999
Mr LN Chouksey	Skilled Supporting Staff	Messenger	17.12.1988	17.12.1988
		LIBRARY SECTION		
Mrs Nirmala Mahajan	Asstt. Chief Tech. Officer	T 7-8	15.03.1993	15.03.1993
		CENTRAL LAB		
Dr Santosh Ranjan Mohanty	Pr. Scientist	Officer In-Charge	18.06.2009	18.06.2009
		REFERRAL LAB		
Dr Pradip Dey	Pr. Scientist & I/c PC (STCR)	Officer In-Charge	03.06.1993	01.02.2012
		FARM SECTION		
Dr AK Vishwakarma	Pr. Scientist	Officer In-Charge	16.04.2003	01.08.2013
Mr Om Prakash Shukla	Technical Officer	T-5 (Tractor Mech.)	22.04.1989	22.04.1989
Mr CT 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	Sr. Technical Assistant	T-4	30.12.1988	30.12.1988
Mr Bhagwat Prasad	Skilled Supporting Staff	Beldar	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				
Dr Shirale AO	Scientist	Officer Incharge	01.01.2015	10.04.2015
ADMINISTRATION SECTION				
Mr Sunil Kumar Gupta	SAO	Administration	14.11.1986	01.04.2017
Mr Rajesh Dubey	AF&AO	Audit & account	21.12.1988	26.11.1998
Mr Anupam Sahasi Rajput	AAO	Administration	14.03.1990	14.03.1990
Mrs Babita Tiwari	Assistant	Central store	30.05.1996	30.05.1996
Mr Bansilal Sarsodia	Assistant	Purchase section	10.09.1997	10.09.1997
Mr Hira Lal Gupta	Assistant	Bill section	23.12.1988	23.12.1988
Mr Om Prakash Yadav	UDC	Audit & Account	19.12.1988	19.12.1988
Mr Jineshwar Prasad	UDC	Bill Section	13.12.1988	13.12.1988
Mr Sanjay Katinga	LDC	Cash Section	20.06.1989	20.06.1989
Mrs Raksha Dixit	LDC	Establishment Section	24.05.2013	24.05.2013
Mr Anurag	Security Supervisor	Security section	29.09.1997	29.09.1997
Mr Pramod Kumar Raut	Skilled Supporting Staff	Beldar	21.07.1992	21.07.1992
Mr Sanjay Narayan Gharde	Skilled Supporting Staff	Lab attendant	15.06.1999	15.06.1999
Mr Dharam Raj Singh	Skilled Supporting Staff	Messenger	10.09.1993	14.06.1999
Mr AK Mishra	Skilled Supporting Staff	Lab attendant	01.09.1993	10.06.1999

Promotion

1. Dr. Vasudev Meena, Scientist promoted from Revised Research Level-10 to Revised Research Level-11 w.e.f. September 15, 2016.
2. Dr. Hiranmoy Das, Scientist promoted from Revised Research Pay Level-10 to Revised Research Level-11 w.e.f. September 15, 2016.
3. Dr. Asit Mandal, promoted from Scientist (Revised Research Pay Level-11) to Senior Scientist (Revised Research Pay Level-12) w.e.f June 23, 2018.
4. Dr. M. Vassanda Coumar, promoted from Scientist (Revised Research Pay Level-11) to Senior Scientist (Revised Research Pay Level-12) w.e.f November 04, 2018.
5. Dr. Sudeshna Bhattacharjya, Scientist promoted from Revised Research Pay Level- 10 to Revised Research Pay Level-11 w.e.f. January 01, 2019.
6. Dr. Shirale Abhay Omprakash, Scientist promoted from Revised Research Pay Level-10 to Revised Research Pay Level-11 w.e.f. January 01, 2019.
7. Dr. Sangeeta Lenka, Senior Scientist promoted from Revised Research Pay Level-12 to Revised Research Level-13A w.e.f. January 08, 2019.
8. Mr. D.R. Darwai, promoted from Technical Officer (T-5) to Sr. Technical Officer (T-6) w.e.f. January 23, 2018.
9. Mrs. Nirmala Mahajan, promoted from Assistant Chief Technical Officer (T-7/8) to Chief Technical Officer (T-9) w.e.f. March 15, 2020.
10. Mr. Jai Singh promoted from Senior Technical Officer (T-6) to Assistant Chief Technical Officer (T-7/8) w.e.f. May 22, 2020.
11. Late Shri Vinod Choudhary, promoted from Sernior Technical Assistant (T-4) to Technical Officer (T-5) w.e.f. October 30, 2020.
12. Shri Venny Joy, PA got 3rd MACP from Pay Matrix Level – 6 to Pay Matrix Level -7 w.e.f. February 14, 2021.
13. Mrs. Geeta Yadav, PS got 3rd MACP from Pay Matrix Level – 7 to Pay Matrix Level -8 w.e.f. March 29, 2021.
14. Shri Bansilal Sarsodia, Assistant got 3rd MACP from Pay Matrix Level – 7 to Pay Matrix Level -8 w.e.f. March 29, 2021.
15. Mr. Sukhram Sen, promoted from Senior Technical Assistant (T-4) to Technical Officer (T-5) w.e.f. June 29, 2021.
16. Mrs. Babita Tiwari, promoted from Assistant to Assistant Administrative Officer w.e.f. July 20, 2021.
17. Mrs. Yojana Meshram, promoted from Personal Assistant to Private Secretary w.e.f. July 24, 2021.
18. Shri Sanjay Katenga, promoted from Lower Division Clerk to the post of Upper Division Clerk w.e.f. July 24, 2021.
19. Shri Sunil Kumar Gupta, promoted from Senior Administrative Officer to the post of Chief Administrative Officer w.e.f. September 29, 2021.
20. Shri Rajesh Dubey, promoted from Assistant Finance & Accounts Officer to the post of Finance & Accounts Officer w.e.f. November 03, 2021.
21. Shri Jineshwar Prasad, promoted from Upper Division Clerk to the post of Assistant w.e.f. December 24, 2021.
22. Shri Om Prakash Yadav, promoted from Upper

Division Clerk to the post of Assistant w.e.f. December 24, 2021.

23. Smt. Raksha Dixit, promoted from Lower Division Clerk to Upper Division Clerk w.e.f. December 27, 2021.

14. Shri Sunny Kumar, promoted from Steno Grade III to Personal Assistant w.e.f. December, 30, 2021.

Transfer

1. Dr. Vasudev Meena, Scientist transferred to ICAR-DRMR, Bharatpur, Rajasthan on January 23, 2021.
2. Mr. Bhamar Singh Yadav, SSS transferred to ICAR-IISWC, Dehradun on October 8, 2021.
3. Shri Rajesh Dubey, Assistant Finance & Accounts Officer transferred to ICAR-CIAE Bhopal on November 05, 2021.

Joining

1. Mr. Rahul Mishra, Scientist joined at ICAR-IISS, Bhopal on January 11, 2021.

2. Dr. Dinesh Kumar Yadav, Scientist joined at ICAR-IISS, Bhopal on January 12, 2021.

3. Dr. Khushboo Rani, Scientist joined at ICAR-IISS, Bhopal on January 13, 2021.

4. Mr. Abinash Das, Scientist joined at ICAR-IISS, Bhopal on January 13, 2021.

5. Mr. Prashant Gour, Lower Division Clerk joined at ICAR-IISS, Bhopal on January 15, 2021.

6. Mr. Mahesh Kumar Mulani, SFAO joined at ICAR-IISS, Bhopal on October 13, 2021.

Probation Clearance

1. Ms. Alka Rani, Scientist cleared Probation period w.e.f. January 04, 2021.

Superannuation

1. Mr. Sunil Kumar Gupta, Chief Administrative Officer superannuated on September 30, 2021.

Deceased

1. Mr. Vinod Chaudhary, Technical Officer expired on April 14, 2021.
2. Dr. S. Ramana, Principal Scientist expired on April 18, 2021.

Remarks


भारतीय मृदा विज्ञान संस्थान
INDIAN INSTITUTE OF SOIL SCIENCE
World Soil Day


ICAR-IISS
Halt
Salinization
Boost
Soil
Productivity
World
Day
2021


Van Mahotsav Week
(वन महोत्सव सप्ताह)
10-16 July, 2021
ICAR-Indian Institute of Soil Science


कृषि विज्ञान केन्द्र, राजनांदगांव