वार्षिक प्रतिवेदन
Annual Report 2019

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
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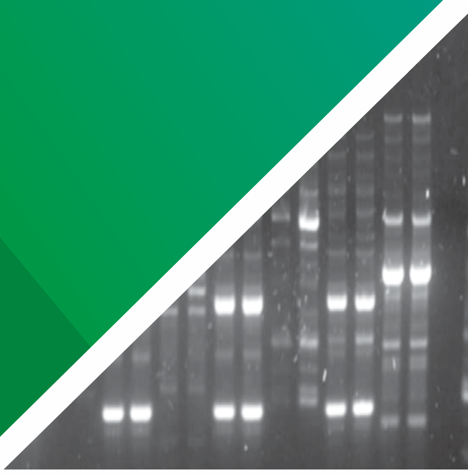


भाकृअनुप – भारतीय मृदा विज्ञान संस्थान
ICAR-Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal 462038
(ISO 9001 : 2015 Certified)
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SARDAR PATEL OUTSTANDING ICAR INSTITUTION AWARD- 2018

(For Small Institute Category)

CITATION

ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh has been bestowed Sardar Patel Outstanding ICAR Institution Award- 2018 for Small Institute together with ICAR-Indian Institute of Millets Research (IIMR), Hyderabad.

ICAR - Indian Institute of Soil Science, Bhopal, the only institute exclusively focused on soil science has conducted frontier research on basic and strategic aspects in various types of soils for last 30 years. The institute has achieved landmark success in improving soil health management and achieving balanced crop nutrition through integrated soil management technologies and soil test crop response based nutrient recommendations that have enhanced productivity significantly while conserving soil and nutrient resources and improving nutrient and water use efficiency. The institute has continuously expanded the horizons of its activity to meet the emerging challenges of soil science research and raised the standards to global level which is reflected in terms of significant international publication, recognition and citations. The institute continues to focus on new endeavors through basic and strategic research in emerging areas to maintain a leadership role in the field of soil science. Recently the institute has developed a mini lab named 'Mridaparikshak' for soil health assessment which can measure fifteen soil parameters and is proving very instrumental in fulfilling the task of providing soil health card to each farmer of the country. Improving soil quality, input use efficiency, carbon sequestration, GIS based fertility mapping, conservation agriculture, organic farming, microbial diversity and biofertilizers soil genomics, bio-fortification, waste management, climate change mitigation strategies, nano fertilizers etc., are some of the major research accomplishments of the institute.

With Best Compliments

(Ashok K. Patra)
Director
ICAR-Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal – 462 038

ICAR - IISS
Annual Report 2019

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Healthy soil for a healthy life

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Preface

In India, deterioration of soil health is a major concern for sustainable intensification of agricultural productivity and environmental quality. Regular and proper monitoring of our soil resources and providing appropriate technological interventions for enhancing soil health and crop productivity to meet the food and nutritional security of the country is thus extremely important.

ICAR-Indian Institute of Soil Science (ICAR-IISS), Bhopal is dedicated in research with mandate "to provide scientific basis for enhancing and sustaining productivity of soil resource with minimal environmental degradation". The ongoing-flagship areas of work by the institute are exploring/developing new fertilizer materials and increasing nutrient and water use efficiency, conservation agriculture and carbon sequestration, assessing soil microbial diversity and genomics and their potential use in agro-ecology, soil pollution, remediation and environmental security.

This Annual Report describes the progress on the work undertaken and some of the new technologies and methodologies developed and refined, such as development of prediction models for soil organic carbon (SOC) and physical properties using Mid Infra-red Spectroscopy (MIR); new liquid formulation of microbial consortia for rapid decomposition of agro-wastes; bioremediation of heavy metals from compost using microbial inoculants; identification and delineation of micro and secondary nutrient deficiencies and soil fertility maps of the country; vulnerability assessment of agriculture towards climate change; mainstreaming conservation agriculture; prediction of nitrogen supplying capacity of soil using glomalin protein; identification of nutrient use efficient genotypes of wheat; exploring glauconite as a source of potassium; deriving critical limit of cadmium in soil, phytoremediation of acid mine drainage affected areas, etc. Besides, the Institute has also participated in different activities, such as proficiency test of Global Soil Laboratory Network (GLOSOLAN) towards harmonization of soil testing methods under the Global Soil Partnership of FAO, Rome. The Institute has also disseminated technologies through FLDs and kisan sangosthi for wider adoption by farming community for sustaining soil health and crop productivity.

My sincere appreciation to all the Project Coordinators, Head of the Divisions, scientists and staff members of the institute for their keen interest and painstaking efforts in carrying out the research and participation in various developmental activities of the Institute, and compiling information as and when required.

It is a matter of great satisfaction and pride for all of us that our institute was bestowed with Sardar Patel Outstanding ICAR Institution Award-2018. This prestigious award came as a result of significant achievements of our institute in last 5 years. Besides, research work of many Scientists was individually recognized by several awards and honors.

My appreciation to editorial members Drs. R. Elanchezhian, A.K. Tripathi, J. Somasundaram, R.H. Wanjari, Pramod Jha and Sangeeta Lenka 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 type setting the manuscript is also appreciated.

My deep sense of gratitude and respect to Hon'ble Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR for his consistent guidance, inspiration and encouragement and for providing necessary financial support for overall growth and development of the institute. I am highly thankful to Dr. S.K. Chaudhari, DDG (NRM) and Ex-ADG (SWM) and Dr. K. Alagusundaram, DDG (Agril. Engg.) and Ex-I/c DDG (NRM) for their active involvement, full co-operation, constructive suggestions and support in carrying out various research and development activities for overall progress and visibility of the institute.

Bhopal
April 2020

(Ashok K. Patra)
Director

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कार्यकारी सारांश

विषयवस्तु 1: मृदा स्वास्थ्य एवं पोषक तत्व उपयोग दक्षता

- वर्टिसोल मृदा पर गेहूँ के 121 जीनोटाइप्स में पोषक तत्व उपयोग कुशल जीनोटाइप का चयन करने के लिए एग्रो-मॉर्फोलॉजिकल और जैव-रासायनिक मापदण्डों को दर्ज किया गया। विविध जर्मप्लाज्म की जाँच उर्वरकों की अनुशंसित मात्रा एवं नाइट्रोजन और फास्फोरस की 50 प्रतिशत अनुशंसित खुराक स्तरों के तहत की गई। विभिन्न अनुशंसित खुराक के साथ पत्ती क्षेत्र, क्लोरोफिल की मात्रा और गेहूँ के पौधों में सापेक्ष पानी की मात्रा में भिन्नता देखी गई।
- अकेले ग्लूकोनाइट अनुप्रयोग के प्रभाव या गोबर की खाद और पोटेशियम घोलक बैक्टीरिया के साथ सूक्ष्मजैविक टीका के संयोजन में बेसिलस सेरेस का अध्ययन किया गया। परिणामों से पता चलता है कि ताप उपचार (कैल्साइन्ड ग्लूकोनाइट) ग्लूकोनाइट के अम्लीकरण और गोबर की खाद के उपयोग दोनों ने मिट्टी में ग्लूकोनाइट से पोटेशियम निष्कर्षण पर स्पष्ट प्रभाव दिखाया।
- लम्बी अवधि के रूझान ने स्पष्ट रूप से संकेत दिया है कि मक्का में सामान्य अनुशंसित मात्रा और अकार्बनिक पोषक तत्वों के अन्य संयोजनों की तुलना में गोबर की खाद के साथ 75 प्रतिशत ना.फा.पो. के संयोजन से मक्का की उपज में सुधार एवं निरंतरता बनी हुई है। जबकि चना के दानों की उपज 75 प्रतिशत ना.फा.पो. एवं 5 टन/हे. गोबर की खाद की अवशिष्ट उर्वरता के उपचार के साथ काफी अधिक थी।
- सोडियम साइट्रेट विधि द्वारा आसानी से निकाले जाने योग्य ग्लोमालिन से संबंधित मिट्टी के प्रोटीन के पूल को मोटे तौर पर एक मिट्टी उपलब्ध नाइट्रोजन आपूर्ति सूचक के रूप में देखा जा सकता है जो मिट्टी में व्यवस्थिति रूप से बाध्य नाइट्रोजन के प्राथमिक पूल को दर्शाता है और इस प्रकार मिट्टी में उपलब्ध संभावित कार्बनिक नाइट्रोजन के रूप में देखा जा सकता है। यह निष्कर्ष निकाला जा सकता है कि ई ई जी एस पी संभवत: मिट्टी में नाइट्रोजन उपलब्धता के सूचकांक के रूप में उपयोग किया जा सकता है।
- म.प्र. के बालाघाट जिले के कवीली, कुल्पा और सर्रा गाँवों के आदिवासी किसानों के खेतों के लिए मृदा स्वास्थ्य कार्ड, जैविक आदानों जैसे गोबर की खाद, अजोला, हरी पत्तियों जैसे ग्लिरिसीडिया (ग्लिरिसीडिया सेपियम), कम्पोस्ट और अस्थि चूर्ण के संदर्भ में सिफारिशें देने के लिए तैयार किया गया।
- उत्तराखंड के ऊधम सिंह नगर जिले में किए गए अध्ययन ने संकेत दिया है कि उच्च उर्वरक अनुप्रयोग के कारण पानी की गुणवत्ता, मिट्टी की गुणवत्ता के मापदण्डों से अधिक प्रभावित होती है।
- गेहूँ की फसल की कटाई उपरान्त एकत्र किए गए मिट्टी के नमूनों के फॉस्फोलिपिड फैटी अम्ल विश्लेषण (पी एल एफ ए) से पता चलता है कि उच्च कार्बन डाईऑक्साइड स्तर और /अथवा तापमान उपचारों में कवक-बैक्टीरिया अनुपात में उल्लेखनीय वृद्धि, और ग्राम+ / ग्राम- के अनुपात में उल्लेखनीय कमी पाई गई।
- आयन चयनात्मक क्षेत्र प्रभाव ट्रांजिस्टर का उपयोग करके नाइट्रेट, फास्फेट और पोटेशियम आयनों के अनुमान के लिए अच्छे अंशांकन वक्र विकसित किए गए।
- जैविक कृषि प्रणाली के तहत, गेहूँ, सरसों, चना एवं अलसी की अधिकतम उपज 75 प्रतिशत कार्बनिक + 25 प्रतिशत अकार्बनिक उपचार के साथ दर्ज की गई और इसके बाद 100 प्रतिशत जैविक उपचार पद्धतियों में। इसके अलावा क्षारीय फास्फेट और बीटा ग्लूकोसिडेज एंजाइम गतिविधियों को 100 प्रतिशत कार्बनिक उपचार में सबसे अधिक दर्ज किया गया, इसके बाद 75 प्रतिशत कार्बनिक + 25 प्रतिशत अकार्बनिक और 75 प्रतिशत कार्बनिक + अभिनव उपचार मिट्टी में, जो कार्बनिक पदार्थों के प्रयोग से मिट्टी के सूक्ष्मजीवों पर लाभकारी प्रभाव का संकेत देते हैं।
- इंडो-गैंगेटिक मैदानी इलाकों की इनसेप्टिसोल मृदा पर एम आई आर स्पेक्ट्रोस्कोपी के प्रयोग से मिट्टी के कार्बनिक और पी एच के एक साथ आकलन के लिए काफी संभावनाएं दिखाईं। हालांकि एम आई आर तरंग दैर्ध्य और मिट्टी के

गुणों के बीच के आंतरिक संबंधों को समझने के लिए विस्तृत अध्ययनों की जरूरत को महसूस किया जाता है ताकि एम आई आर का उपयोग मिट्टी के गुणों के मापन के लिए एक विश्वसनीय और सटीक विधि के रूप में किया जा सके।

- यादृच्छिक वन मॉडल, सटीकता के स्वीकार्य स्तर के साथ उन्नाव (उ.प्र.) जिले में मध्यम ओर गम्भीर लवणीय-क्षारीय मिट्टी की पहचान करने में सक्षम था। नमक प्रभावित मिट्टी के स्थानिक वितरण ने भी नहर के साथ निकटता का संबंध दर्शाया।
- जलवायु विविधता वाले मध्य प्रदेश के सीहोर और राजगढ़ जिलों की जमीन में मृदा उर्वरता मानचित्रण और भू-गुणों का विश्लेषण (मृदा कार्बनिक कार्बन, लेवाइल कार्बन, फास्फोरस, पोटेशियम, विद्युत चालकता और जल धारण क्षमता) किया गया।
- मिट्टी में किए पोषक गतिकी अध्ययन ने संकेत दिया कि पोषक तत्वों के संतुलित प्रयोग से मिट्टी में लगभग सभी पोषक तत्वों (नाइट्रोजन, फास्फोरस, पोटाश, गन्धक और बोरोन) के उपलब्ध रूपों में वृद्धि हुई। इसके विपरीत, पोषक तत्वों (नियंत्रण, नाइट्रोजन और नाइट्रोजन +फास्फोरस) के असंतुलित प्रयोग से पोषक तत्वों की मात्रा में गिरावट आई। इस प्रकार सघन खेती के तहत पौधों के रिजर्व पूल से पोषक तत्वों कों प्राप्त करना होता है जिसके परिणामस्वरूप मिट्टी की उर्वरता में थकान और लम्बे समय में समग्र स्थिरता हो सकती है।
- विभिन्न राज्यों के 109 जिलों से एकत्रित मिट्टी के नमूनों के विश्लेषण से ज्ञात हुआ है कि हिमाचल प्रदेश, झारखंड, जम्मू कश्मीर, केरल, कर्नाटक, मणिपुर, तमिलनाडु, उत्तराखंड में विनमय कैल्शियम और मैग्नीशियम का स्तर क्रमशः 1.13 से 11290 मिग्रा./किग्रा. एवं 0.40 से 7680 मिग्रा./किग्रा. पाया गया। केरल और मणिपुर राज्यों ने कैल्शियम और मैग्नीशियम की कमी के तहत उच्च प्रतिशत क्षेत्र दिखाया।
- सरसों के प्रजनन शरीर विज्ञान पर बोरोन तनाव के प्रभाव का अध्ययन किया गया और यह देखा गया कि फली और बीज कम और उच्च बोरोन आपूर्ति से प्रतिकूल रूप से प्रभावित पाई गई।
- एक किलोग्राम बोरोन/हे. + 20 किग्रा. गन्धक/हे. + 100 प्रतिशत ना.फा.पो. के अनुप्रयोग से असम में चना की उपज सबसे अधिक दर्ज की गई।
- बाजरा की फसल में एस टी सी आर-आई पी एन एस + 4.0 टन/हे. गोबर की खाद वाले उपचार में यूरियेज, फास्फेटेज और डिहाइड्रोजिनेज जैसी उच्च एंजाइमेटिक गतिविधियाँ दर्ज की गई।

विषयवस्तु 2: संरक्षित कृषि, कार्बन सीक्यूस्ट्रेशन एवं जलवायु परिवर्तन

- नो-टिल प्रणाली में फसल अवशेषों के अवधारण से सक्रिय पूल में कार्बन का उच्च अनुपात प्राप्त हुआ जबकि निष्क्रिय पूल में कार्बन के अनुपात में कमी आई। नो-टिल प्रणाली में फसल अवशेषों के अवधारण से कार्बन के बहुत लेबाइल और लेबाइल पूल में योगदान हुआ।
- मीथेन की खपत क्षमता मक्का-गेहूँ में अधिक और मक्का-चने फसल चक्र में कम पाई गई। हालाँकि मीथेन खपत के प्रति नो-टिल प्रणाली का सकारात्मक प्रभाव मक्का-गेहूँ की तुलना में सोयाबीन-गेहूँ और मक्का-चने में देखा गया।
- अधिकतम उपज और उपज विशेषताओं को नो-टिल प्रणाली के अन्तर्गत सोयाबीन-गेहूँ और मक्का-चना फसल प्रणाली के तहत 90 प्रतिशत फसल अवशेष स्तरों के साथ दर्ज किया गया।
- किसानों के खेतों में प्रदर्शन से शून्य जुताई के तहत सोयाबीन, गेहूँ और चने की अधिक उपज एवं उपज विशेषताओं का पता चला।
- मक्का-गेहूँ फसल प्रणाली के अन्तर्गत 150 प्रतिशत नाइट्रोजन के साथ उच्च मृदा कार्बनिक कार्बन एवं कार्बन स्तरीकरण प्राप्त हुआ।
- ए पी एस आई एम मॉडल ने संतोषजनक रूप से टी ओ सी और उच्च टी ओ सी की भविष्यवाणी की थी जो तीसरी फसल चक्र के बाद नो-टिल प्रणाली में बताई गई थी। सी टी प्रणाली की तुलना में एन टी में छह फसल चक्रों के अन्त में 18 प्रतिशत और 11 प्रतिशत अधिक कुल कार्बनिक कार्बन देखा गया।
- अवशेषों के प्रतिधारण के साथ सी टी की तुलना में आर टी और एन टी जैसी संरक्षण कृषि प्रथाओं ने मिट्टी के पुंजीकरण और संरचनात्मक स्थिरता में सुधार किया।
- अध्ययन ने संकेत दिया है कि मध्य प्रदेश के जिलों की समग्र कृषि भेद्यता को आर सी पी 4.5 और आर सी पी 8.5 के दोनों उत्सर्जन परिदृश्यों की वर्तमान स्थितियों की तुलना में मध्य से अंत सदी तक कम होने का अनुमान है।

विषयवस्तु 3 : सूक्ष्मजैविक विविधता और जैव-प्रौद्योगिकी

- माइक्रोबियल कंसोर्टिया (चार कवक, चार बैक्टीरिया, दो एक्टीनोबैक्टीरिया, एक खमीर, एक लैक्टोबैसिलस) के तरल का विकास भाकृअनुप-भारतीय मृदा विज्ञान संस्थान, भोपाल में किया गया है और बड़े पैमाने पर प्रभावकारिता के मूल्यांकन के तहत है। भाकृअनुप-भारतीय मृदा विज्ञान संस्थान के माइक्रोबियल कंसोर्टिया को सुजानी, देवघर (झारखंड) में बड़े पैमाने पर प्रदर्शन किया।
- कम्पोस्ट गुणवत्ता मानक का मूल्यांकन किया गया है और यह पाया गया कि रसोई और सब्जी कचरे से 20 दिनों के बाद प्रक्षेत्र में प्रयोग हेतु खाद तैयार हो जाती है, उसके बाद बागवानी अपशिष्ट (30 दिन) और प्रक्षेत्र अपशिष्ट (45 दिन)।
- चयनात्मक कवक का उपयोग करने वाले बायोफिल्टर, जस्ता (30 प्रतिशत), निकिल (>30 प्रतिशत), लैड (>40 प्रतिशत) और कैडमियम (>20 प्रतिशत) के उन्मूलन के लिए प्रभावी पाए गए और इसलिए खाद की गुणवत्ता में सुधार हुआ। सेराटिया प्रजाति में अधिकतम मात्रा में एक्सो-पॉलीसैकराइड का अनुमान लगाया गया। यह बेहतर बायो-फिल्टरेशन के लिए उपयोग हो सकता है।
- एंजाइम गतिविधियां जैसे फ्लोरोसीन डायासरडेट, डिहाइड्रोजिनेज, क्षारीय फास्फेटेज और बीटा ग्लूकोसिडेज, 100 प्रतिशत कार्बनिक में उच्चतम पाई गईं और उसके बाद 75 प्रतिशत कार्बनिक + 25 प्रतिशत अकार्बनिक उपचार में। यह मिट्टी के सूक्ष्मजीवों पर लाभकारी प्रभाव का संकेत देते हैं।
- कैसुरीना इक्विसिटिफोलिया और अलनस नाइटिडा जैसे गैर-लैग्यूमिनस वानिकी पौधों के लिए आशाजनक सूक्ष्मजैविक निवेशकों की पहचान की गई।
- अरहर के नोड्यूल्स के एंडोफाइटिक समुदाय के मेटोजीनोमिक विश्लेषण से पता चला कि प्रमुख कवक प्रजातियां फुसेरियम मालासेजिया, सेराटोबासिडियम, क्ल्युवरोमीस, पेनिसिलियम और एसपरजिलस थी।
- वर्टीसोल मृदा पर दीर्घकालीन उर्वरक अनुप्रयोग के तहत फास्फोरस का खनिजीकरण पी एस बी और फास्फोरस खनिज अंशो की प्रचुरता द्वारा नियंत्रित किया गया था।

विषयवस्तु 4 : मृदा प्रदूषण, बचाव एवं पर्यावर्णीय सुरक्षा

- पौधे की पौध विषालुता दृष्टिकोण के आधार पर लाल मृदा (एल्फिसोल) के लिए कैडमियम की क्रान्तिक सीमा का निर्धारण किया गया। इसमें मृदा में उपस्थिति कुल कैडमियम की मात्रा और 1 M कैल्शियम क्लोराईड से निष्कर्षित कैडमियम की मात्रा में महत्वपूर्ण रैखिक सम्बंध देखे गए।
- चंबल नदी के बहाव क्षेत्र में पानी की उच्च ई सी और पी एच, औद्योगिक अपशिष्ट के कारण पाया गया जो गेहूँ, चना, मटर के साथ-साथ मिट्टी के स्वास्थ्य और उत्पादन पर प्रतिकूल प्रभाव डालता है।
- टाइफा अंगुस्टिफोलिया के साथ फाइटोरेमीडिएशन का मूल्यांकन ताँबा, लोहा एवं मैंगनीज के एसिड माइन ड्रेनेज प्रभावित क्षेत्रों में किया गया।
- मृदा स्वास्थ्य और फसल उत्पादकता को बनाए रखने के लिए एवं संस्थान प्रौद्योगिकियों के व्यापक प्रसार के लिए लगभग 100 क्षेत्र प्रदर्शन, 200 अग्रिम पंक्ति प्रदर्शन और 15 किसान संगोष्ठी का आयोजन किया गया।

Executive Summary

Theme I: Soil Health and Nutrient Use Efficiency

- Agro-morphological and biochemical parameters were recorded in 121 wheat genotypes in vertisols to identify nutrient use efficient genotypes. The diverse germplasm were screened under recommended dose of fertilizers and 50% of the recommended levels of N and P. Considerable amount of variation was observed on leaf area, chlorophyll content and relative water content of the wheat plants with different fertilizer doses.
- The effect of glauconite application alone or in combination with FYM and microbial inoculation with potassium dissolving bacteria, *Bacillus cereus* was studied. The results revealed that the heat treatment (calcined glauconite), acidulation of glauconite and use of FYM showed pronounced effect on K release from glauconite in the soils.
- Long term trend clearly indicated that maize grain yield improved and sustained under the integration of 75% NPK with FYM as compared to GRD and other combinations of organic and inorganic nutrients. Whereas, chickpea grain yield was significantly higher with residual fertility of 75%NPK+ FYM at 5 Mg ha^{-1}.
- The pool of easily extractable glomalin related soil proteins (EEGRSP) extracted by sodium citrate method can be viewed broadly as a soil available N supply indicator that reflects the primary pool of organically bound N in soil and, thus, as a potentially available organic N in soil. It could be concluded that EEGRSP may potentially be used as an index of N availability in soil.
- Soil Health Card for tribal farmlands of the Kaweli, Kulpa and Sarra villages of Balaghat districts was prepared in order to give recommendations in terms of organic inputs like farmyard manure, azolla, green leaves like gliricidia (*Gliricidia sepium*), compost and steamed bone meal.
- Study undertaken at Udham Singh Nagar district of Uttarakhand indicated that water quality is more affected than soil quality parameters because of high fertilization.
- The Phospholipid Fatty Acid analysis (PLFA) of soil samples collected after wheat crop indicated a significant increase in fungi-bacteria ratio, and significant reduction in ratio of Gram+/Gram- bacteria and ratio of saturated to unsaturated fatty acid content under elevated CO_2 and/or temperature treatments.
- Good calibration curves for the estimation of nitrate, phosphate and potassium ions have been developed using ion selective field effect transistors (ISFET).
- Under organic farming system, highest yield of wheat, mustard, chickpea and linseed were recorded with 75% organic + 25% inorganic followed by 100% organic treatment practices. Also alkaline phosphatase and β Glucosidase enzymes activities were recorded highest in 100% organic followed by 75% organic + 25 % inorganic and 75% organic + innovative treatment indicating beneficial effect of addition of organics on soil microorganisms.
- Mid Infra Red (MIR) spectroscopy showed great potential for simultaneous estimation of soil organic carbon, and pH of Inceptisols of Indo-gangetic plains. However, detailed studies are warranted to understand the intrinsic relationships between MIR wavelengths and soil properties so that MIR can be used as a reliable and precise method for measurement of soil properties.
- The random forest model was able to identify the moderate and severe saline-sodic soils in Unnao district with acceptable level of accuracy. The spatial distribution of salt-affected soils also depicted an association with nearness to canal.
- Soil fertility mapping and geospatial analysis of soil properties (SOC, labile carbon, P, K, soil pH, EC, water holding capacity) in croplands of climatically vulnerable districts Sehore and Rajgarh of Madhya Pradesh was carried out.
- The nutrient dynamics studies carried out across the soil indicated that balanced use of nutrients resulted in increase of available forms of almost all the nutrients (N, P, K, S & B) in soil. On the contrary, imbalanced use of nutrients (control, N and NP) resulted in decline of nutrient content. Thus, under intensive cultivation, plant has to derive nutrients from reserve pool that may result in fatigue in soil

fertility and overall sustainability in long run.

- The analysis of soil samples collected from 109 districts of different states viz., Himachal Pradesh, Jharkhand, Jammu & Kashmir, Kerala, Karnataka, Manipur, Tamil Nadu and Uttarakhand revealed that the status of exchangeable Ca and Mg was in the range of 1.13 to 11920 mg kg^{-1} and 0.40 to 7680 mg kg^{-1}, respectively. The states of Kerala and Manipur showed higher per cent of area under Ca and Mg deficiency.
- Influence of boron stress on reproductive physiology of mustard was studied and it was observed that pod and seed yield were adversely affected by low and high B supply.
- Application of 1.0 kg B ha^{-1} + 20 kg S ha^{-1} + 100% NPK recorded the highest seed yield of black gram in Assam.
- Higher enzymatic activities such as urease, phosphatase and dehydrogenase were recorded under STCR-IPNS-4.0 t ha^{-1} in pearl millet.

Theme II: Conservation Agriculture, Carbon Sequestration and Climate Change

- The retention of residue under no till system resulted in higher proportion of carbon in active pool whereas proportion of C in passive pool was decreased. Retention of residue under no till system contributed carbon to very labile and labile pools.
- CH_4 consumption potential was found to be higher in maize-wheat and least in maize-gram. However, positive effect of NT towards CH_4 consumption was observed in soybean-wheat and maize-gram than maize-wheat.
- Maximum yield and yield attributes were recorded under NT with 90% residue levels under soybean-wheat and maize-chickpea cropping system.
- Demonstration at farmers fields revealed higher yield and yield attributes of soybean, wheat and chickpea under zero tillage.
- No tillage with 150% N showed higher SOC and carbon stratification ratio under maize-wheat system.
- APSIM model satisfactorily predicted TOC and higher TOC were reported in NT system after the third crop cycles onwards. At the end of six crop cycles, 18% and 11% higher TOC carbon was observed in NT compared to CT system.
- CA practices such as RT and NT with residue retention improved soil aggregation and structural stability than CT.
- Study indicated that the overall agriculture vulnerability of the Madhya Pradesh districts is projected to decrease towards mid-and end-century as compared to the current conditions for both emission scenarios of RCP 4.5 and RCP 8.5.

Theme III: Microbial Diversity and Biotechnology

- The liquid formulation of microbial consortia (four fungi, four bacteria , two actinobacteria,one yeast, one lactobacillus) was developed by the institute and are under evaluation for efficacy in large scale. The microbial consortia was demonstrated in a large scale at Sujani, Deoghar (Jharkhand).
- Compost quality standard has been assessed and it was found that compost is ready for field application after 20 days from kitchen and vegetable waste followed by horticultural waste (30 days) and farm waste (45 days).
- Biofilters using selective fungi were effective for elicitation of Zn (~ 30%) and Ni (>30), Pb (>40%), Cd (>20%) and therefore improve the quality of compost. Maximum amount of exo-polysachharide was estimated in Serratia sp. This may be useful for better biofiltration.
- Enzyme activity such as fluorescein diacetate, dehydrogenase, alkaline phosphatase and β Glucosidase were found highest in 100% organic followed by 75% organic + 25% inorganic indicating beneficial effect of organics on soil microorganisms.
- Identified promising microbial inoculants for non-leguminous forestry plants such as *Casuarina equisetifolia* and *Alnus nitida*.
- Metagenomic analysis of endophytic community of pigeon pea nodules revealed that the dominant

fungal species were *Fusarium, Malassezia, Ceratobasidium, Kluyveromyces, Penicillium* and *Aspergillus*.

- Mineralization of P was regulated by the abundance of PSB and P mineral fractions under long term fertilizer application practices in Vertisols.

Theme IV: Soil Pollution, Remediation and Environmental Security

- Critical limit of cadmium was derived for red soil (alfisol) based on plant phytotoxicity approach and significant linear relationship were observed between the extractable fraction by 1M $CaCl_2$ extractant and total Cd content in soil.
- Higher EC and pH of water in downstream area of Chambal river was found due to industrial effluents which adversely affected the growth and production of wheat, chick pea as well as soil health.
- Phytoremediation with *Typha angustifolia* was evaluated in the acid mine drainage affected areas of Malanjkhand copper mining area with copper, iron and manganese.
- About 100 field demonstrations, 200 frontline demonstrations and 15 kisan sangoshthi were organized for wider dissemination of institute technologies for sustaining soil health and crop productivity.

1. Introduction

The sustainable development goal (SDG) 2 of UN i.e. Zero hunger depends primarily upon the sustainable use of soil resources to achieve food security, improved nutrition and promoting sustainable agriculture. Till now, intensive agriculture has resulted in unprecedented exploitation of scarce soil resources worldwide. Though, India has achieved self-sufficiency in food grain production, yet there is a need to produce more food from limited resources for burgeoning population. However, during last 4-5 decades, soil health is declining at faster rate with higher rates of erosion, declining factor productivity and reduced nutrient use efficiency, loss of soil biota and degradation of land due to environmental pollution. Under such critical scenario, 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 intense efforts to attain its mission and received national and international recognitions. The institute activity has been strengthened further by the scientific and managerial activities of three All India Coordinated Research Projects, 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, bio and phyto-remediation, etc. The salient research findings, infrastructural development, technology transfer, human resource development, awards and recognitions and linkages and collaborations etc. are briefly highlighted in this annual report.

1.1 Mission and Mandate

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

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

1.2 Priorities and Thrust Areas

The priorities of the institute are to broaden the soil science research by encouraging multidisciplinary research for efficient utilization of already created infrastructure and, therefore, carry out research work rigorously in the following critical areas:

Programme 1: Soil Health and Nutrient 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, Carbon Sequestration and Climate Change

- Conservation agriculture and carbon sequestration for sustainable management of land and soil resources
- Tillage, water and nutrient interactions
- Crop simulation modeling and crop adaptation to

climate change
- Remote sensing & GIS

Programme 3: Microbial Diversity and Genomics

- Characterization and prospecting of soil biodiversity
- 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-ecosystem

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 wastes
- Developing soil management practices for minimizing emission of greenhouse gases
- Environmental impact and risk assessment of nanoparticles on soil health and plant nutrition.

1.3 Organization Set-Up

Divisions

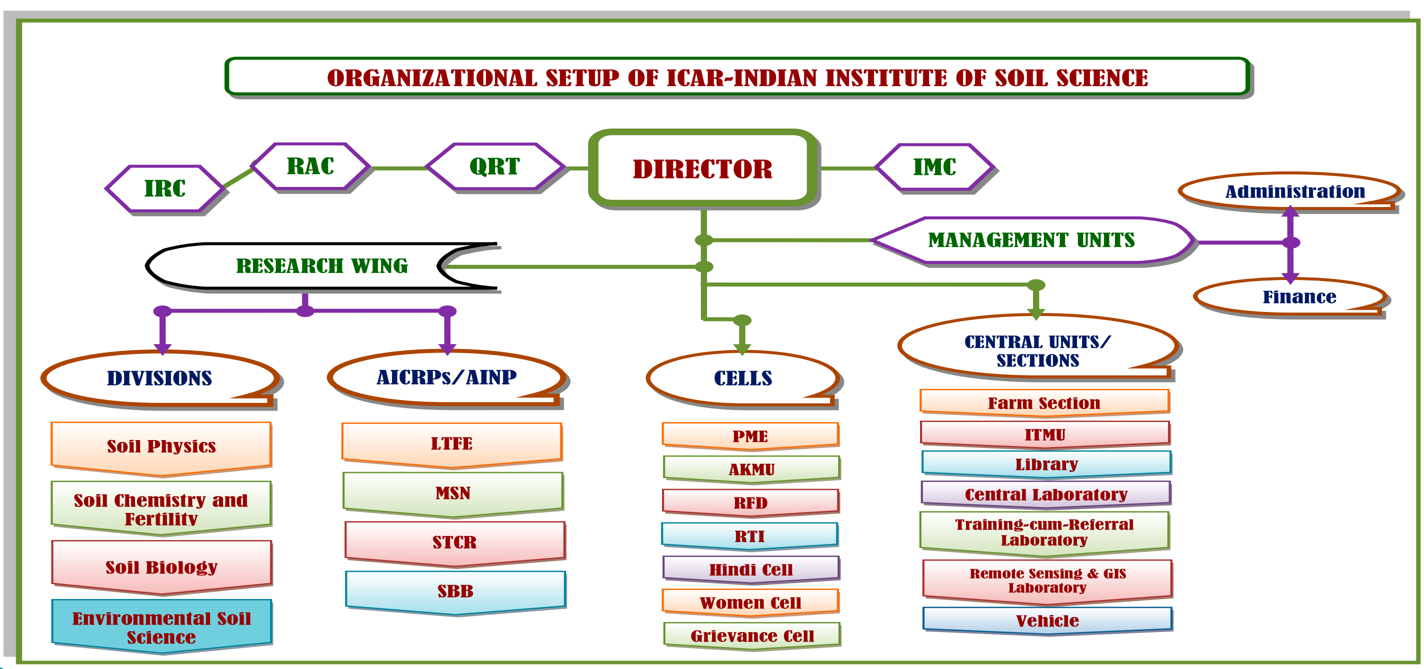
(i) Soil Physics
(ii) Soil Chemistry & Fertility
(iii) Soil Biology
(iv) Environmental Soil Science

Sections/ Central Units/Technical Units/Cells

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

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

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



1.4 Manpower

a) Scientific

S. No.	Discipline	Sanctioned				In Position			
		PS	SS	S	Total	PS	SS	S	Total
1	RMP	1	0	0	1	1	0	0	1
2	Agricultural Economics	0	1	1	2	0	0	0	0
3	Agricultural Extension	0	0	1	1	0	0	1	1
4	Agricultural Microbiology	1	1	2	4	0	1	2	3
5	Agricultural Statistics	0	1	2	3	0	0	1	1
6	Agronomy	1	2	4	7	0	1	4	5
7	Computer Application	0	1	0	1	0	0	0	0
8	Plant Biochemistry	0	1	1	2	0	1	0	1
9	Plant Physiology	1	1	1	3	1	1	1	3
10	Soil Science	9	8	16	33	8	7	19	34
	Total	**13**	**16**	**28**	**57**	**10**	**11**	**28**	**49**

b) Technical

S. No.	Posts	Sanctioned	In Position
1	T-1	11	10
2	T-2	-	-
3	T-3	7	6
4	T-4	-	-
5	T-5	-	-
6	T-6	1	0
7	T-7-8	-	-
8	T-9	-	-
	Total	**19**	**16**

c) Administrative

S. No.	Designation	Sanctioned	In Position
1	Sr. Administrative Officer	1	1
2	Finance & Accounts Officer	1	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	4
8	Stenographer Gr-III	2	2
9	Security Supervisor	1	1

S. No.	Designation	Sanctioned	In Position
10	Upper Division Clerk	2	2
11	Lower Division Clerk	3	2
12	Skilled Supporting Staff	17	17
	Total	**42**	**36**
	Grand Total	**118**	**101**

1.5 Finance: Budget statement (Rs. in Lakh) 1 April to 31 Dec 2019 is as follows

S.No.	Institute/AICRPs	Budget	Expenditure
1	Main IISS Institute	1852.32	1674.37
2	AICRP- LTFE	397.37	377.41
3	AICRP- STCR	585.99	582.58
4	AICRP- MSPE	568.08	563.16
5	AINP on SBB	190.39	185.63
6	CRP on CA	288.98	214.04
	Total	**3883.13**	**3597.19**

1.6 Resource Generation

S.No.	Head of Account	up to 31.12.2019
1	Sale of farm produce	1318336.00
2	Sale of publication and advertisement	67213.00
3	Licence fee	279077.55
4	Interest earned on loans & advances	894084.00
5	Receipts from schemes	465448.00
6	Analytical and testing fee	13850.00
7	Diploma Charges	228.00
8	Interest earned on short term deposits	4863991.00
9	Recovery of loans and advances	1375097.00
10	Miscellaneous Receipts	90781.00
	TOTAL	**9368105.55**

2. Research Achievements

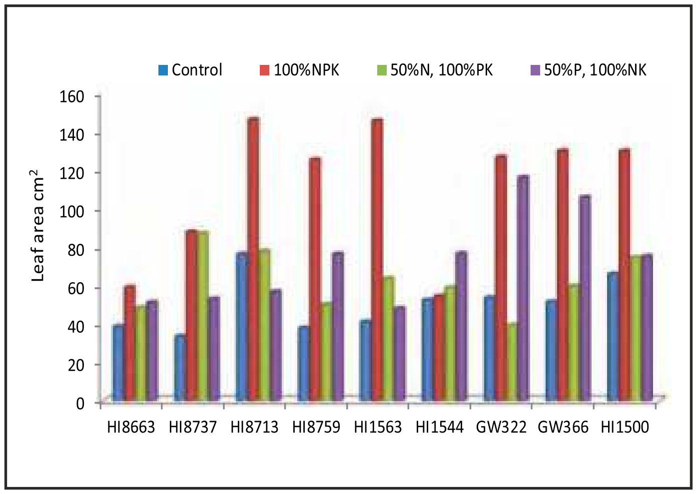
Theme-I: Soil Health and Nutrient Use Efficiency

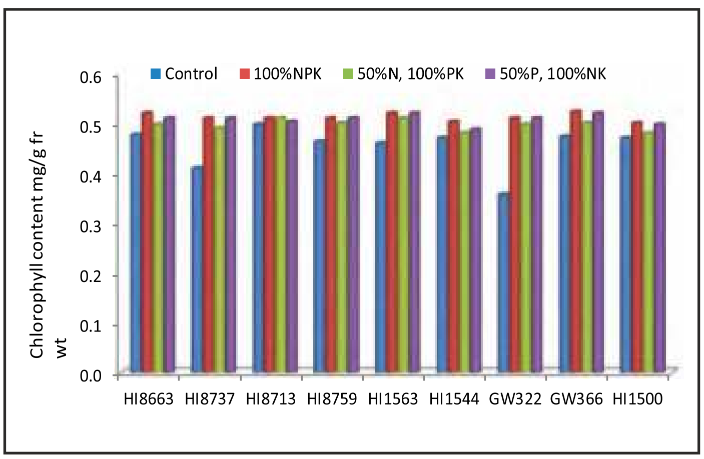
2.1 Improving Nutrient Use Efficiency

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

A study was conducted to evaluate the nutrient use efficiency in 121 wheat genotypes in Vertisols (Plate 2.1.1). The diverse germplasm were screened under recommended dose of fertilizers and 50% of the recommended levels of N and P. Agro-morphological, physiological and biochemical traits were recorded in the germplasm. Leaf area, chlorophyll content and relative water content of the wheat plants varied with different fertilizer doses. Higher leaf area and RWC% was recorded with plants treated with 100%NPK and 50%P& 100%NK at 30 DAS (Fig. 2.1.1). Variation in the total chlorophyll content in the wheat varieties were also recorded as shown in Fig. 2.1.1. The grain yield and yield related traits were being analysed.

Plate 2.1.1 Field view of the genotypes grown under different fertilizer doses





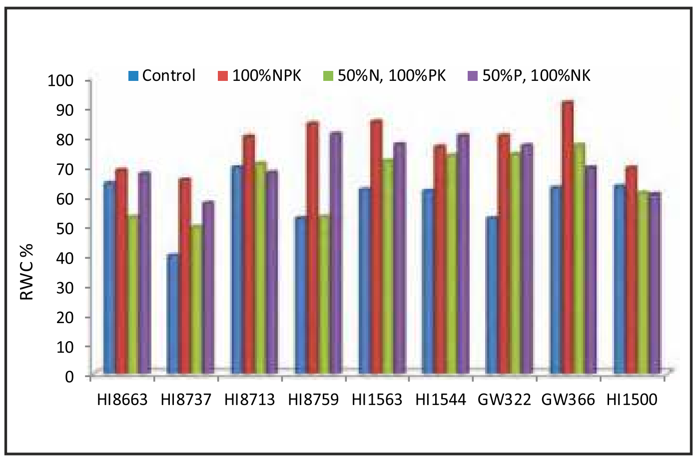
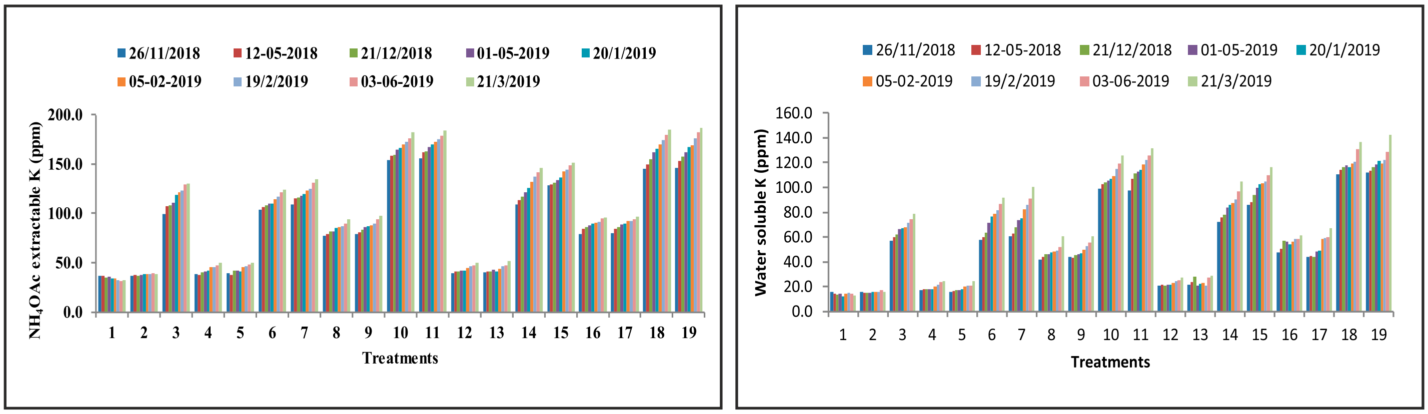


Fig. 2.1.1 Leaf area, relative water content and chlorophyll content of wheat varieties under different fertilizer doses

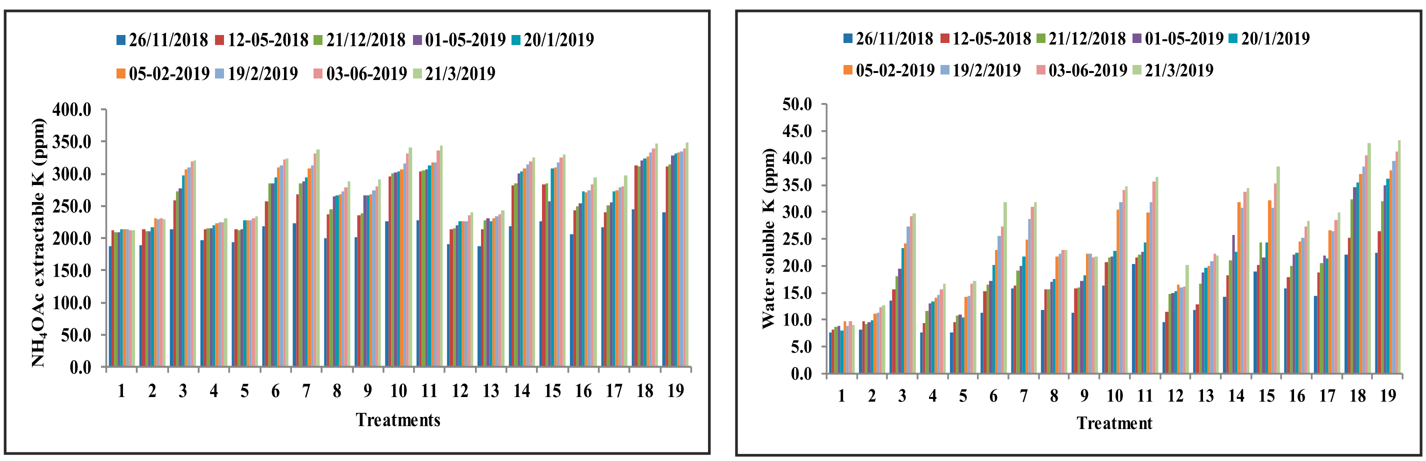
2.1.2 Exploring glauconite as a source of potassium for crops

Incubation experiments were conducted to study the potassium release behavior of glauconite after application in black (Vertisol, Wanirambhapur soil series) and red (Alfisol, Vijaypura soil series) soils. The effect of glauconite application (2.0 mm size) alone or in combination with FYM and microbial inoculation with potassium dissolving bacteria (KSB) (*Bacillus cereus*) was studied. The results of the experiment suggested that the heat treatment (calcined glauconite), acidulation of glauconite and use of FYM showed pronounced effect on K release from glauconite in both the soils. Among the different treatments, application of acidulated calcined glauconite along with FYM and microbial inoculation with *Bacillus cereus* showed highest release of potassium throughout the incubation period (Fig. 2.1.2a & b).



T1- Soil (No glauconite); T2- Soil + KSB; T3- Soil + FYM; T4- Soil + Glauconite (G); T5- Soil + G + KSB; T6- Soil + G + FYM; T7- Soil + G + KSB + FYM; T8- Soil + Calcined G; T9- Soil + Calcined G + KSB; T10- Soil + Calcined G + FYM; T11- Soil + Calcined G + KSB + FYM; T12- Soil + Acidulated G; T13- Soil + Acidulated G + KSB; T14- Soil + Acidulated G + FYM; T15- Soil + Acidulated G + KSB + FYM; T16- Soil + Acidulated calcined G; T17 Soil + Acidulated calcined G + KSB; T18- Soil + Acidulated calcined G + FYM; T19- Soil + Acidulated calcined G + FYM + KSB

Fig. 2.1.2a Potassium release behaviour of glauconite following application in red soil at different time interval



T1- Soil (No glauconite); T2- Soil + KSB; T3- Soil + FYM; T4- Soil + Glauconite (G); T5- Soil + G + KSB; T6- Soil + G + FYM; T7- Soil + G + KSB + FYM; T8- Soil + Calcined G; T9- Soil + Calcined G + KSB; T10- Soil + Calcined G + FYM; T11- Soil + Calcined G + KSB + FYM; T12- Soil + Acidulated G; T13- Soil + Acidulated G + KSB; T14- Soil + Acidulated G + FYM; T15- Soil + Acidulated G + KSB + FYM; T16- Soil + Acidulated calcined G; T17- Soil + Acidulated calcined G + KSB; T18- Soil + Acidulated calcined G + FYM; T19- Soil + Acidulated calcined G + FYM + KSB

Fig. 2.1.2b Potassium release behaviour of glauconite following application in black soil at different time interval

Pot experiments were conducted to study the effect of glauconite application with and without amendments on maize (kharif) and wheat (rabi) in black (Vertisol, Wanirambhapur soil series) and red soils (Alfisol, Vijaypura soil series). Application of glauconite alone as source of K was not effective. However, application of calcined glauconite [Glauconite and calcium chloride ($CaCl_2$ $2H_2O$) in 1:1 ratio heated at 900^{0}C for 60 min] and acidulated calcined glauconite application alone or in combination with FYM showed higher growth of maize. It was found that application of glauconite and FYM was effective in enhancing growth of maize (Plate 2.1.2a).

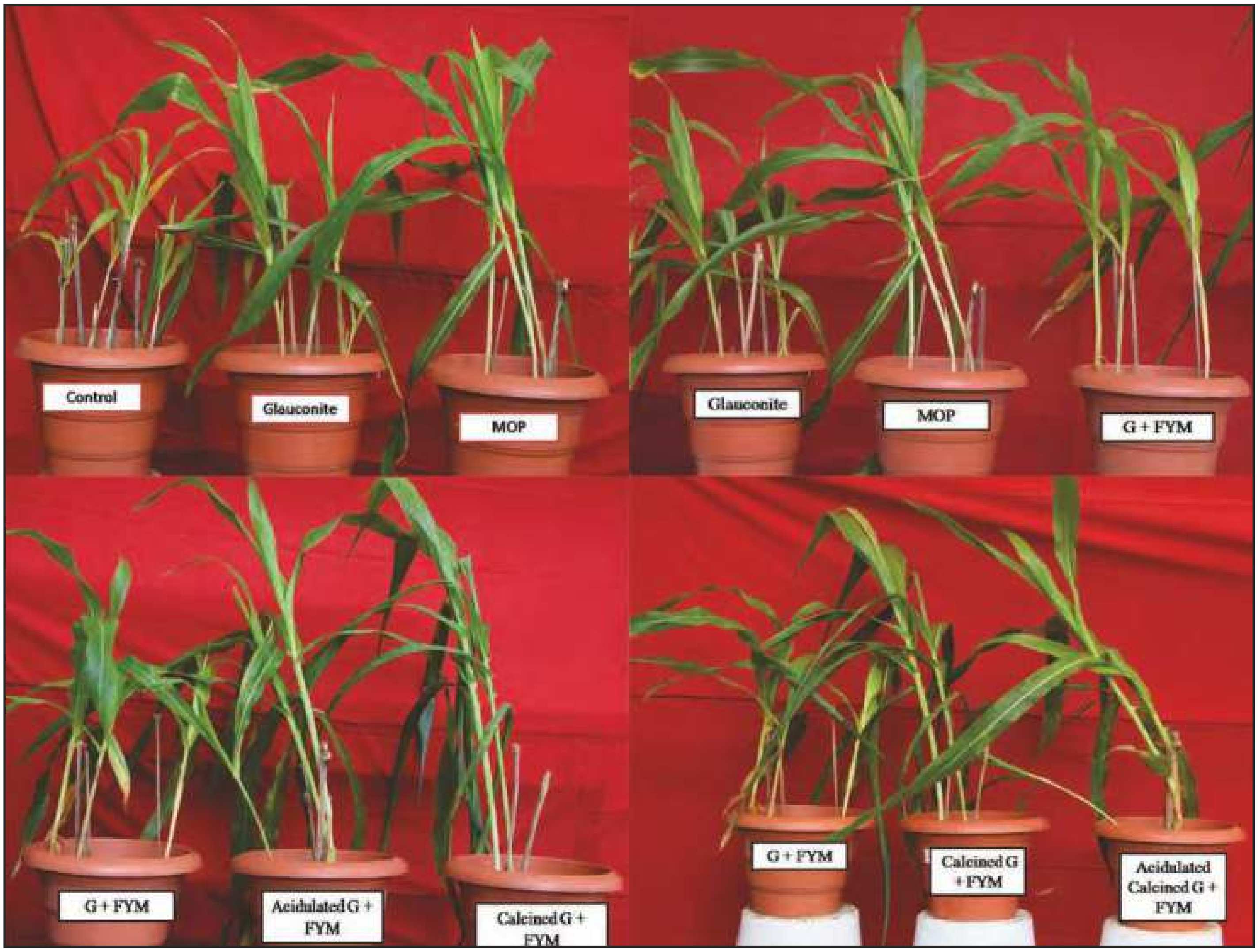


Plate 2.1.2a Response of maize to glauconite application in Alfisol

Bio-extraction of potassium from glauconite nano-particle in an Alfisols

Glauconite is a potassium (K) bearing mineral which generally contains 6-10% K_2O and mostly available in various natural deposits in India. By applying top-down approach through high energy ball mill, glauconite mineral was converted into nano-particulate form (Plate 2.1.2b & c and Fig. 2.1.2c & d). The release of K from glauconite nano-particle in soil was studied in a pot culture experiment. Five different treatments like control, 100 mg kg^{-1} K_2O, 150 mg kg^{-1} K_2O, 200 mg kg^{-1} K_2O were imposed using glauconite nano-particle and 100 mg kg^{-1} K_2O from muriate of potash (MOP) as K source were applied in soil to grow the maize (*Zea mays* L.) plant. Results revealed that the highest $K+$ concentration was observed in shoot at the application of 200 mg kg^{-1} K_2O through glauconite nano-particles and recorded 115% more $K+$ concentration in shoots as compared to control. Minimum electrical conductivity value in maize leaves 170 μS/cm was recorded in control soil while maximum value, 695 μS/cm was obtained in 200 mg/kg glauconite nanoparticle applied soil. Like that of electrical conductivity, plant height after 45 days growth and leaf area measurement after harvesting showed the same increasing pattern in values with maximum values, 148 cm and 1750 m^2 respectively, observed from 200 mg/kg glauconite nanoparticle applied soil at 4^{th} harvesting. Highest nitrate reductase activity obtained in 200 mg/kg glauconite nanoparticle provided soil while least value was observed in control and result trend revealed that there is a positive correlation in increase in value of nitrate reductase activity with increasing concentration of K_2O from glauconite nano-particle and subsequent increasing number of harvestings. All the data obtained through plant physiological parameter measurement led to conclude that glauconite nano-particle has slow K releasing behaviour. Overall, glauconite nano-particles could supply K throughout the growth period and enhanced biomass yield of maize plant without showing any K deficiency symptom.

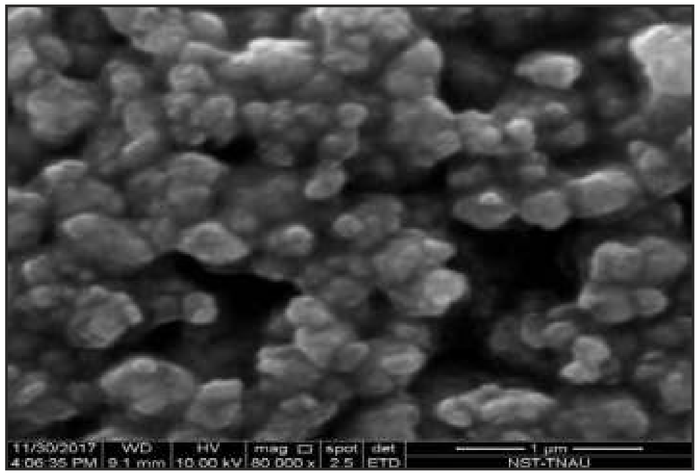


Plate 2.1.2c SEM micrograph of glauconite nano particle

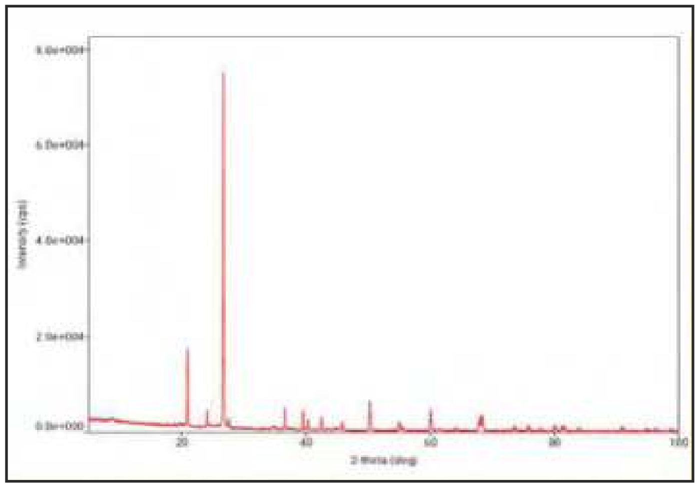


Fig. 2.1.2c XRD analysis of glauconite nano-particle

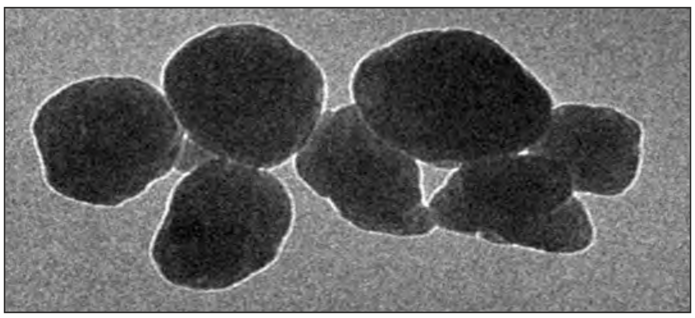


Plate 2.1.2b TEM micrograph of glauconite nano-particle

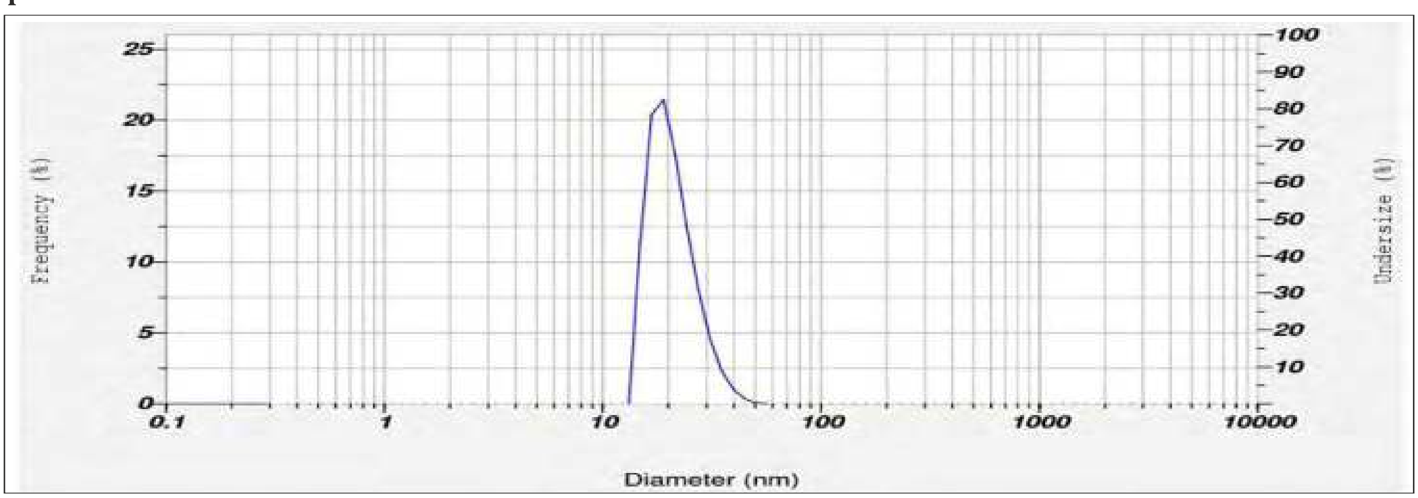


Fig. 2.1.2d Particle size (20 nm) of glauconite nano-particle studied by DLS

2.1.3 Long-term integrated nutrient management practices on maize-chickpea yield

Maize grain yield was significantly influenced with the integrated nutrient management (INM) practices in long term fertilizer experiment at IISS research farm during 2019. The treatment descriptions are listed in Table 2.1.3. Maize grain and stover yield was significantly improved with STCR based INM module i.e. 75% NPK of STCR along with FYM at 5 Mg ha^{-1} as compared to recommended fertilizer management practices and 100% STCR based NPK fertilizers (Fig. 2.1.3a). STCR based 100% NPK fertilizers also improved the grain and stover yield as compared to organic treatments and general recommended dose (GRD). Long term trend clearly indicated that maize grain yield (Fig. 2.1.3b) improved and sustained under the integration of 75% NPK with FYM as compared to GRD and other combinations of organic and inorganic nutrients. Whereas, chickpea grain yield was significantly higher with residual fertility of 75%NPK+ FYM at 5Mg ha^{-1}. Residual fertility of FYM at 20 Mg ha^{-1} (every year) and 75%NPK+FYM at 20 Mg ha^{-1} (once in four years) treatments also improved grain yield compared to the other treatments. Residual fertility of poultry manure and urban compost along with 75% NPK also improved yield more than 100% NPK alone. Overall, the residual fertility of integration of organics had significant effect on grain yield of chickpea than the residual fertility of GRD and 100% NPK of STCR alone.

Table 2.1.3 Effect of Long-term integrated nutrient management (INM) practices on maize-chickpea yield

Treatment	Maize	Chickpea
T1 Control	No Fertilizer/ Manure	No Fertilizer/ Manure
T2 GRD	120- 60- 30	20-60-20
T3 RD (STCR)	160-60-50 (Target- 5 t maize)	0-0-0 (1.5 t chickpea)
T4	75% NPK of T3	100% P only
T5	75% NPK of T3 +5 t FYM	100% P only
T6	75% NPK of T3+ 1 t PM	100% P only
T7	75%NPK of T3 + 5 t UC	100% P only
T8	75% NPK of T3 +MR	100% P only+ MR as Mulch
T9	MR +1 t PM+Gly 2 t/ha	100% P only+ MR as Mulch
T10	MR + 5t FYM+Gly 2 t/ha	100% P only+ MR as Mulch
T11	20 t FYM (every season)	5 t FYM (Every Season)
T12	75% NPK of T3 +20 t FYM* (once in 4 years)	100% P only

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

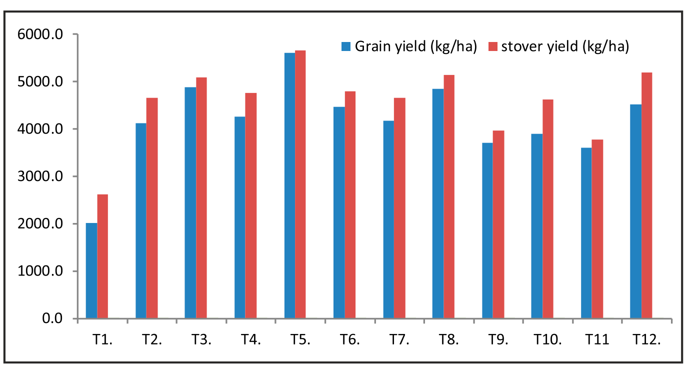


Fig. 2.1.3a Yield performance of maize under different integrated nutrient management modules

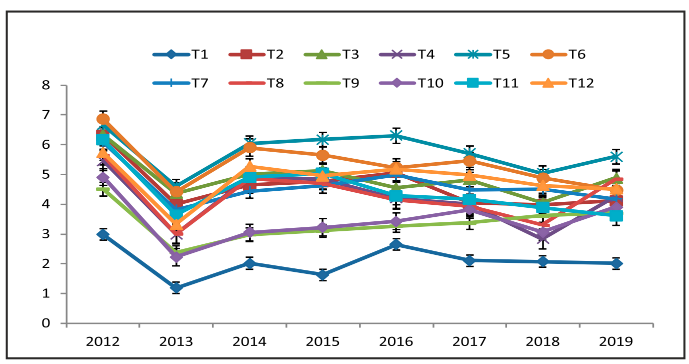


Fig. 2.1.3b Trends of grain maize yield over the years under different integrated nutrient management practices

2.1.4 Easily extractable glomalin related soil protein: A good predictor of nitrogen supplying capacity of soil

Glomalin-related soil protein (GRSP) is a glycoprotein which is produced by the hyphae of arbuscular mycorrhizal fungi (AMF). Soil samples were collected from 0-10 and 10-20 cm of soil depths from six years of NT system under soybean-wheat cropping system as well as from agri-horticulture, horticulture, pastureland, organic and conventional agriculture system of Vertisol of central India. Nitrogen mineralization potential of soils was assessed under different land use systems using aerobic incubation method. Extractable NO_3-N was measured both prior to commencing the incubation (0 d) and after 35 days. The moisture content of 50 g air-dry soil was adjusted to 60% of water-holding capacity prior to its incubation in a plastic jar at a constant temperature of 25°C. The soil protein extraction protocol is based on a neu¬tral sodium citrate buffer solution. The protein concentration was determined using the Bradford dye-binding assay using bovine serum albumin as the standard. Net N mineralization during 35 days incubation was significantly and positively correlated with the easily extractable glomalin related soil protein (EEGRSP) concentration (R^2=0.67, P=0.001). Hence, the pool of proteins extracted by this method can be viewed broadly as a soil available N supply indicator that reflects the primary pool of organically bound N in soil and, thus, as a potentially available organic N in soil. It could be concluded that EEGRSP may potentially be used as an index of N availability in soil (Fig. 2.1.4).

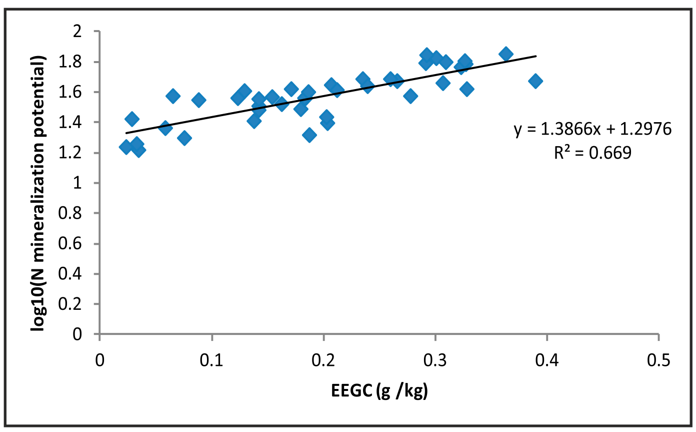


Fig. 2.1.4 Relationship between N mineralization potential and easily extractable glomalin

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

The survey on agriculture technologies practiced in tribal farmers of the Kaweli, Kulpa and Sarra villages of Balaghat districts showed that their rice-fallow systems are more or less organic-by-default systems, where they use on-farm resources like farmyard manure, wood ash, leaf litter etc. As these farmers grow crops mainly to meet the nutritional requirement of their family, their affinity towards the traditional low cost agricultural practices are more. In addition, geographical isolation of tribal farmlands due to the surrounding dense forest cover prevented diffusion of conventional agricultural technologies among them. Analysis of soil samples collected from the villages showed wide variations in the available plant nutrients between farmlands. Severe Boron deficiency was observed in almost all farmlands. As the tribal farmlands are organic, Soil Health Card was also prepared in order to give recommendations in terms of organic inputs like farmyard manure, azolla, green leaves like gliricidia (*Gliricidia sepium*), compost and steamed bone meal (Plate 2.1.5).

Also, in order to educate the tribal farmers about the importance of various plant nutrients for healthy crop growth as well as to guide them how to use the organic nutrient inputs recommended in the Soil Health Card, customized leaflets were prepared. These leaflets will be distributed to the tribal farmers of the three villages along with their Soil Health Cards.

Plate 2.1.5 A template of Soil Health Card

2.1.6 Assessing the impact of imbalanced use of chemical fertilizers on soil quality

In intensive agriculture areas, effect of high quantity of fertilizer use on soil and water quality has been debated at both scientific and at policy levels. A study thus was taken up collecting georeferenced soil and water samples from Udham Singh Nagar district of Uttarakhand at 10×10 km grids. Consumption of chemical fertilizers in the study district was at 545 kg ha^{-1} with rice-wheat and sugarcane-wheat as the major cropping systems. Soil samples from 0-15 and 15-30 cm depths were analyzed for key parameters including pH, EC, soil organic carbon, available N, P, K and S, labile carbon and activity of key soil enzymes. Ground water samples were analyzed for NO_3-N content. The content of SOC varied from 0.20 to 1.44% in the surface layer (0-15 cm depth) with about 44% of samples was found in the medium range. However, 79% samples were found low in available N content (<250 kg ha^{-1}). On the other hand, all the samples were rated high in available P content (>25 kg ha^{-1}). About 60% samples were deficient in available S content. The activity of soil enzymes was satisfactory, with about 69% samples showed dehydrogenase activity in the range of 100-200 μg TPF/24 hr. The nitrate-N content in the analyzed water samples varied from 5 to 25 mg L^{-1} with about 66% water samples containing more than the permissible limit of 10 mg L^{-1} of NO_3-N. Results indicate water quality is more affected than soil quality parameters because of high fertilization in the studied district (Fig. 2.1.6 a, b and c).

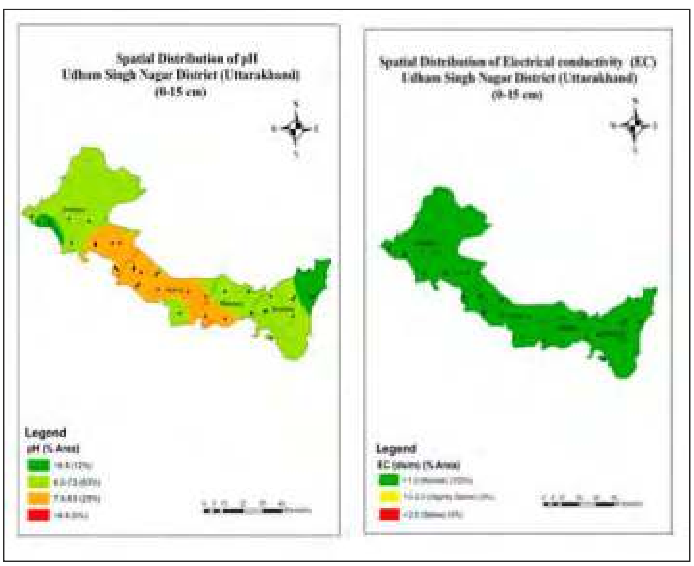


Fig. 2.1.6a Spatial distribution of pH and EC

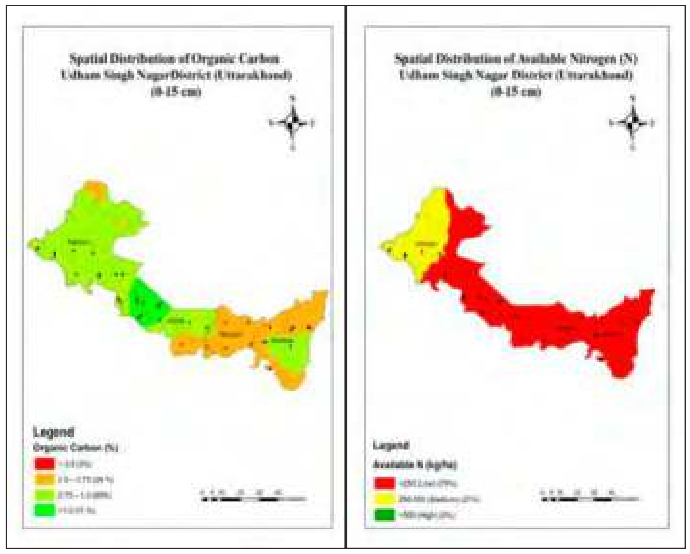


Fig. 2.1.6b Spatial distribution of organic carbon and available N

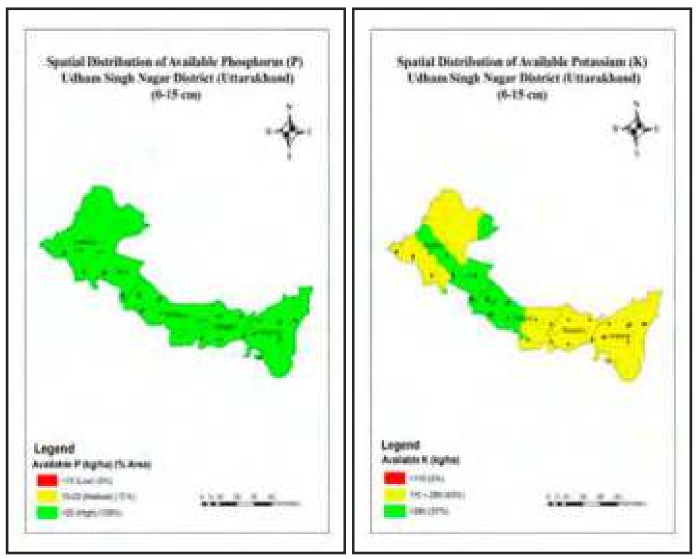


Fig. 2.1.6c Spatial distribution of P and K

2.1.7 Carbon dioxide enrichment effect on soil carbon mineralization and microbial activity in soybean-wheat cropping system

Despite numerous literatures suggesting fertilization effect of elevated CO_2 concentration in C3 plants, information on the effect of CO_2 fertilization on microbial activity and microbial composition is limited. Thus, a field experiment was conducted for two consecutive cropping seasons under soybean-wheat cropping system under elevated CO_2 and/or elevated temperature conditions in Open Top Field

Chambers (OTC) in the Vertisols of Bhopal. The crops were grown under two atmospheric CO_2 levels (ambient and 550 ppmv) and two air temperature levels (ambient, 2.0°C above ambient) in OTCs with four different nitrogen (N) levels (0, 50, 100 and 150% N of the recommended dose). Measurement of mineralizable carbon content by alkali trap method indicated elevated CO_2 and/or temperature resulting in a higher soil respiration as compared to ambient. The signature lipid profile from the Phospholipid Fatty Acid analysis (PLFA) of soil samples collected after 2nd year wheat crop indicated a significant increase in fungi-bacteria ratio, and significant reduction in ratio of Gram+/Gram- bacteria and ratio of saturated to unsaturated fatty acid content under elevated CO_2 and/or temperature treatments. The amplified ribosomal DNA restriction analysis (ARDRA) of prokaryotic 16s rDNA using Taq1 restriction enzyme, indicated shift in the microbial composition under elevated CO_2 and/or temperature treatments. The gel fingerprint reveals a narrowing down of microbial diversity under the climate change conditions (Fig. 2.1.7a and b).

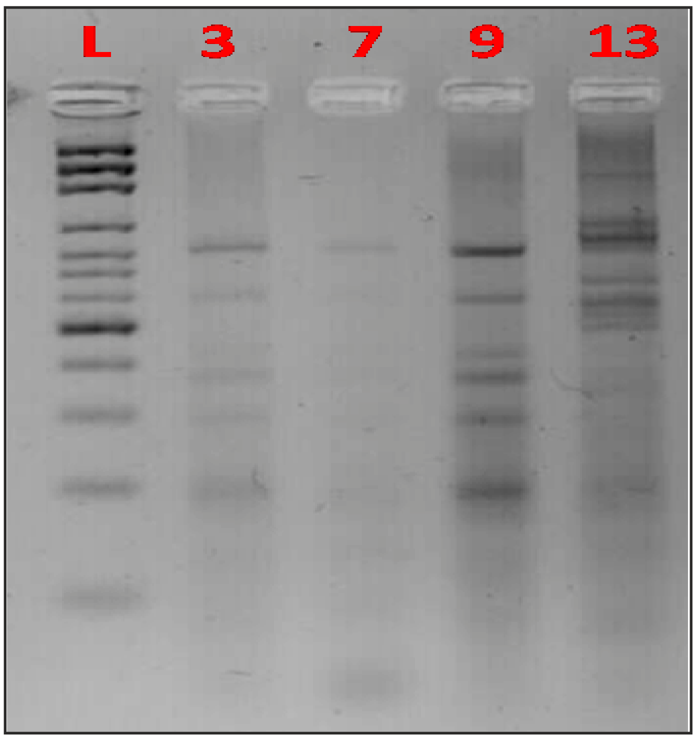


Fig. 2.1.7a Fingerprint generated after restriction digestion of DNA with Taq1

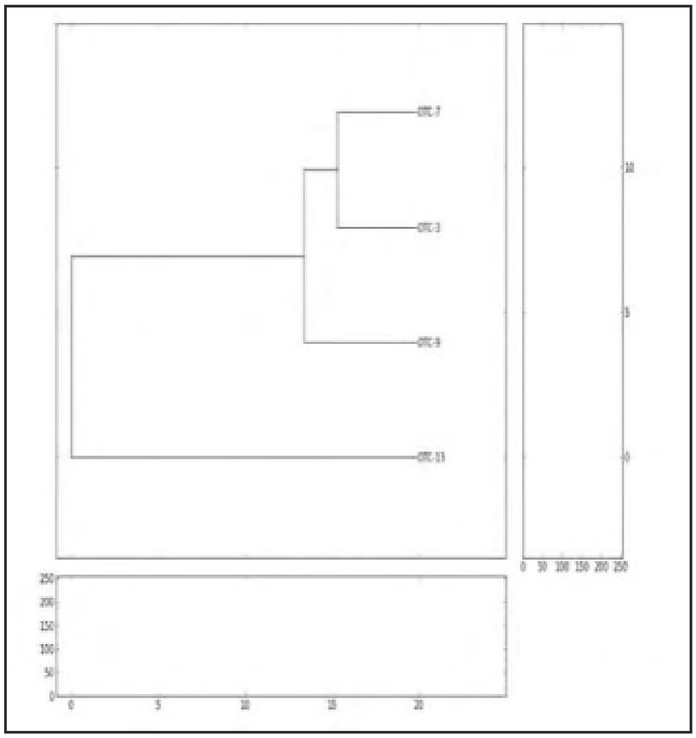


Fig. 2.1.7b Clustering of samples based on similarity of restriction digestion fingerprint

Carbon dioxide elevation enhances uptake of micronutrients in soybean

The field study in Open Top Field Chambers with two CO_2 levels and four N levels indicated elevation in CO_2 did not significantly alter the concentration of Zn, Cu, Fe and Mn in seed and straw of soybean. However, in straw, significant increase in Cu concentration was observed. In terms of uptake, CO_2 elevation showed significant increase in uptake of micronutrients in both seed and straw. Uptake of Zn, Cu, Fe and Mn increased by 39, 34, 59 and 47%, respectively in seed and 30, 65, 32 and 29% in straw. Total uptake (seed and straw) of Cu and Fe increased by 48% each, whereas, uptake of Zn increased by 37% and Mn by 40% under elevated CO_2. The study indicates implications for micronutrient management for maintaining optimum productivity and sustaining soil health under changing climate (Fig. 2.1.7c).

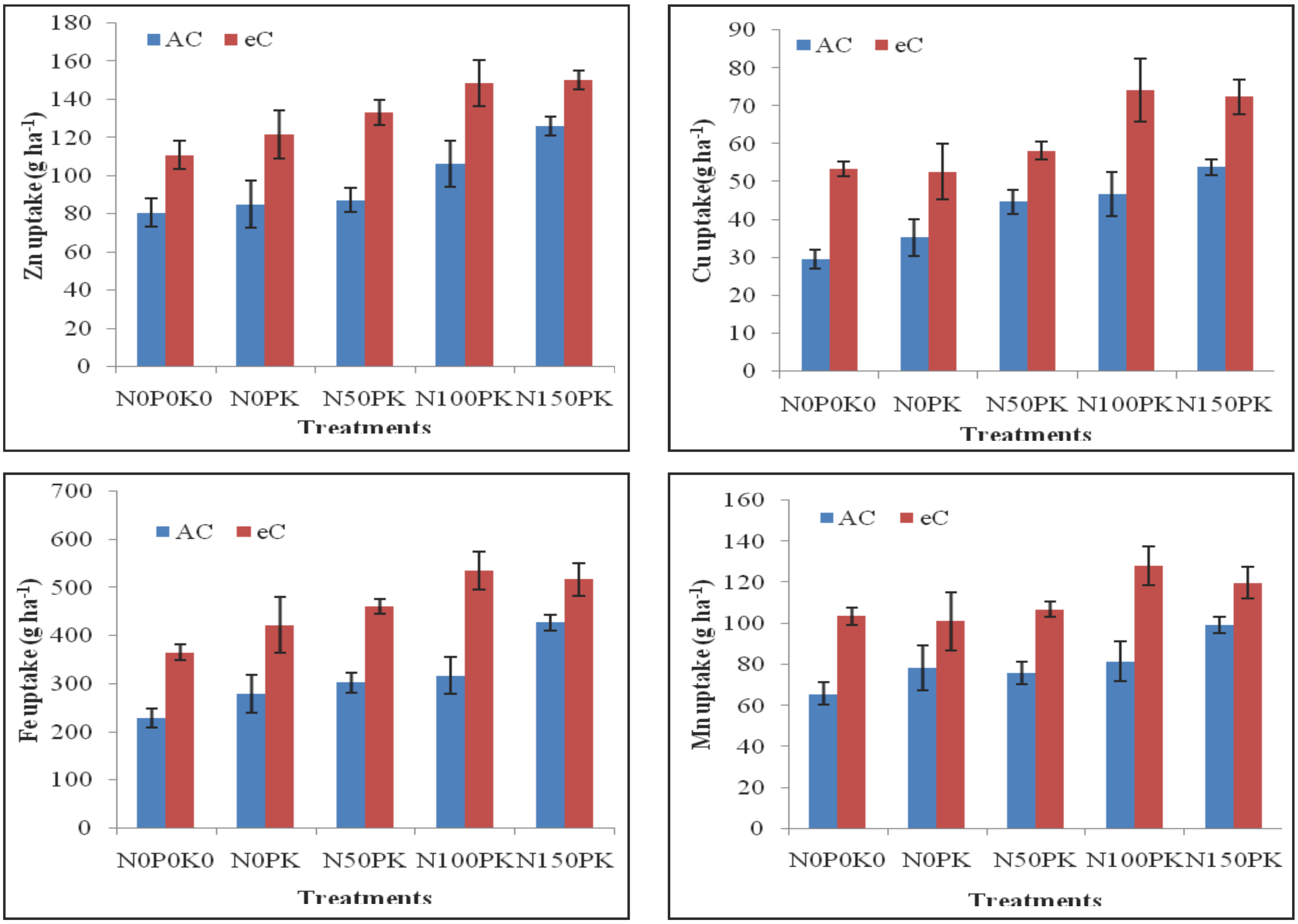


Fig. 2.1.7c Uptake of micronutrients under elevated CO_2

2.1.8 Automated soil nutrient sensing system

To automate the whole process of soil testing starting from sample collection to analysis, an auto soil sampler fixed with tractor has been developed in collaboration with ICAR-CIAE. This can automatically collect the soil samples through tractor thus reducing the time for soil sample collection. For developing methodology of quick analysis, the soil samples from Vertisols, Bhopal and inceptisols, Chandigarh were collected and analysed for fertility parameters using standard lab procedures and ion selective field effect transistors (ISFET). The good calibration curves for the estimation of nitrate, phosphate and potassium ions have been successfully prepared (Fig. 2.1.8 showing calibration for nitrate). The use of ISFET is expected to simplify and expedite the process of soil analysis.

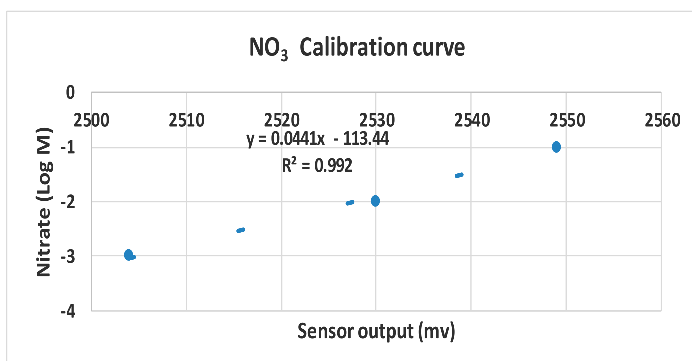


Fig. 2.1.8 Nitrate calibration curve drawn through ion selective field effect transistors (ISFET)

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

Field experiments were conducted during *rabi* season of 2019-20 at research farm of ICAR-Indian Institute of Soil Science. The yield (grain/seed) of wheat, mustard, chickpea and linseed were significantly differed under

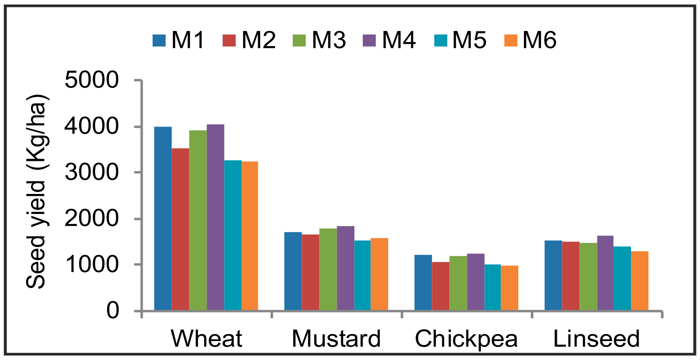


Fig. 2.1.9a Yield of wheat, mustard, chickpea and linseed (kg ha^{-1}) under different nutrient management practices

different nutrient management systems. The highest yield of wheat, mustard, chickpea and linseed were recorded with 75% organic + 25% inorganic followed by 100% organic treatment practices which were higher than 100% inorganic and state recommendation (Fig. 2.1.9a).

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

Response of different varieties of wheat and chickpea under organic farming

Performence of different varieties of wheat and chickpea were evaluated for their yield response to screen out promising varieties for organic management practices in Central India. Among the varieties of wheat grown under similar nutrient source and doses, GW-366 was out performed in yield while Lok-1 produced poor yield. Among the HI varieties, the highest yield was observed with HI 8498 compared to other HI varieties.In case of chickpea varieties, yield of JG-130 recorded higher yield followed by JG-63 RVS-202 and JG-6. Seed yield (2003 kg/ha) of JG-130 was found significantly higher than others (Fig. 2.1.9b and c).

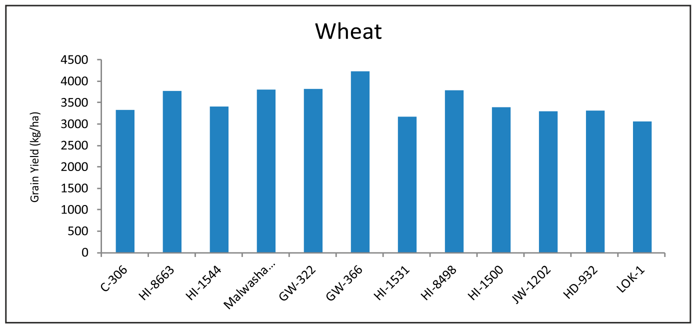


Fig. 2.1.9 b Performance evaluation of different varieties of wheat crops under organic practices

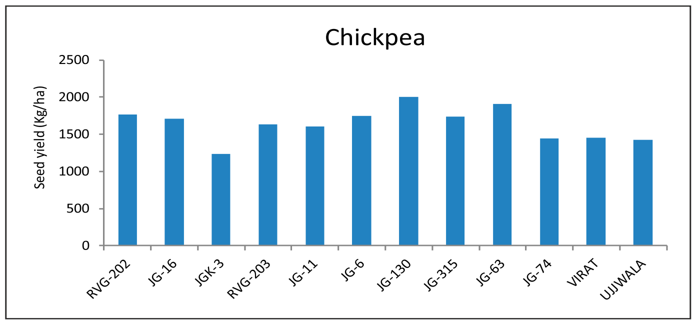


Fig. 2.1.9c Performance evaluation of different varieties of chickpea crops under organic practices

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

Grain yield of mustard significantly differed due to different weed management practices under organic production systems in deep black soils. Results revealed that mustard grain yield was significantly influenced by non-chemical weed management practices. Incorporation of cotton seed cake + one hand weeding was recorded significantly highest grain yield (1240 kg ha^{-1}) followed by intercropping with chickpea treatment, two hand weeding at 25 and 50 DAS, one mechanical weeding at 25 DAS + one hand weeding at 50 DAS as compared to control. However, the weed management practices, weed mulch (water hyacinth 4 t/ha dwb) + one hand pulling at 40 DAS and mulching with dried leaf of mango @ 5t/ha was recorded the similar grain yield (Fig. 2.1.9d).

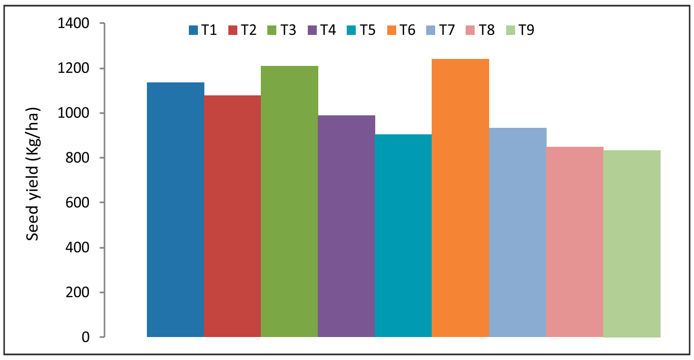


Fig. 2.1.9d Evaluation of weed management practices for mustard production

Organic Conditions

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

Soil fertility status under organic farming

Soil fertility in terms of soil organic carbon (SOC) and soil available nutrients (PK) significantly influenced by different nutrient management practices except available N. The highest SOC and available nutreints were recorded in 100% organic management followed by 75% organic + 25% inorganic/innovative and lowest was found in state recommendations and 100% inorganic management (Table 2.1.9).

Table 2.1.9 Soil organic carbon and available nutrient status in soil

Treatments	SOC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
100% Organic	1.01	246	103	683
75% Organic + Innovative	0.96	235	98	650
50% Organic + 50% Inorganic	**0.90**	**233**	**85**	635
75% Organic + 25% Inorganic	0.93	234	102	621
100% Inorganic	0.70	229	70	616
State recommendation	0.68	232	54	620
LSD (0.05%)	0.04	NS	13	33

Soil biological activity under organic farming

Soil enzyme activity is an indicator of the activities of soil microbes, which correlated with microbial dynamics. Assessment of enzyme activity in the soil environment represents activity of soil microbes participating in transformation of a particular substrate or overall nutrient transformation. Enzyme activity in terms of fluorescein diacetate (FDA), dehydrogenase, alkaline phosphatase and β Glucosidase were determined in soil as influenced by different nutrient management practices. Fluorescein diacetate hydrolysis activity was found to be highest under 100% organic plot which was close to 75% organic+ innovative/25% inorganic as compared to 100% inorganic in wheat (Fig. 2.1.9e). For other crops also FDA hydrolysis was recorded highest in 100% Organic followed by 75% organic + innovative/25% inorganic treatment indicating beneficial effect of addition of organics on soil microorganisms (Fig. 2.1.9f). Among the cropping systems, soybean-wheat recorded higher FDA followed by soybean-mustard and soybean-chickpea. Dehydrogenase activity was recorded highest in organic management compared to inorganic and integrated management. Similarly, alkaline phosphatase and β Glucosidase enzymes activities were recorded highest in 100% organic followed by 75% organic + 25% inorganic and 75% organic + innovative treatment indicating beneficial effect of addition of organics on soil microorganisms (Fig. 2.1.9g and h)

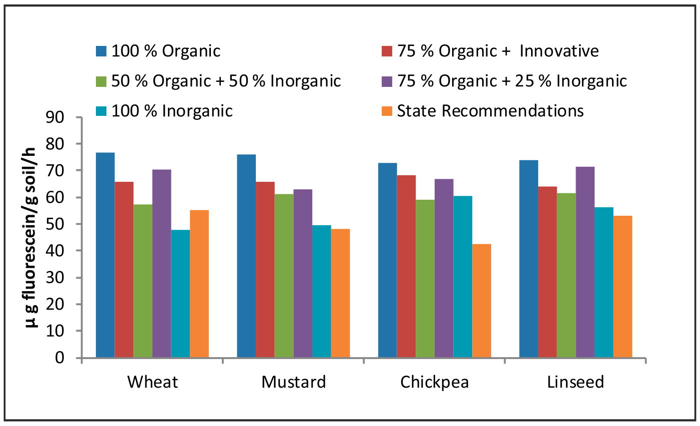


Fig. 2.1.9e Fluorescein diacetate hydrolysis activity as affected by different nutrient sources in different crops

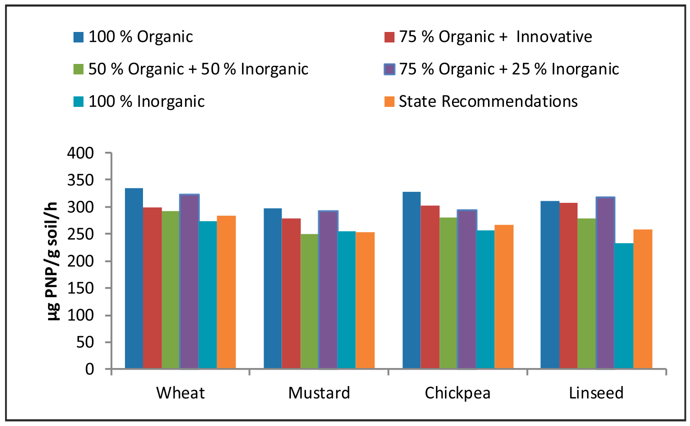


Fig. 2.1.9g Alkaline phosphatase activity as affected by different nutrient sources under different crops

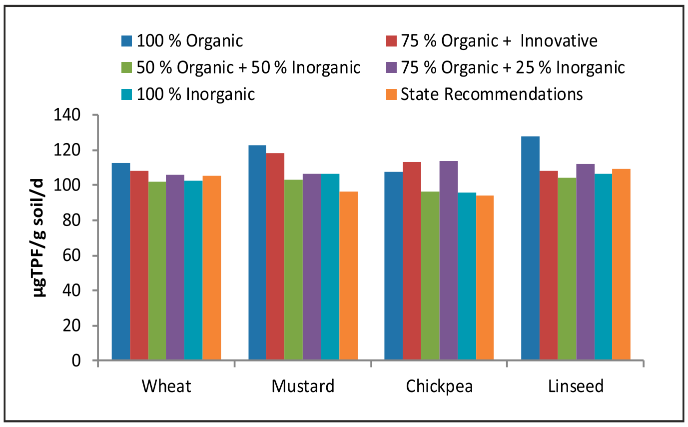


Fig. 2.1.9f Soil dehydrogenase activity as affected by different nutrient sources under different crops

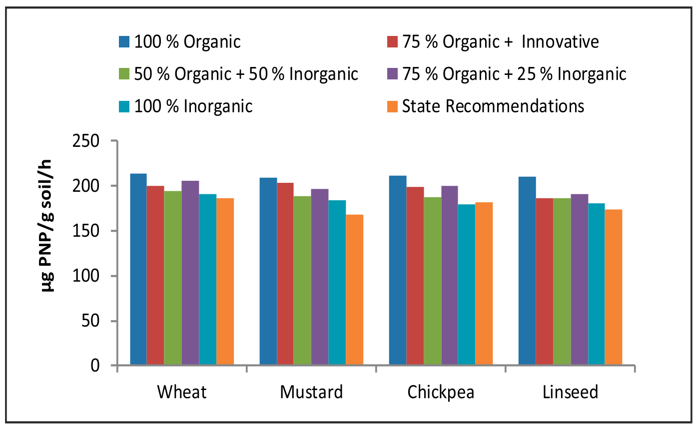


Fig. 2.1.9h β Glucosidase activity as affected by different nutrient sources under different crops

2.1.10 Assessment of mid-infrared spectroscopic technique for rapid estimation of properties of Inceptisols

Mid-infrared reflectance spectroscopy is emerging as one of the promising technology for rapid and cost-effective alternative for routine laboratory analysis of many soil properties. However, this technique needs calibration and validation with the laboratory analyzed data for development of prediction models for different soil properties which will be applicable for a soil type. A study was conducted to evaluate the potential of the mid infrared spectroscopy technique for non-destructive measurement of some important properties of Inceptisols. For this study, 454 geo-referenced soil samples of Inceptisols order, collected from the upper and middle Indo-gangetic plains of Haryana, Uttar Pradesh and Bihar, were used. Soil samples from 0-15 cm soil layer were collected mainly from arable land and about 20% were collected form grassland and forest landscape. The mid-infrared diffuse reflectance spectra in the waveband ranged from 4000 to 500 cm^{-1} of the dried and ground soil samples were recorded using a DRIFT module Bruker Alpha Fourier-transform MIR spectrometer. Soil properties, viz. electrical conductivity (EC), pH, soil organic carbon (SOC) content, available P, available K, sand, silt and clay percentage, determined through standard laboratory procedure and corresponding MIR refelctance spectra (Fig. 2.1.10a, b and c) were used to develop and testing the different chemometric calibration models. Savitzky–Golay first-derivative pre-processing of the soil spectral data were used for model development. In this study, partial least-squares regression (PLSR) and random forest regression techniques were tested for calibration of spectral data with wet chemistry data to obtain predictive models for individual soil properties. The accuracy and robustness of predictive models were assessed by evaluating the co-efficient of determination (R^2), root mean square error (RMSE) and ratio of performance to inter-quartile distance (RPIQ) values of validation. About 80% soil samples were used for model development and 20% samples were used for validation/testing of models. Attempts were also made to identify spectral regions/ bands contributing more towards prediction of a particular soil property from the distribution of regression coefficients among the spectral bands. The PLSR models in general performed better for estimation of most of the studied soil properties. The SOC and pH of the soil were predicted well using both the PLSR and RF models but, it failed to predict extractable nutrient viz., available P and K content of soil with reasonable accuracy. Identified specific bands contributing towards prediction of soil SOC, and pH, are depicted in Figure 2. Spectral bands identified will help in understanding the underlying phenomenon contributing towards estimation of a particular soil property. MIR spectroscopy showed great potential for simultaneous estimation of soil organic carbon, and pH of Inceptisols of Indo-gangetic plains. However, detailed studies are warranted to understand the intrinsic relationships between MIR wavelengths and soil properties so that MIR can be used as a reliable and precise method for measurement of soil properties.

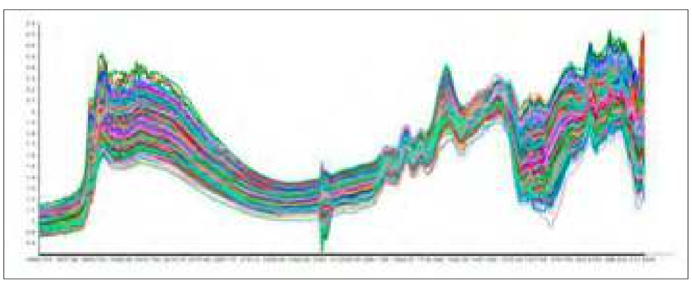
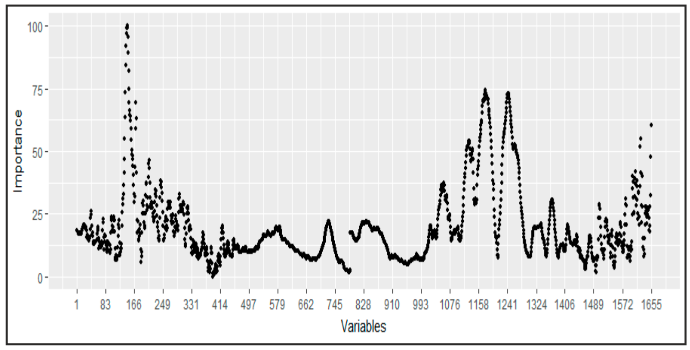


Fig. 2.1.10a MIR Spectra of soil samples from the upper and middle Indo-gangetic plains using alpha-FT-MIR spectrometer

pH



Soil Organic carbon

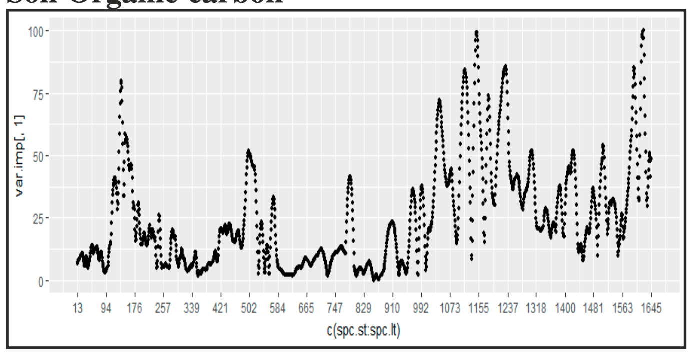


Fig. 2.1.10b PLSR model regression coefficients of pH and SOC showing the relative weightage of spectral bands contributing towards their prediction

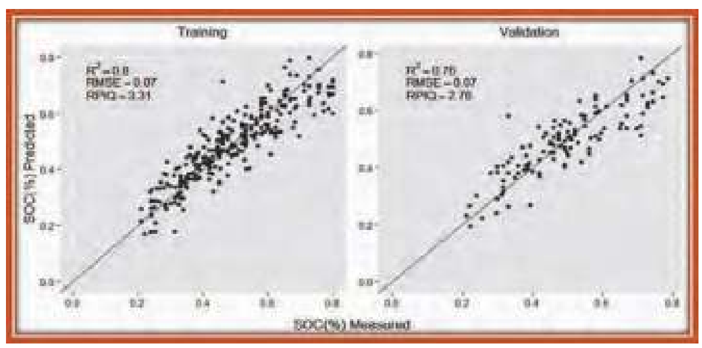


Fig. 2.1.10c Scatter plot of partial least square regression (PLSR) MIR predicted model vs actual laboratory measured values and a 1:1 line for reference of validation for SOC content(%) in Inceptisols

2.1.11 Identification of salt-affected soils in Unnao district using remote sensing approach

About 6.74 million hectares of area is reported to be under salt-affected soils in India. Therefore, an attempt was made to identify salt-affected soils in Unnao district of Uttar Pradesh using satellite remote sensing. A machine learning technique i.e. random forest was applied on individual bands of the Landsat 8 images and various salinity indices computed using those bands, Digital Elevation Model data, ground water depth data, nearness to canal, and MODIS NDVI 16 days composite data to identify salt affected soils. Nearly 1680 sample points were taken for training and testing of random forest model of which 600 samples belonged to salt-affected soils and remaining 1100 points represented other features. 70% data was used for training and 30% data for testing the random forest model. The trained model was then used for the identification of salt-affected soils in the district. The results were validated with field observations and with high resolution Google Earth data. It was found that the random forest model was able to identify the moderate and severe saline-sodic soils in Unnao district with acceptable level of accuracy. The spatial distribution of salt-affected soils also depicted an association with nearness to canal (Fig. 2.1.11)

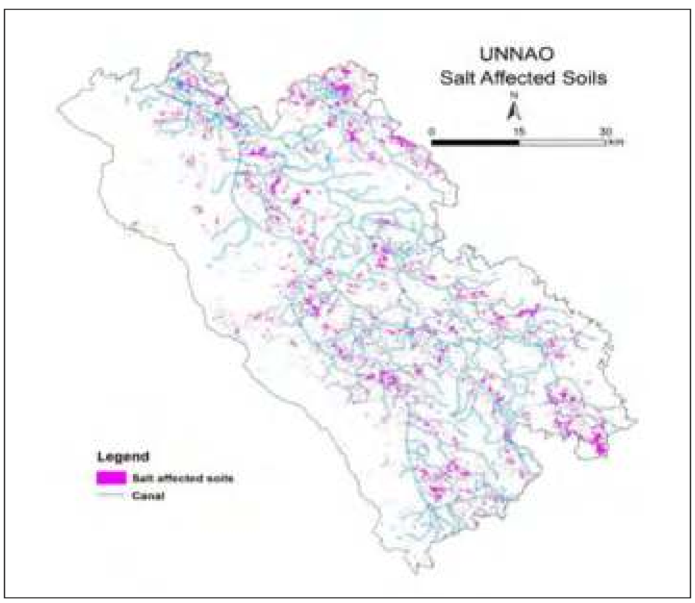
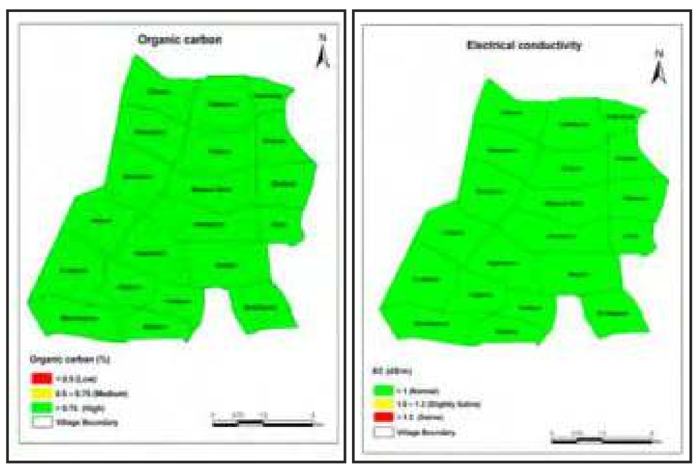


Fig. 2.1.11 Map of saline-sodic soils of Unnao district as identified by satellite remote sensing using random forest technique

2.1.12 Soil fertility maps and geospatial analysis of soil properties in croplands of climatically vulnerable districts of Madhya Pradesh

Soil fertility maps of Rajgarh

A study was conducted in twenty climate smart adopted villages of northern Rajgarh in M.P. to understand the spatial variability of soil properties using GIS and a geostatistical model. These soil samples were analyzed for SOC, labile carbon, phosphorus (P), potassium (K), soil pH, electrical conductivity (EC), water holding capacity (WHC), micronutrients [iron (Fe), manganese (Mn), zinc (Zn) and copper(Cu)] and dehydrogenase activity (DHA) following standard protocols. These sample points were geo referenced and surface maps of soil properties were prepared using the semivariogram model through Kriging techniques in Arc GIS 10.1. For each soil parameter semivariograms were calculated and their main parameters (nugget, sill and range) were obtained. Moderate spatial dependence for K, labile C, Cu, Fe, Zn, Mn strong spatial dependence for SOC, EC, water holding capacity, P, DHA and week spatial dependence for pH were recorded. The best fit model (exponential/ spherical/Gaussian/) was identified to describe the spatial dependence of soil parameters based on root mean square error. All micronutrients except Zn were found high in this region. The Zn content was also adequate and high except for two villages Manoharpura and Hirapura. The soil maps generated could be used as a guide for site-specific nutrient management in the study region (Fig. 2.1.12a).



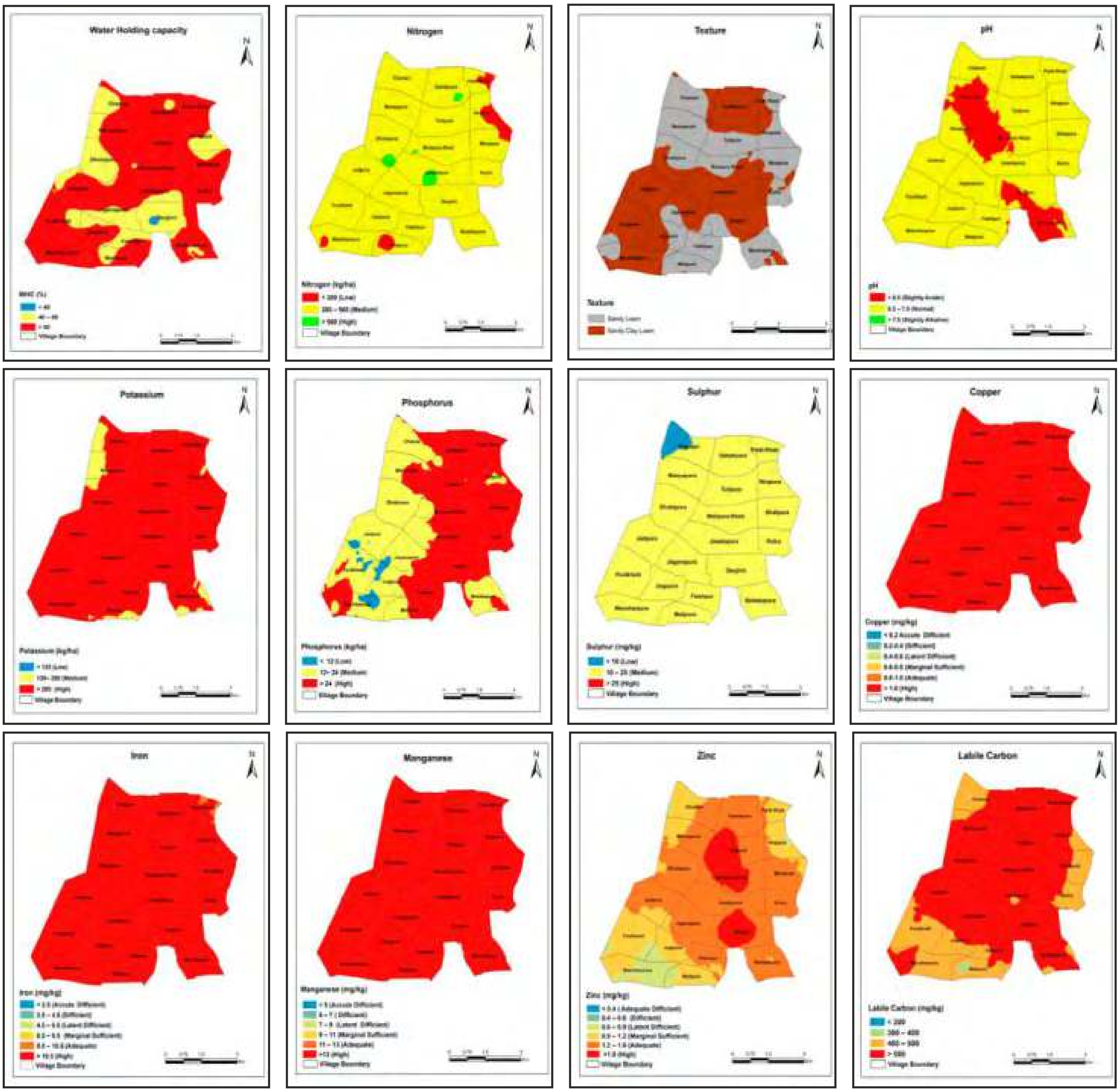


Fig. 2.1.12a Soil fertility maps for adopted villages of Rajgarh district in M.P.

Soil fertility maps of Sehore

Spatial variability of soil pH (pH), electrical conductivity (EC), soil organic carbon (SOC) content, exchangeable potassium (K), available phosphorus (P), micronutrients (Fe, Mn, Zn and Cu) contents dehydrogenase activity (DHA) was studied following standard protocols in twenty climate smart adopted villages of Sehore in Madhya Pradesh. The soil samples were collected from 0-15 cm soil depth and these sample points were geo referenced and surface maps of soil properties were prepared using the semivariogram model through Kriging techniques in Arc GIS 10.1. For each soil parameter semivariograms were calculated and their main parameters (nugget, sill and range) were obtained. The ratio of nugget to total variation was about 37-69%, indicating that the spatial correlation of the tested soil properties (labile C, WHC, SOC, EC, Fe, Mn, Zn, Cu) at the large scale was moderately dependent. The estimated spatial distributions of the soil properties by kriging under decreasing sampling densities, all correlated significantly ($p<0.05$) with those obtained from original data. Geostatistical analysis revealed that the best fit models were gaussian, exponential and spherical for different soil properties with weak, moderate and strong spatial dependency (Fig. 2.1.12b).

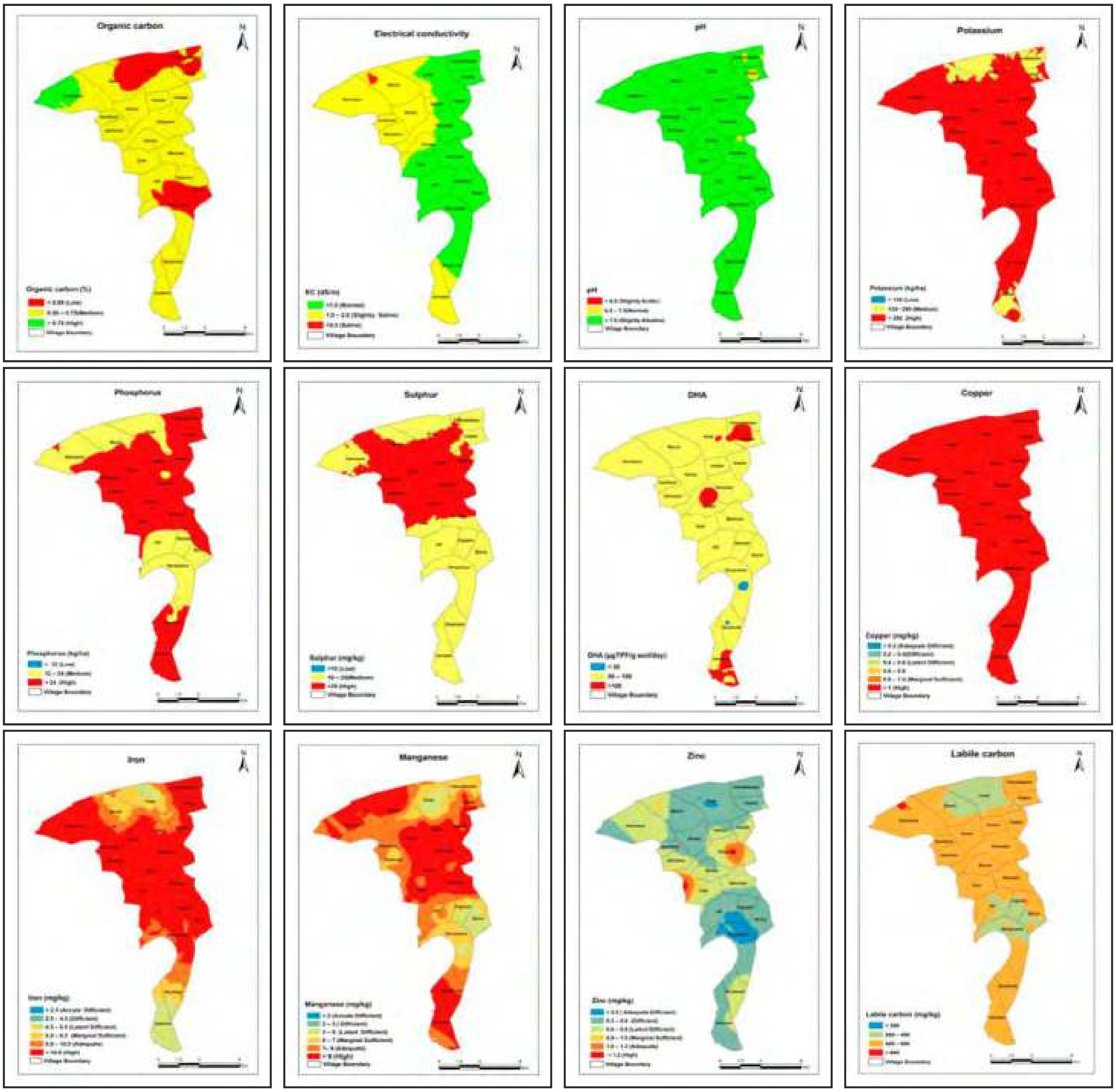


Fig. 2.1.12 b Soil fertility maps for adopted villages of Sehore district in M.P.

2.2 AICRP on Long Term Fertilizer Experiments (LTFE)

2.2.1 Nutrient Dynamics under Long Term Fertilizer Experiments in India

Studies conducted on nutrient dynamics at different sites of long term fertilizer experiments are given below:

Coimbatore

Nitrogen

Nitrogen in soil is most dynamic in nature and found in several forms which are in equilibrium. Data (Table 2.2.1a) revealed that application of fertilizer N maintain NH_4-N and NO_3-N and total hydrolysable N in larger amount than control. Application of FYM further increased the level of these fractions in soil. This indicated that application of fertilizer maintained supply of N to soil and part of applied nitrogen goes to revive different forms like fixed N and unidentified non hydrolysable N. Further fractionation of hydrolyzable N indicated that application of fertilizer N either alone or with other nutrients and organic manure maintained relatively larger amount of hydrolyzable NH_4-N and amino acid which are active fractions of N even though hydrolyzable N is released to soil for plant. This means if supply of N is maintained then these two forms of N should be made available to plant. A very low content of these two fractions in control plot support the statements.

Table 2.2.1a Effect of long term fertilization on nitrogen fractions (mg kg^{-1}) in soil after harvest of maize

Treatments	Inorganic N fractions				Organic N fractions				
	Exch. NH_4-N	NO_3-N	Fixed NH_4-N	Total Hydroly sable N	Hydro-lysable NH_4-N	Hexo samine N	Amino acid N	Uniden-tified Hydroly sable N	Uniden-tified non hydro-lysable N
Control	3.2	8.2	18.6	213.3	95.3	21.4	71.2	33.7	74.6
100% N	6.5	11.4	26.1	264.6	112.9	25.1	84.9	67.7	128.5
100% NP	6.2	11.7	26.6	269.9	117.4	25.9	87.1	69.5	178.1
100% NPK	6.3	11.2	26.3	269.0	125.5	27.5	94.3	68.7	181.2
150% NPK	7.1	13.1	29.4	291.4	131.7	28.7	99.5	81.5	212.3
100% NPK (-S)	6.6	11.4	26.4	263.2	121.1	26.8	91.7	68.7	171.8
100% NPK + Zn	6.4	11.6	26.1	263.6	123.4	26.9	91.2	70.3	184.7
100% NPK + FYM	8.2	13.9	29.9	311.1	136.2	29.3	102.7	83.1	217.9
LSD (P = 0.05)	0.27	0.58	1.02	11.08	5.04	1.08	4.12	4.53	8.06

Phosphorus

Phosphorus also occurs in several forms and changes from one form to another forms depending on soil and external supply of P. Data (Table 2.2.1b) revealed that continuous absence of P in fertilizer schedule resulted maximum decline of Ca-P followed by Al-P and Fe-P. However, on application of fertilizer P resulted in maximum increase of Ca-P and organic-P. Even though increase in Al-P and Fe-P was also noted but with a very low magnitude. This means Ca-P is most dominant fractions in these soils which released P in the absence P supply and fixed P in this form on P application.

Table 2.2.1b Effect of long term fertilization on P fractions (mg kg^{-1}) in soil after harvest of maize

Treatments	Inorganic N fractions					Organic P
	Saloid P	Fe - P	Al - P	Ca - P	Reductant soluble P	Unidentified non hydrolysable N
Control	6.7	14.6	13.8	51.3	13.84	257.2
100% N	8.8	20.2	14.2	55.3	15.53	291.4
100% NP	11.5	24.7	18.6	106.4	19.54	353.5

Treatments	Inorganic N fractions					Organic P
	Saloid P	Fe - P	Al - P	Ca - P	Reductant soluble P	Unidentified non hydrolysable N
100% NPK	11.9	24.6	19.7	106.3	19.85	359.1
150% NPK	17.8	30.8	20.3	134.7	23.02	411.4
100% NPK (-S)	11.6	24.1	19.4	98.2	19.61	357.3
100% NPK + Zn	12.2	24.0	20.1	103.0	19.72	374.8
100% NPK + FYM	17.7	31.3	21.7	140.6	23.64	419.9
LSD (P = 0.05)	0.67	1.97	0.72	6.01	0.82	18.9

Potassium

The continuous application of K resulted increase in water soluble and exchangeable K in soil (Fig. 2.2.1a) and did not make any change in non-exchangeable K so far. Critical examination of data further revealed decline in non-exchangeable and lattice in absence of K in fertilizer schedule. This means in absence of K supply, plant gets the K from non-exchangeable and lattice K through water soluble and exchangeable K. Therefore, due consideration has to be given to non-exchangeable K in order to predict soil health. Similarly, continuous monitoring is required to maintain supply of K vis-à-vis productivity.

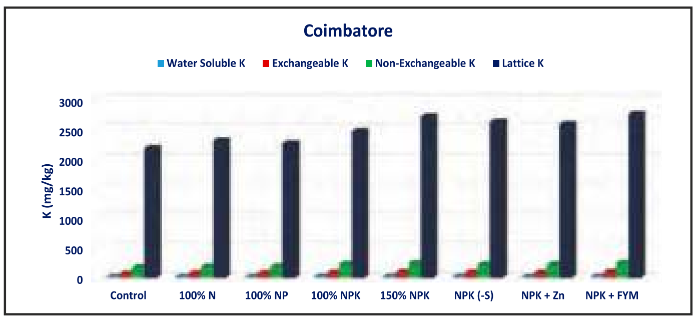


Fig. 2.2.1a Effect of long term fertilization on K forms (mg kg^{-1})

Ludhiana

Nitrogen

Data on N fraction revealed that application of N along with other nutrient resulted increase in total hydrolysable N in soil (Table 2.2.1c). Among the hydrolysable fraction of N, majority of N remain in hydrolysable NH_4-N form. Even though increase in amino acid and amino sugar was also noted but the magnitude was less. It is interesting to note that on application of FYM over NPK and application of super optimum dose (150% NPK) resulted in accumulation of resistant pool of N (Non-hydrolysable N). Decline in resistant pool of N in control plot indicated that in case if there is a crop demand for N, it can be released to soil from resistant pool.

Multiple regression analysis of grain yield with fractions of N revealed that hydrolysable N explained 89.5% to maize yield and 83.8% to wheat yield (Table 2.2.1d). Inclusion of amino acid and other fraction of N resulted increase in contribution by 1% in case of maize yield and in case of wheat yield, however, inclusion of other fractions (Amino acid, amino sugar, UHN) did not improve the relationship. This means ammonical N is most important as far as yields are concerned and attempt should be made to enhance such N fraction through agronomical practices.

Table 2.2.1c Long-term effects of fertilizers and farmyard manure on the distribution of nitrogen organic fractions

Treatment	Hydrolysable Total N	Ammonia N	Amino acid N	Amino sugar N	Unknow hydrolysable N	Non- hydrolysable N
Control	308	88.6	88.7	33.0	97.4	90.0
100% N	386	103.5	110.7	36.0	135.8	113.1
100% NP	408	116.7	114.8	39.0	137.8	114.3
100% NPK	477	133.3	143.7	53.3	146.6	118.0
150% NPK	498	137.7	153.3	58.3	148.3	144.0
100% NPK+FYM	539	147.0	163.3	61.8	167.2	174.9
LSD (P=0.05)	8.7	12.1	6.6	6.3	3.7	2.9

Table 2.2.1d Relationship of organic fractions of N with wheat yield and N uptake

Parameter	Constant	Hydrolysable N	Ammonia-N	Amino-	Amino sugar N	Unknow hydrolysable N	Non- hydrolysable N
Yield of maize	-30.35	0.529					0.895**
	-27.79	0.357	0.171				0.907**
	-26.24	0.333	0.125	0.156			0.910**
	-29.74	0.304	0.048	0.215	0.101		0.915**
	-29.76	0.320	0.26	0.056	0.089	0.029	0.916**[1]
Yield of wheat	-33.46	0.525					0.838**
	-33.45	0.507	0.021				0.838**
	-43.25	0.648	0.320	-0.356			0.883**
	-46.13	0.581	0.421	-0.152	-0.563		0.914**
	-46.02	0.333	-0.033	-0.432	-0.644	-0.159	0.936**

** Significant at 1% level of significance

Methane emission under rice-wheat cropping system

Average daily fluxes and total CH_4 emissions during rice growth were significantly affected by fertilizer applications (Table 2.2.1e). The noticeable increase in CH_4 fluxes commenced from 37 days after transplanting (i.e. vegetative stage) and maximum at 53rd days after transplanting. However, declined in fluxes was noted at 69th days after transplanting (i.e. reproductive stage) and continued at 105 DAT, irrespective of fertilizer treatments. High emission of CH_4 coincided with the active growth stage like tillering, vegetative and reproductive stages of rice. From 53 to 69 DAT, CH_4 fluxes remained at a higher level may be due to the higher root exudation at reproductive stage. Increased organic matter input through root exudates, decaying roots and differentiation of plant anatomy including development of aerenchyma were suggested to be responsible for favouring low redox potential hence increase the CH_4 flux. A highly significant correlation with labile carbon was observed at this stage ($r = 0.940$**). Although, decline was observed from 90 DAT to 105 DAT, CH_4 fluxes ranged from 0.04 kg ha^{-1} day^{-1} to 0.31 kg ha^{-1} day^{-1}. The rate of CH_4 emissions declined after reproductive stage in all treatments and reduced to a negligible level at harvest.

Table 2.2.1e Methane fluxes (kg CH_4 ha^{-1} day^{-1}) from rice fields under long-term inorganic and integrated fertilization

Parameter	Days after transplanting (DAT)						
	2	19	37	53	69	90	105
Control	0.05^{a}	0.03^{a}	0.06^{a}	0.52^{a}	0.13^{a}	0.05^{a}	0.04^{a}
100% NPK	0.12^{b}	0.16^{b}	0.21^{b}	1.17^{b}	1.09^{b}	0.11^{b}	0.14^{b}
100% NPK+GM	0.14b^{c}	0.08^{a}	0.43^{c}	1.51^{c}	1.33^{b}	0.17^{c}	0.19^{bc}
100% NPK+SI	0.17^{c}	0.23^{b}	0.95^{e}	2.59^{d}	1.78^{c}	0.24^{d}	0.31^{d}
100% NPK+FYM	0.13^{b}	0.16^{b}	0.66^{d}	2.30^{d}	1.36^{b}	0.19^{c}	0.23^{c}

GM= green manure; SI= straw incorporation; FYM= farmyard manure; Values within a column, followed by different letters are significantly different at $p \leq 0.05$ by DMRT.

Methane emission, global warming potential (GWP) and yield-scaled GWP

Data pertaining to total CH_4 emissions (Table 2.2.1f) indicated that long-term fertilization had significantly higher cumulative seasonal CH_4 emissions as compared to the control. The application of 100% NPK alone resulted in 49.6 kg ha^{-1} (254%) more emission of CH_4 over the control. Among the integrated treatments, the highest CH_4 emission was recorded in 100% NPK+SI (103.1 kg ha^{-1}) followed by 100% NPK+FYM (82.7 kg ha^{-1}) and lowest in 100% NPK+GM (63.5 kg ha^{-1}). The per cent increase of CH_4 emissions under 100% NPK+SI, 100% NPK+FYM and 100% NPK+GM 108%, 67% and 28%, respectively, over the application of mineral fertilizer (100% NPK).

The global warming potential (GWP) of CH_4 emission varied between 0.47 Mg ha^{-1} CO_2 equivalent in control to 3.43 Mg ha^{-1} CO_2 equivalent in 100% NPK+SI treatment. Application of mineral fertilizer (100% NPK) recorded significantly higher GWP (251%) as compared to the control. Among the conjunctive use of organic manures and inorganic fertilizers, the maximum GWP were recorded with application of 100%NPK+SI (3.43 Mg ha^{-1} CO_2 eq.) followed by 100% NPK+FYM (2.75 Mg ha^{-1} CO_2 equivalent) and minimum with 100% NPK+GM (2.12 Mg ha^{-1} CO_2 equivalent.) which was 108%, 67% and 28% higher over the 100% NPK, respectively.

Table 2.2.1f Effect of long-term fertilizers application on methane emission and GWP from rice fields

Treatment	Average Flux (kg ha^{-1} day^{-1})	Methane emission (kg ha^{-1})	GWP (Mg ha^{-1} CO_2 equivalent)	YS-GWP (Mg CO_2 eq. Mg^{-1})
Control	0.13 ± 0.01^{a}	14 ± 0.8^{a}	0.47 ± 0.02^{a}	0.12 ± 0.01^{a}
100% NPK	0.43 ± 0.07^{b}	49.6 ± 8.29^{b}	1.65 ± 0.28^{b}	0.28 ± 0.04^{b}
100% NPK+GM	0.55 ± 0.04^{c}	63.5 ± 5.01^{c}	2.12 ± 0.17^{c}	0.30 ± 0.02^{b}
100% NPK+SI	0.89 ± 0.02^{e}	103.1 ± 3.46^{e}	3.43 ± 0.11^{e}	0.55 ± 0.01^{d}
100% NPK+FYM	0.72 ± 0.02^{d}	82.7 ± 2.59^{d}	2.75 ± 0.08^{d}	0.40 ± 0.01^{c}

Values within a column, followed by different letters are significantly different at $P \leq 0.05$ by DMRT

Bangalore

Phosphorus

In Alfisols, availability of P has been always a problem as Al and Fe fixes it in acidic pH range. Data generated on P dynamic revealed that majority of applied P led to formation of complexes with Al, Fe and Ca as well (Table 2.2.1g). In the absence of P supply, there was decline in Al, Fe and Ca as well. In absence of P supply decline in Al, Fe and P indicate that plant absorb P from these forms. However, decline is not very perceptive, may be because of poor yield of crop in the absence of supply of P and K. Application of FYM enhanced the available P fraction. Decline in Al and Fe^{+3} on application FYM indicated the availability of Al and Fe got reduced to sorb P because of chelation of Al on Fe by organic complexes and moderation of soil pH on application of FYM support the hypothesis.

Table 2.2.1g Effect of long term manure and fertilizers application on fractions of P (mg kg^{-1}) in soil under finger millet–maize cropping system

Treatment	Available P_2O_5	Al-P	Fe-P	Occl-P	Ca-P	Total-P
Control	6.56	24.00	33.92	27.67	23.54	152.42
100% N	5.37	22.11	30.32	27.08	19.84	133.33
100% NP	53.41	92.89	102.62	66.54	61.22	498.72
100% NPK	48.41	96.91	115.77	63.45	53.10	498.78
150% NPK	74.23	118.52	167.55	85.74	76.04	568.85

Treatment	Available P_2O_5	Al-P	Fe-P	Occl-P	Ca-P	Total-P
100% NPK+Lime	49.19	91.44	105.82	66.27	81.20	501.50
100% NPK+FYM	94.10	76.85	84.65	65.55	63.72	551.57
100% NPK (S-free)	46.05	94.39	115.11	69.94	55.55	488.02
100% NPK+FYM+lime	96.54	64.85	81.95	53.65	87.65	563.70
LSD (P=0.05)	2.46	3.66	4.49	2.67	2.64	21.71

Al-P= Aluminium bound phosphorus; Fe-P= Iron bound phosphorus; Occl-P=Occlude phosphorus and Ca-P= Calcium bound phosphorus

Boron

In acid soil, B could be limiting nutrient due to its mobility in soil along with rainwater. Data revealed that application of fertilizer nutrient resulted in increase in available B in soil and other fractions also, whereas there is declined in plot that received only 100% N (Table 2.2.1h). Increase in B could be due to impurities of B in SSP and healthy plant growth helped in mobilizing it from soil.

Table 2.2.1h Effect of long term manure and fertilizers application on fractions of boron in soil under finger millet–maize cropping system (mg kg^{-1})

Treatments	Avail-B	Readily S-B	Spa-B	Org-B	Total-B
Control	0.83	1.53	0.33	6.7	85.35
100% N	0.77	1.03	0.22	5.4	78.58
100% NP	0.92	1.52	0.33	6.86	91.89
100% NPK	0.91	1.53	0.31	4.46	96.25
150% NPK	0.97	1.59	0.28	6.89	98.55
100% NPK(S-free)	0.89	1.54	0.36	6.56	92.89
100% NPK+Lime	0.98	1.63	0.35	7.16	95.84
100% NPK+FYM	1.01	1.65	0.47	7.26	123.96
100% NPK+FYM+lime	1.13	1.67	0.57	8.14	152.45
LSD (P=0.05)	0.04	0.063	0.016	0.29	4.49

Ready S-B=Readily soluble boron; Spa-B= Specifically adsorbed boron and Org- B=Organically bound boron

Sulphur

Sulfur does exist in soil in several forms and its availability is more dependent on organic sulfur. Data revealed that application of S resulted in increase in available S and organic fraction which are reflected in total sulfur (Fig. 2.2.1b).

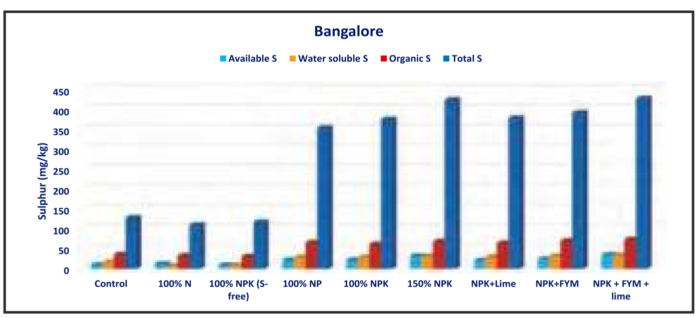


Fig. 2.2.1b Effect of long term manure and fertilizers application on fractions of S

Also a decline of S in organic fraction in absence of S application indicated that plant organic S is mineralized and converted into available forms of sulfur. Poor yield did not supply much organic material to soil through residual biomass.

Pattambi

Phosphorus

Perusal of the P fractions (Fig. 2.2.1c) revealed that application of P resulted in accumulation of P in the form of Fe-P and organic P. Application of FYM and green manuring favoured accumulation of organic form of P. Larger decline in Ca-P and Al-P in the absence of P (Control) indicated that these two forms of P are contributing more P to the plant in absence of P fertilizer.

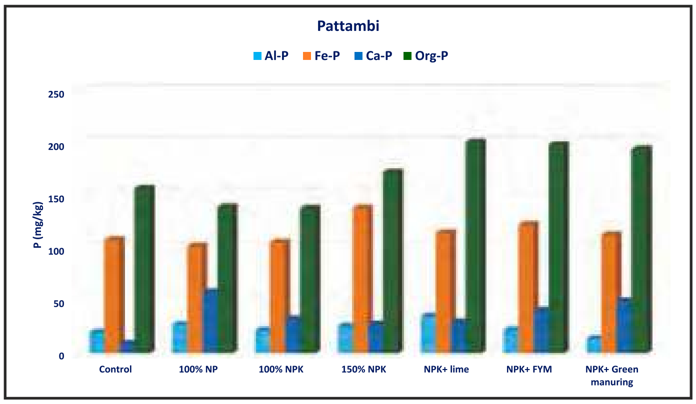


Fig. 2.2.1c Phosphorous fractions in Alfisols of Pattambi

Potassium

Data on K forms in acid soils of Pattambi revealed that soil has maintained very low K in water soluble forms (Fig. 2.2.1d).

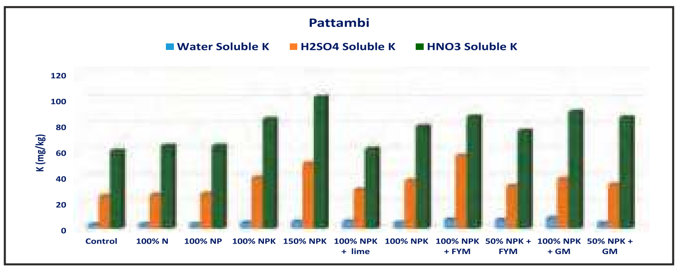


Fig. 2.2.1d Potassium forms in Alfisols of Pattambi

The extraction of K through HNO_3 is larger than K extracted by H_2SO_4. This is probably due to more dissolution power of HNO_3 than H_2SO_4. Thus, it is clear that application of K resulted in more extraction of K irrespective of extracting agent which means a part of applied K remains in soil.

Barrackpore

Potassium

Data on different forms of K revealed that application of K maintained available (water soluble + exchangeable) forms of K in larger quantity compared to the treatment which did not receive K over the years (Table 2.2.1i). Data further indicated that in the absence of K supply during last 42 years has resulted decline in reserve K (i.e. non exchangeable K) which means plant derives K from this source in the absence of K supply. Almost similar trend was noted in the subsurface layer (15-30 cm) indicating that plant also derived K from lower layers. Hence, it can be concluded that K supply should be made to maintain available K status in the soil so as to sustain the soil productivity.

Table 2.2.1i Distribution of different forms of soil K after 42 years of cropping with jute-rice-wheat

Treatments	Water soluble K (mg kg^{-1})	Exchangeable K (mg kg^{-1})	Non-exchangeable K (mg kg^{-1})	Available K (mg kg^{-1})
Control	7.6	55.0	62.6	85.35
100% N	8.3	52.2	60.5	78.58
100% NP	8.7	49.5	58.2	91.89
50% NPK	9.2	69.5	78.7	98.55
100% NPK	10.0	84.5	94.5	92.89
150% NPK	12.6	91.0	103.6	152.45
100% NPK + FYM	12.8	92.7	105.5	4.49

Palampur

Potassium

Data on dynamics of K generated in Alfisols of Palampur revealed that continuous application of (in sufficient amount) has maintained available K in larger amount compared to the treatment which did not receive K over the years (Table 2.2.1j). Data further indicated that in absence of K application, K from non-exchangeable form moved out to available form to maintain the equilibrium. This means in the absence of K, non-exchangeable K will be depleted and soil may show fatigue after few years of cultivation. Therefore, it is necessary to give due care to K supply in Alfisols in order to sustain soil productivity.

Table 2.2.1j Effect of long-term use of chemical fertilizers and amendments on potassium forms (mg kg^{-1})

Treatments	Water soluble K	Exchangeable K	0.5 N HCl Extractable-K	Non- exchangeable K
Control	13.23	44.57	125.43	545.70
100% N	16.00	49.30	132.13	532.57
100% NP	8.90	50.53	125.47	512.83
100% NPK	17.77	56.23	154.83	665.83
150% NPK	25.60	59.90	180.07	710.77
100% NPK (-S)	15.70	63.43	195.60	680.60
100% NPK + Zn	21.20	50.07	231.77	601.70
100% NPK + FYM	22.83	66.27	215.33	627.50
100% NPK + lime	18.77	58.40	174.67	643.77
LSD (P=0.05)	3.38	8.65	34.63	36.97

New Delhi

Soil organic carbon

Perusal of data (Fig. 2.2.1e) indicated that application of nutrient in balanced form resulted increase in soil carbon in bulk soil, macro and micro aggregate as compared to imbalanced use of nutrient (Control, N, NP).

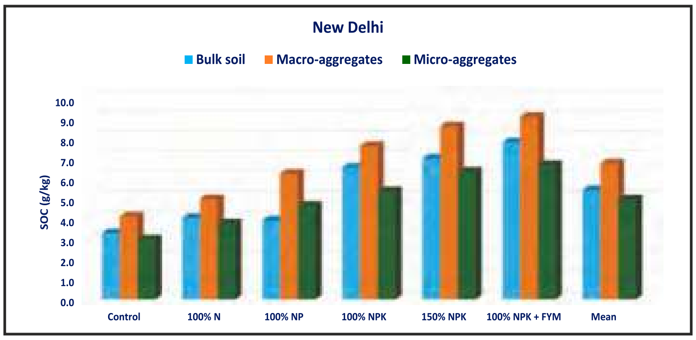


Fig. 2.2.1e Total SOC in different soil aggregates

Increase in carbon in macro and micro aggregate is due to increase in proportion of both the aggregate on application of fertilizer due to addition of carbon. Further increase in carbon on application of FYM supports the statement.

Potassium

Data on K fractionation (Table 2.2.1k) revealed that application of K maintained larger values in all the fractions compared to control, 100% N and NP treatments which did not receive K over the years. Absence of K in fertilizer schedule resulted in decline of non-exchangeable and total K indicating plant derived K from non-exchangeable fraction. Uncultivated fallow maintained all the fraction in larger quantity except water soluble K compared to cultivated soil. This could be probably due to irrigation water which contains about 6-7 ppm K.

Table 2.2.1k Distribution of soil K forms (mg kg^{-1}) in different soil depth as affected by long-term fertilization and manuring

Treatments	Water soluble K	Exchangeable K	Non-Exchangeable K	Total K
Control	16.6	93	1273	18062
100% N	12.9	90	1213	17447
100% NP	15.5	84	1202	17313
100% NPK	17.3	106	1375	18170
150% NPK	19.7	109	1395	18402
100% NPK+FYM	17.4	113	1412	18727
Mean	16.6	99	1312	18020
Uncultivated soil	17.8	122	1407	18135

Boron

Imbalanced use of nutrients resulted in decline of available B and specifically adsorbed B (Table 2.2.11). It is interesting to note that available B and specifically adsorbed B are almost similar as far as quality is concerned whereas oxides and organically bound B is 2 and 4 times larger in quantity, respectively. Majority of B is noted in residual form. However, application of FYM maintained larger amount of B in all the fractions in soil which is due to supply of B by FYM as well as mobilization action of FYM during mineralization.

Table 2.2.11 Fractions of B (mg kg^{-1}) as influenced by long-term fertilization and manuring

Treatments	B fractions					
	Readily soluble	Specifically adsorbed	Oxide bound	Organically bound	Residual	Total B
Control	0.75 (2.00)	0.66 (1.76)	1.49 (3.95)	2.50 (6.63)	32.3 (85.7)	37.7 (100)
100% N	0.61 (1.67)	0.60 (1.64)	1.44 (3.93)	2.63 (7.18)	31.4 (85.6)	36.7 (100)
100% NP	0.67 (1.84)	0.64 (1.74)	1.45 (3.99)	2.69 (7.38)	31.0 (85.1)	36.5 (100)
100% NPK	0.70 (1.82)	0.73 (1.89)	1.55 (4.03)	2.83 (7.34)	32.7 (84.9)	38.5 (100)
150% NPK	0.64 (1.56)	0.72 (1.76)	1.62 (3.98)	3.06 (7.5)	34.7 (85.2)	40.7 (100)
100% NPK+FYM	0.82 (1.84)	0.86 (1.92)	1.57 (3.51)	5.86 (13.1)	35.8 (79.7)	44.9 (100)
Mean	0.70	0.70	1.52	3.26	33.0	39.2
LSD (P=0.05)	0.1	0.07	NS	0.38	NS	4.51

Values in parenthesis shows percentage of the total

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

2.3.1 Status of calcium (Ca) and magnesium (Mg) deficiency

The analysis of soil samples collected from 109 districts of different states viz., Himachal Pradesh, Jharkhand, Jammu & Kashmir, Kerala, Karnataka, Manipur, Tamil Nadu and Uttarakhand revealed that the status of exchangeable Ca and Mg was in the range of 1.13 to 11920 mg kg^{-1} and 0.40 to 7680 mg kg^{-1}, respectively (Table 2.3.1). The states of Kerala and Manipur showed higher per cent of area under Ca and Mg deficiency.

Table 2.3.1 Status of avilable Ca and Mg in different states

State	No of districts covered	Ca			Mg		
		Range (mg kg^{-1})	Mean (mg kg^{-1})	Deficient Area (%)	Range (mg kg^{-1})	Mean (mg kg^{-1})	Deficient Area (%)
Himachal Pradesh	12	148-2952	782.7	0.0	32.4-3726	206	0.3
Jharkhand	5	83-2092	438.8	6.3	32.4-518.6	200	3.0
Jammu & Kashmir	21	12.7-691	307.6	3.8	0.4-71.3	21.8	3.8
Kerala	13	8.6-3828	573.6	15.8	1.8-1825	108	45.9
Karnataka	9	120-11920	2147.2	0.0	5.6-5832	576	0.0
Manipur	5	21.5-760	253.5	42.3	10.8-385	113	28.4
Tamil Nadu	31	1.13-9760	1740.6	3.7	2.6-7680	459	5.1
Uttarakhand	13	15.8-6244	1419.4	0	1.6-2832	108	0.3

The crop responses to Ca and Mg application have been recorded in coarse textured and acidic soils of Odisha, Jharkhand, West Bengal, North-Eastern states, Himachal Pradesh, Jammu and Kashmir, Kerala and Tamil Nadu. Calcium is usually not deficient in soils for many agronomic crops, except for the crops which are grown on acid soils of low cation exchange capacity (CEC). In general, the response of the crops to lime application is because of ameliorative action to alter the availability of other ions in soil rather than actual increase in Ca concentration.

2.3.2 Assessment of multi-micro and secondary nutrients deficiency

Over the years multi-micro and secondary nutrients deficiencies have emerged in different areas of the country. At present, on an average 9.9, 8.3, 6.2, 5.8, 3.7, 3.3, 2.8 and 2.4% samples were found to be deficient in S+Zn, Zn+B, S+B, Zn+Fe, S+Fe, Zn+Mn, Zn+Cu and Fe+B nutrients combinations, respectively (Table 2.3.2). The deficiency of S+Zn was higher in states like Rajasthan (29.9%), Madhya Pradesh (18.8%), Goa (17.6%), Bihar (15.8%) and Gujarat (15.6%). Whereas, Zn+B deficiency was higher in Bihar (20.5%), Odisha (17.1%) and Karnataka (15.4%) having acid leached Alfisols and red and lateritic soils. The states like Jharkhand (35.1%), Odisha (22.5%), West Bengal (20.1%) and Karnataka (16.6%) had higher level of S+B deficiency. Rajasthan was having highest level of Zn+Fe (23.3%), S+Fe (16.9%), Zn+Mn (22.5%) and S+Zn+Fe (11.8%) deficiency. Three nutrient deficiencies like S+Zn+B, S+Zn+Fe and Zn+Fe+B were on average 2.5, 1.9 and 1.1%, respectively. The deficiencies of four or more than four nutrients was very less (less than 0.5%) in most of the states. The results clearly reveal that deficiency of single micronutrient is most predominant as compared to the combination of two or three or four or more than four elements simultaneously.

Table 2.3.2 Extent of multi-micro and secondary nutrients deficiency in soils

State	Deficiency of micro and secondary nutrients combinations (%)										
	S+Zn	Zn+B	S+B	Zn + Fe	S+Fe	Zn + Mn	Zn + Cu	Fe+B	S+Zn +B	S+Zn +Fe	Zn + Fe + B
Andhra Pradesh	6.2	2.1	2.6	6.9	4.6	0.6	0.6	1.8	0.7	1.9	0.6
Arunachal Pradesh	0.3	2.4	2.7	0.0	0.3	0.4	0.3	0.5	0.3	0.0	0.0
Assam	6.3	7.5	4.6	0.0	0.0	0.0	1.1	0.0	2.0	0.0	0.0
Bihar	15.8	20.5	11.9	5.2	2.6	4.6	2.2	8.2	7.3	1.9	3.9
Chhattisgarh	6.6	6.5	7.2	3.1	3.0	1.4	1.2	0.2	2.0	1.7	0.1
Goa	17.6	6.3	9.3	2.2	0.6	10.3	2.1	0.6	5.1	0.4	0.3
Gujarat	15.6	7.3	8.0	11.7	12.7	0.2	0.3	4.4	3.3	5.8	2.0
Haryana	6.6	0.7	1.8	6.5	9.8	1.8	2.2	1.4	0.4	3.2	0.5
Himachal Pradesh	0.1	3.7	0.9	0.1	0.0	0.9	0.3	0.2	0.1	0.0	0.1
Jammu & Kashmir	0.8	4.6	1.3	0.1	0.1	0.6	0.2	0.3	0.2	0.0	0.1
Jharkhand	9.4	10.1	35.1	0.0	0.0	0.0	0.3	0.0	6.5	0.0	0.0
Karnataka	14.4	15.4	16.6	3.9	3.2	0.1	1.3	3.2	7.3	1.8	1.6
Kerala	2.3	4.9	7.2	0.9	0.1	0.6	0.2	0.4	0.2	0.1	0.2
Madhya Pradesh	18.8	2.3	1.7	5.8	2.7	1.5	0.4	0.6	1.0	1.9	0.4
Maharashtra	10.1	5.2	3.6	9.8	5.3	1.8	0.1	5.2	1.2	3.0	1.5
Manipur	0.3	5.9	2.1	0.9	0.1	0.3	0.9	1.7	0.3	0.0	0.5

State	Deficiency of micro and secondary nutrients combinations (%)										
	S+Zn	Zn+B	S+B	Zn + Fe	S+Fe	Zn + Mn	Zn + Cu	Fe+B	S+Zn +B	S+Zn +Fe	Zn + Fe + B
Meghalaya	0.3	1.3	0.7	0.1	0.5	0.4	0.1	0.7	0.0	0.0	0.1
Mizoram	0.0	1.2	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0
Nagaland	0.3	2.3	0.3	0.4	0.0	0.3	0.1	0.6	0.0	0.0	0.3
Odisha	14.5	17.1	22.5	3.0	1.9	0.6	2.9	2.7	8.5	1.1	1.2
Punjab	7.1	3.8	5.8	4.3	5.6	6.8	2.7	2.0	1.5	1.9	0.7
Rajasthan	29.9	0.6	1.2	23.3	16.9	22.5	7.8	0.1	0.3	11.8	0.0
Tamil Nadu	6.4	13.3	2.5	8.2	1.0	5.6	9.9	2.0	1.7	0.8	1.3
Telangana	7.0	8.9	9.6	4.7	4.5	0.8	0.6	4.1	2.3	1.2	1.3
Tripura	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Uttar Pradesh	9.1	5.6	6.3	4.7	6.7	4.5	1.0	2.1	1.9	2.0	0.5
Uttarakhand	1.5	0.9	1.3	0.2	0.1	0.9	0.6	0.0	0.2	0.0	0.0
West Bengal	9.1	4.3	20.1	0.0	0.0	0.4	0.6	0.0	2.5	0.0	0.0
India	**9.9**	**8.3**	**6.2**	**5.8**	**3.7**	**3.3**	**2.8**	**2.4**	**2.5**	**1.9**	**1.1**

2.3.3 Influence of boron stress on reproductive physiology of mustard

The effect of boron stress on mustard (*Brassica campestris* L.) var. T6 was assessed in refined sand culture with at graded levels of boron viz., 0.0033, 0.033, 0.33, 0.66, 1.65 and 3.3 mg L^{-1}. Boron was supplied as boric acid. The depression in plant growth was apparent at low (0.0033 mg B L^{-1}) boron after 31 days of sowing. At this stage, at low (< 0.33 mg B L^{-1}) boron supply, plants appeared short owing to shortening of internodes. The number and size of leaves were reduced. At 32 days after

Table 2.3.3 Effect of graded levels of boron on biomass, seed yield and tissue concentration of mustard

Plant part	Boron supply (mg L^{-1})					
	0.0033	0.033	0.33	0.66	1.65	3.30
			At 68 days after sowing			
Whole plant dry weight (g $plant^{-1}$)	1.08	4.5	5.2	4.08	3.91	3.88
Leaf B Conc. ($\mu g\ g^{-1}$ dry matter)	4.75	11.50	51.0	87.0	236.0	360.0
Stem B Conc.($\mu g\ g^{-1}$ dry matter)	6.75	8.0	8.0	19.0	23.0	128.0
Root B Conc.($\mu g\ g^{-1}$ dry matter)	4.0	13.5	17.0	33.5	36.0	43.0
			At 96 days after sowing			
Whole plant dry weight (g $plant^{-1}$)	-	10.48	15.88	17.32	15.72	11.99
Seed weight (g $plant^{-1}$)	-	1.04	1.77	1.93	1.79	1.31

sowing, owing to B deficiency, young leaves of plants grown at 0.0033 mg B L^{-1} developed interveinal chlorosis from apex which later spread downward along the margins. Interveinal chlorosis intensified and turned necrotic with increase in age (viz., at 44 days after sowing). With increase in time period, plants showed condensation of internodes, leaves turned thick and brittle. Size of the young leaves was markedly reduced as compared to the plants grown with adequate B supply. In persistent acute boron deficiency, death of apical growing point occurred. Plants grown at lowest level of B (0.0033 mg B L^{-1}) could not survive. While with excess (3.3 mg B L^{-1}) B supply, the plant growth depressed after 27 days of sowing (Table 2.3.3). Owing to excess boron (1.65 and 3.3 mg B L^{-1}) supply, the growth of plants got reduced and chlorosis initiated from margins of old leaves. With passage of time, the chlorosis of margins developed necrosis, leaf size and number of branches were reduced. At severity the old leaves turned necrotic, thin and papery and most of them shed prematurely. The depression in growth of plants owing to excess boron was more pronounced than at deficient boron. The above mentioned symptoms spread from older to middle leaves. At 68 days after sowing, biomass of plants increased with an increase in boron supply from acute deficiency (0.0033 mg L^{-1}) to adequate (0.33 mg B L^{-1}) B level. But further increase in B supply (3.3 mg L^{-1}) decreased the biomass of plants (Table 2.3.4). Pod and seed yield were adversely affected by low and high B supply. Boron concentration in seeds increased from 10.25 to 80.0 μg g^{-1} with increase in B supply. Owing to B stress catalase activity decreased with both low and excess B supply. A marked increase in the activity of enzyme in reproductive parts was observed in plants subjected to excess (> 0.33 mg L^{-1}) than deficient (< 0.33 mg L^{-1}) supply of boron.

2.3.4 Amelioration of boron (B) and sulphur (S) deficiency in black gram

In order to develop amelioration technique to address B and S deficiency in black gram in Assam, a field experiment was carried out in B and S deficient soil at Jorhat. Results indicated that application of 1.0 kg B ha^{-1} + 20 kg S ha $^{-1}$ along with the recommended dose of fertilizer (RDF) (100% NPK) recorded the highest seed yield (0.90 t ha^{-1}) (Table 2.3.4). However, it was statistically at par with the seed yield obtained under the treatments 1.5 kg B ha^{-1} +10 kg S ha^{-1} +RDF and 1.5 kg B ha^{-1} + 20 kg S ha^{-1} + RDF. The lowest grain yield (0.56 t ha^{-1}) was observed in the control treatment where only RDF was applied. Increasing levels of boron increased the uptake of B seed. Maximum uptake of 26.98 g ha^{-1} was recorded in treatment receiving application of 1.5 kg B ha^{-1} along with 20 kg S ha^{-1} + RDF and it was at par with B uptake with 1.0 kg B ha^{-1} + 20 kg S ha^{-1} + RDF and 1.5 kg B ha^{-1} + 10 kg S ha^{-1} + RDF. The least uptake was observed in the control plots. Application of 1.0 kg B ha^{-1} + 20 kg S ha^{-1} + RDF recorded the highest uptake of sulphur by seed (2.88 g ha^{-1}). The lowest B and uptake was observed in the control plots.

Table 2.3.4 Effect of B and S application on seed yield, uptake by blackgram seed

Treatments	Seed yield (t ha^{-1})	Seed B uptake (g ha^{-1})	Seed S uptake (kg ha^{-1})
Control (RDF)	0.56	11.22	0.83
0.5 kg B ha^{-1} + RDF	0.65	15.30	1.30
1.0 kg B ha^{-1} + RDF	0.69	18.25	1.61
1.5 kg B ha^{-1} + RDF	0.75	20.77	1.93
0.5 kg B ha^{-1} + 10 kg S kg ha^{-1} + RDF	0.72	18.43	2.05
1.0 kg B ha^{-1} + 10 kg S ha^{-1} + RDF	0.78	21.48	2.17
1.5 kg B ha^{-1} + 10 kg S ha^{-1} + RDF	0.82	23.98	2.47
0.5 kg B ha^{-1} + 20 kg S ha^{-1} + RDF	0.79	21.26	2.27
1.0 kg B ha^{-1} + 20 kg S ha^{-1} + RDF	0.90	25.98	2.88
1.5 kg B ha^{-1} + 20 kg Sha^{-1} + RDF	0.87	26.98	2.69
CD (5%)	0.10	3.21	0.37

2.4 AICRP on Soil Test Crop Response (STCR)

2.4.1 Assessment of enzymatic activities in STCR-IPNS experiment on pearl millet

Urease

Effect of varying fertiliser doses of NPK and IPNS on urease activity was assessed at different growth stages of pearl millet. Irrespective of the treatments, urease activity had decreased from vegetative to harvest stage. The urease activity ranged from 175 to 318, 109 to 238, 74 to 179 and 39 to 102 μg NH_4-N g^{-1} hr^{-1} at vegetative, panicle initiation, grain filling and harvest stages, respectively (Table 2.4.1a). Irrespective of stages, higher urease activity was recorded in STCR-IPNS-4.0 t ha^{-1} which was at par with STCR-IPNS- 3.5 t ha^{-1} and was significantly higher than all other treatments. Absolute control recorded significantly lower urease activity as compared to all other treatments. Irrespective of stages of crop growth, blanket (100% RDF alone) recorded relatively lower urease activity (225, 178, 117 and 66 μg NH_4-N g^{-1} hr^{-1}, respectively) as compared to all STCR treatments and it was on par with FYM alone @ 12.5 t ha^{-1} which recorded 210, 168,109 and 64 ug NH_4-N g^{-1} hr^{-1}, respectively while absolute control recorded the lowest urease activity (175, 109, 74 and 39 μg NH_4-N g^{-1} hr^{-1}, respectively). The results showed that with increase in yield targets, there was a corresponding increase in urease activity. Among the same yield targets, the urease activity under STCR-IPNS treatments were numerically higher than those under STCR-NPK alone and significantly higher than blanket (100% RDF alone), FYM alone @ 6.25 t ha^{-1}, FYM alone @ 12.5 t ha^{-1} and absolute control.

Table 2.4.1a Effect of varying fertiliser doses of NPK and IPNS on urease activity (μg NH_4-N $g^{-1}hr^{-1}$) at different growth stages of pearl millet

Treatment	Vegetative	Panicle Initiation	Grain filling	Harvest
STCR- NPK alone - 3.0 t ha^{-1}	237	186	126	73
STCR- NPK alone - 3.5 t ha^{-1}	269	212	156	84
STCR - NPK alone - 4.0 t ha^{-1}	276	220	162	88
STCR - IPNS - 3.0 t ha^{-1}	245	194	131	75
STCR - IPNS - 3.5 t ha^{-1}	309	235	173	99
STCR - IPNS - 4.0 t ha^{-1}	318	238	179	102
FYM alone @ 6.25 t ha^{-1}	190	156	95	54
FYM alone @ 12.5 t ha-1	210	168	109	64
Blanket (100% RDF alone)	225	178	117	66
Blanket + FYM @ 12.5 t ha^{-1}	2373	215	159	85
Absolute control	175	109	74	39
SE_d	6.9	4.9	4.7	3.7
CD (P=0.05)	14	10	13.4	7.9

Phosphatase

The phosphatase activity ranged from 53.1 to 83.4, 42.1 to 71.6, 35.2 to 62.5 and 21.3 to 39.2 μg PNP g^{-1} hr^{-1} at vegetative, panicle initiation, grain filling and harvest stages respectively showing a decreasing trend from vegetative to harvest stage (Table 2.4.1b). Irrespective of stages, higher phosphatase activity was recorded in STCR-IPNS-4.0 t ha^{-1} which was at par with STCR-NPK alone-4.0 t ha^{-1} and were significantly higher than all other treatments. Absolute control recorded significantly lower phosphatase activity as compared to all other treatments Irrespective of stages of crop growth, blanket (100% RDF alone) recorded relatively lower phosphatase activity (63.5, 58.1, 50.2 and 29.2 μg PNP g^{-1} hr^{-1} at vegetative, panicle initiation, grain filling and harvest respectively) as compared to all STCR treatments and it was on par with FYM alone @ 12.5 t ha^{-1} which recorded 61.4, 56.9, 48.9 and 27.7 μg PNP g^{-1} hr^{-1}, respectively while absolute control recorded the lowest phosphatase activity (53.1, 42.1, 35.2 and 21.3 μg PNP g^{-1} hr^{-1} at vegetative, panicle initiation, grain filling and harvest respectively). The results showed that with increase in yield targets, there was a corresponding increase in phosphatase activity.

Table 2.4.1b Effect of varying fertiliser doses of NPK and IPNS on Alkaline phosphatase activity (μg PNP g^{-1} hr^{-1}) at different growth stages of pearl millet

Treatments	Vegetative	Panicle Initiation	Grain filling	Harvest
STCR- NPK alone - 3.0 t ha^{-1}	65.8	60.2	52.1	31.5
STCR- NPK alone - 3.5 t ha^{-1}	70.5	64.8	56.3	34.1
STCR - NPK alone - 4.0 t ha^{-1}	72.9	65.6	57.2	35.3
STCR - IPNS - 3.0 t ha^{-1}	67.4	61.2	53.2	32.3
STCR - IPNS - 3.5 t ha^{-1}	81.9	70.5	60.9	38.7
STCR - IPNS - 4.0 t ha^{-1}	83.4	71.6	62.5	39.2
FYM alone @ 6.25 t ha^{-1}	57.2	48.4	45.4	24.3
FYM alone @ 12.5 t ha^{-1}	61.4	56.9	48.9	27.7
Blanket (100% RDF alone)	63.5	58.1	50.2	29.2
Blanket + FYM @ 12.5 t ha^{-1}	72.0	65.3	56.8	34.9
Absolute control	53.1	42.1	35.2	21.3
SE_d	1.37	1.40	1.20	0.75
CD (P=0.05)	2.9	2.9	2.5	1.6

Dehydrogenase

STCR-IPNS and STCR-NPK alone treatments showed a significant influence on the dehydrogenase activity.The dehydrogenase activity ranged from 2.92 to 6.41, 2.31 to 6.12, 2.18 to 5.44 and 1.08 to 4.13 μg TPF $g^{-1}day^{-1}$ at vegetative, panicle initiation, grain filling and harvest stages, respectively (Table 2.4.1c).

Table 2.4.1c Effect of varying fertiliser doses of NPK and IPNS on dehydrogenase activity (μg TPF g^{-1} day^{-1}) at different growth stages of pearl millet

Treatments	Vegetative	Panicle Initiation	Grain filling	Harvest
STCR- NPK alone - 3.0 t ha^{-1}	65.8	60.2	52.1	31.5
STCR- NPK alone - 3.5 t ha^{-1}	70.5	64.8	56.3	34.1
STCR - NPK alone - 4.0 t ha^{-1}	72.9	65.6	57.2	35.3
STCR - IPNS - 3.0 t ha^{-1}	67.4	61.2	53.2	32.3
STCR - IPNS - 3.5 t ha^{-1}	81.9	70.5	60.9	38.7
STCR - IPNS - 4.0 t ha^{-1}	83.4	71.6	62.5	39.2
FYM alone @ 6.25 t ha^{-1}	57.2	48.4	45.4	24.3
FYM alone @ 12.5 t ha^{-1}	61.4	56.9	48.9	27.7
Blanket (100% RDF alone)	63.5	58.1	50.2	29.2
Blanket + FYM @ 12.5 t ha^{-1}	72.0	65.3	56.8	34.9
Absolute control	53.1	42.1	35.2	21.3
SEd	1.37	1.40	1.20	0.75
CD (P=0.05)	2.9	2.9	2.5	1.6

At all the stages, the highest dehydrogenase activity was recorded in STCR-IPNS- 4.0 t ha^{-1} which was on par with STCR-IPNS-3.5 t ha^{-1} and was higher than all other treatments. Absolute control recorded the lowest dehydrogenase activity.

Irrespective of stages of crop growth, blanket (100% RDF alone) recorded relatively lower dehydrogenase activity (4.89, 4.29, 3.89 and 2.57 μg TPF g^{-1} day^{-1}, respectively) as compared to all STCR treatments and it was on par with T8 (FYM alone @ 12.5 t ha^{-1}) which recorded 4.69, 4.18, 3.78 and 2.36 μg TPF g^{-1} day^{-1}, respectively while absolute control recorded the lowest dehydrogenase activity of 2.92, 2.31, 2.18 and 1.08 μg TPF g^{-1} day^{-1}, respectively. The results showed that with increase in yield targets, there was a corresponding increase in dehydrogenase activity. Among the same yield targets, the dehydrogenase activity under STCR-IPNS treatments were numerically higher than those under STCR-NPK alone and significantly higher than blanket (100% RDF alone), FYM alone @ 6.25 t ha^{-1}, FYM alone @ 12.5 t ha^{-1} and absolute control.

Theme II. Conservation Agriculture, Carbon Sequestration and Climate Change

2.5 Conservation Agriculture and Cimate Change

2.5.1 Impact of CA practices on soil health, carbon sequestration and green house gas emissions in different production systems

Tillage and residue management influence soil quality via its effects on soil physical, chemical, and biological properties, which in turn affect crop productivity. This study evaluates the effects of different levels of residue retention (0 and 90%) under no-till (NT) system vis a vis other land use systems in vertisol of central India on soil bulk density, total organic carbon (TOC), Walkley and Black carbon (C), active C, water soluble C, easily extractable glomalin and nitrogen mineralization potential of the soil. Samples were collected from 0-10 and 10-20 cm of soil depths from six years of NT system under soybean-wheat cropping system. In order to quantify the conservation agriculture (CA) impacts on soil quality, samples were also collected from other land use systems viz. Agri-horticulture, horticulture, pasture land, organic and conventional agriculture to make comparison to the CA systems. After following six years of NT system in soybean-wheat cropping system, no significant difference in soil bulk density was recorded between 0 and 90% of residue retention treatments. However, land use system significantly affected the soil bulk density. Adoption of long term (Horticulture & agri-horticulture system-40 years) significantly reduced soil bulk density (1.14 Mg m^{-3}) in comparison to no till system (1.43 Mg m^{-3}). Retention of residue to the tune of 90% significantly improved soil total carbon (1.74%) in 0-10 cm of soil depth in comparison to 0% of residue retained plot (1.52%). Six years of residue retention maintained TOC at par with organic farming trial which is running since 2004. Among the different land use systems, agri-horticulture system maintained highest concentration of total carbon (2.1%) followed by NT system with 90% of residue retention. We also recorded 64% improvement in particulate organic carbon (POC) concentration in residue retained plot as compared to no residue retention treatment. However, organic farming system maintained highest concentration of POC (0.60%). Conventional agriculture treatment had the lowest concentration of POC (0.18%). In comparison to conventional agriculture system, there was a two fold increase in POC concentration in 90% residue retained treatment in comparison to conventional agriculture system. Here also agri-horticulture system maintained highest concentration (0.93%) of POC. Water soluble carbon (WSC) in soil was significantly affected by residue retention. Six years of residue retention under NT plot resulted in 17% improvement in WSC in soil, which is even greater than the WSC content of organic amended treatments. Easily extractable glomalin related soil protein (EEGRSP), an index of organic N supplying capacity of soil found significantly improved with the retention of residue. Retention of residue resulted in 80% improvement in EEGRSP concentration in comparison to no residue retained plot.

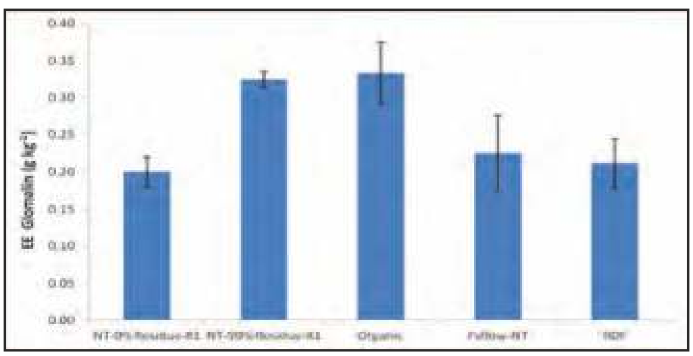


Fig. 2.5.1a Easily extractable glomalin concentration as affected by different cropping and tillage systems

This clearly indicates that retention of residue under

NT system helps in improvement in nitrogen supplying capacity of soil. The highest concentration of 0.33 g kg^{-1} of EEGRSP was found in 0-10 cm of soil depth in organic farming treatment, which was at par with the NT system with 90% of residue retention and agri-horticulture system (Fig. 2.5.1a). Nitrogen mineralization capacity of soils under different land use systems were assesses by anaerobic incubation method. It was observed that retention of residue to the tune of 90% resulted in 80% improvement in N mineralization potential of soil, which was 16% higher than the organic farming treatment. The highest N mineralization potential (64 mg/kg/7 days) was recorded in agri-horticultural system followed by the treatment of residue retention under no till system (43.7 mg/kg/7 days) (Fig. 2.5.1b).

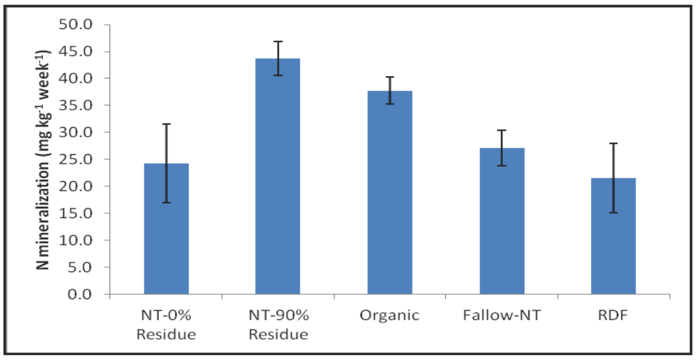


Fig. 2.5.1b Nitrogen mineralization (anaerobic method) as affected by farming systems

It was observed that N mineralization potential of soil under agriculture systems (No till, organic and conventional) is drastically reduced in 10-20cm of soil depth however it was fairly high under the agri-horticulture and pure horticulture systems. Different fractions of soil organic C comprising very labile, labile, less labile and non-labile (recalcitrant) were determined by oxidation with 12 N, 18 N and 24 N H_2SO_4 (acid/aqueous ratios of 0.5:1, 1:1 and 2:1, respectively) (Chan et al., 2001). It was observed that retention of residue under no till system resulted in higher proportion of carbon in active pool whereas proportion of C in passive pool was decreased. Retention of residue under no till system contributed carbon to very labile and labile pools. The reverse trend was recorded under the conventional agriculture. Here, proportion of C in passive pool was higher than the active pool. Conventional agriculture had the highest concentration of C in passive pool although it contained lowest concentration of soil total carbon. This implies that higher carbon input to soil results in priming effect on passive pool of soil organic carbon. An effort was made to predict the nitrogen mineralization potential of soil by developing the relationship between different soil quality parameters and potential N mineralization in soil. It was observed that N mineralization potential of soil as estimated by anaerobic method is significantly and positively correlated with total carbon (r=0.79), WBC (r=0.89), active carbon (r=0.83), very labile carbon (r=0.80) and easily extractable glomalin concentration (0.72). It was observed that nitrogen mineralization potential of soil could be predicted with reasonable accuracy using WBC and active carbon (Adj. R^2=0.91). Results indicated that nitrogen mineralization capacity of soil bears a linear relationship with WBC content (Fig. 2.5.1c).

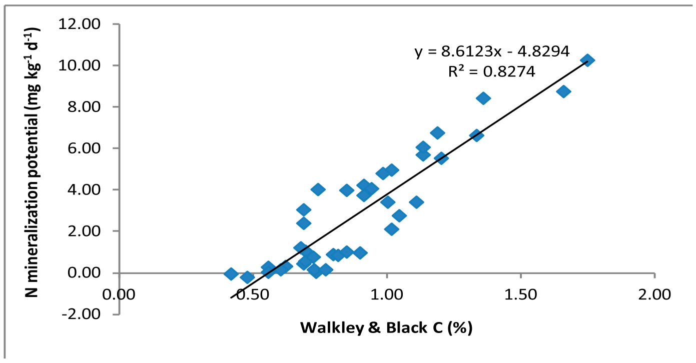
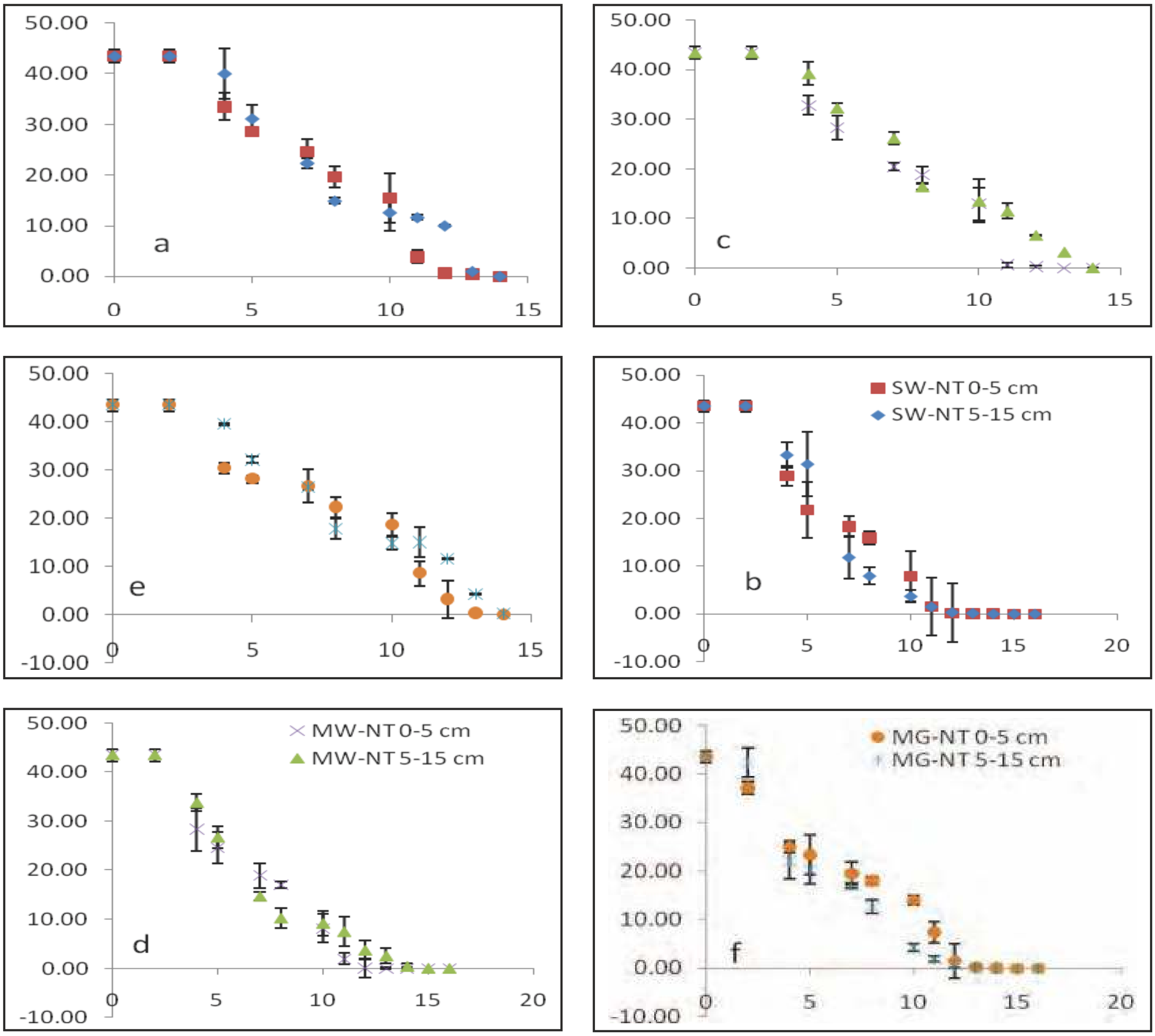


Fig. 2.5.1c Relationship between N mineralization potential and Walkley and Black Carbon concentration

Methane consumption potential of soybean-wheat, maize-wheat, and maize-gram cropping systems under no tillage and conventional tillage

Methane (CH_4) consumption in agricultural soils is imperative for mitigation of global climate change. No-tillage is currently being recommended for sustainable agriculture. However, the effect of tillage on CH_4 consumption potential of soil in different cropping systems is less studied. Field experiments carried out with soybean-wheat (SW), maize-wheat (MW), and maize-gram (MG) cropping systems under conventional tillage (CT) with residue removed and no tillage (NT) with residue retention. Soybean and maize were cultivated during kharif while wheat and chickpea in rabi season consecutively for 9 years. Soil samples collected during vegetative stages of soybean and maize from different cropping systems. CH_4 consumption, abundance of methanotrophs as particulate methane monooxygenase (pmoA) gene copies, soil and crop parameters were estimated. CH_4 consumption rate was higher in no tillage and upper soil layer (0-5 cm) than conventional tillage and 5-15 cm depth (Fig. 2.5.1d).

CH_4 consumption rate k (ln μg CH_4 consumed g^{-1} soil d^{-1}) ranged from 0.35 to 0.56 in the trend of MW>SW>MG in 0-5 cm. Abundance of pmoA gene copies ranged from 43×10^4 g^{-1} soil to 13×10^4 g^{-1} soil. Their abundance was highest in MW-NT and lowest in MG-CT. Available N, P and K were higher in 0-5 cm than in 5-15 cm depth. Soil and plant parameters, abundance of pmoA genes significantly ($p<0.05$) positively correlated with the CH_4 consumption rate. NT stimulated CH_4 consumption compared to CT irrespective of cropping systems. Study highlight that CH_4 consumption potential was highest in MW and least in MG. However, the magnitude of positive effect of NT towards CH_4 consumption was higher in SW and MG than MW.



Incubation period (days)

Fig. 2.5.1d Consumption of CH_4 in rhizospheric soil of crops under different cropping systems and conservation agricultural practices. Cropping systems were soybean-wheat (SW), maize-wheat (MW), and maize-gram (MG). Conservation agriculture practices were conventional tillage (CT) and no tillage (NT). Soil samples were collected after 9 years during *kharif* season 2018, from two depths (0-5 cm, and 5-15 cm).

2.5.2 Effect of different residue levels on crop performance under conservation agriculture in Vertisols

The experiment was initiated with the aim to study the impact of different residue levels on crop establishment, soil health and resource conservation in terms of water and energy saving, in soybean –wheat and maize-chickpea cropping systems.

Soybean- wheat cropping system

Wheat (C-306) was sown in the field (2018-19) with Happy Seeder @ 80 kg ha^{-1} at a row to row spacing of 27.5 cm in the applied residue of soybean crop. Recommended doses of nutrients @ 80 kg N, 60 kg P_2O_5, and 40 kg K2O ha^{-1} through Urea, DAP and MOP respectively, was uniformly applied in all the treatments. Among different residue level treatments maximum plant height at harvest (109.17cm) was recorded with T4 treatment (90% residue) and minimum plant height at harvest (98.22) was recorded under T1 (control without residue). Among different residue level treatments, maximum grain and straw yield (43.21 q/ha and 74.50 q/ha) was recorded under T4 (90% residue) which was significantly superior over rest of the treatments and minimum grain and straw yield (35.88 q/ha and 66.96 q/ha) was recorded under T1 (control) (Table 2.5.2a and Plate 2.5.2a).

Table 2.5.2a Effect of different residue level retention under conservation agriculture on plant height, grain and straw yield of wheat

Treatment	Plant height (cm)	Grain Yield (q/ha)	Straw yield (q/ha)
T_1 (Control)	98.22	35.88	66.96
T_2 (30% residue)	100.78	37.59	68.58
T_3 (60% residue)	104.06	40.86	72.85
T_4 (90% residue)	109.17	43.21	74.50
CD (P=0.05)	1.96	1.66	2.18

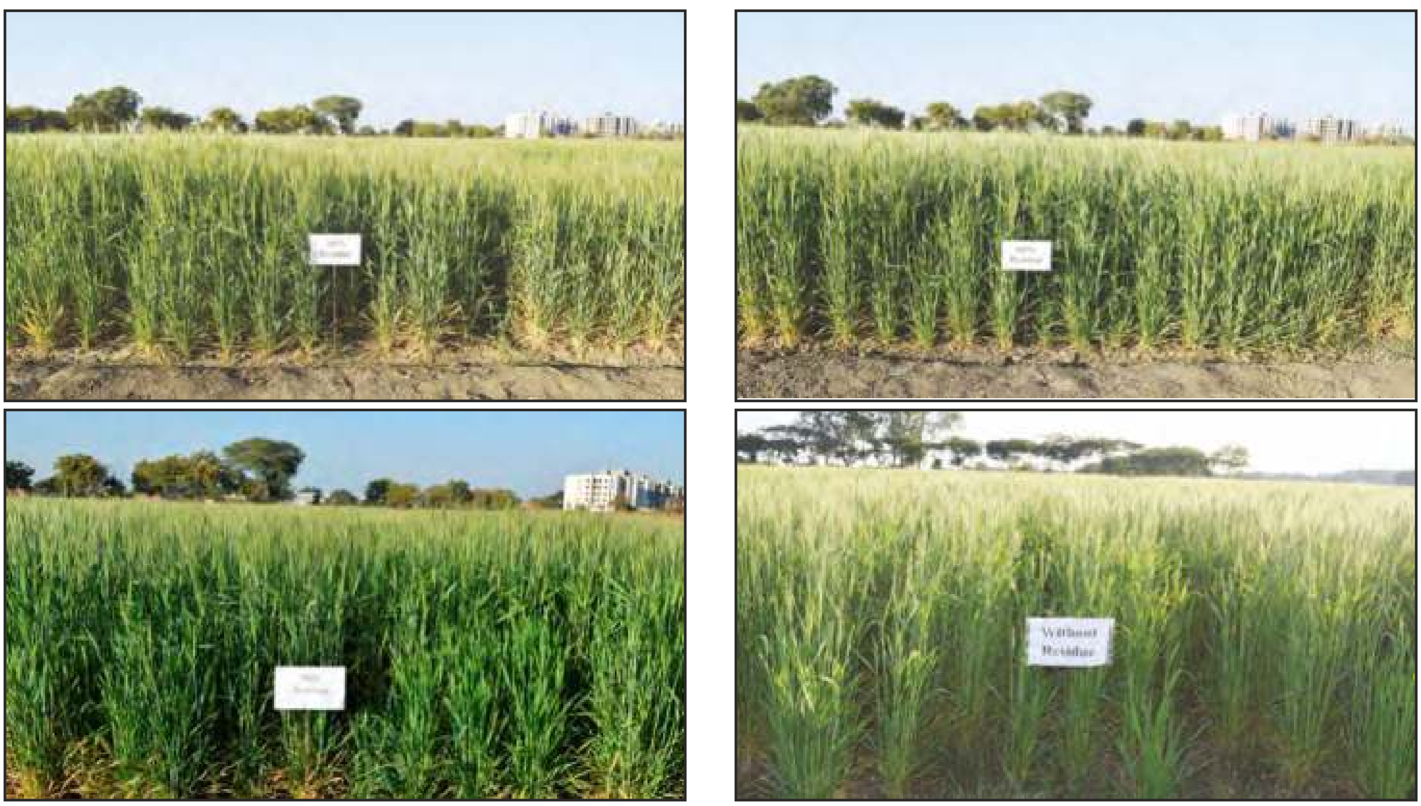


Plate 2.5.2a Performance of wheat under different residue management

Soybean (RVS 2001-4) was sown in the field with Happy Seeder @ 80 kg ha^{-1} at a row to row spacing of 27.5 cm in the standing residue of wheat crop in the field as per treatments. Recommended doses of nutrients @ 30 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} through Urea, DAP and MOP respectively, was uniformly applied in all the treatments. Observations on various growth and yield attributes were recorded at different growth stages of soybean crop. Maximum plant height of soybean was recorded under treatment T4 (90% residue) 73.78 cm at harvest, followed by treatments T3 (60% residue), and T2 (30% residue) which differs significantly among each other, whereas the minimum plant height 65.33 cm was recorded under the treatment T1 (control). Among different residue level treatments maximum number of branches/plant & average number of pods/plant (6.50 and 41.76) was recorded under treatment T4 (90% residue) which was significantly higher as compared to all the treatments. Minimum number of branches/plant and average number of pods/plant (5.17 and 34.52) were recorded under T1 (control). Maximum number of seed per pod was recorded under the treatment T4 - 90% residue and T3 -60% residue (2.72) which were significantly superior to treatment T2 - 30% residue (2.56) and T1 (control) which were on par with each other (Table 2.5.2b).

Table 2.5.2b Effect of different residue level retention under conservation agriculture on growth parameters of soybean

Treatment	Plant height (cm)	No. of branches/plant	No. of pods/plant	No. of seeds/pod
T_1 (Control)	65.33	5.17	34.52	2.56
T_2 (30% residue)	68.56	5.39	36.12	2.56
T_3 (60% residue)	71.78	5.94	37.52	2.72
T_4 (90% residue)	73.78	6.50	41.76	2.72
CD (P=0.05)	1.77	0.28	2.15	0.12

Among different treatments maximum seed yield was recorded in treatment T_4-90% residue (1567.08 kg ha^{-1}) which was on par with other residue level treatments, while lowest seed yield was recorded in under treatment T_1 (control) 1417.08 kg ha^{-1}). Maximum straw yield (4258.33 kg ha^{-1}) was recorded under T_4 which was significantly higher as compared to control (3325 kg ha^{-1}). Maximum harvest index was recorded under control (30.35%) which was significantly higher as compared to T_4 (27.30%) (Table 2.5.2c and Plate 2.5.2b).

Table 2.5.2c Effect of different residue level retention under conservation agriculture on yield attributes of soybean

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	HI (%)
T_1 (Control)	1417.1	3325.0	30.3
T_2 (30% residue)	1503.7	3847.9	28.1
T_3 (60% residue)	1463.7	3787.1	28.1
T_4 (90% residue)	1567.1	4258.3	27.3
CD (P=0.05)	249.22	717.9	2.2

Plate 2.5.2b Performance of soybean under different residue management

Chickpea

Chickpea (RVG-202) was sown in the field (2018-19) with Happy Seeder @ 80 kg ha^{-1} at a row to row spacing of 27.5 cm in the standing residue of maize crop in the field as per treatments. The recommended doses of nutrients @ 30 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} through Urea, DAP and MOP respectively, was uniformly applied in all the treatments. Among different residue level treatments maximum plant height (56.17 cm), number of branches /plant (49.33) and number of pods/plant (186.80) was recorded with T4 treatment (90% residue) which was significantly higher as compared to all the treatments. Among different residue level treatments minimum value for these parameters were recorded under T1 (control without residue) (Table 2.5.2d).

Table 2.5.2d Effect of different residue level retention under conservation agriculture on growth parameters of chickpea.

Treatment	Plant height (cm)	No of branches	No. of Pods/plant
T_1 (Control)	41.00	23.83	131.83
T_2 (30% residue)	44.11	33.89	146.20
T_3 (60% residue)	52.44	36.83	165.83
T_4 (90% residue)	56.17	49.33	186.80
CD (P=0.05)	2.42	3.20	15.01

Among different residue level treatments maximum seed index (22.83 g), seed yield (27.42 q/ha) and straw yield (27.58 q/ha) was recorded with T_4 treatment (90% residue) which were significantly higher as compared to control. Among different residue level treatments minimum value for these parameters were recorded under T_1 (control without residue) (Table 2.5.2e and Plate 2.5.2c).

Table 2.5.2e Effect of different residue level retention under conservation agriculture on yield parameters of chickpea

Treatment	Seed index (g)	Seed yield (q/ha)	Straw yield (q/ha)
T_1 (Control)	20.17	21.89	20.86
T_2 (30% residue)	21.67	23.72	23.67
T_3 (60% residue)	21.83	26.50	25.40
T_4 (90% residue)	22.83	27.42	27.58
CD (P=0.05)	1.54	2.816	2.867

Plate 2.5.2c Performance of chickpea under different residue management

Maize

Maize (variety – Nath Samrat- 1144) was sown @ 25 kg/ha with the help of Happy Seeder at a plant to plant and row to row spacing of 55 x 20 cm. The residue of chickpea crop was applied manually after threshing as per the treatments. The recommended doses of nutrients @ 120 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} through Urea, DAP and MOP respectively, was uniformly applied in all the treatments. Among different residue level treatments maximum plant height at harvest (175.94 cm) was recorded with T4 treatment (90% residue) and minimum plant height at harvest (168.50 cm) was recorded under T1 (control without residue). Among different residue level treatments, maximum grain yield and straw yield (41.79 q/ha and 70.07q/ha) was recorded under T4 (90% residue) treatment and minimum grain yield and straw yield (34.03 q/ha and 62.51 q/ha) was recorded under T1 (Control) (Table 2.5.2f and Plate 2.5.2d).

Table 2.5.2f Effect of different residue level retention under conservation agriculture on growth parameters of Maize

Treatment	Plant height (cm)	Grain yield (q/ha)	Straw yield (q/ ha)
T_1 (Control)	168.50	34.03	62.51
T_2 (30% residue)	171.78	35.52	64.40
T_3 (60% residue)	173.89	39.19	68.28
T_4 (90% residue)	175.94	41.79	70.07
CD (P=0.05)	1.39	12.34	7.58

Plate 2.5.2d Performance of maize under different residue management

Demonstration of best-bet conservation agriculture practices on farmers' fields in vertisols of central India

Farmer field experiments were conducted in a participatory mode during *rabi* season 2018-19 comprising of 12 demonstrations with wheat crop and 8 with chickpea 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 farmers practice. A perusal of the data revealed that maximum plant height, ear length, number of tillers grain yield, straw yield and harvest index were recorded under zero tillage (Table 2.5.2g).

Table 2.5.2g Performance of wheat at farmer field during *rabi* 2018-19 (N=12)

Treatment	Plant height (cm)	Ear length (cm)	No. of tillers	Grain yield (q/ha)	Straw yield (q/ha)	HI (%)
ZT	79.29	10.16	21.65	42.86	77.88	35.50
RT	77.94	10.10	19.14	37.62	76.86	32.86
CT	76.50	9.62	16.24	35.50	70.50	33.49

A perusal of the data revealed that maximum plant height, ear length, number of tillers grain yield, straw yield and harvest index were recorded under zero tillage (Table 2.5.2h).

Table 2.5.2h Performance of chickpea at farmer field during *rabi* 2018-19 (N=8)

Treatment	Plant height (cm)	No of branches	Grain yield (q/ha)	Straw yield (q/ha)	HI (%)
ZT	56.54	28.37	19.89	26.02	43.32
RT	55.66	24.26	17.72	25.75	40.76
CT	51.00	24.10	18.50	25.10	42.43

Twenty field demonstrations were conducted comprising of zero tillage, reduced tillage and compared with farmers practice during kharif season 2019-20 with soybean crop. A perusal of the data revealed that maximum plant height, seed yield, straw yield and harvest index were recorded under zero tillage (Table 2.5.2i and Plate 2.5.2e).

Table 2.5.2i Performance of soybean at farmer field during 2019-20 (*Kharif*) (N=20)

Treatment	Plant height at harvest (cm)	Seed yield (q/ha)	Straw yield (q/ha)	HI (%)
ZT	52.90	13.93	34.55	28.92
RT	50.81	13.18	32.78	28.95
CT	50.50	12.06	30.50	28.34


Plate 2.5.2e Best-bet conservation agriculture practices on farmers' fields

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

During the *rabi* season (2018-2019) wheat crop was grown with four levels of fertilizer treatments (100% RDF, 75% RDF, STCR and Leaf colour chart based fertilizer management), three tillage management treatments (CT-Conventional tillage, RT-Reduced tillage and NT- No tillage) and three irrigation methods (Flood, sprinkler and drip irrigation). Among the irrigation treatment slightly higher yield of wheat was recorded in flood irrigation (5143 kg/ha) followed by drip (4758 kg/ha) irrigation treatment. Wheat yield was the lowest (4536 kg/ha) in sprinkler system. Among the tillage treatments grain and biomass yield did not vary significantly (Table 2.5.3a and Plate 2.5.3a). Temporal changes in plant height and dry biomass yield followed a similar trend among the treatments. Effect of irrigation management and tillage treatments on changes in the soil hydro-thermal regime was also studied twice during the growing season.


Plate 2.5.3a Wheat crop grown under flood, drip and sprinkler irrigation

Table 2.5.3a Effect of irrigation, tillage and fertilizer levels on grain, straw yield and harvest index of wheat (2018-19)

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index (%)
	Irrigation methods		
Flood	5143	7095	42
Sprinkler	4536	5739	44
Drip	4758	6624	42
LSD (0.05)	NS	NS	NS
	Tillage systems		
CT	4837	6352	44
RT	4835	6403	43
NT	4765	6703	42
LSD (0.05)	NS	NS	NS
	Nutrient Doses		
100% RDF	5007	6755	43
75% RDF	4753	6640	42
STCR	4693	6195	44
LCC	4796	6354	43
LSD (0.05)	NS	NS	NS

A field experiment on soybean-wheat cropping system was conducted for the second year to evaluate the performance of different irrigation, tillage and nutrient management packages and to identify the most suitable irrigation and nutrient management package for conservation agriculture in Vertisols of central India. During the *kharif* season (2019) soybean (cv RVS 2001-4) was grown with three fertilizer management treatments (F1=100% RDF, F2=75% DRF,F3=STCR(soil test crop response) and three tillage treatments (CT-Conventional tillage, RT-Reduced tillage and NT- No tillage). The yield level of soybean was slightly lower compared to the last year due to very heavy and continuous rainfall during the later part of soybean growth period. The soybean yield varied between 1581 kg/ha and 1674 kg/ha. The treatment difference among the seed yield was not significant. Similar trend was also recorded in biomass yield of soybean (Table 2.5.3b and Plate 2.5.3b).

Table 2.5.3b Effect of tillage and fertilizer treatment on seed, biomass yield and harvest index of soybean in 2019

	Grain yield (q ha^{-1})				Straw yield (q/ha^{-1})				Harvest Index			
	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
CT	1665	1644	1674	1661	1987	2384	2336	2236	0.46	0.41	0.42	0.43
RT	1581	1594	1642	1605	2202	1987	2295	2162	0.42	0.44	0.44	0.43
NT	1605	1570	1638	1604	2659	2280	2149	2363	0.40	0.42	0.44	0.42
Mean	1617	1603	1651		2283	2217	2260		0.42	0.42	0.43	
LSD (0.05)	Tillage : NS, Fertilizer Dose : NS, Tillage x Fertilizer dose : NS=				Tillage : NS, Fertilizer Dose : NS, Tillage x Fertilizer dose : NS				Tillage : NS, Fertilizer Dose : NS, Tillage x Fertilizer dose : NS			

Plate 2.5.3b Sowing of soybean in wheat residue retained no tillage plots by using Kamboj Happy Seeder

2.5.4 Stratification of soil organic carbon (SOC) as affected by tillage practices and cropping system

The carbon stratification ratio (CSR) is the ratio between SOC stock in two soil layers, usually the topsoil (0-5 cm), with the strong influence of soil and crop management practices, and the adjacent soil layer (5-15 cm), which is less affected by these operations. Due to the differences in the soil-nutrient distribution by various management strategies, the stratification of SOC has been reported as an essential indicator of soil quality. In general, higher CSR values are related to agro-ecosystems, which provided the maintenance or increase of soil quality. This experiment was carried out to quantify the effect of different tillage and cropping system on CSR after six years of treatment imposition (Fig. 2.5.4a).

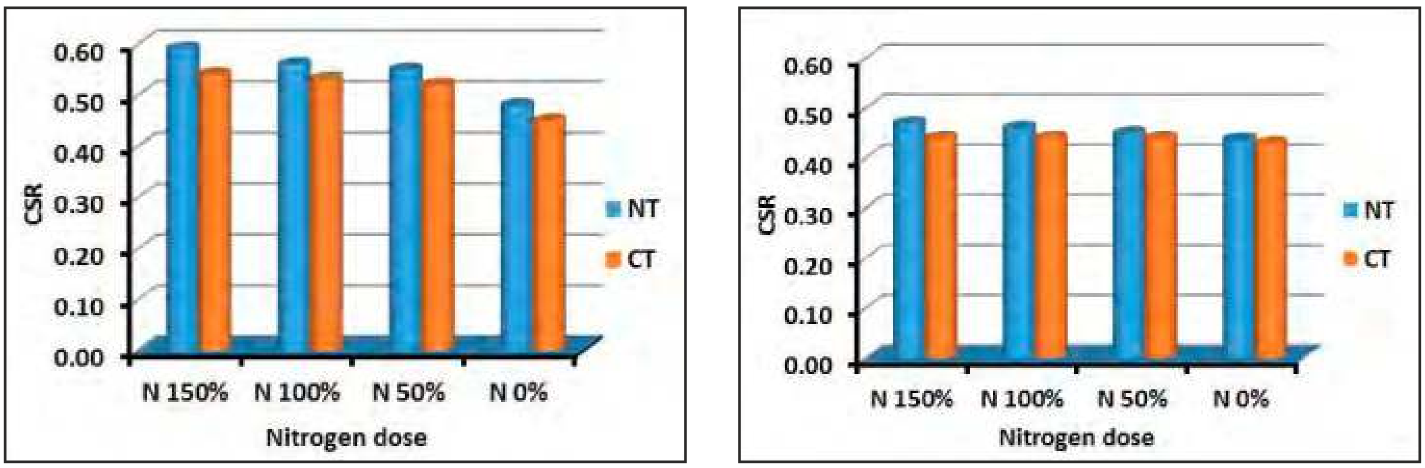


Fig. 2.5.4a Carbon stratification ratio under different tillage and cropping system

The average CSR in Maize-Wheat was 0.53, which was 18% higher than the Maize-Chickpea cropping system. Comparing the tillage system, the average CSR of No-tillage (NT) and conventional tillage (CT) were 0.50 and 0.47, respectively. Among the different nitrogen treatments, N150% showed higher CSR, followed by N100%, N50%, and N0% in both cropping systems. This trend indicates that the NT, Maize-wheat and N150% may expedite the accumulation of SOC in the surface layer because the C input is higher in the surface soil under these treatments (Fig. 2.5.4b)

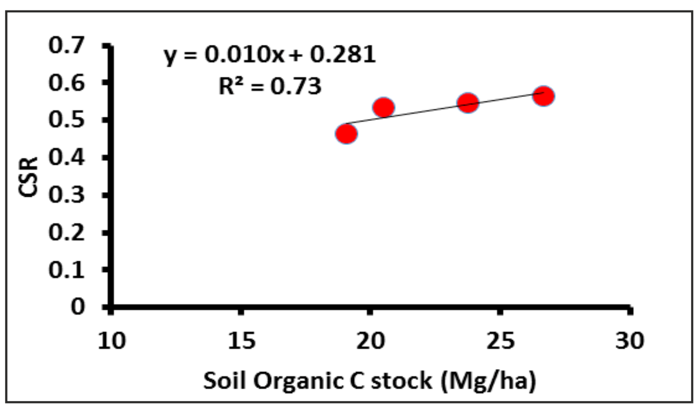


Fig. 2.5.4b Relationship between annual carbon input and CSR

Good linear relationships between soil carbon stock and CSR were observed. This indicates that an increase of carbon stock (input) leads to a direct increase of CSR, confirming the strong influence of aboveground carbon input for SOC accumulation in the topsoil layers.

2.5.5 Impact of conservation agriculture on crop yields and relationship with soil properties

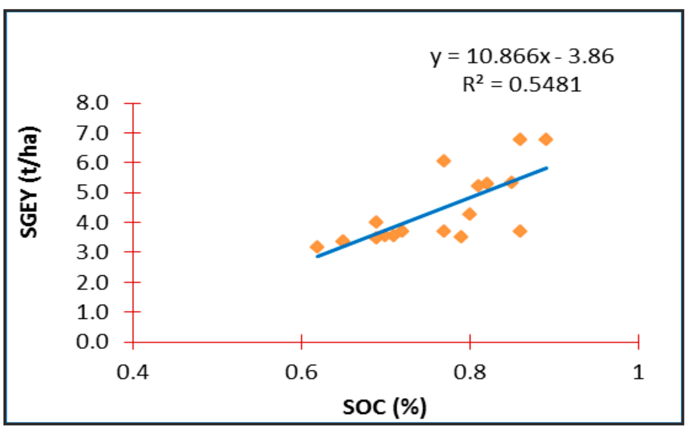
Crop yield parameters were recorded during 9th crop cycles and presented in Table 2.5.5. Grain yields of different crops were converted into soybean grain equivalent yield (SGEY) for comparing different cropping system. Tillage had no significant effect on the soybean grain equivalent yield (SGEY), whereas cropping system had a greater effect on SGE yield. Among various cropping system studied, maize-wheat had significantly higher yield (7401 kg/ha) followed by soybean-wheat (6432 kg/ha) under NT. Similar trend was observed under CT.

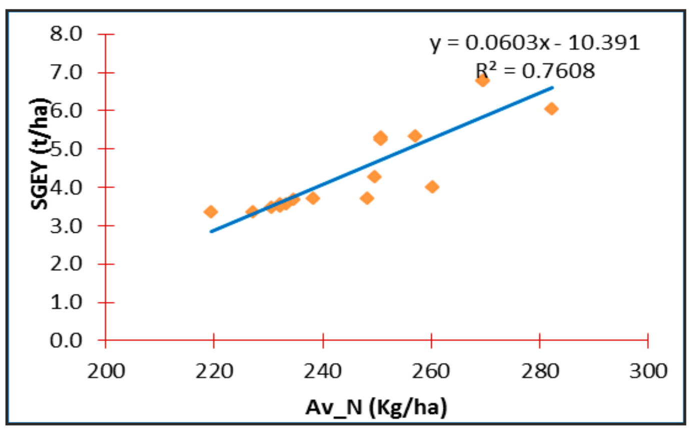
Table 2.5.5 Effect of different tillage and cropping system on soybean grain equivalent yield (kg/ha)

Row Labels	Grain yield	SGEY	Biomass Yield
Conventional Tillage with residue removed	**6030.3**	**4203.5**	**8535.0**
Maize-Gram	5249.5	5564.6	6439.4
Maize-Wheat	7136.4	3569.5	11404.0
Soybean-Wheat	5705.1	3476.3	7761.6
No-Tillage with residue retention	**6470.5**	**4515.1**	**9062.8**
Maize-Gram	5577.8	5767.8	6568.2
Maize-Wheat	7401.5	3899.2	10426.8
Soybean-Wheat	6432.2	3878.1	10193.5
Grand Total	**6250.4**	**4359.3**	**8798.9**

SGEY : Soybean grain equivalent yield, MSP : Minimum support price (Rs/q) in 2018-2019 for soybean Rs 3399; maize Rs 1700; wheat 1840; gram Rs 4620

The relationship between crop yields and various soil properties is presented fig. Relationship yield with soil organic, available N, P and K and mean weight diameter was estimated by determining the value of co-efficient of variation between soybean grain equivalent yield (SEGY) and different soil properties (Fig. 2.5.5 a to d). We observed that significant positive correlation between crop yield and soil properties.





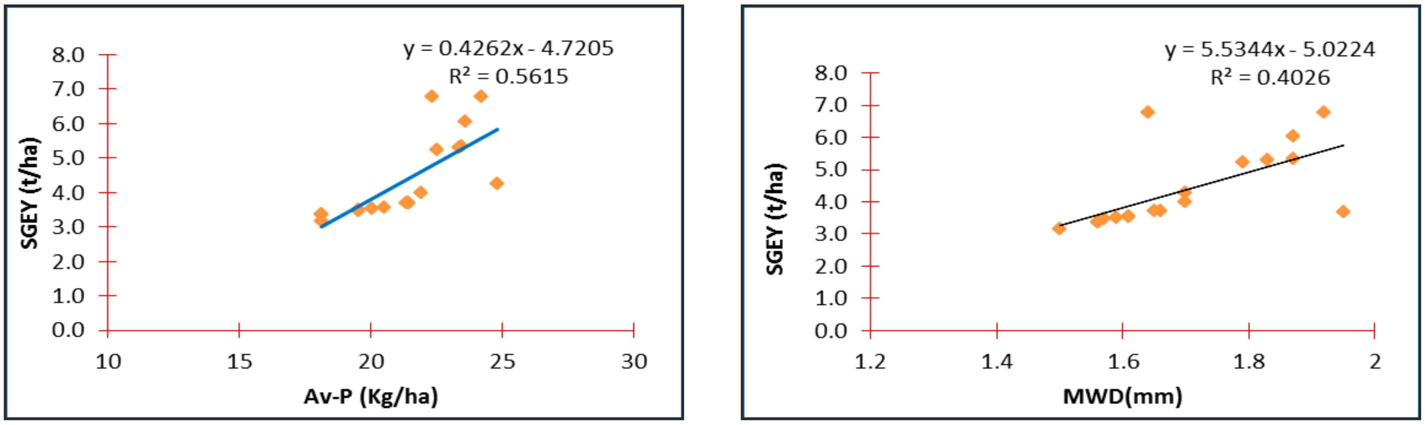


Fig. 2.5.5 Relation between soybean grain equivalent yield (a) SOC, (b) Av-N, (c) Av-P, and (d) MWD

2.5.6 Investigating crop water production function considering irrigation capacities and grain yield under different N application rate (Wheat cv GW 322)

The Agricultural Production Systems sIMulator model (APSIM) validated in a prior study on spring wheat (GW-322) was used to simulate yield, aboveground crop biomass (BM), and evapotranspiration under four irrigation capacities (ICs) (1, 2, 3, and 5 mm/day) with two irrigation methods (sprinkler and floods) and two nitrogen (N) application rates i.e. 120 and 150 kg ha^{-1} to develop crop water production function (CWPF) management scenarios. The CWPF expresses the relationship between crop yield and total seasonal irrigation and can be a useful tool for irrigation planning purposes. With this function decision makers can assess irrigation water needs to meet production targets or, conversely, estimate likely crop production for fixed volumes of water. Simulation results showed wheat yield increased with increase in ICs under both irrigation methods (Table 2.5.6). The relationship between grain yield (GY) and ICs for different nitrogen management is presented in Fig. 2.5.6 suggest that ICs affect crop yield substantially. The maximum GY was obtained under IC of 5 mm/day.

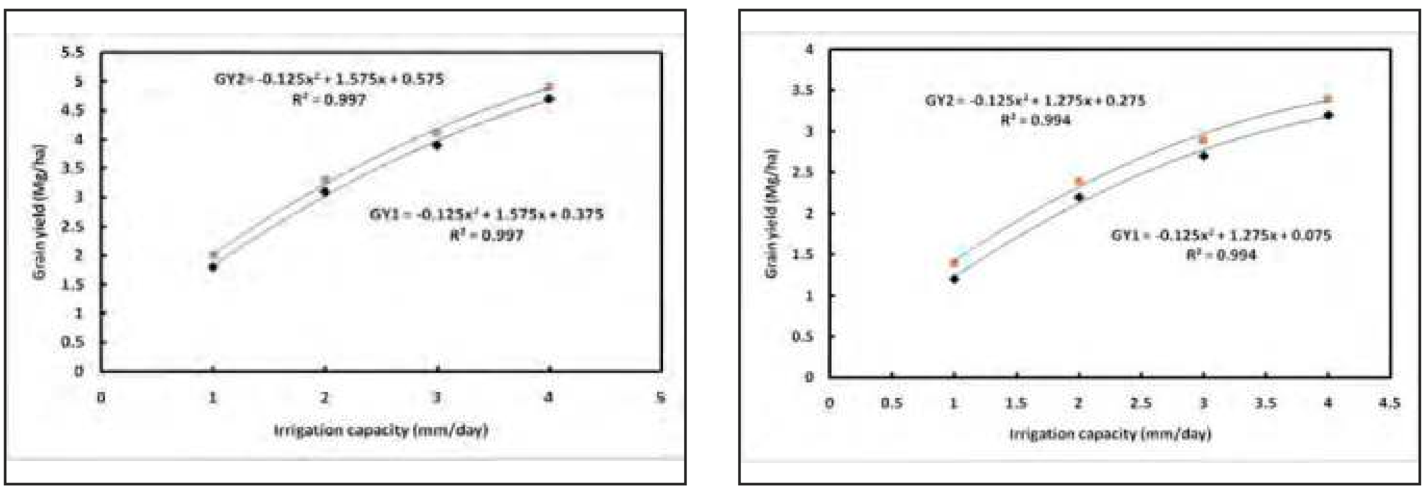


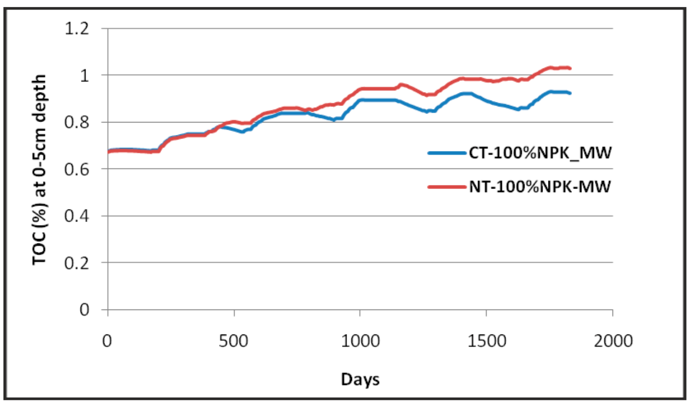
Fig. 2.5.6 Crop water production function under different irrigation capacities (IC) and N treatments. 5 irrigations (1+4), 4 irrigation (1+3) and 3 irrigations (1+2) and 2 irrigations (1+1) which are equivalent to 4, 3, 2, and 1 mm/day irrigation capacity (IC)-from CRI to grain filling. GY1 indicates yield under 120 N kg/ha; GY2 indicates 150 N kg/ha.

Table 2.5.6 Crop water production function under different irrigation capacities (IC, mm/day) and N treatments

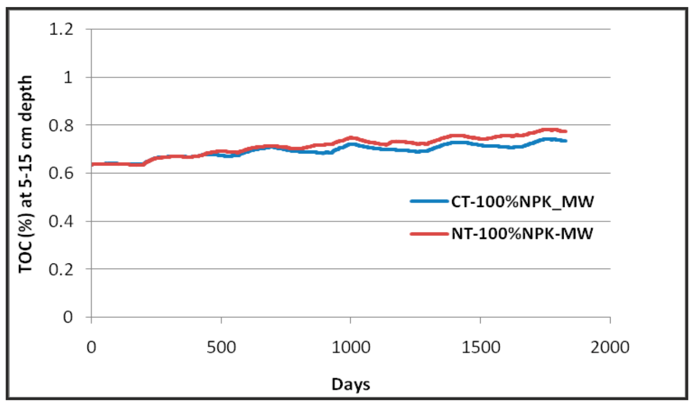
N (kg/ha)	Equation	R^2
Sprinkler Irrigation		
120	Grain Yield = $-0.125*IC^2+1.575*IC + 0.375$	0.997
150	Grain Yield = $-0.125*IC^2+1.575*IC + 0.575$	0.997
Flood Irrigation		
120	Grain Yield = $-0.125x^2+1.275x + 0.075$	0.994
150	Grain Yield = $-0.125x^2+1.275x + 0.025$	0.994

2.5.7 Modeling impact of different tillage systems on soil organic carbon

Tillage affects variety of biophysical processes that affect the environment, such as greenhouse gas emissions or soil carbon sequestration and can influence various forms of soil degradation. Presently, No-tillage (NT) is being promoted as a strategy to mitigate greenhouse gas (GHG) emissions. In general, NT tend to increase SOC storage through a reduced decomposition and consequently reduces GHG emissions. This study was undertaken to study the soil carbon dynamics under the conventional tillage (CT) and no-tillage system (NT) in maize-wheat rotation over the six years. Results showed that model is satisfactorily predicting the total organic (TOC) in both the depth. Higher TOC were reported in NT system in both depth after the third crop cycles onwards. At the end of six crop cycles, 18% and 11% higher TOC carbon was observed in NT compared to CT system. (Fig. 2.5.7)



(a)

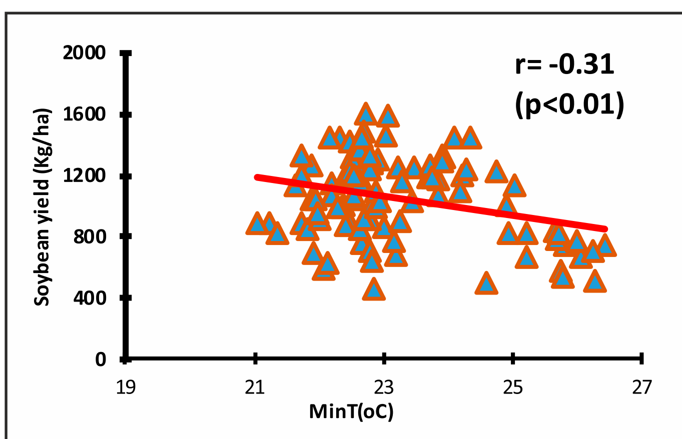


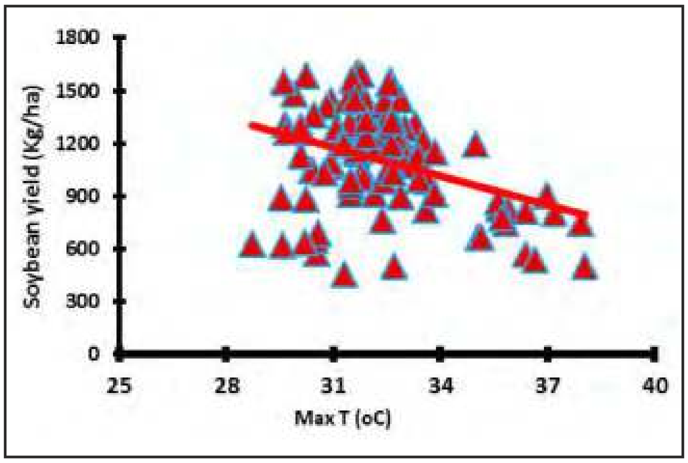
(b)

Fig. 2.5.7 Impact of tillage system on total soil organic carbon (a) 0-5 cm) (b) 5-15 cm in Maize-wheat rotation

2.5.8 Climate variability and soybean grain yields in Madhya Pradesh state

The Intergovernmental Panel on Climate Change (IPCC) has confirmed that there is substantial evidence that the mean and extremes of climate variables such as temperature and rainfall, have been changing in recent decades, and will have a significant effect on crop yield. To determine the relationship between climatic variability and soybean crop yields (kg/ha) in central India, a correlation analysis was performed. (Fig 2.5.8 a, b, c)





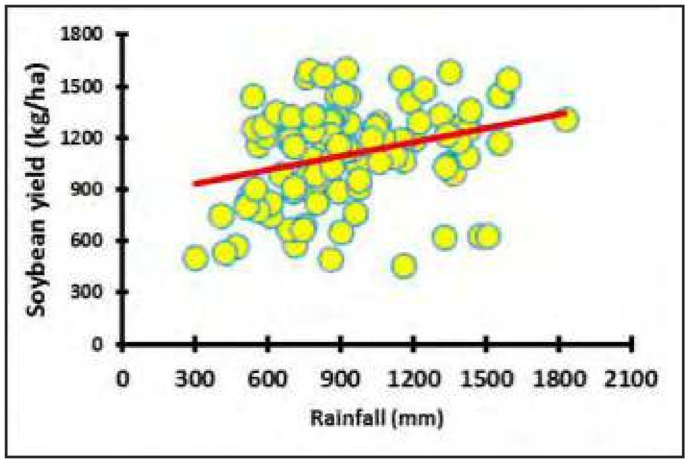
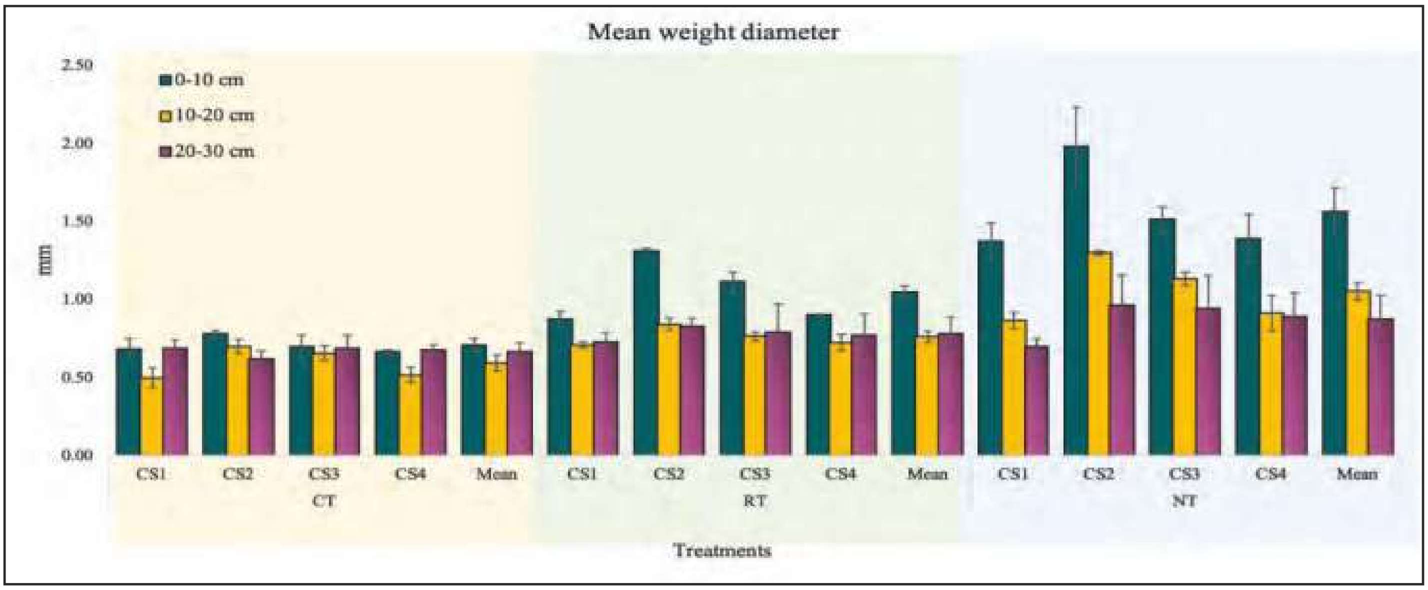


Fig. 2.5.8 Correlation between (a) Min T, (b) Max T and (c) rainfall and soybean grain yields in the study area

The meteorological data considered in this study for the month of June, July, August, and October. The yield data of the soybean crop was used for Dewas, Dhar, Balaghat, Betul, Bhind, and Bhopal districts. The result revealed that there was a negative and significant relationship between the temperature and soybean yield in central India. However, a positive and significant correlation was found between soybean yield and rainfall.

2.5.9 Impact of conservation agriculture on soil aggregation, water stable aggregates and soil organic carbon

Soil structure is defined by arrangement and organisation of individual soil particles of sand, silt and clay in a definite pattern by several binding agents. Soil structural stability or aggregate stability is defined by the soil capacity to maintain the arrangement and association between soil particles when exposed to various stresses. The tillage (T) and cropping systems (CS) exerted significant ($P<0.05$) influence on soil aggregation which is represented through mean weight diameter (MWD) of the soil aggregates after eight crop cycles (Fig. 2.5.9a). In fact, RT and NT recorded higher MWD values than CT in all the soil depths (D). The MWD value in RT was 48.8, 28.16 and 17.26 percent higher than CT under 0-10 cm, 10-20 cm and 20-30 cm soil depth respectively whereas NT showed 121.35, 77.66 and 31.37 percent increase in MWD than those of CT under 0-10 cm, 10-20 cm and 20-30 cm, respectively. Therefore, the decreasing order of MWD values in the tillage treatments was NT > RT > CT. Higher MWD and WSA values in NT and RT as compared to CT revealed better soil aggregation and aggregate stability under conservation tillage plots. However, under 20-30 cm of soil depth, only the MWD values in NT had a significant edge over in CT. Out of different cropping systems, MWD in soybean-pigeon pea (2:1) (1.98 mm) was highest followed by maize-gram (1.37 mm). Significant differences of MWD due to the tillage effects were more prominent under 0-10 cm and 10-20 cm depth ($P<0.05$). The correlation study between MWD and SOC revealed highly significant positive correlation ($R=0.66^{***}$; $P<0.01$). The interaction effects of T X CS, D X T and D X CS were highly significant ($P<0.05$), revealing the strong influence of tillage practices, soil depth and the cropping systems on soil aggregation. In case of aggregate stability against water erosion, in general, NT recorded highest WSA (73.73%) followed by RT (72.28%) and CT (66.00%). NT performed at par with RT, however, showing better aggregate stability than CT under 0-10 cm and 10-20 cm. However, there were no significant difference of WSA between tillage treatments under 20-30 cm. The higher the WSA values, the better the aggregate stability towards water erosion. High WSA has a large influence on water infiltration rate and soil hydraulic conductivity. WSA was sensitive to increased soil depth as significant difference of WSA could be found in 0-10 cm soil depth ($P<0.05$) (Fig. 2.5.9b). The diversified cropping systems could not significantly affect the aggregate stability. Moreover, there were no significant interaction effects of tillage, soil depth and cropping system. The significant correlation of MWD and WSA with SOC indicated the promotion of soil aggregation by soil organic matter through bonding of clay-polycations-organic matter-polycations-clay complexes and altering the hydrophobicity of soil particle. Organic matter (root fragments) and presence of mycorrhizal hyphae can also promote better soil aggregation in conservation tillage. In addition to it, lesser soil disturbances in RT and NT coupled with the addition of crop residues (Plate 2.5.9) than CT also contributed to higher MWD and WSA under these treatments. Lower values of MWD and WSA in CT depicted higher chances of physical breakdown of soil aggregates that might lead to higher oxidation rate of SOC which is reflected by lower SOC in CT than NT and RT. Due to continuous tillage operations carried out in CT destructs the soil aggregates and soil organic matter is redistributed within the soil profile The positive linear correlation between SOC and MWD proved the effectiveness of increased SOC in minimizing the slaking and destruction of soil aggregates when exposed to water. Higher SOC (Fig. 2.5.9c), less disturbances and residue retention in soil under RT and NT could increases fungal hyphae and other soil microbes that can produce soil cementing agents such as exopolysachharides that enhances soil aggregation. In general, it is shown that RT and NT helped in constructing better soil aggregation and structural stability than CT, thus making it less susceptible to wind and water erosion and highly desirable for sustaining agricultural productivity.

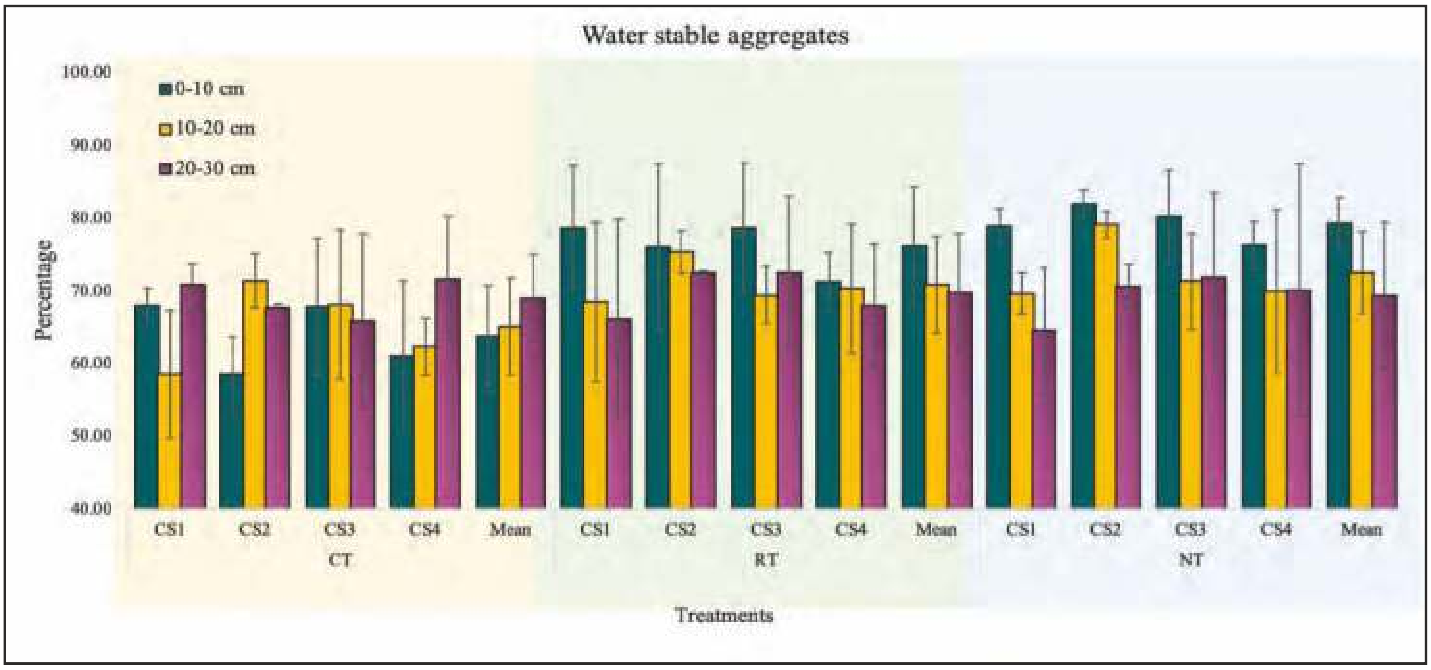


CT- conventional tillage; RT-Reduced Tillage; NT-No-tillage

CS1: Soybean-wheat; CS2: Soybean+Pigeon pea (2:1); CS3: Maize-gram; CS4: Maize+P.pea (2:1)

Fig. 2.5.9a Effect of different tillage on soil aggregation after 8 crop cycles

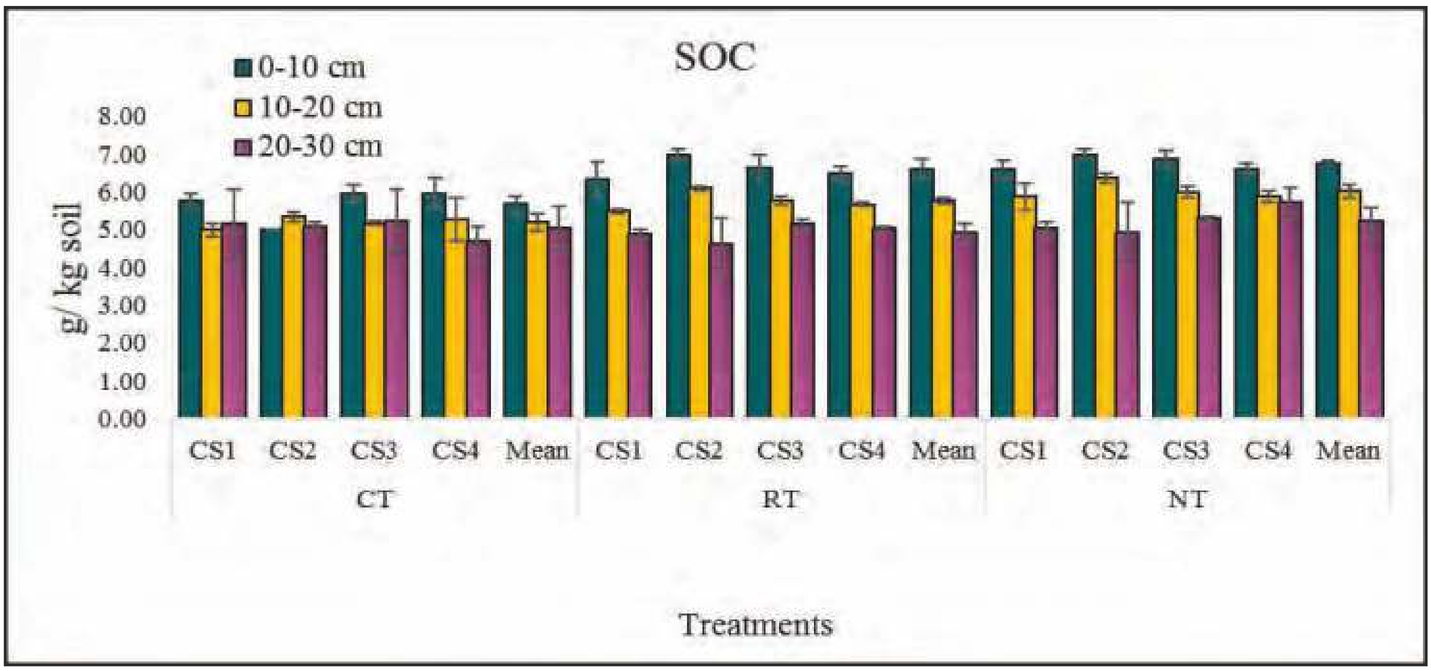
Plate 2.5.9 Crop residue retention/addition under reduced tillage and no-tillage system



CT- conventional tillage; RT-Reduced Tillage; NT-No-tillage

CS1: Soybean-wheat; CS2: Soybean+Pigeon pea (2:1); CS3: Maize-gram; CS4: Maize+P.pea (2:1)

Fig. 2.5.9b Effect of different tillage on water stable aggregates (WSA) after 8 crop cycles



CT- conventional tillage; RT-Reduced Tillage; NT-No-tillage

CS1: Soybean-wheat; CS2: Soybean+Pigeon pea (2:1); CS3: Maize-gram; CS4: Maize+P.pea (2:1)

Fig. 2.5.9c Effect of different tillage on soil organic carbon (SOC) after 8 crop cycles

2.5.10 Impacts of conservation agriculture on runoff and soil loss under different cropping system in vertisols:

A new project was initiated from July 2019 with two main objectives i.e. (i)To determine the run-off and soil loss under different tillage and cropping systems. (ii) To study the effect of runoff and soil loss on soil properties and crop productivity. Under this project two cropping systems namely soybean-wheat and maize-chickpea will be evaluated for runoff, soil loss and crop productivity. For this project total five treatments (i) Conventional Tillage (ii) Reduced Tillage + 30% Residue (iii) Reduced Tillage + 60% Residue (iv) No- Tillage + 30% Residue (v) No-Tillage + 60% Residue were laid out in Randomised block design with three replication (Table 2.5.10). During *kharif* 2019 soybean and maize crops were sown to nullify soil fertility gradient of the experimental site. The experimental site was reshaped and multi-slot divisors with runoff collecting tanks were fixed at experimental site. During *rabi* season wheat and chick pea crops were planted in to the respective plots and recording of various crop growth parameters is going on (Plate 2.5.10 a & b).

Table 2.5.10 Biological and grain yield of soybean

Treatments	Biological yield (t/ha)	Grain yield (t/ha)	HI
Conventional Tillage	4.83±0.71	2.1±0.19	0.44±0.025
Reduced Tillage + 30% residue retention	4.76±0.48	2.09±0.18	0.44±0.017
Reduced Tillage + 60% residue retention	4.78±0.59	2.11±0.19	0.44±0.021
No Tillage + 30% residue retention	4.92±0.67	2.09±0.23	0.42±0.003
No Tillage + 60% residue retention	4.46±0.25	1.92±0.19	0.43±0.04

Plate 2.5.10a Chickpea Crop

Plate 2.5.10b Wheat Crop

2.5.11 Effect of carbon and nitrogen addition on soil carbon mineralization and priming under different temperature and moisture regimes

The application of crop residues and other organic materials with the purpose of improving soil fertility and SOC status can also promote native SOC mineralization via the 'priming' effect. The ^{13}C labelled glucose and maize straw (natural abundance ^{13}C) was used to differentiate C mineralization from C substrate and native SOC. The incubation study aimed to gain insight into the effect of soil moisture (field capacity and 80% FC) and mineral N availability on the priming effect of two C substrates (stable ^{13}C-labelled glucose and maize straw) with contrasting biodegradability under different temperatures (30, 40°C). The results indicated addition of carbon substrate increased priming of SOC at all temperatures and moisture contents (Fig. 2.5.11a). Nitrogen application reduced the C priming effect of both C substrates at all temperature and moisture levels. This reduction was more prominent with both C substrate in the 80% field capacity soil. Further priming of SOC increased with increase in temperature.

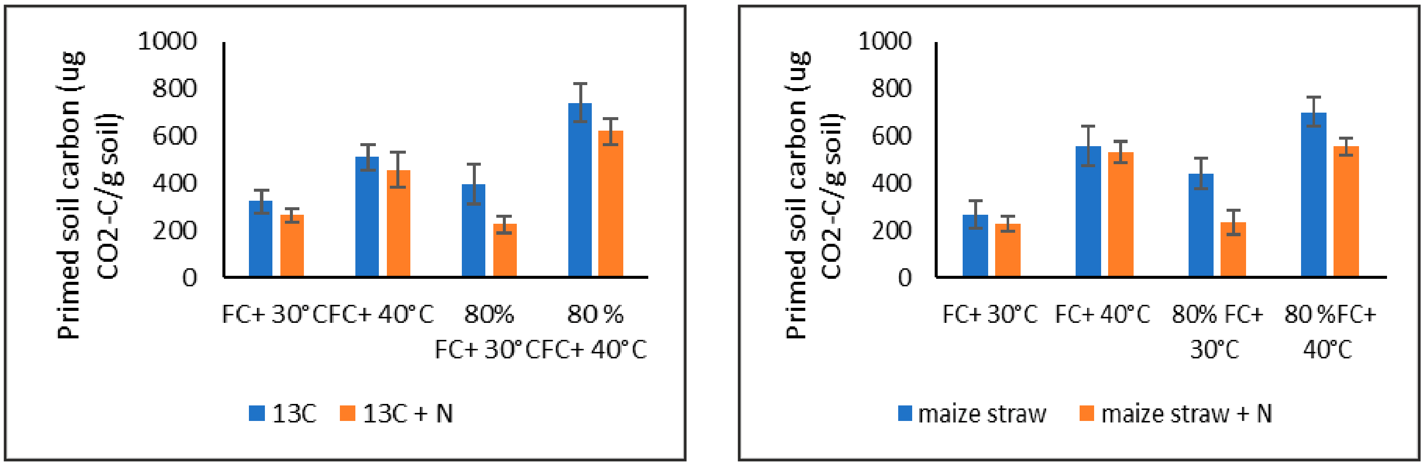
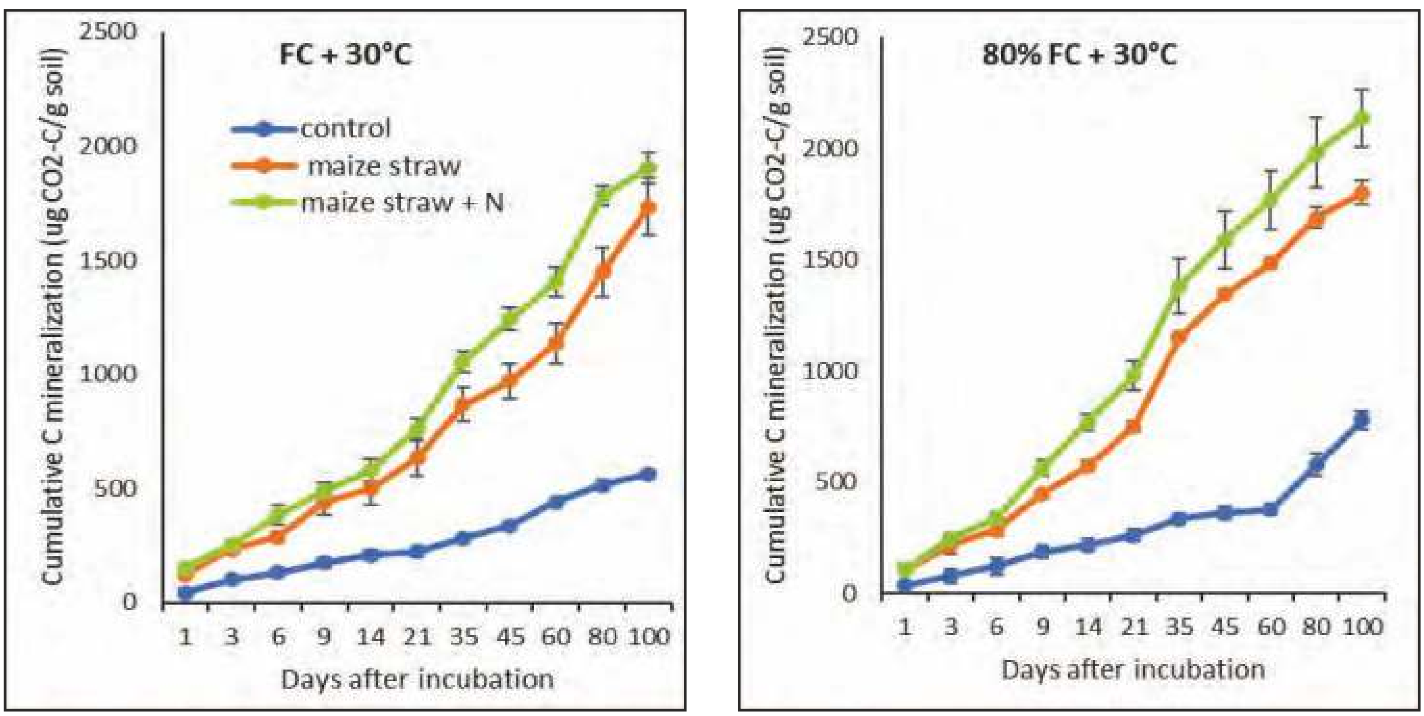


Fig. 2.5.11a Effect of carbon substrate and external nitrogen addition on soil carbon priming under different temperature and moisture regime.

The different effect of inorganic N addition was observed on cumulative SOC mineralization for different C substrate, moisture regimes and temperatures over 100 days incubation period. N addition with labile C (13C labelled glucose) decreased mineralization of SOC across all temperature and moisture. However, N addition with maize straw increased mineralization of SOC across all temperature and moisture. SOC mineralization was greater at 80% field capacity than field capacity moisture content across temperatures and C, N treatments. Temperature sensitivity (Q10) of SOC mineralization decreased with increase in temperature decrease in moisture content of soil (Fig. 2.5.11b and c).



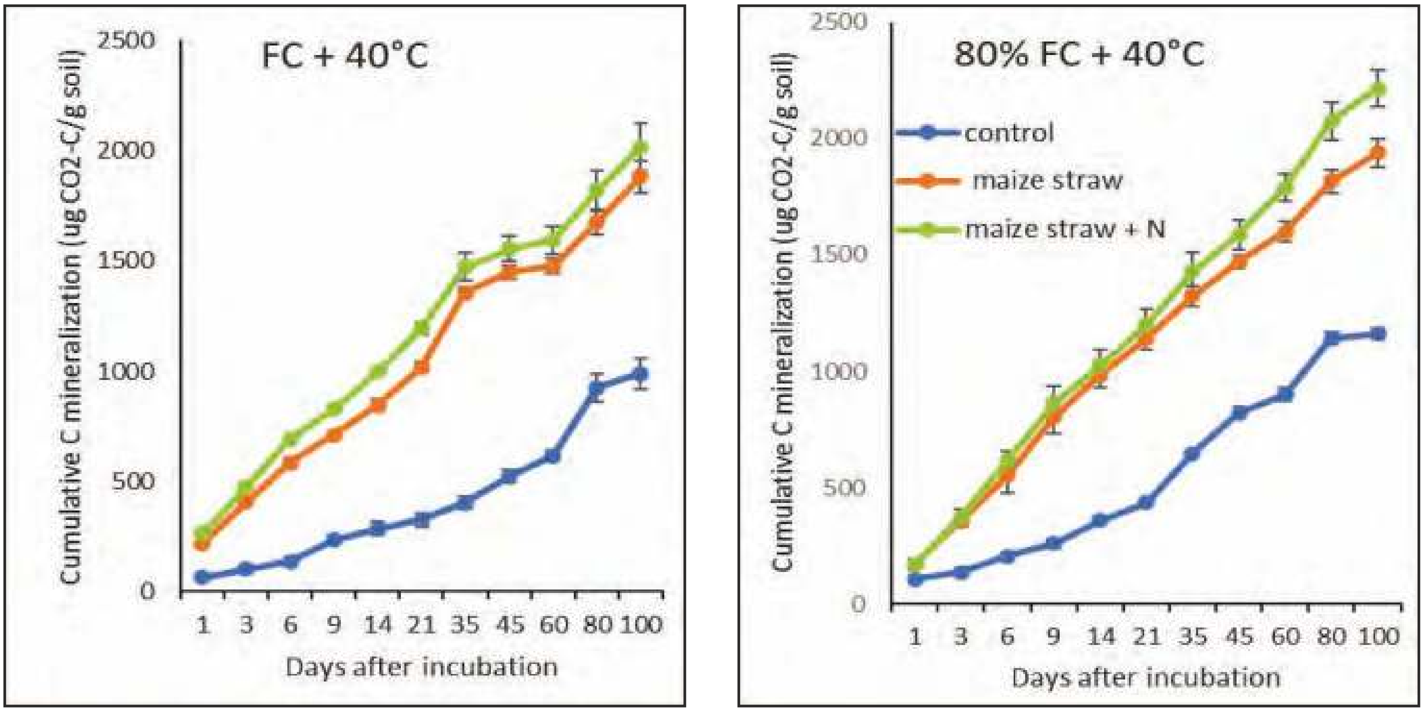


Fig. 2.5.11b Dynamics of cumulative carbon mineralization under different moisture regimes, temperatures, C and N additions over 100 days of incubation. The plotted values are average of three replicates and standard errors are represented by error bars.

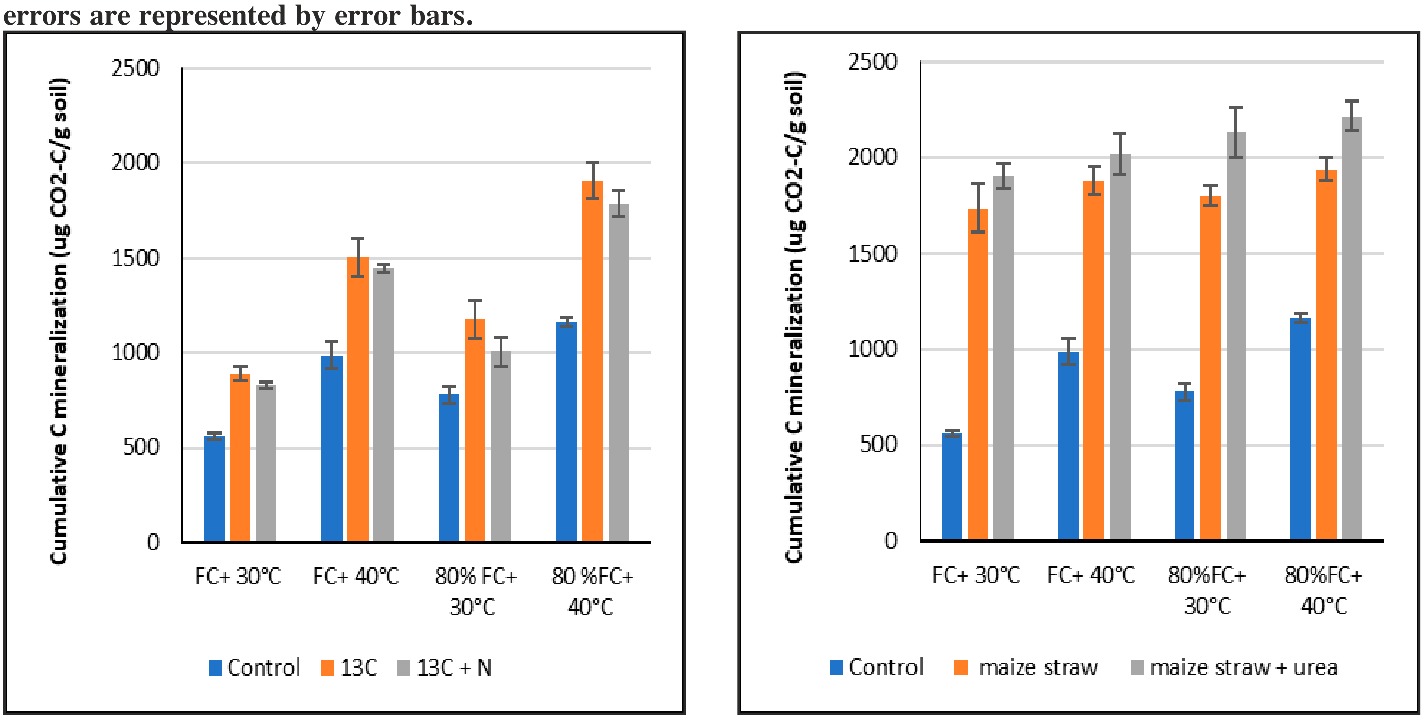


Fig. 2.5.11c Cumulative carbon mineralization under different moisture regimes, temperatures, C and N additions over 100 days of incubation. The plotted values are average of three replicates and standard errors are represented by error bars.

2.5.12 Assessment of agricultural vulnerability of Madhya Pradesh

The study indicated that the overall agriculture vulnerability of the Madhya Pradesh districts is projected to decrease towards mid-and end-century as compared to the current conditions for both emission scenarios of RCP 4.5 and RCP 8.5. Districts vulnerability under RCP 8.5 scenario was found to be lower as compared to RCP 4.5 scenario. The projected decrease in vulnerability towards end-century is more than that of mid-century for both the climate scenarios. The main contributing factors in reducing the agriculture vulnerability are increase in yield for rice and wheat crops, increase in fertilizer use, cropping intensity and irrigated area (Fig. 2.5.12).

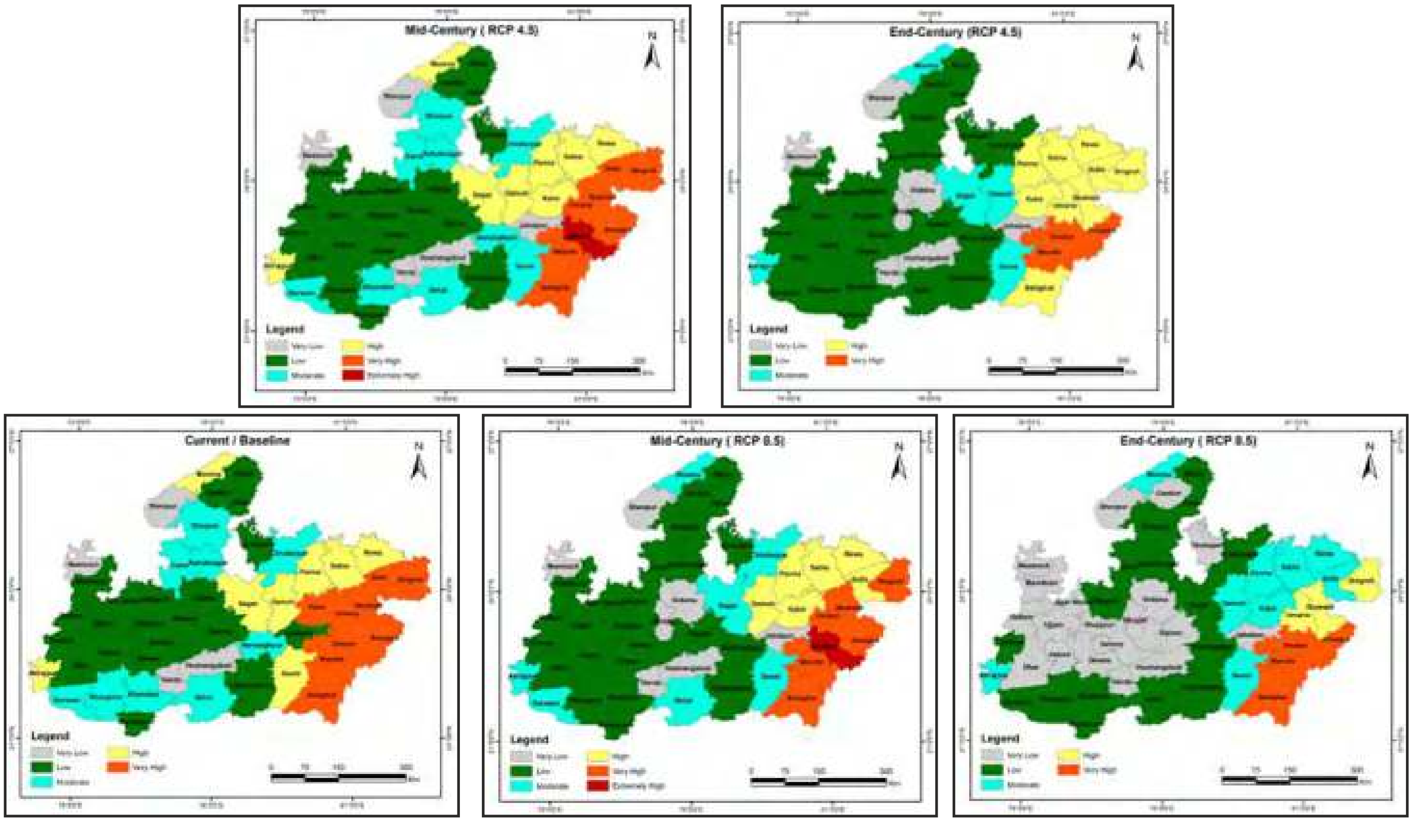


Fig. 2.5.12 Agricultural vulnerability maps for all districts of Madhya Pradesh

Theme-III: Microbial Diversity and Genomics

2.6 Microbial Diversity and Genomics

2.6.1 Bioremediation of heavy metal from compost using microbial inoculants

Rapid expansion of urbanization and agriculture intensification are accompanied with generation of huge bio-waste containing heavy metals, pathogens and other contaminants. To improve the compost quality present investigation evaluated the ability of selected microbial isolates for removal of heavy metal from mature compost and to develop bio-filtration strategies utilizing them for expulsion of substantial heavy metals from decomposed manure. Various microbial-inoculants such as fungi, yeast and bacterial cultures were exposed under different concentration of Cd and Cr (0-50ppm), Zn and Pb (0-400ppm), and Ni and Cu (0-100ppm) to study the growth, minimum inhibitory concentration (MIC) and heavy metal removal capacity of microbes under segregated municipal solid waste compost. Among isolated fungi, *T. Viride* and *A. heteromorphus* (Plate 2.6.1) was promising biomaterial for removal of heavy metals followed by yeast (*Saccharomyces cerevisiae*) and bacteria (*Pseudomonas sp., Kocuria sp. and Serratia sp.*). These microbial inoculums may be used as bio-filter to remove heavy metals from compost and improve the quality of compost. It was observed that all these mesophilic fungi are highly susceptible to Cd and Cr at 5 and 10 ppm. Further, it was observed that these fungi are highly susceptible to Cu and Ni at 25 and 50 ppm, and these fungi are highly susceptible to Zn and Pb at 400 ppm (Table 2.6.1a, b, c and Fig.2.6.1a). Determination of MIC indicates the lowest concentration at which organisms isolates failed to grow.

In order to understand the chemical nature of the adsorbed surface of these fungi, it has been analyzed by Fourier Transform Infrared spectrophotometer and all the bands were documented. It was found that the functional groups like amide (-NH_2), hydroxyl (-OH), carboxylate anions (-COO), carbonyl groups (-CO), C-F, and C-Br were responsible for biosorption of heavy metals by fungi through chelation mechanism with heavy metals (Fig.2.6.1b). We found that *T.viridi* and *Aspergillus flavus* were capable to remove the highest amount of Pb (>40%) and Cd (20%) and Ni (> 30%).

The most essential constituent of bacterial cell is exo-polysaccharide (EPS), having ion sequestration capability, thus, in the present study four bacterial strains were used, 3 strains showed EPS production. The maximum amount of EPS was estimated in *Serratia sp*. (16.2 mg ml^{-1}). This may be useful for better bio-filtration.

Table 2.6.1a Growth of different living fungi in liquid media containing 0–50 ppm of Cd, and Cr heavy metals

Concentration	*T. viride*	*A.heteromorphus*	*R.pusillus*	*A.flavus*
Cadmium (Cd)		**Dry weight (g)**		
0	0.851	0.892	0.213	0.210
5	0.742	0.605	0.210	0.128
10	0.674	0.540	0.201	0.116
20	0.371	0.370	0.055	0.097
25	0.345	0.368	0.048	0.092
50	0.311	0.310	0.032	0.087
Chromium (Cr)		**Dry weight (g)**		
0	0.782	0.912	0.311	0.138
5	0.762	0.703	0.218	0.137
10	0.700	0.618	0.211	0.133
20	0.434	0.480	0.152	0.114
25	0.304	0.300	0.059	0.090
50	0.290	0.224	0.047	0.082

Table 2.6.1b Growth of different living fungi in liquid media containing 0–100 ppm of Ni and Cu heavy metals

Concentration	*T. viride*	*A.heteromorphus*	*R.pusillus*	*A.flavus*
Nickel (Ni)		**Dry weight (g)**		
0	0.699	0.790	0.103	0.150
5	0.612	0.643	0.124	0.143
10	0.592	0.600	0.122	0.112
20	0.571	0.563	0.085	0.108
25	0.476	0.510	0.068	0.092
50	0.202	0.298	0.037	0.056
75	0.191	0.207	0.023	0.013
100	0.172	0.192	0.006	0.007

Concentration	*T. viride*	*A.heteromorphus*	*R.pusillus*	*A.flavus*
Copper (Cu)		**Dry weight (g)**		
0	0.629	0.790	0.211	0.150
5	0.602	0.689	0.198	0.143
10	0.590	0.512	0.183	0.114
20	0.560	0.500	0.115	0.108
25	0.466	0.443	0.086	0.087
50	0.224	0.202	0.059	0.071
75	0.201	0.021	0.036	0.042
100	0.162	0.010	0.009	0.014

Table 2.6.1c Growth of different living fungi in liquid media containing 0–400 ppm of Pb and Zn heavy metals

Concentration	*T. viride*	*A.heteromorphus*	*R.pusillus*	*A.flavus*
Zinc (Zn)		**Dry weight (g)**		
0	0.972	0.890	0.739	0.854
10	0.879	0.778	0.672	0.797
20	0.832	0.723	0.531	0.683
40	0.780	0.681	0.476	0.551
80	0.776	0.552	0.318	0.453
160	0.511	0.470	0.255	0.329
320	0.421	0.311	0.246	0.206
400	0.183	0.159	0.114	0.103
Lead (Pb)		**Dry weight (g)**		
0	0.845	0.789	0.593	0.907
10	0.794	0.712	0.519	0.891
20	0.713	0.691	0.436	0.840
40	0.687	0.616	0.367	0.765
80	0.605	0.575	0.292	0.712
160	0.528	0.491	0.158	0.533
320	0.422	0.237	0.096	0.426
400	0.286	0.105	0.043	0.253

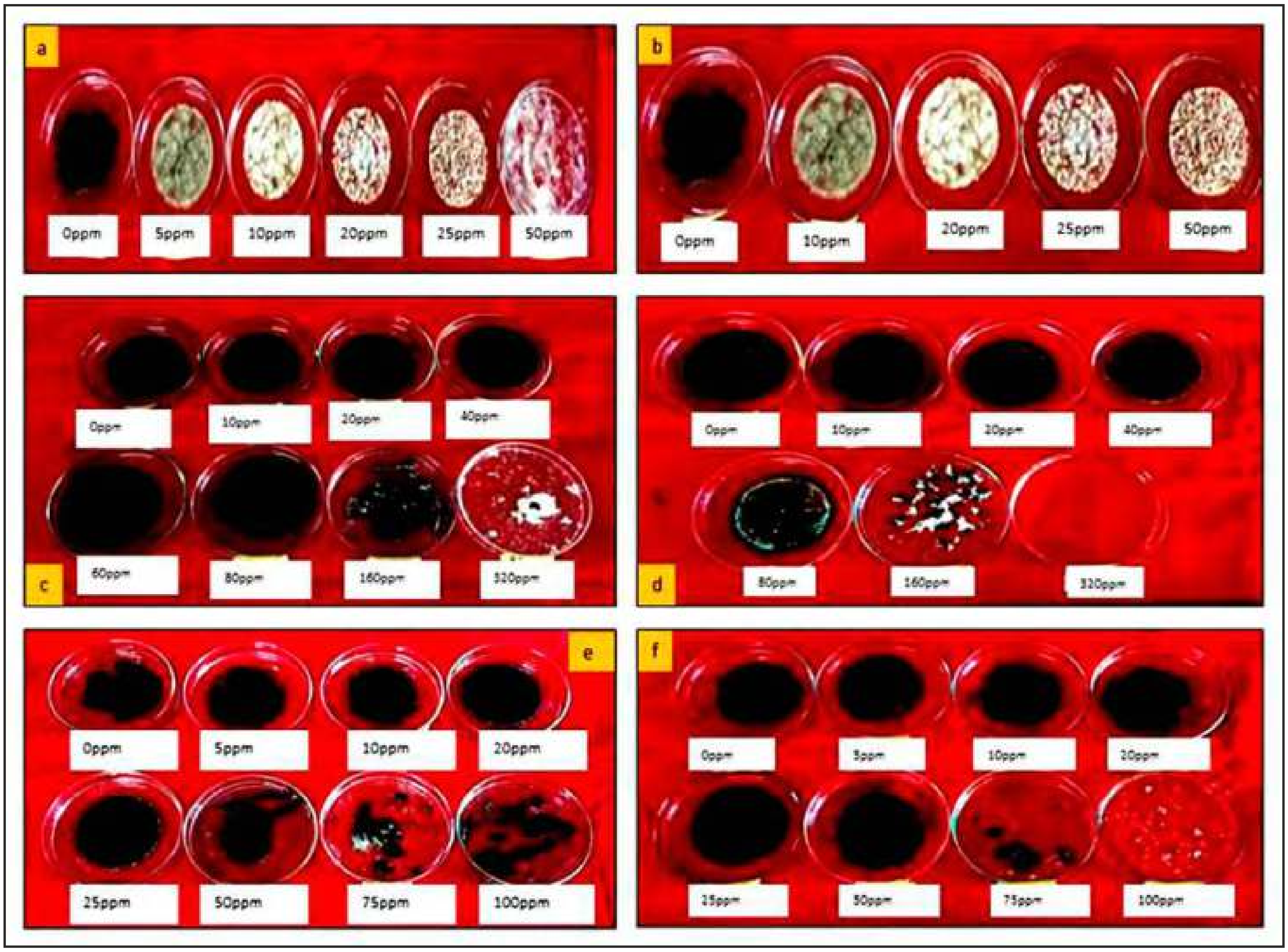


Plate 2.6.1 Effect of different doses of heavy metal on the growth of *Aspergillus heteromorphus*

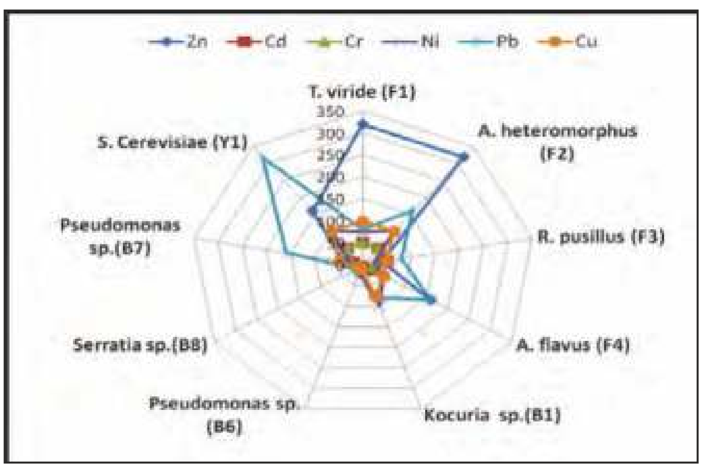


Fig. 2.6.1a (i) Cadmium (Cd) (ii) Chromium (Cr) (iii) Zinc (Zn) (iv) Lead (Pb) (v) Nickel (Ni) (vi) Copper (Cu)

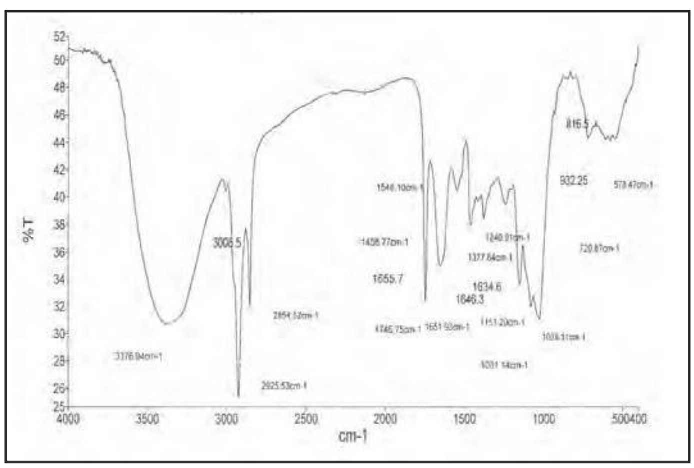


Fig. 2.6.1b Minimum inhibitory concentration (μg ml^{-1}) of heavy metals against living fungi, bacteria and yeast

2.7 AINP on Soil Biodiversity and Biofertilizers

2.7.1 Microbial inoculants for non-leguminous forestry plants

Root nodules of *Casuarina equisetifolia* and *Alnus nitida* were collected from two districts of Himachal Pradesh i.e. Solan (Kunihar, Nalagarh and Nauni) and Kullu (Patlikuhl, Manali and Bajaura), respectively. Lobes of the harvested nodules were cleaned thoroughly with tap water and surface sterilized by soaking in 30% (v/v) H_2O_2 for 15-20 minutes. The lobes were then rinsed several times with sterile distilled water and aseptically crushed using sterile pestle and mortar. The resulting suspension was then streaked on different media to isolate actinorhiza lisolates. About 33 isolates were obtained, out of which 10 isolates exhibited high plant growth promoting traits. These strains were evaluated for their growth promotion of *Casuarina equisetifolia* and *Alnus nitida*. The isolate CG1 significantly increased the shoot (49%) and root length (59%) of *Casuarina equisetifolia*. Similarly, the isolate ANG11 improved shoot (56%) and root length (56%) of *Alnus nitida* over uninoculated control (Plate 2.7.1). Both isolates will be further explored for developing microbial inoculants for forestry plants.

Plate 2.7.1 Effect of *Actinorhizal sp* on growth of forestry plants *Casuarina equisetifolia* and *Alnus nitida*

2.7.2 Activities under India UK Nitrogen Fixation Centre (IUNFC)

Metagenomic analysis of endophytic community of pigeon pea was carried out to identify the nodule inhabiting microbial communities. Total DNA was extracted from the nodules and both bacterial and fungal communities were analysed by sequencing V3-V4 region of the 16S rRNA gene and ITS region respectively. DNA sequencing was carried out using allumina MiSeq through paired end library construction. Bacterial library showed that Proteobacteria were the most abundant phyla, covering up to 45–80% of the total species. Cyanobacteria were the second major phyla followed by Verrucomicrobia and Firmicutes. Among N fixing bacteria, *Phaseolus acutifolius* and *Bradyrhizobium* were most abundant ones followed by Ensifer. The presence of non-nitrogen fixing microbial communities in nodules of pigeon pea suggests that these bacteria probably provide favourable condition for nitrogen fixers. Among fungi, Ascomycota covered 39–78% followed by Basidiomycota. The dominant fungal species were Fusarium and Malassezia, Ceratobasidium, Kluyveromyces, Penicillium and Aspergillus (Fig. 2.7.2a and b).

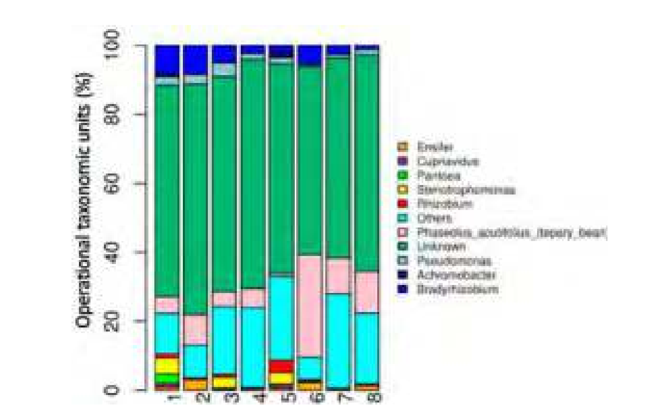


Fig. 2.7.2a Bacterial OTUs based on V3-V4 region amplification library in pigeon pea nodule

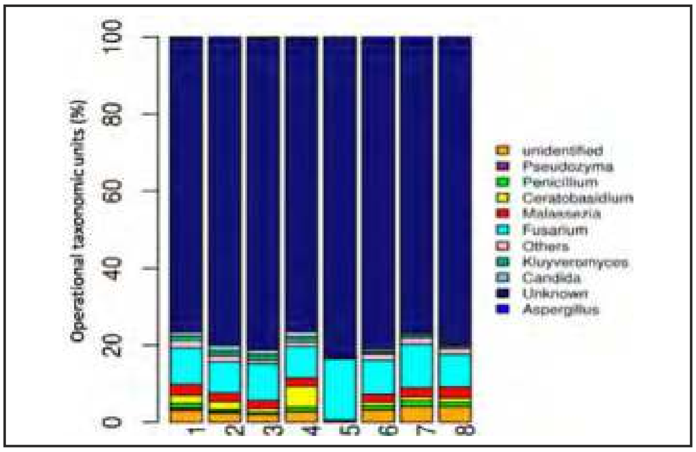


Fig. 2.7.2b Fungal OTUs based on ITS library in pigeon pea nodules

2.7.3 Phosphorus mineralization potential of phosphate solubilizing bacteria in response to long term fertilizer application in a tropical vertisol

This experiment envisages unravelling phosphorus (P) mineralization potential of soil under long term fertilizer application. The study was based on hypotheses that long term fertilizer application influences P mineralization, which in turn depends on the nutritional status, minerals and abundances of phosphate solubilising bacteria. To examine these hypotheses, experiments were carried out using soils from 50 years long term fertilizer experimental fields. Treatments included fallow (no fertilizer, no crop), control (no fertilizer, with crop), recommended dose of fertilizers N, NP, NPK and NPK + FYM. Efficient PSB were isolated to evaluate their P mineralization potential using $Ca_3(PO_4)_2$, rock phosphate and sodium phytate as P sources. P mineralization rate was highest in NP and lowest in fallow (Fig. 2.7.3). Abundance of total eubacteria and PSB was high in NP and low in fallow. The 16S rRNA sequence submitted to GenBank was assigned with a accession number MN174806.1 and referred as Paraburkholderiasp strain igkv1. The PSB isolates mineralized ($p<0.05$) $Ca_3(PO_4)_2$, rock phosphate as well as sodium phytate. Acid phosphatase activity was highest in $Ca_3(PO_4)_2$ and lowest in sodium phytate. Study concludes that PSB mineralized P sources by reducing pH of the medium as well as through secretion of acid phosphatase. Mineralization of P in vertisol is regulated by the abundance of PSB and P mineral fractions under long term fertilizer application practices.

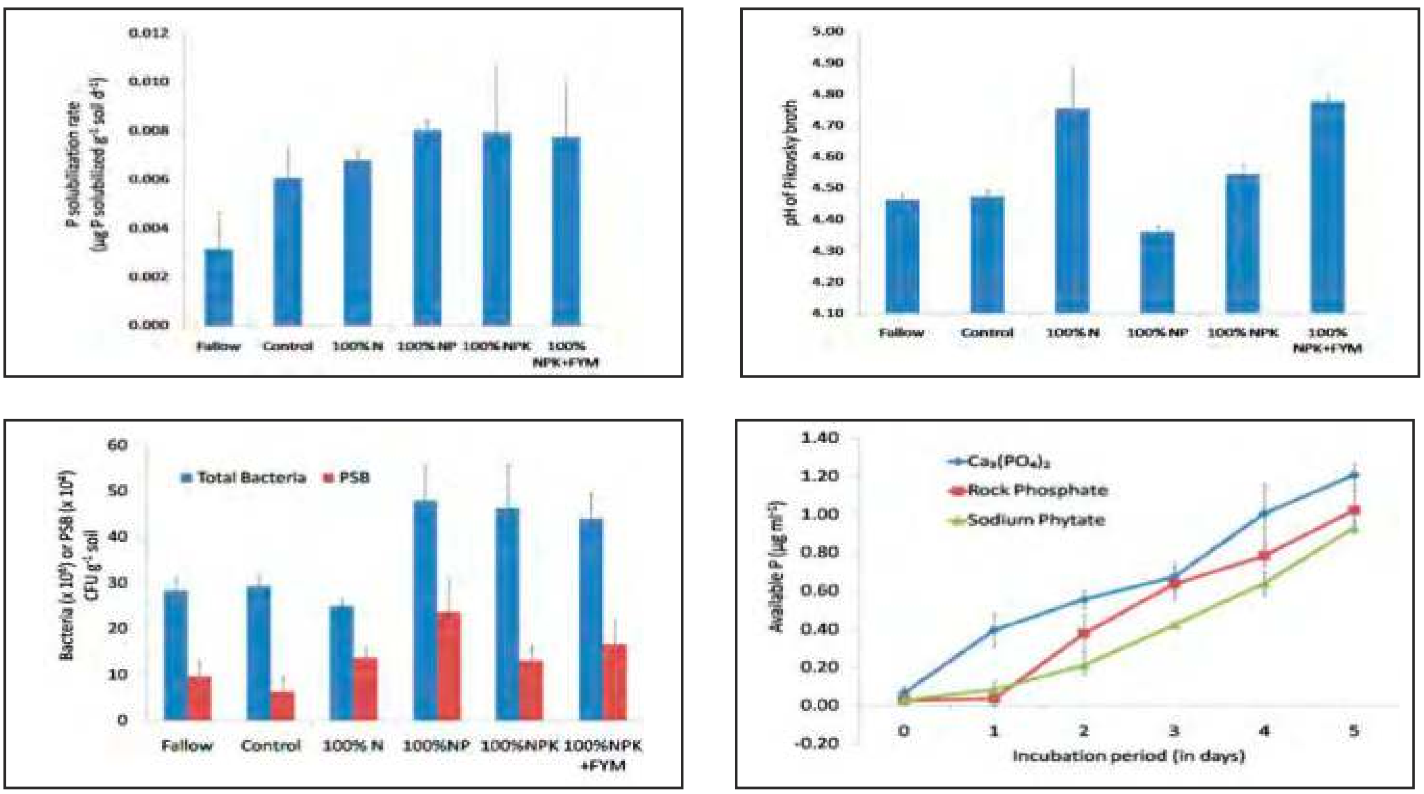


Fig 2.7.3 Top left - Phosphorous mineralization rate of soils under long term fertilizer application; Top right - Effect of P mineralization by phosphate solubilising organisms on soil pH; Bottom left - Abundances of total aerobic bacteria and phosphate solubilising bacteria (PSB); Bottom right - Mineralization or solubilisation of different P sources by PSB.

Theme - IV: Soil Pollution, Remediation and Environmental Pollution

2.8 Soil Pollution and Remediation

2.8.1 Accumulation of essential and non-essential trace elements in rice grain: possible health impacts on rice consumers in West Bengal, India

Rice is the major staple food to the population in rural West Bengal, India and Bangladesh. Depletion and excess accumulation of different trace elements, which are essential and non-essential to the human body, in rice can have a detrimental impact on the rice consumer. Therefore, a study was undertaken to investigate the accumulation of different trace elements in rice consumed in the rural households of Nadia district in West Bengal. Concentration (mg kg^{-1}) of essential elements in rice follows the order of Fe (39.4) > Zn (9.79) > Mn (4.40) > Cu (3.26) > Co (0.03), while this order for non-essential elements is Pb (1.70) > Ni (0.22) > Cd (0.04). In general, accumulation in rice is higher for elements that show higher mobility under reducing conditions (e.g. Fe, Mn, etc.) compared to elements with lower mobility under such conditions (e.g. Cd, etc.). These orders of accumulation can be attributed to the irrigation practice of continuous flooding of the soil during rice cultivation and the abundance of these elements in the paddy soil itself. By combining these analytical results to the data obtained from questionnaire survey, it is estimated that rice consumption can be either enough or a major source to fulfill the daily requirement of Fe, Cu, Mn, and Zn necessary for different physiological functions in the human body for the population in rural Bengal. At the same time, it can be a potential route of Cd, Ni, and Pb exposure to develop their non-carcinogenic and carcinogenic health effects among the population (Table 2.8.1). For non-essential elements, hazardous quotient (HQ) and cancer risk (CR) were calculated to determine the susceptibility of the study population to the non-carcinogenic health effect and developing cancer in their lifetime due to exposure through rice consumption (Table 2.8.1). The mean HQ value was highest for Pb (3.22) followed by Cd (0.29), and Ni (0.09). This study highlights that attempt should be made to reduce the accumulation of other non-essential elements in rice grain to ensure the health safety of the people who rarely get a balanced diet and rely on rice consumption to meet the daily calorific intake in rural Bengal. Essential and non-essential elements are quantified in rice consumed in rural West Bengal. Concentration of elements with higher mobility in anoxic condition is high in rice. Although rice is a major source of essential elements to the people in West Bengal, it can also be an exposure route for Cd, Ni, and Pb to the people in Nadia district of West Bengal.

Table 2.8.1 Hazard Quotient (HQ)/ hazard index (HI) and cancer risk of non-essential trace elements of the participants from the consumption of rice

Statistics	Cd		Ni		Pb		HI	CR_T
	HQ	CR	HQ	CR	HQ	CR		
Min	0.03	0.70	0.01	0.23	0.46	0.02	3.28	2.11
10^{th} %ile	0.09	1.83	0.03	0.70	1.27	0.06	6.02	6.28
25^{th} %ile	0.14	3.03	0.04	1.04	1.92	0.09	8.89	9.13
Median	0.24	5.14	0.06	1.62	2.51	0.12	11.1	13.5
Mean	0.29	6.22	0.09	2.24	3.22	0.16	12.1	14.1
75^{th} %ile	0.34	7.24	0.11	2.87	3.18	0.15	14.7	17.4
90^{th} %ile	0.50	10.7	0.17	4.35	5.90	0.29	19.8	22.0
Max	1.45	31.1	0.60	15.5	22.9	1.11	29.8	49.0

[a]HQ > 1 indicates potential risk of adverse non-carcinogenic health effect of non-essential trace elements among the population (USEPA, 1998).; [b]CR > 1 per 104 people suggests that non-essential trace elements exposure has the potentiality to develop cancer among the population during lifetime (USEPA, 1998).

2.8.2 Critical limit of cadmium for red soil (Alfisol) based on plant phytotoxicity approach

To derive phytotoxicity limits of cadmium for Alfisol a pot culture experiments were conducted and also an incubation study was conducted to evaluate the suitable extractants for predicting bioavailable cadmium concentration in soil. Bulk soil samples were collected from Kanpur and Ranchi (lateritic soil) for conducting pot culture and incubation studies. The cadmium was spiked with graded levels ranging from 0 to 40 mg/kg soil (0, 2, 5, 10, 15, 20, 30, 40 mg/kg soil) in lateritic soil (Ranchi series; Sub-order: Typic Haplustalf) and test crop spinach was grown. The results showed that cadmium application had significant yield reduction over control. The dry weight of spinach at highest level (40 mg/kg) of cadmium application was 39.7% and 38.5% as compared to control (Fig. 2.8.2a). Plant accumulation of cadmium increased with increasing levels of cadmium. At the highest level (40 mg/kg) of cadmium application, the leaf Cd concentration was 123.05 mg/kg of biomass with the transfer coefficient value of 4.23 (Fig. 2.8.2b). Also different extractants (0.01M $CaCl_2$, 1M $CaCl_2$, DTPA and 0.43M HNO_3) were evaluated to predict the bioavailable concentration of Cd in soil (Table 2.8.2). The results thus indicate that the bioavailable concentration of Cd in soil depends on soil pH, SOC and clay content. Irrespective of the extractants used, the bioavailable content of cadmium for spinach crop was lower in soil having higher pH, SOC and clay content. Among the different extractants, the magnitudes of bioavailable fraction were highest in 0.43M HNO_3 followed by 1M $CaCl_2$, DTPA and 0.01M $CaCl_2$ extractant. Significant linear relationship were observed between the extractable fraction by 1M $CaCl_2$ extractant and total Cd content in soil with R^2 value of 0.985. Similarly, significant linear relationships were observed between the extractable fraction by 1M $CaCl_2$ extractant and plant content in soil with R^2 value of 0.968.

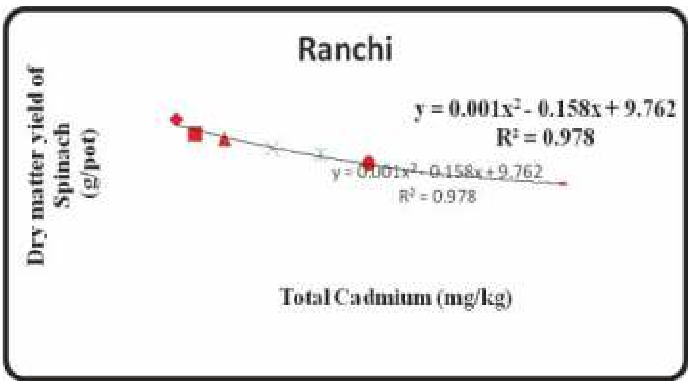


Fig. 2.8.2a Effect of Cd levels on dry matter yield of Spinach in Alfisol

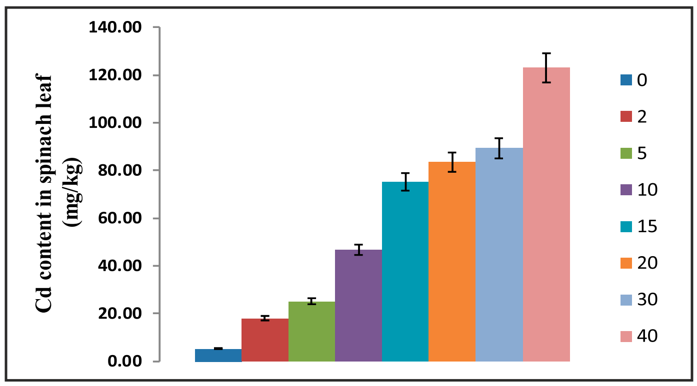


Fig. 2.8.2b Effect of Cd levels on cadmium content in spinach leaf in Alfisol

Table 2.8.2 Different extractants for predicting bioavailable content of Cd in Alfisol

Cd spiking (mg/kg)	Bioavailable content of cadmium (mg/kg) in cadmium spiked Alfisol			
	0.01 M $CaCl_2$	1M $CaCl_2$	DTPA	0.43M HNO_3
0	1.39	0.89	0.03	2.11
2	3.88	2.50	0.09	6.28
5	5.24	3.37	0.14	9.13
10	8.12	5.22	0.24	13.5
15	8.48	5.45	0.29	14.1
20	11.2	7.17	0.34	17.4
30	0.53	16.25	17.07	28.22
40	0.76	25.31	19.74	37.80

2.8.3 Impact of industrial effluent water in Chambal river water and wheat crop growth surrounding Nagda

Companies like M/s Grasim Industries Ltd., M/s Lensex India Pvt Ltd, M/s Arkema Catalyst India Ltd, Aromi Chemicals and M/s Goyal Gases Pvt Ltd are located on the bank of Chambal river at Nagda. Here, effluents coming out from industries along with municipal domestic sewage water are ultimately discharged into the river. Due to scarcity of surface or groundwater, farmers of the surrounding areas are using this river water for irrigating their agricultural fields. In situ measurement of EC and pH of the river water of downstream area was 6.982 dS/m and 7.62 respectively, whereas in upstream area of Chambal river it was 0.45 dS/m and 7.10, respectively. Further, the discharged industrial effluents have changed the color of downstream river water to red. As farmers of downstream area used this contaminated river water to irrigate the field, it badly affected the crop (wheat, chick pea etc.) growth, production and soil health (Plate 2.8.3).

Plate 2.8.3 In-situ measurement of pH, EC of Chambal river water and its ill effects on wheat crop growth at Nagda, M.P.

2.8.4 Phytoremediation of acid mine drainage (AMD) affected areas in Malanjkhand copper mining area

Malanjkhand copper site is a base metal mine which contains copper, iron, manganese along with fluoride and some toxic elements like arsenic, lead, and cadmium in the parent rock. The mine water samples were collected from various drainage/seepage locations in and around the project site. The copper concentration in mine water was below 45 mg per liter in majority of samples collected for the study. Iron concentration varied between 0.08 and 5.55 mg per liter. Manganese was 0.81–3.60 mg per liter. The pH range of mine water was 3.1 to 6.5. Typha angustifolia (Typhaceae) plant was used to decontaminate the AMD affected area inside the mine premises (Plate 2.8.4).

Plate 2.8.4 Phytoremediation of AMD affected areas by Typha angustifolia

2.8.5 Water quality and baseline concentration of heavy metals in mine drainage water of Singrauli

A preliminary survey was conducted to assess the baseline information on water quality and heavy metals in drainage water of Singrauli coal mine. Major sampling of the area was carried out in September, 2019 at some selected georeferenced locations (Plate 2.8.5). The sampling sites were located along waste dump leachates, discharge pond, mine effluents and tailing dam reservoir. Some water quality properties viz. pH, EC, ORP (oxidation-reduction potential), DO (Dissolved oxygen), TDS (Total dissolved solids) as well as some heavy metals with their mean, median and range values are presented in Fig.2.8.5.

Plate 2.8.5 Some water sampling points in Singrauli coal mine

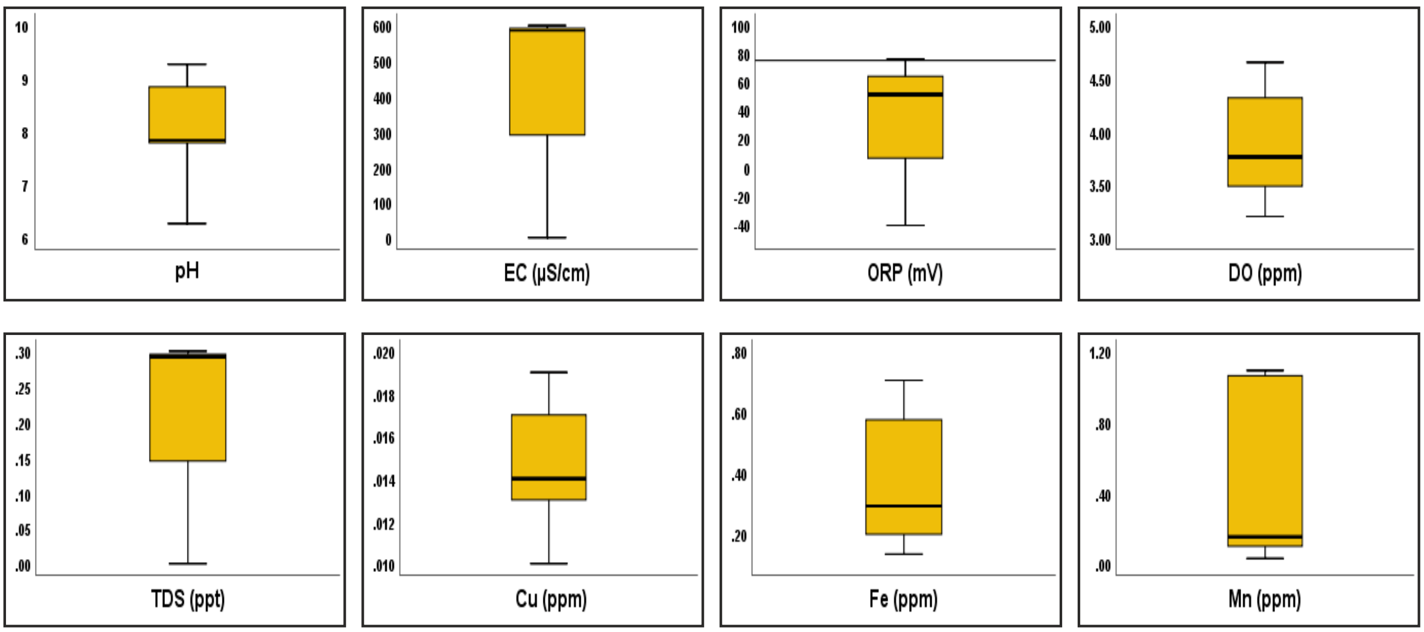


Fig. 2.8.5 Box-plot diagram to show different water parameters and some heavy metal concentrations

3. Transfer of Technology

3.1 TOT by ICAR-IISS

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

Crop based module- *kharif* season 2019-20

Conservation agriculture based 70 demonstrations were conducted during Kharif season 2019-20 (60 Soybean and 10 Rice). Soybean productivity ranged between 15.60 to 17.45 q/ha in different villages with an average of 16.47 q/ha. Similarly Rice crop also recorded seed yield varied between 38.35 to 40.22 q/ha with an average of 39.43 q/ha under farmers field condition in the selected villages.

Intervention	Villages	Crop	Area (ha)	Number of Households	Yield (q/ha)
Conservation agriculture based low cost, energy saving sustainable management for improving crop productivity and improving soil health.	Bhairopur	Rice	0.81	4	39.72
		Soybean	3.04	15	17.45
	Kanchbavli	Rice	0.40	2	40.22
		Soybean	0.81	4	15.60
	Khamkheda	Rice	0.81	4	38.35
		Soybean	7.49	37	16.51
	Kalyanpur	Rice	-	-	-
		Soybean	0.81	4	16.33




Rice and Soybean crop under farmers field condition

Demonstrations on *rabi* crops

Conservation agriculture based low cost, energy saving sustainable management for improving crop productivity and improving soil health based 72 demonstrations were conducted during *rabi* season 2019-20 (52 wheat and 20 gram) under farmers field condition in the selected villages.

Intervention	Villages	Crop	Area (ha)	Number of Households
Conservation agriculture based low cost, energy saving sustainable management for improving crop productivity and improving soil health.	Bhairopur	Gram	1.21	6
		Wheat	3.44	17
	Khamkheda	Gram	0.81	4
		Wheat	0.81	4
	Khamkheda	Gram	1.82	9
		Wheat	5.26	26
	Kalyanpur	Gram	0.20	1
		Wheat	1.01	5

Horticulture based module

Under horticulture based modules, improved package of practices for better vegetables yield were demonstrated in sixty two farmers field. In winter season, the vegetables of tomato, brinjal and cabbage were grown under the demonstration trial. The balanced nutrient application and need based pesticide was applied for better growth and production of vegetable. Due to balanced nutrient application and control of weed and insect-pest, the crop yield was increased under demonstrations as compare to farmer's practices. Tomato productivity ranged between 36.56 to 37.00 t/ha in different villages with an average of 36.78 t/ha. Brinjal crop recorded yield varied between 33.57 to 36.39 t/ha with an average of 35.32 t/ha. Cabbage crop recorded yield varied between 37.09 to 46.67 t/ha with an average of 41.32 t/ha.

Plantation crops

About 400 saplings of mango, 800 plants of papaya, 400 guava and 400 saplings of drumstick were successfully planted in the 16 farmers' field. The plantation of fruit trees was done as per recommended management practices.

Vermicomposting

Farmers were trained in vermicompost preparation and fifty vermibed for demonstration of vermicomposting techniques to the identified progressive farmers in the adopted villages were distributed. Vermicompost production in these beds is under progress in farmer's field.

NRM activities carried out in the village Khamkheda

Demonstration of baler machine at Khamkheda village

Training programme organised on 32nd Foundation Day

Field day and demonstration of conservation agriculture machinery

Seed distribution of soybean


Field visit

Farmers' training


Felicitation of innovative farmers at ICAR-NAARM, Hyderabad

One day training programme on "Soil Health Awareness Week"

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

Farmers' training on soil health management

Three days training program on "Soil health management" was organized for the tribal framers of Betul district of Madhya Pradesh at Krishi Vigyan Kendra Betul during 26-28 November, 2019. About 57 tribal farmers from six villages participated in the three days program. Scientists from ICAR-IISS Bhopal made the participant farmers aware about the importance of managing the physical, chemical and biological aspects of soil health for sustainable crop growth. Also, farmers were exposed to concepts such as conservation tillage practices and use of biofertilizers for enhancing soil health. Farmers were trained to collect soil samples from their farmlands for laboratory analysis. In addition to classes on soil health management, lectures on raising of horticultural crops and crop protection in rabi crops were also given by KVK scientists.

Training on soil health management under STC at KVK Betul

Kisan Sangoshthi on soil health card

Kisan Sangoshthi was organized at Krishi Vigyan Kendra Betul for the tribal farmers of the district on November 29, 2019 to sensitize farmers about soil health card and soil test based fertilizer use in their farmlands. Scientist from both ICAR-IISS Bhopal and KVK Betul interacted with farmers during the event and clarified the doubts and concerns of the participant farmers.

Kisan Sangoshthi on soil health card under STC at KVK, Betul

3.1.3 On-farm demonstration on resource conservation technologies

To disseminate the various resource conservation technologies (RCTs), a demonstration was conducted at the ICAR-IISS research farm. The RCTs include the no-tillage and reduce tillage on broad bed and furrow system in combination with three cropping systems viz. soybean-wheat, maize–chickpea and soybean-pigeon intercropping system. About 125 farmers have visited this demonstration during the 2019-2020.

3.1.4 Rapid decomposition of biowaste

In this technology a unique consortia of ligno-cellulolytic microbes has been developed for rapid recycling of different organic waste. The isolated and screened consortia of microbes consisting of Bacteria, Fungi and Actinomycetes in defined proportion were applied in a close vessel for enhancing decomposition. The liquid medium for microbial consortia contains cow-dung slurry, urea, curd, jaggery and microbial strains (10^5 viable cell fungal culture, 10^8 viable cell bacterial and actinomycetes culture) to ensure proper proliferation and rapid decomposition at thermophillic stage of composting. In this project, a shredder (Ekcel-ShrdR) has been developed to shred the waste mass into 3-6 cm size pieces with a capacity of 200 kg/hour and a composter (Ekcel-CompostR) with a capacity of 1000 kg was fabricated to maintain thermophilic condition (50-55°C) for rapid breakdown of the most recalcitrant materials such as lignin, hemicelluloses and cellulose to further reduce the composting period and facilitate microbial action. The microbial consortia christened as Accel-Microbial consortium were inoculated to hasten up the decomposition process under thermophilic condition.

Result showed that domestic waste and vegetable waste can be decomposed within 20-25 days, horticultural waste for 30-35 days and farms waste for 35-45 days compared to 6 month of usual period of conventional composting of agrowaste. This could also save the manpower by 50% besides enriching soil and cleaning environment. In order to popularize the work performance of this technology, it is now being demonstrated at ICAR-IISS, Bhopal and ICAR-KVK Deoghar (Jharkhand) to recycle the organic wastes in larger quantity.

3.2 ToT by AICRPs/AINP

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

Response of potato crop to magnesium application

To demonstrate the effect of $MgSO_4$ along with recommended NPK (120:240:120 kg NPK ha^{-1}) on the tuber yield of potato, four FLD's were conducted in Kombaiyaru and Chinnaullepalayam villages of Erode district (Tamil Nadu). Application of 60 kg $MgSO_4$ along with recommended NPK increased the yield of fresh tuber by 17.6 to 25.7% (13.2 to 19.4 t ha^{-1}) over NPK control (10.5 to 16.5 t ha^{-1}) (Table 3.2.1). It also increased the Mg content (0.15 to 0.22 mg in tuber and 0.55 to 0.82 mg in plants kg^{-1}) and its uptake (7.43 to 11.9 g in tuber and 9.08 to 16.2 g ha^{-1} in plant, respectively). Inclusion of $MgSO_4$ in the fertilizer schedule increased the soil Mg availability to sufficient status (52.1 to 69.5 mg kg^{-1}).

FLDs on the effect of $MgSO_4$ on potato (Kombaiyaru and Chinnaullepalayam villages) in Tamil Nadu

Table 3.2.1. Effect of $MgSO_4$ on the yield, Mg availability and its uptake by potato

Treatments	Locations	Fresh tuber yield (t ha^{-1})	% Yield increase	DMP (kg ha^{-1})	Exch. Mg (mg kg^{-1})	Mg content (mg kg^{-1})		Mg uptake (g ha^{-1})	
						Tuber	Plant	Tuber	Plant
NPK	L1	12.6	-	1350	40.5	0.12	0.41	5.28	5.54
	L2	16.5	-	1625	22.3	0.16	0.55	6.64	8.94
	L3	13.2	-	1820	48.9	0.17	0.38	6.93	6.92
	L4	10.5	-	1985	47.5	0.18	0.49	8.58	9.73
	Mean	13.2	-	1695	42.3	0.16	0.46	6.86	7.78
NPK+60 kg $MgSO_4$ ha^{-1}	L1	15.5	23.0	1650	69.5	0.15	0.55	7.43	9.08
	L2	19.4	17.6	1880	52.1	0.18	0.82	8.22	15.4
	L3	15.8	19.7	2050	62.3	0.20	0.56	9.29	11.5
	L4	13.2	25.7	2250	56.8	0.22	0.72	11.9	16.2
	Mean	16.0	21.5	1958	60.2	0.19	0.66	9.21	13.0

3.2.2 AICRP on Soil Test Crop Response

The capacity building programme-cum-field day were organized by different centres of AICRP STCR to create awareness about soil testing in major crops in different agro-ecological regions of the country (Table 3.2.2).

Table 3.2.2 Beneficiaries under capacity building programme-cum field day (January to December, 2019)

State	District	Village	Total participants	No. of women farmers
Kerala	Thrissur	Chavakkad	47	21
		Thekkumkkara	26	12
		Chettuva	31	18
		Cherpu	34	18
Uttarakhand	Nainital	Gola par, Haldwani	34	10
Himachal Pradesh	Kangra	Bandbihar /Palampur	25	15
Rajasthan	Bikaner	ARS, Bikaner	270	132
		Dhingsari/Panchu	58	-
Pondicherry	Karaikal	Karikkalampakkam	25	5
		Kariyamanickam	150	30
		Thattanchavady	150	10
		Melakasakudy	25	5
		Kottucherry	25	3
Tamil Nadu	Salem	Pethakurichi	87	29
Telangana	Vijayanagaram	Suryanagaram/ Kurupam	64	8
	Adilabad	Markaguda/ Indravelli	56	4
	Rangareddy	Sherguda Bhadraipalli / Kothur	40	6
	Nizamabad	Rudrur/ Varni	58	14
	Nizamabad	Depo Thanda & Ruplanaik Thanda/Varni	36	8
	Adilabad	Raiguda/Sirikonda	30	3
	Rangareddy	Sherguda Bhadraipalli/Kothur	94	14
Chhattisgarh	Kanker	Deo Kongera	30	15
	Uttar Bastar – Kanker	Kapsi/Kanker	52	10
	Bastar	Kondaloor/Tokapal	100	21
Odisha	Keonjhar	Sendkap/Keonjhar Sadar	26	7
	Deogarh	Ghiabandha/Reamal	17	8
	Gajapati	Pabarada/Nuaguda	21	9
	Deogarh	Ghiabandha/Reamal	27	16
	Gajapati	Pabarada/Nuaguda	18	5
	Gajapati	Tabarada/Nuaguda	15	4
Madhya Pradesh	Seoni	Simariya	11	02
	Dindori	Shivari	23	07
	Mandla	Orai	17	04
	Dindori	Shivari	13	03

State	District	Village	Total participants	No. of women farmers
	Jabalpur	Tikariya	15	06
	Jabalpur	Sahajuri	19	05
	Dindori	Ghundisarai & Khannitola	15	03
	Mandla	Gajipur & Chatuamar	12	03
	Jabalpur	Luhari	09	02
	Seoni	Fareda	11	05
	Jabalpur	Tikariya	07	01
	Dindori	Ghundisarai	37	08
	Mandla	Gajipur & Chatuamar	35	02
	Jabalpur	Sahajpuri	51	08
	Jabalpur	KVK	31	-
	Dindori	Ghundisarai	73	22
	Mandla	Gajipur & Chatuamar	58	07

3.2.3 STC under AICRP on STCR

Verification trials / FLDs under STC

The verification trials and front line demonstrations (FLDs) were conducted on different varieties and crops at different centres to test STCR equations (Table 3.2.3a). These trials were demonstrated in different agro-ecological regions of the country.

Table 3.2.3a Verification trials under STC Scheme (January to December, 2019)

Crop/variety	Locations	Name of districts	No. of FLDs	Yield (q ha^{-1})		Increased yield (%)
				Farmers practices	STCR	
Kerala						
Tomato (Anagha)	Pattanchery	Palakkad	1	239.70	299.60	25.00
Cowpea (Anaswara)	Pattanchery, Kaiparamb and Madakkathara	Palakkad and Thrissur	3	155.60	167.20	7.40
Uttar Pradesh						
Rice	Shahpur/Naugarh	Chandauli	2	37.50	50.10	33.60
Himachal Pradesh						
Soybean (Palam Soya)	Panchrukhi	Kangra	6	10.20	18.60	82.00
Toria (Bhiwani)	Una	Una	6	4.32	9.33	116.00
Haryana						
Raya (RCH 749 and RCH 406)	Devan, Miran Dhani, Miran II, Balawas (Dry-land) and Miran Dhani (Dry land)	Hisar	5	17.57	24.75	40.87
Wheat (WH 1105)	Bhiwani Rohilla, Kaimiri, Gangwa and Devan	Hisar	4	50.66	61.83	22.04

Crop/variety	Locations	Name of districts	No. of FLDs	Yield (q ha^{-1})		Increased yield (%)
				Farmers practices	STCR	
Bt. Cotton (RCH 773)	Harikot, Bhiwani Rohilla, Devan and Kalwas	Hisar	4	24.40	32.80	34.40
Pearl millet (HHB 223)	Bagla, Kirtan, Neoli Kalan and Kabrel	Hisar	4	24.80	31.90	28.60
Rajasthan						
Taramira	Lunkarnsar	Bikaner	1	10.40	14.68	41.15
Pondicherry						
Bhendi-hybrid	Karikkalampakkam	Pondicherry	3	135.00	179.50	32.90
Karnataka						
Ragi (GPU-28)	Turuvekere / Dwaranahalli	Tumkur	2	51.04	60.41	18.35
Maize (Hema)	Turuvekere / Dwaranahalli	Tumkur	1	80.40	94.50	17.54
Ragi (Indaff-9)	Pavagada/ Balenahalli	Tumkur	2	33.32	40.25	20.79
Maize (Hema)	Pavagada/ Balenahalli	Tumkur	1	59.36	67.07	12.99
Groundnut (TMV-2)	Pavagada/ Balenahalli	Tumkur	1	18.42	19.91	8.09
Maize (Hema)	Tiptur / Kibbanahalli	Tumkur	1	54.00	60.50	12.04
Ragi (GPU-28)	Tiptur / Kibbanahalli	Tumkur	2	28.50	32.50	14.03
Foxtail millet (SIA-3156)	Tiptur / Kibbanahalli	Tumkur	1	6.00	14.00	133.33
Ragi (GPU-28)	Tumkur / Biranakallu	Tumkur	4	41.70	49.77	19.35
Ragi (GPU-28)	Sira / Kotta	Tumkur	2	35.00	44.75	27.85
Tamil Nadu						
TNAU maize hybrid (CO 6)	Govindhapuram & Balbakki (Omalur Block)	Salem	2	61.60	100.20	62.70
Little Millet (CO 4)	Kammanpatti and Mottan-ampatti (Attur &Vadama-durai block)	Dindigul	2	13.20	20.30	53.80
Chrysanthemum (Poor-nima Hybrid)	Kammanpatti, Pudukam-manpatti & Avellode (Attur &Vadamadurai Block); Jodukuli (Kadayampatti block)	Dindigul and Salem	6	124.00	219.00	76.60
Telangana						
Sesamum (Gowri)	Utukur and Chintakomma dinne mandal	Kadapa	1	4.60	5.97	29.80
Maize (P3396)	Utukur and Chintakomma dinne mandal	Kadapa	1	23.17	27.57	19.00
Sugracane (Haritha 85 R186)	Rudrur Varni mandal	Nizamabad	1	103.00	111.00	7.80
Sugarcane (2010/ 854)	Rudrur Varni mandal	Nizamabad	1	86.00	88.00	2.30

Crop/variety	Locations	Name of districts	No. of FLDs	Yield (q ha^{-1})		Increased yield (%)
				Farmers practices	STCR	
Rice (RNR15048)	Himayathnagar and Moinabad mandal	Rangareddy	3	52.55	56.33	7.19
Madhya Pradesh						
Paddy (Kranti)	Sihora / Tikariya	Jabalpur	2	36.75	47.93	30.42
Paddy (MTU-1010)	Kundam / Sahajpuri	Jabalpur	1	35.87	46.61	29.94
Paddy (Kranti)	Kundam / Sahajpuri	Jabalpur	2	37.43	49.66	32.67
Soybean (JS-2029)	Kundam / Sahajpuri	Jabalpur	1	12.37	16.24	31.29
Paddy (MTU-1010)	Seoni / Simariya	Seoni	1	34.95	45.31	29.64
Paddy (MTU-1010)	Seoni / Binjhawada	Seoni	1	34.58	44.75	29.41
Soybean (JS-2069)	Seoni / Fareda	Seoni	1	10.65	13.58	27.51

FLDs under STC

The front line demonstrations (FLDs) were conducted on different varieties and crops at different centres to test STCR equations (Table 3.2.3b). These trials were demonstrated in different agro-ecological regions of the country.

Table 3.2.3b FLDs conducted under STC Scheme (January to December, 2019)

Crop/variety	Block/village	Name of districts	No. of FLDs	Yield (q ha^{-1})		Increased yield (%)
				Farmers practices	STCR	
Uttar Pradesh						
Maize	Jharigawan/Naugarh	Chandauli	5	29.10	39.50	36.21
Rice	Persiya & Jharigawan/ Naugarh	Chandauli	10	33.50	44.50	32.24
Tamil Nadu						
Bhendi (NS-7772)	Pattiarkoilpthy		1			
Bhendi (TNAU Hybrid CO 4)	Pachanvayapathy	Coimbatore	1	87.00	148.60	71.00
Bhendi (TNAU Hybrid CO 4)	Pattiarkoilpthy		1			
Onion (Local)	Pattiarkoilpthy	Coimbatore	3	125.30	197.70	57.90
Tomato (Local)	Alangandi and Ukkaiya-nur	Coimbatore	2	464.00	786.50	69.50
Sorghum (Local)	Ukkaiyanur	Coimbatore	1	19.90	34.50	73.40
Radish (Hybrid – Ural)	Pattiarkoilpthy	Coimbatore	2	305.00	487.00	59.70
Maize (TNAU Maize Hybrid Co-6)	Neelampathi and	Coimbatore	2	53.70	95.10	77.00
Telangana						
Maize (DHM 117)	Gudivenaka, Thanda Shamshabad	Rangareddy	3	61.90	68.30	10.30
Maize (DHM117)	Veljerla, Farooqnagar	Rangareddy	3	52.80	57.50	8.90

Crop/variety	Block/village	Name of districts	No. of FLDs	Yield (q ha^{-1})		Increased yield (%)
				Farmers practices	STCR	
Bengal gram (NBEG-3)	Markaguda, Indravelli	Adilabad	6	16.30	17.50	7.40
Groundnut (K-6)	Sivannapet, Kuruppam	Vijayanagaram	1	20.50	22.80	11.20
Groundnut (K-6)	Kollikota, Kuruppam	Vijayanagaram	1	21.50	22.60	5.00
Groundnut (K-6)	Paderu	Vijayanagaram	2	20.00	21.50	7.50
Sweet corn (Sugar-75)	Suryanagarm, Kuruppam	Vijayanagaram	1	145.00	170.00	17.20
Sweet corn (Sugar-75)	Durballi Kuruppam	Vijayanagaram	1	185.00	205.00	10.80
Rice (KNM-118)	Tagilepally, Varni, Sevalal Thanda, Rupla-naik and Depo	Nizamabad	6	64.80	68.02	5.00
Odisha						
Tomato (Utkal Raja)	Ghiabandha/Reamal	Deogarh	10	173.00	218.00	26.00
Lady's finger (Shakti)	Sendkap/Keonjhar Sadar	Keonjhar	10	95.00	121.00	27.00
Brinjal (VNR-B5)	Tabarada/Nuaguda	Gajapati	13	177.00	220.00	24.00
Madhya Pradesh						
Wheat (GW-322, JW-3211, MP-3020)	Bajag / Shivari	Dindori	5	25.73	35.47	37.85
Chickpea (JG-14, JG-63)	Bajag / Shivari	Dindori	5	8.87	12.79	44.19
Wheat (GW-273, GW-322)	Bichhiya / Orai	Mandla	5	27.15	37.84	39.37
Chickpea (JG-14, JG-63)	Bichhiya / Orai	Mandla	5	9.52	13.95	46.53
Paddy (Kranti, MTU-1010, IR-64)	Shahpura / Ghundisarai & Khannitola/Indauri	Dindori	5	29.67	41.53	39.97
Paddy (Kranti, MTU-1010, IR-64)	Mandla / Gajipur & Chat-uamar	Mandla	5	31.44	44.86	42.68
Soybean (JS-2069)	Seoni / Fareda	Seoni	1	10.65	13.58	27.51

3.3 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. Some of activities are given below:


Activities under MGMG

Table 3.2.2 MGMG groups and adopted villages

S.No.	Group	Name of adopted villages
1	Dr AK Patra, Director, ICAR-IISS Dr AB Singh, PS, & Nodal Officer, MGMG Dr Abhay Shirale, Scientist, SC&F Dr Sudeshna Bhattacharjya, Scientist, SBD Dr Narayan Lal, Scientist, SC&F	Dobra, Khejra, Perwalia Sadak, BadarkhaSadak, Mubarakpur
2	Dr MC Manna, HOD, SBD Dr P Tripathi PS & Co-Nodal officer Dr NK Sinha, Scientist, SPD Dr Dolamani Amat Scientist, SBD	Acharpura, Parewakheda, Arwali, Hazampura and Parewaliasahani
3	Dr Muneshwar Singh, PC, LTFE Dr RH Wanjari, PS, LTFE Dr K Bharati, PS, SBD Mrs Seema Bhardwaj, Scientist, SPD	Choupdakala, GhatKheri, SayyaidSemara, Emaliya Chopra and Amoni
4	Dr JK Saha, HOD, ESS Dr Hiranmoy Das, Scientist (STCR) Dr Vasudev Meena, Scientist, ESS Dr Madhu Mounti Saha, Scientist, ESS	Islam Nagar, Dewalkhedi, Bharonpura, Kalyanpura, PuramanBhavan
5	Dr KM Hati, PS, SPD Dr Sanjay Srivastava, PS, SC &F Dr KC Shinogi, Scientist, SC &F Dr Gurav Priya Pandurang, Scientist SC & F	Bankhedi, Baroda, Sojna, Amaravadi and Kuravadi
6	Dr AK Shukla, PC, MSN Dr R Elanchezhian, PS, SC&F Dr RK Singh, PS, SPD Dr JK Thakur, Scientist, SBD	Sagoni, Munirgarh, Gudawal, Chhattarpura, Chikloddhurd
7	Dr AK Biswas, HOD, SC&F Dr Brij Lal Lakaria, PS, SC&F Dr Asha Sahu, Scientist, SBD Dr Bharat P. Meena, Scientist, SC&F	Golkhedi, Binapur, Kanchbavli, Khamkheda and Raslakhedi
8	Dr RS Choudhary, HOD, SPD Dr P Jha, PS, SC&F Dr AK Vishwakarma, PS, SPD Dr Abhijit Sarkar, Scientist, ESS	Raipur, Kanera, Momanpur, Kadhaiya and Karod-Khurd

S.No.	Group	Name of adopted villages
9	Dr P Dey, PC, STCR Dr NK Lenka, PS, SC&F Dr M Mohanty, PS, SPD Dr M Vassanda Coumar, SS, ESS	Ratibad, RasuliyaPathar, Mugaliahat, Ratanpur-Sadak, Chandukhedi
10	Dr AK Tripathi, PS, SBD Dr S Ramana, PS, SBD Dr J Somasundaram, PS, SPD Dr Asit Mandal, Scientist, SBD	Dobra Jagir, KoluaKhurd, Sagoni Kalan, ChorSagoni, AdampurChhawni
11	Dr Ajay, PS, ESS Dr Tapan Adhikari, PS, ESS Dr Sangeeta Lenka, SS, ESS Dr Jitendra Kumar, Scientist, SPD	Shahpur, Devpur, KasiBarkeda, Sagoni, and BarkediHajam
12	Dr SR Mohanty, PS & I/c BNF Dr Sanjib Kumar Behra, SS, MSN Ms Alka Rani, Scientist, SPD Dr Nisha Sahu, Scientist, ESS	Pipaliya Bajkhan, Dewalkhedi and Malikhedi

4. Training and Capacity Building

4.1 Training Attended by Staff

a. Participation in Training (Category-wise)

S. No.	Category	No. of employees undergone training during April 2019–December 2019
1	Scientist	4
2	Technical	1
3	Administrative & Finance	3
4	Skilled Supporting Staff	0
	Total	8

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

S. No.	RE for HRD 2019-20	Actual Expenditure 2019-20 for HRD
1.	1.00	0.97

c. Training attended during April to December 2019

Category: Scientific staff

S.No	Name of employee	Title	Organizer	Duration
1.	Dr. M. Vassanda Coumar	Training Programme on "Environmental Management"	Centre for Agriculture, Environment and Water, Galilee International Management Institute, Israel	September 10-23, 2019
2	Dr. A.K. Vishwakarma	Management Development Programme on Leadership Development	ICAR- NAARM, Hyderabad	December 2-13, 2019
3	Mrs Seema Bhardwaj	Short Course on "Recent Advances in solar energy utilization for agro produce processing and production system	ICAR-CIAE, Bhopal	December 10-19, 2019
4.	Ms. Alka Rani	Professional Attachment Training	ICAR-NBSS&LUP, Nagpur	May 24-August 23, 2019

C2 Category: Technical staff

S.No	Name of employee	Title	Organizer	Duration
1	Mr. Jai Singh	Motivation, Positive Thinking and Communication Skills for Technical Officers (T-5 and above) of ICAR Institutes	ICAR- IISWC, Dehradun Spon-soredby NAARM, Hyderabad	May 2-7, 2019

C3 Category: Administrative staff

S.No	Name of employee	Title	Organizer	Duration
1	Mrs. Babita Tiwari	Orientation Courses in Records Management for Record Officers	National Archives of India, Records Centre, 10-A, Jhalana Doongri, Institutional Area, Jaipur	September 4-6, 2019
2	Mr. S.K. Gupta	Administrative and Financial Management for Deputy Secretaries, Chief Administartive. Officers, Chief Finance and Accounts Officers, SAOs, Under Secretaries and SFAOs of ICAR Institutes	ICAR-NDRI, Karnal	September 24-27, 2019
3	Mr. Anurag	Capacity Building Programme towards a Secure and Resilient Workplace	ICAR- CPRI, Shimla	November 25-27, 2019

4.2 Professional Attachment Training for Scientist Probationers

S.No	Name of the Scientist	Name of the College/Institute/ University	Duration (month)	Name of the Scientist/Mentor
1	Dr. Anand Kumar Neoram	ICAR- CAZRI, Jodhpur	May 18-September 2, 2019	Dr. J. Somasundaram

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. Mahendra Bakoria	R.A.K, College of Agriculture Sehore (RVSKVV) MP	M.Sc. (Soil Science)	Dr. K. Bharati
2	Mr. Vivek Singh	IGKV, Raipur	M.Sc. (Soil Science)	Dr. S.R. Mohanty
3	Ms.Radha Raghuwansi	R.A.K, College of Agriculture Sehore (RVSKVV) MP	M.Sc. (Soil Science)	Dr. J. Somasundaram
4	Ms. Bharti Parmar	Rajmata Vijyaraje Scindia Krishi Vishwavidyalaya, Gwalior (MP)	M.Sc. (Agronomy)	Dr. R.H. Wanjari
5	Ms. Priyanka Singh	Rajmata Vijyaraje Scindia Krishi Vishwavidyalaya, Gwalior (MP)	M.Sc. (Soil Science)	Dr. R. Elanchezhian
6.	Ms. Saroj Gour	Rajmata Vijyaraje Scindia Krishi Vishwavidyalaya, Gwalior (MP)	M.Sc. (Soil Science)	Dr. A.O. Shirale
7.	Mr. Virendra	Rajmata Vijyaraje Scindia Krishi Vishwavidyalaya, Gwalior (MP)	M.Sc. (Soil Science)	Dr. B.P. Meena
8.	Ms. Namita Bhagat	IGKV Raipur	M.Sc. (Soil Science)	Dr. S. Srivastava
9.	Mr. Rahul Kumawat	R.A.K, College of Agriculture Sehore (RVSKVV) MP	M.Sc. (Soil Science)	Dr. R.K. Singh

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

Name of Scientist	Topic	Date	Venue	Remarks
Dr. A.B. Singh	Organic Farming System Approach	May 4, 2019	Centre for Advanced Research & Development, Bhopal (MP)	33 candidates of Agri-Clinic and Agri-Business
Dr. A.B. Singh	Harit Khadki Upyogita	May 10, 2019	Doordarshan Kendra Bhopal	Presentation on Television
Dr. A.B. Singh	Organic Farming & Soil health management	July 3, 2019	Krishi Vigyan Kendra Raisen (MP)	Diploma in Agricultural Extension Services for Input Dealers (DAESI) programme
Dr. A.B. Singh	Rapid Composting Technology to Recycle city and Rural Waste	August 29 to September 3, 2019	KVK Deoghar, Jharkhand	Farmers from Deoghar
Dr. A.B. Singh	Organic Farming & Soil health management	September 29, 2019	Krishi Vigyan Kendra Raisen (MP)	Diploma in Agricultural Extension Services for Input Dealers (DAESI) programme
Drs. Sangeeta Lenka, J.K. Thakur and Asit Mandal	Exposure visit	November 16, 2019	ICAR-IISS, Bhopal	150 students and their escort teachers from Navodaya Vidyalaya Samiti selected for Regional Science Congress
Dr. A.B. Singh	Organic Farming & Soil health management	November 20, 2019	Krishi Vigyan Kendra Dhar	35 Dealers Diploma in Agricultural Extension Services for Input Dealers (DAESI)
Dr. A.B. Singh	Organic Farming and vermicomposting techniques	November 28, 2019	KVK Betul	150 Farmers
Drs. A.B. Singh, R. Elanchezhian, R.H. Wanjari, Ajay, Asha Sahu and J. Somasundaram	Organic Farming and Vermicomposting techniques and soil health management	December 2, 2019	ICAR-IISS Bhopal	50 B Sc. students of BSSS College Bhopal
Drs. A.B. Singh, R. Elanchezhian, R.H. Wanjari, Ajay, Asha Sahu and J. Somasundaram	Soil health Management	December 2, 2019	Sardar Patel School, Karond, Bhopal	100 School students
Dr. A.B. Singh	Organic farming and vermicomposting technique	December 6, 2019	ICAR-IISS, Bhopal	50 SC Farmers
Dr. A.B. Singh	Organic farming and soil health management in Farm School programme	December 7, 2019	Sonkatch, Berasia Block, Bhopal	Sponsored by Project Director ATMA
Dr. A.K. Vishwakarma	Promotion of Soil Health for sustaining productivity	December 7, 2019	Khamkheda,Dist. Bhopal	100 Farmers
Dr A. B. Singh	Organic Farming and Composting techniques	December 13, 2019	Project Director Dausa Rajasthan	50 farmers

5. Awards, Honours and Recognitions

5.1 Awards

- Institute was bestowed with Sardar Patel Outstanding Institution Award for the year 2018 on ICAR Foundation Day 2019.

- Dr MC Manna (2019) Recipient of 9th Prof. P.K.De Memorial Lecture Award organised by Indian Society of Soil Science, Kolkata Chapter on July 19, 2019.

- Dr SR Mohanty awarded Fulbright Fellowship under Fulbright Nehru Academic and Professional Excellence (FNAPE) 2019.
- Dr R Elanchezhian awarded NABS Fellowship for Agriculture and Forestry Sciences Section at the 11th NABS Conference on Climate Change-Driven Challenges on Indian Biodiversity: Innovative Solutions for Sustainable Development during September 25-27, 2019 organized at Pondicherry University, Pondicherry.

- Drs N.K. Lenka and Sangeeta Lenka received Dr. J.S.P. Yadav Memorial Award for Excellence in Soil Science-2019 at the 84th Annual Convention of the Indian Society of Soil Science at Varanasi from November 15-18, 2019.

- Dr Monoranjan Mohanty received 12th International Congress Commemmoration Award 2019 from the Indian Society of Soil Science, New Delhi in 84th Annual Convention of the Indian Society of Soil Science at BHU, Varanasi.

- Mrs.Seema Bhardwaj selected for the 'Young Scientist Award-2019' in '10th International Conference on Agriculture, Horticulture and Food Sciences by the Society of Tropical Agriculture, New Delhi, India during December 21-22, 2019.
- Dr J Somasundaram, received the Scientist Award for commendable contribution to soil science by Dr. B. Vasantharaj David Foundation, Tamil Nadu, India on November 18, 2019.

- Drs Sangeeta Lenka, NK Lenka, Asit Mandal, Vasudev Meena, Muneshwar Singh, Bharat Singh, Priyanka Jadon, Swarnima Shrivastva, JK Saha, AK Patra recieved Best Poster Award in 84th Annual Convention of the Indian Society of Soil Science at Varanasi during November 15-18, 2019.

5.2 Honours and Recognitions

- Dr AK Patra nominated as member of FAI Advisory Committee on Agricultural Sciences.
- Dr AK Patra elected as President of the Indian Society of Soil Science for 2019-20.

- Dr AK Patra delivered Presidential Lecture in the 84th Annual Convention of Indian Society of Soil Science at BHU, Varanasi during November 13-18, 2019.
- Dr AK Patra delivered a keynote address and chaired a Session of the Biotechnology International Conference during April 4-8, 2019 held at AKS University, Satna, MP.
- Dr AK Patra acted as member of Maharashtra Agricultural Universities Recruitment Board (MAURB), Maharashtra Council of Agricultural Education & Research, Pune during August 19-20, 2019.
- Dr AK Patra acted as an expert for site selection of additional KVK Sagar, M.P. during September 12-13, 2019.
- Dr AK Patra acted as an expert to develop guidelines for testing and demonstration of nano fertilizers during December 18-19, 2019.
- Dr AK Biswas delivered the 30th Dr. S.P. Raychaudhuri Memorial Lecture of ISSS organized by the Kolkata Chapter of ISSS on September 27, 2019.

- Dr JK Saha is Member of 'National Network of

Experts and Resources for Subsurface Investigations and Remediation of Contaminated Sites (NERCS)' at IIT, Delhi.

- Dr JK Saha is Member of Mentors' community in the 'Mentoring Research Programme (MRP)' of International Support Network for African Development, University of Ibadan, Ibadan, Nigeria.
- Dr Sangeeta Lenka worked as Rapporteur in Workshop on "Improving Soybean Yield in Central India-Potential Strategies" organized by National Academy of Agricultural Sciences Bhopal Chapter on October 1, 2019 at ICAR-IISS, Bhopal.
- Dr Sangeeta Lenka invited as Panelist on "Achieving land degradation neutral India by 2030 through managing organic carbon in soils: Issues and Strategies" in Workshop on "Carbon Management in Soils through Resource Conservation Technologies: Issues and Strategies" on November 2, 2019 at BCKV, Mohanpur, West Bengal.
- Dr BP Meena acted as an external examiner to set question paper of course no. AGRON-112 title Fundamentals of Agronomy to academic session 2019 of Banda University of Agriculture & Technology, Banda, UP.
- Dr BP Meena received a Certificate of reviewing awarded by Field Crop Research in 2019.
- Dr Brij Lal Lakaria acted as member of Editorial Board of the Indian Journal of Soil Conservation by the Indian Association of Soil and Water Conservationists, Uttranchal, Dehradun w.e.f. March 2018.
- Dr Brij Lal Lakaria acted as an external Examiner for evaluation of Ph.D. of CSK HPKV, Palampur, H.P.
- Dr Brij Lal Lakaria acted as an Expert for interview board of Rajasthan Public Service Commission for the selection of Assistant Agriculture Officers for the State of Rajasthan during 08-10 July, 2019 at RPSC, Ajmer.
- Dr SR Mohanty acted as an external committee member for JRF selection at RGPV, Bhopal on July 23, 2019
- Dr Pramod Jha acted as an external examiner for Ph.D. Viva Voce of Mr Hareesh Kumar IGKV, Raipur on November 15 2019.
- Dr Pramod Jha acted as an external examiner for comprehensive Viva Voce of two Ph.D. students of IGKV, Raipur on July 24, 2019.
- Dr Brij Lal Lakaria acted as an organizing secretary for organizing brainstorming session on 'Biochar: Potential, usefulness and limitations in context to Indian Agriculture' at ICAR-Indian Institute of Soil Science, Bhopal, on 27 November, 2019.
- Dr R Elanchezhian acted as an expert for Development of Course materials for Diploma in Vocational Education and Training in Agriculture for NCERT, MHRD GOI during May 15-17, 2019 at PSS Central Institute of Vocational Education Shyamala Hills, Bhopal.
- Dr R Elanchezhian acted as an organizing secretary for ICAR-IISS - in the service of farmers cum celebration of "Sardar Patel Outstanding ICAR Institution Award" to ICAR-IISS on July 22, 2019.
- Dr AK Vishwakarma acted as an expert member in interview at PSS ICAR-CIAE, Bhopal on May 29, 2019.
- Dr AK Vishwakarma acted as an expert member for selection of Scientist at KVK, Raisen on June 27, 2019.
- Dr Pradip Dey nominated by DDG (NRM) for Zonal Monitoring Committee in NICRA KVKs (Tikamgarh/Chhattarpur/Satna) district of Madhya Pradesh during December 19-22, 2019.
- Dr NK Lenka nominated by DG, ICAR for assessment of scientist at ICAR-Central Institute for Sub-tropical Horticulture, Lucknow on 25 March 2019.
- Dr NK Lenka elected as Treasurer, Bhopal Chapter of the National Academy of Agricultural Sciences.
- Dr NK Lenka acted as Organizing Secretary of the Workshop on 'Improving Soybean Yield in Central India' organized by NAAS-Bhopal Chapter at ICAR-Indian Institute of Soil Science, Bhopal on 1st October, 2019.
- Dr Sanjay Srivastava invited to act as Adviser to assist the Chairman of Rajasthan Public Service Commission in recruitment process during July 1-3, 2019.
- Dr Sanjay Srivastava was elected as Vice-Chairman of South East Asia Laboratory Network (SEALNET) of FAO during 3rd SEALNET meeting

held in Manila, Philippines in September, 2019.

- Dr Sanjay Srivastava acted as examiner for the evaluation of Ph.D. Thesis at Tamil Nadu Agricultural University, Coimbatore.
- Dr Sanjay Srivastava received "Reviewer's Excellence Award" certificate from Indian Journal of Agricultural Research in recognition of significant and outstanding contribution to the Journal and reviewing the article.
- Dr J Somasundaram invited as lead speaker in workshop on "Carbon Management in Soils through Resource Conservation Technologies: Issues and Strategies"on November 2, 2019 at BCKV, Mohanpur, West Bengal.
- Dr J Somasundaram delivered a lecture in Workshop on 'GHG emissions studies and future planning' on August 29, 2019 at ICAR-NRRI, Cuttack
- Dr RS Chaudhary chaired the Session VII on "Soil Physics, Soil Education and Public Awareness" during 84th Annual Convention of Indian Society of Soil Scienceat BHU, Varanasi November 16, 2019.
- Dr KM Hati acted as an external expert for the Viva-Voce examination of a M.Sc.(Ag.) at BHU, Varanasi on July 5, 2019.
- Dr RS Chaudhary nominated as an advisor by Rajasthan Public Service Commission during August 8-9 2019 at Ajmer, Rajasthan.
- Dr RS Chaudhary delivered Dr D P Motiramani Memorial Lecture of ISSS on September 30, 2019 at ICAR-IISS, Bhopal.
- Dr RH Wanjari invited as lead speaker in Global Organic Conference on 'Natural Resource Management for Sustainable Agriculture, Soil Health and Quality Food' organised by Society for Agricultural Research and Development and Centre for Organic Agriculture and Trainng (Dr PDKV Akola) at Nagpur during September 15-17, 2019.
- Dr Pradip Dey elected as Vice-President of ISSS for the Biennium 2019 and 2020.
- Mrs Seema Bhardwaj received Reviewer Certificate for contribution to quality and success of journal by International Journal of Agriculture Science on
- Dr SR Mohanty reviewed PhD thesis, Department of Soil Science and Agricultural Chemistry, MPKV, Rahuri, June 7, 2019.

6. Linkages and Collaborations

The Institute has linkages with several ICAR institutes and SAUs located throughout the country. The three AICRPs (LTFE, MSPE & STCR) and an AINP on SBB stationed at ICAR-IISS Bhopal have 82 cooperating centers spread across almost all the SAUs of the country. As lead centre, the Institute is undertaking platform project of CRP on Conservation Agriculture and external funded projects (INDO-UK Nitrogen centre, National Agricultural Science Fund, DST, DBT, NICRA) involving linkage with several ICAR Institutes. Also, efforts have been made to strengthen research collaborative activities with SAUs through guidance of PG students by the Institute scientists. Besides, several private firms, viz., Zuari Agro Chemicals Ltd.; Indofil Industries Ltd.; SNF Pvt. Ltd, Vishakhapatanam; and Hindustan Copper Ltd., Malanjkhand, Rhodia Specialty Chemicals India limited, Mumbai, M/s Grasim Industries Limited, Nagda, Ujjain, M.P.and UPL Pvt. Ltd, Mumbai are collaborating with the Institute on various R&D activities.

List of co-operating centres under AICRPs/AINP

Name of Employee	No. of Cooperating Centres		
	ICAR	SAUs/ SGUs	Total
AICRP on LTFE UAS GKVK, Bangalore; OUAT, Bhubaneswar; TNAU, Coimbatore; PJTSAU, Hyderabad; JNKVV, Jabalpur; PAU, Ludhiana; CSKHPKV, Junagarh; MPUAT, Udaipur; VNMAU, Parbhani; Dr PDKV, Akola; IGKVV, Raipur; ICAR-IARI, New Delhi; ICAR-CRIJAF, Barrackpore; ICAR-IASRI, New Delhi	3	15	18
AICRP on MSPE PJTSAU, Hyderabad; RAU, Pusa; AAU, Anand; HAU, Hisar; JNKVV, Jabalpur; Dr PDKV, Akola; OUAT, Bhubaneshwar; PAU, Ludhiana; TNAU, Coimbatore; GBPUAT, Pantnagar; AAU, Jorhat; BCKV, Kalyani; RAU, Ranchi; CSKHPKV, Palampur; CSAUAT, Kanpur; KAU Kerala; UAS Bengaluru; CAU, Manipur; NIANP Bengaluru; ICAR-IARI, New Delhi; RLBCAU, Jhansi	2	19	21
AICRP on STCR PJTSAU, Hyderabad; RAU, Pusa; IGKV, Raipur; ICAR-IARI, New Delhi; HAU, Hisar; HPKV, Palampur, GKVK, Bengaluru; KAU, Vellanikara; JNKVV, Jabalpur; MPKV, Rahuri; OUAT, Bhubaneswar; PAU, Ludhiana; SKRAU, Bikaner; TNAU, Coimbatore; GPUAT, Pantnagar; BCKVV, Kalyani; ICAR-CRIJAF, Barrackpore; PAJANCOA, Puduchery; BHU, Varanasi; AAU, Jorhat; JAU, Gujarat; SKUAT, Srinagar; BAU, Ranchi; ICAR-IISR, Lucknow; ICAR-Complex, Manipur	4	21	25
AINP on Soil Biodiversity-Biofertilizers AAU, Jorhat; ANGRAU, Amaravathi; BAU, Ranchi; HAU, Hisar; JNKVV, Jabalpur; KAU, Thrissur; KAU, Vellayani; MAU, Parbhani; MPUAT, Udaipur; OUAT, Bhubaneswar; RAU, Pusa; TNAU, Coimbatore; YSPUHF, Solan; CRRI, Hazaribagh; University of Delhi, New Delhi; ICAR-IARI, New Delhi; DGR, Junagarh; GBPUAT, Pantnagar; UAS, Dharwad	3	15	18

7. Ongoing Research Projects

7.1 Programme I: Soil Health and Nutrient Use Efficiency

(A) Institute Project

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

   Investigators: Muneshwar Singh, AK Biswas, BP Meena, AB Singh, RS Chaudhary

2. Evaluating rock phosphates for their suitability for direct application

   Investigators: Sanjay Srivastava, AK Tripathi, P Dey, Prabhat Tripathi and Gurav Priya Pandurang

3. Assessment of important soil properties of India using mid-infrared spectroscopy

   Investigators: KM Hati, M Mohanty, Pramod Jha, RS Chaudhary, Nishant Sinha, JK Thakur, M Vassanda Coumar, Pradip Dey, Muneshwar Singh, AK Patra and Javed Rizvi

4. Evaluation of glauconite as source of potassium for crops.

   Investigators: AO Shirale, Gurav Priya Pandurang, Sanjay Srivastava, BP Meena and AK Biswas

5. Enhancing the productivity of major crops through improving the natural resource base of tribal inhabited areas of central India.

   Investigators: Shinogi KC, Sanjay Srivastava, AL Kamble, BP Meena, NK Sinha, K Bharati, Gurav Priya Pandurang, AK Tripathi, Hiranmoy Das, RL Raut (KVK, Balaghat), Rameshwar Ahirwar (KVK, Balaghat), Aparna Jaiswal (COA, Balaghat)

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

   Investigators: Gurav Priya Pandurang, AO Shirale, BP Meena, BL Lakaria, Sanjay Srivastava, P Chandran

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

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

8. Impact Assessment of Neem Coated Urea and Soil Health Card in Central and Western India

   Investigators: A.L. Kamble and Hiranmoy Das

9. Socio-Economic impact of use of polluted irrigation water on soil quality and crop productivity near Ratlam industrial area in Madhya Pradesh

   Investigators: Utkarsh Tiwari, J.K. Saha, M.V. Coumar, A.L. Kamble and Hiranmoy Das

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

    Investigators: Drs RH Wanjari, R Elanchezian, Prabhat Tripathi, RK Singh, KC Shinogi, M Vassanda Coumar, Vasudev Meena, AL Kamble, Utkarsh Tiwari, J Somasundaram, Abhay Shirale, Asit Mandal, Hiranmoy Das, AB Singh, Asha Sahu, SK Behera, AK Vishwakarma, Monoranjan 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)

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

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

(B) Externally Funded Projects

12. Network Project on Organic Farming (ICAR, New Delhi)

    Investigators: AB Singh, BP Meena, Brij Lal Lakaria, S Ramana and JK Thakur

13. Simulating the effect of elevated CO_2 and temperature on water productivity and nutrient use in soybean-wheat cropping system (NASF funded)

    Investigators: NK Lenka, Sangeeta Lenka, AK Shukla, R Elanchezhian, JK Thakur, Pradip Dey, P Chandra, KK Singh

14. Ensuring food security, sustainability and soil health through resource conservation based farmer FIRST approach in central India, sponsored by ICAR New Delhi

    Investigators: AK Patra, AK Vishwakarma, RK Singh, AB Singh, BL Lakaria, RH Wanjari, K Bharati, AL Kamble, Asha Sahu, Shinogi KC, *Abhay O Shirale, Hiranmoy Das*

15. Assessing the impact of imbalanced use of chemical fertilizer on soil health using a soil function based quantitative approach funded by DST, New Delhi

    Investigators: NK Lenka, BP Meena, Sangeeta Lenka, AO Shirale, RH Wanjari

7.2 Programme II: Conservation Agriculture, Carbon Sequestration and Climate Change

A. Institute Projects

16. Assessing greenhouse gas emission and soil carbon storage with reversal in tillage practice

    Investigators: Sangeeta Lenka, NK Lenka, S Bhattacharjya

17. Climate change impact on soil and water productivity of major crops in central India

    Investigators: NK Sinha, Seema Bhardwaj

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

    Investigators: Prabhat Tripathi, RK Singh, Seema Bhardwaj

B. External funded projects

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

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, Abhay Shirale

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

   Investigators: RK Singh, Sanjay Srivastava, 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, K Bharati

20. Hyper-spectral remote sensing approaches to evaluate soil quality and crop productivity of central India funded by DST

    Investigators: M Mohanty, NK Sinha, KM Hati, RK Singh, Pradip Dey, RS Chaudhary, AK Patra, BB Gaikwad

21. Vulnerability and impact assessment of climate change on soil and crop production in Madhya Pradesh funded by UNDP-GEF-MoEFCC.

    Investigators: Sangeeta Lenka, NK Lenka, M Mohanty, RH Wanjari, AK Patra

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 funded by NICRA II-Phase

    Investigators: M Mohanty, Pramod Jha, Sangeeta Lenka, J Somasundaram, NK Sinha, AK Vishwakarma, RS Chaudhary, Muneshwar Singh and Seema Bhardwaj

23. Assessing the potential impact of climate smart technologies on soil health and nutrient accounting in selected vulnerable districts of MP funded by EPCO, Bhopal

    Investigators: Sangeeta Lenka, NK Lenka, MV Coumar, M Mohanty, Dolamani Amat, JK Saha, AK Patra

24. Assessing the potential impact of climate change and management on soil carbon and nitrogen storage in selected ecosystems of India funded by NASF

    Investigators: Sangeeta Lenka, NK Lenka, Vasudev Meena, Asit Mandal, Biswapati Mandal (BCKV, West Bengal)

25. Sustainable adaptive management of water resources to variable climates of Madhya Pradesh funded by ICARDA

    Investigators: M Mohanty, NK Sinha, AK Patra

26. 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

Investigators: M Mohanty, VS Bhatia, NK Sinha, Prabhat Tripathi, RS Chaudhary, Seema Bhardwaj and AK Patra

7.3 Programme III – Soil Microbial Diversity and Biotechnology

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

27. Effects of long term use of fertilizer and manure on soil functional diversity and nutrient supplying capacity under different soils and cropping systems.

Investigators: Sudeshna. Bhattacharjya, Asha Sahu, MC Manna, Muneshwar Singh, RH Wanjari, MP Sharma, AK Patra

B. Externally Funded Projects

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

Investigators: SR Mohanty, DLN Rao

29. Metagenomic mapping of microbial diversity in rhizosphere of major crops of India and Argentina offsetting production potential funded by DST

Investigators: SR Mohanty, AK Patra, K Bharati, Muneshwar Singh, JK Thakur

30. Exploring soil microbial community and mechanism in soil carbon sequestration under long term land uses in semi-arid sub-humid Central India funded by SERB, DST

Investigator: S Bhattacharjya

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 funded by DST

Investigators: SR Mohanty, K Bharati, S Gangil (ICAR-CIAE, Bhopal)

32. Evaluation of Soybean-rhizobia interaction under elevated CO_2 and temperature to develop climate ready microbial inoculants for central India funded by AMAAS

Investigators: SR Mohanty, A Mandal, K Bharati

32. Enhancing decomposition rate and quality of biowaste through microbial consortia for improving soil health funded by ICAR NASF

Investigators: MC Manna, Asha Sahu, Sudeshna Bhattacharjya, AB Singh, AK Tripathi, JK Thakur, Dolamani Amat

34. Exploring endophytic fungi for the phytoremediation of heavy metal contaminated soils funded by DST

Investigators: Asit Mandal, JK Thakur, MC Manna, AK Patra, M Vassanda Coumar

7.4 Programme IV: Soil Pollution, Remediation and Environmental Security

A. Institute Project

35. Assessment of cotton for the remediation of soils contaminated with heavy metals

Investigators: S Ramana, AK Tripathi, K Bharati and Asha Sahu

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

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

B. Externally Funded Projects

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

Investigators: Ajay, Tapan Adhiakari, K Bharati, Asit Mandal and JK Saha

38. Reclamation and rehabilitation of copper mining affected land in malanjkhand area of madhya pradesh, sponsored by Hindustan Copper Ltd. Malanjkhand

Investigators: Ajay, Tapan Adhikari, Asit Mandal and JK Saha

39. Management of municpal solid waste contaminated dumping area of Bhanpur, Bhopal funded by MPCST

Investigators: Ajay, Tapan Adhikari, K Bharati and Asit Mandal

Collaborative projects in other institutes where IISS scientists are associated in

40. Development of an Automated Soil Nutrient Sensing System

Investigators: Sanjay Srivastava, AO Shirale, PS Tiwari (ICAR-CIAE, Bhopal), Vijay Kumar (ICAR-CIAE, Bhopal), Ramesh Kumar Sahani (ICAR-CIAE, Bhopal), Baban Kumar (CSIR-CSIO, Chandigarh) and Neelam (CSIR-CSIO, Chandigarh)

8. Consultancies, Contractual Services, Patents and Technology Commercialization

S. No.	Title	Sponsorer	Project team
1	Evaluation of efficacy of sulphur and zinc containing complex fertilizers for maximizing yield through balanced nutrition of different crops in India	M/s Zuari Agro Chemicals Limited	AK Shukla, AK Biswas, Sanjay Srivastava, SK Behera , BP Meena
2	Evaluation of efficacy of zinc metalosate and boron metalosate foliar supplements for maximizing yield through balanced nutrition of important crops grown in India	M/s Indofil Industries Limited	AK Shukla, AK Biswas, S K Behera, BP Meena
3	Effect of aquasorb on water and nutrient use efficiency & crop productivity of soybean and tomato in selected soils of India	M/s SNF India Pvt. Ltd. Vishakhapatanam	RS Chaudhary, RK Singh, KM Hati, BP Meena, AK Biswas, M Mohanty and AK Patra
4	Effect of slow N release formulations for enhancing productivity and nitrogen use efficiency in cereals	M/s Rhodia Specialty Chemicals India limited, Mumbai	BL Lakaria, Pramod Jha, Sanjay Srivastava, AK Vishwakarma, AK Biswas and AK Patra
5	Evaluation of Soil Test Kit of Warkem, Mumbai	M/s Warkem Pvt. Ltd, Mumbai	Sanjay Srivastrava, Pramod Jha, A.O. Shirale, M. Vassanda Coumar, Gurav Priya Pandurang, A.K. Biswas, Pradip Dey and A.K. Patra
6	Impact of viscose staple fibre industry treated effluent on soil health and crop production surroundings Nagda, MP	M/s Grasim Industries Limited, Nagda, Ujjain (M.P.)	Tapan Adhikari, JK Saha, M. Vassanda Coumar, RH Wanjari, NK Sinha and AK Patra
7	Evaluation of effect of Zeba fertilizer product on nitrate-N leaching	M/s UPL Limited, Mumbai	AK Biswas, R Elanchezhian, NK Lenka, AO Shirale, AK Patra

9. Publications

9.1 Papers in Research Journal

9.1.1 International/ National (NAAS rating more than 6)

Aher SB, Lakaria BL, Singh AB, Kaleshananda S, Ramana S, Ramesh K, Thakur JK, Rajput PS and Yashona DS (2019). Effect of organic sources of nutrients on performance of soybean (*Glycine max*) Indian Journal of Agricultural Sciences 89(11):1787–91.

Behera SK, Mathur RK, Suresh K (2019).Assessing the variation in leaf nutrient concentrations of oil palm germplasms.Indian Journal of Agricultural Sciences 89(8): 1236-1240.

Behera SK, Shukla, AK, Suresh, K and Mathur, RK (2019). Estimation of soil properties and leaf nutrients status of oil palm plantations in an intensively cultivated region of India.Current Science 117(3): 497-502.

Bhattacharjya Sudeshna, SahuAsha, Manna MC, Patra AK (2019). Potential of surplus crop residues, horticultural waste and animal excreta as a nutrient source in the central and western regions of India. Current Science 116(8):1314.

Chitdeshwari T, Jegadeeswari D,Shukla AK (2019). Screening groundnut (Arachishypogaea) genotypes for sulphur efficiency.Legume Research DOI: 10.18805/LR-4128.

Dey A, Srivastava PC, Pachauri SP, Shukla AK (2019). Release kinetics of some nutrients from a sandy loam soil treated with different organic amendments. Communications in Soil Science and Plant Analysis DOI:10.1080/00103624.2019.1678630.

Dhaliwal SS, Hari Ram, Shukla AK, Mavi GS (2019). Zinc biofortification of bread wheat, triticale, and durum wheat cultivars by foliar zinc fertilization. Journal of Plant Nutrition DOI: 10.1080/01904167.2019.1584218.

Dotaniya ML, Saha JK, Rajendiran S, Coumar MV, Meena VD, Das H, Kumar Ajay, Patra AK (2019). Reducing chromium uptake through application of calcium and sodium in spinach. Environmental Monitoring and Assessment 191:754-762.

Dotaniya ML, Saha JK, Rajendiran S, Vassanda Coumar M, Meena VD, Kundu S, Patra AK (2019). Chromium toxicity mediated by application of chloride and sulfate ions in Vertisol of Central India. Environmental Monitoring and Assessment 191(7): 429. DOI: 10.1007/s10661-019-7563-4.

Ghosh Avijit, Bhattacharyya Ranjan, Dey Abir, Dwivedi BS, Meena MC, Manna MC, Agnihortri R (2019). Long-term fertilisation impact on temperature sensitivity of aggregate associated soil organic carbon in a sub-tropical inceptisol. Soil and Tillage Research https://doi.org/10.1016/j.still.2019.104369.

Ghosh Avijit, Kumar Sunil, Manna MC, Singh Amit K, Sharma Poonam, Sarkar Abhijit, Saha Madhumonti, Bhattacharyya Ranjan, Misra Sukanya, Biswas SS, Biswas DR, Gautam Kamini, Kumar RV (2019). Long-term *in situ* moisture conservation in horti-pasture system improves biological health of degraded land. Journal of Environmental Management DOI: 10.1016/j.jenvman.2019.109339

Ghosh Avijit, Singh AB, RV Kumar, Manna MC, Bhattacharyya Rajan, Rahman M, Sharma Poonam, Rajput PS, Misra Sukanya (2019). Soil Enzymes and microbial elemental stoichiometry as bio-indicators of Soil quality in diverse cropping systems and nutrient management practices of Indian Vertisols. Applied Soil Ecology https://doi.org/10.1016/j.apsoil.2019.06.007.

Golui D, Datta SP, Dwivedi BS, Meena, MC, Varghese E, Sanyal SK, Ray P, Shukla AK, Trivedi VK (2019). Assessing soil degradation in relation to metalpollution -A multivariate approach. Soil and Sediment Contamination: An International Journal 28:7, 630-649.

Kour R, Jain D, Bhojiya AA, Sukhwal A, Sanadhya S, Saheewala H, Jat G, Singh A, Mohanty SR (2019). Zinc biosorption, biochemical and molecular characterization of plant growth-promoting zinc-tolerant bacteria. 3 Biotech 9(11):421.

Kollah B, Singh B, Parihar M, Ahirwa U, Atoliya N, Dubey G, Patra AK, Mohanty SR (2019). Elevated CO_2, chlorpyrifos and biochar influence nitrification and microbial abundance in the rhizosphere of wheat cultivated in a tropical vertisol. Rhizosphere 10:100151.

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

Lal B, Gautam Priyanka, Nayak AK, Panda BB, Bihari P, Tripathi R, Shahid M, Guru PK, Chatterjee D, Kumar U, Meena BP (2019). Energy and carbon budgeting of tillage for environmentally clean and resilient soil health of rice-maize cropping system. Journal of Cleaner Production 226:815-830.

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Lenka NK, Lenka S, Singh KK, Kumar Ajay, Aher SB, Yashona DS, Dey P, Agrawal PK, Biswas AK, Patra AK (2019). Effect of elevated CO_2 on plant growth, nutrient partitioning and uptake of major plant nutrients in soybean under varied nitrogen application levels. Journal of Plant Nutrition and Soil Science 182:509-514.

Lenka S, Trivedi P, Singh B, Singh BP, Pendall E, Bass A, Lenka NK (2019). Effect of crop residue addition on soil organic carbon priming as influenced by temperature and soil properties. Geoderma, 347: 70-79.

Mandal Asit, Thakur JK, Sahu Asha, Manna MC, Rao AS, Sarkar Binoy, Patra AK (2019). Effects of Bt-cotton on biological properties of Vertisols in central India. Archives of Agronomy and Soil Science 65(5):670-685.

Meena BP, Biswas AK, Singh Muneshwar, Chaudhary RS, Singh AB, Das H, Patra AK (2019). Long-term sustaining crop productivity and soil health in maize–chickpea system through integrated nutrient management practices in Vertisols of central India. Field Crops Research 232:62-76. https://doi.org/10.1016/j.fcr.2018.12.012.

Meena BP, Kumar Ashok, Lal B, Meena Rang Lal, Shirale AO, Dotaniya ML, Kumar Kuldeep, Sinha NK, Meena SN, Ram Asha, Gautam Priyanka (2019). Sustainability of Popcorn-Potato Cropping System Improves Due to Organic Manure Application and Its Effect on Soil Health. Potato Researchhttps://doi.org/10.1007/s11540-018-9410-3.

Meena HR, Somasundaram J, Kaushik RA, Sarolia DK, Singh RK, Kala S, Meena GL (2019). Integrated nutrient management for enhancing fruit yield of sapota and nutrient availability in Vertisols of Chambal region, India.Communication in Soil Science & Plant Analysis DOI: 10.1080/00103624.2019.1689248

Mohanty SR, Nagarjuna M, Parmar R, Ahirwar U, Patra AK, Dubey G, Kollah B (2019). Nitrification rates are affected by biogenic nitrate and volatile organic compounds in agricultural soils. Frontiers in Microbiology 10:772.

Nazir G, Kumar P, Shukla AK, Sharma U (2019). Influence of boron fertilization on cauliflower productivity, nutrient uptake and soil nutrient status in an acid Alfisol in Northwestern Himalaya. Communications in Soil Science and Plant Analysis DOI: 10.1080/00103624.2019.1614610.

Padhan Kshitipati, Bhattacharjya Sudeshna, Sahu Asha, Manna MC, Sharma MP, Singh Muneshwar, Wanjari RH, Sharma RP, Sharma GK and Patra AK (2019). Soil N transformation as modulated by soil microbes in a 44 years long term fertilizer experiment in a sub-humid to humid Alfisol. Applied Soil Ecology 145: 1-9.

Priya P Gurav, SK Ray, PL Choudhari AO Shirale, BP Meena, AK Biswas, Patra AK (2019). Potassium in shrink–swell soils of India. Current Science 117(4): 587-596.

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10. Committees/Cells/Sections/Units

Consultancies Contractual Services

Quinquenial Review Committee		
1	Dr VS Tomar	Chairman
2	Dr Biswapati Mandal	Member
3	Dr AL Pharande	Member
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Research Advisory Committee		
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5	Dr DK Das	Member
6	Dr KS Subramaniam	Member
7	Dr SK Chaudhari, DDG (NRM), ICAR	Member
8	Dr AK Patra, Director	Member
9	Dr AK Biswas, I/c Head, Division SC&F	Member-Secretary
Institute Management Committee		
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3	Director of Agriculture, Chhattisgarh Govt. Raipur	Member
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6	Dr MJ Kaledhonkar. PC, AICRP (SWS), CSSRI, Karnal	Member
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8	Dr Sanjay Ray, Head, Jorhat Regional Station of ICAR-NBSS&LUP, Nagpur	Member
9	F&AO, ICAR-IISR, Indore	Member
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11	Mr Om Prakash Yadav, Indore	Member
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3	Dr Muneshwar Singh, PC (LTFE)	Member
4	Dr RS Chaudhary, I/c HOD (SP)	Member

5	Dr AK Biswas, I/c HOD (SC&F)	Member
6	Dr JK Saha, I/c HOD (ESS)	Member
7	Dr Pradip Dey, I/c PC (STCR)	Member
8	Dr AK Shukla, I/c PC (MSN)	Member
9	SAO	Member
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3	Dr AK Vishwakarma, Pr. Scientist	Member
4	Dr Monoranjan Mohanty, Pr. Scientist	Member
5	Dr Vassanda Coumar, Scientist	Member
6	Dr Ankush Lala Kamble, Scientist	Member
7	Finance & Accounts Officer (FAO) AF&AO (Alternate)	Member
8	Senior Administrative Officer (SAO) AAO (Alternate)	Member Secretary
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3	Dr AK Biswas, I/c HOD (SC&F)	Member
4	Dr Pradip Dey, I/c PC (STCR)	Technical Expert
5	Dr MC Manna, HOD (SB)	Technical Expert
6	Dr Niranjan Mishra, Pr. Scientist & I/c ITMU, NIHSAD	Outside Expert
7	Dr Sanjay Srivastava, Pr. Scientist & I/c ITMU	Member-Secretary
Institute Technology Management Unit		
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2	Dr Monoranjan Mohanty, Pr. Scientist	Member
3	Dr JK Thakur, Scientist	Member
4	Dr M Vassanda Coumar, Scientist	Member
5	Dr KC Shinogi, Scientist	Member
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2	Dr Prabahat Tripathi, Pr. Scientist	Member

3	Dr RH Wanjari, Pr. Scientist	Member
4	Dr AK Vishwakarma, Pr. Scientist	Member
5	Dr Vasudev Meena, Scientist	Member
6	Dr KC Shinogi, Scientist	Member
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2	Dr KM Hati, Pr. Scientist	Member
3	Dr AK Vishwakarma, Pr. Scientist	Member
4	Dr Manoranjan Mohanty, Pr. Scientist	Member
5	Dr M Vassanda Coumar, Scientist	Member
6	Dr Asit Mandal, Scientist	Member
7	Mr Sanjay Kumar Kori, Stenographer Grade-III	Member
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4	Dr KC Shinogi, Scientist	Member
5	Dr J Somasundaram, Pr. Scientist & I/c AKMU	Member Secretary
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5	SAO or AAO	Member
6	F&AO or AF&AO	Member
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3	Dr RK Singh, Pr. Scientist	Member
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5	Mr CT Wankhede, Electrician	Member
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3	Dr Prabhat Tripathi, Pr. Scientist	Member
4	SAO or AAO	Member
5	F&AO or AF&AO	Member
6	Dr AK Vishwakarma, Pr. Scientist	Member Secretary
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5	SAO	Member
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4	Dr Monoranjan Mohanty, Pr. Scientist	Member
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5	Dr Sangeeta Lenka, Sr. Scientist	Member
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7	Mr Sunny Kumar, Stenographer Grade-III	Member
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2	All PCs	Member
3	All HoDs	Member
4	I/c PME Cell	Member
5	F&AO	Member
6	SAO	Member
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3	Dr SK Behera, Sr. Scientist & Library Incharge	Member
4	Dr KC Shinogi, Scientist (Alternate Incharge)	Member
5	Dr Madhumonti Saha, Scientist (Alternate Incharge)	Member
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7	SAO	Member
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2	Dr R Elanchezhian, Pr. Scientist	Member
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4	Project Leader of the Contractual Research Project	Member
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2	Dr Asha Sahu, Scientist	Member
3	Dr Sudeshna Bhattacharjya, Scientist	Member
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5	Mrs Geeta Yadav, PS	Member
6	Mrs Raksha Dixit, LDC	Member
7	Mrs Kavita Bai, SSS	Member
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3	Mrs Seema Bhardwaj, Scientist	Member
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4	AAO	Member
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2	Dr Tapan Adhikari, Pr. Scientist	Member
3	Dr Pramod Jha, Pr. Scientist	Member
4	Dr Monoranjan Mohanty, Pr. Scientist	Member
5	SAO	Member
Estate Committee		
1	Dr AB Singh, Pr. Scientist	Chairman
2	Dr RH Wanjari, Pr. Scientist	Member
3	Mr Jai Singh, STO	Member
4	Mr Anurag, Security Supervisor	Member
5	SAO	Member
Seminar Committee		
1	Dr Ajay, Pr. Scientist	Chairman
2	Dr Pramod Jha, Pr. Scientist	Member
3	Dr Sangeeta Lenka, Sr.Scientist	Member
Standing Sports Promotion Committee		
1	Dr Brij Lal Lakaria, Pr. Scientist	Chairman
2	Dr R Elanchezhian, Pr. Scientist	Member

3	Dr AK Vishwakarma, Pr. Scientist	Member
4	Mr Thomas Joseph, Private Secretary	Member
5	Mrs Babita Tiwari, Assistant	Member
6	Mr Anurag, Security Supervisor	Member
7	Mr Hiralal Gupta, Assistant	Member
Monitoring/Utilization of Plant/Machinery/Equipments/Instruments		
1	Dr AB Singh, Pr. Scientist	Incharge
2	Dr AK Tripathi, Pr. Scientist	Mebmer
Remote Sensing and GIS Laboratory		
1	Dr Monoranjan Mohanty, Pr. Scientist	Incharge
2	Dr NK Sinha, Scientist	Member
3	Ms Alka Rani, Scientist	Member
Central Lab		
1	Dr SR Mohanty, Pr. Scientist	Incharge
2	Dr JK Thakur, Scientist	Member
Training Hostel		
1	Dr NK Lenka, Pr. Scientist	Controlling Officer
2	Dr BP Meena, Scientist	Incharge
3	Dr Asit Mandal, Scientist (Alternate)	Member
4	Mr DR Darwai, I/c Farm Superintendent	Care Taker
5	Mr Jai Singh, STO	Member
Swachh Bharat Mission		
1	Dr RS Chaudhary, I/c HoD (SP)	Nodal Officer
2	Dr RK Singh, Pr. Scientist	Co-Nodal Officer
3	Mr Deepak Kaul, ACTO	Member
4	Mr Pramod Chauhan, STO	Member
Agricultural Knowledge Management Unit (AKMU)		
1	Dr J Somasundaram, Pr. Scientist	Incharge
2	Dr NK Sinha, Scientist	Member
3	AAO	Member
Vehicle Operation Committee		
1	Dr AO Shirale, Scientist	Incharge
2	Dr Hiranmoy Das, Scientist	Member
3	Mr Khilan Singh Raghuvanshi, TO	Member
Right To Information (RTI Cell)		
1	Dr R Elanchezhian, Pr. Scientist	Nodal Officer Cum-CPIO (Scientific matters)
2	Mr Sunil Kumar Gupta, SAO	CPIO (Administrative matters)
3	Mr Sanjay Kumar Kori, Stenographer Grade-III	Office Staff
Screen House		
1	Dr S Ramana, Pr. Scientist	Incharge
2	Dr Dolamani Amat, Scientist	Member

HRD (Training)		
1	Dr KM Hati, Pr. Scientist	Nodal Officer
2	Dr Monoranjan Mohanty, Pr. Scientist	Co-Nodal Officer
3	Mr Sanjay Kumar Kori, Stenographer Grade-III	Member
Mera Gaon Mera Gaurav		
1	Dr AB Singh, Pr. Scientist	Nodal Officer
2	Dr Prabhat Tripathi, Pr. Scientist	Co-Nodal Officer
Weed Management		
1	Dr AK Viswhwakarma, Pr. Scientist	Nodal Officer
2	Dr Vasudev Meena, Scientist	Co-nodal Officer
3	Mr Hukum Singh, TO	Member
TSP/STC Programme Implementation Committee		
1	Dr BL Lakaria, Pr. Scientist	Chairman
2	Dr RK Singh, Pr. Scientist	Member
3	Dr Asit Mandal, Scientist	Member
4	Dr Vasudev Meena, Scientist	Member
5	AAO	Member
6	AF&AO	Member
7	Mr Sanjay Katinga, LDC	Member
8	Dr RH Wanjari, Pr. Scientist	Member Secretary & Nodal Officer
Schedule Castes Sub Plan		
1	Dr AB Singh, Pr. Scientist (Nodal Officer, MGMG)	Chairman
2	Dr Prabhat Tripathi, Pr. Scientist (Co-Nodal Officer, MGMG)	Member
3	Dr AK Vishwakarma, Pr. Scientist, I/c Farm/PI of FF Project	Member
4	Dr Monoranjan Mohanty, Pr. Scientist	Member
5	Dr Nishant Kumar Sinha, Scientist	Member
6	Dr Vasudev Meena, Scientist	Member
7	Dr BP Meena, Scientist	Member Secretary

11. Important Meetings/Activities

Institute Research Council

The Institute Research Council (IRC) meeting of the institute was held during June 24-26, 2019 in the committee room of the institute. Dr. A.K. Patra, Director and Chairman of the IRC congratulated the award winning scientists. He stressed that all scientists must submit quality research proposals. At the outset, the Member-Secretary (IRC), Dr. M.C. Manna welcomed the participants and requested the scientists to take the IRC as a platform for discussion on scientific matter for overall improvement of research activities. Dr. R. Elanchezhian (I/c PME Cell) requested all the scientists to present the salient research findings followed by discussion. Thereafter, the ongoing (41Nos.) and new projects (12 Nos.) were presented and reviewed by the IRC.

Foundation Day

The ICAR-Indian Institute of Soil Science (IISS), Nabibagh, Bhopal celebrated its 32nd Foundation Day on 16 April 2019. In the program, Hon'ble Vice-Chancellor, Barkatullah University, Dr. R.J. Rao graced the occasion as the Chief Guest. In his address, he emphasized on different ecosystem functions of soil and underlined the role of soil in the survival of mankind, animal and plant kingdom. He equated soil health with human and animal health and stressed on the fact that if the soil becomes poor in nutrients and minerals, then the food chain gets affected.

Dr. Pankaj Srivastava, Director, Indian Institute of Forest Management (IIFM), Bhopal; Dr. P.C. Sharma, Director, Central Soil Salinity Research Institute (CSSRI), Karnal and Dr. Nachiketa Kotwaliwale, I/c Director, Central Institute of Agricultural Engineering (CIAE), Bhopal graced the functionas Guests of Honour. At the outset, Dr. Ashok K. Patra, Director, ICAR-IISS welcomed the guests and dignitaries and briefed about the mission of the Institute to improve soil productivity with minimal environmental degradation. He highlighted different achievements of the Institute, viz.,Soil testing kit (Mridaparikshak), soil fertility maps for 536 districts, rapid composting unit and use of nanotechnology for soil nutrients from waste mica and rock phosphate. He briefed the audience that presently micronutrient deficiency in the country is increasing and the extent of zinc deficiency is to the extent of 37% and boron in 23% of cultivated area.

Dr. Pankaj Srivastava, Director, IIFM underlined the fact that soil is a finite resource and our first emphasis should be to save soil, then everything else including forest and agriculture ecosystem will be taken care of. Referring a report of ICAR, he informed that 20% productivity increase can be ensured by arresting soil erosion. Dr. P.C. Sharma, Director, ICAR-CSSRI highlighted about the soil health mission and contribution of the Institute to the Government's initiative in soil health card (SHC) scheme.

Progressive farmers from villages adopted under Mera Gaon Mera Gaurav (MGMG), Farmers' FIRST and CRP on Conservation Agriculture schemes and the National and State level award winning farmers were felicitated on the occasion. A farmer-scientists interaction was held on the theme “Site specific soil and water management technologies” in whichfarmers putforth problems being faced related to crop residue management and conservation agriculture, which were elaborately discussed among the participants. During foundation day celebration, dignitaries released various publications such as Institute’s Newsletters, IISS profiles and also launched logo of the institute and e-magazine “HARIT DHARA’.

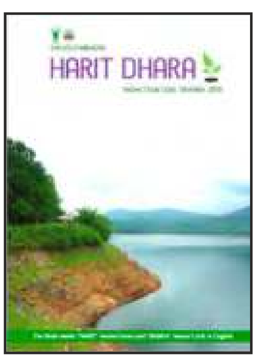
Later, in the afternoon, the Foundation Day lecture was delivered by Dr. P.C. Sharma, Director, ICAR-CSSRI, Karnal. In the foundation day lecture, he briefed upon the growing problem of soil degradation and suggested policy and technology options for conserving soil and natural resources. The program was coordinated by Dr. R. Elanchezhian, Principal Scientist and I/c PME cell.

Launching of the Institute's Logo

The logo of ICAR-IISS, Bhopal depicts the year of establishment (1988) and name of Institute in Hindi and English. The flask with solution and plant; auger within the flask; microbes and earthworm; clouds and soil represent different themes viz., Soil Chemistry and Fertility, Soil Physics, Soil Biology and Environmental Soil Science, respectively. The shloka "मृदा ददाति पोषणं माता सा सर्वेषाम्" signifies the importance of soil in plant and animal nutrition.

Harit Dhara, an E-Magazine

Harit Dhara, a new E-Magazine (six monthly) of the institute was launched on Foundation Day. The Hindi words ‘Harit’ means Green and ‘Dhara’ means Earth in English. The e-magazine is an effort towards creating awareness among various agricultural stakeholders about relevance of good soil health management practices to maintain the green earth. The magazine welcomes the opinion, case studies, traditional knowledge and experiences related to soil health and land management; and the link is available on the institute website (www.iiss.nic.in).



International Yoga Day (21 June 2019)

ICAR-Indian Institute of Soil Science celebrated International Yoga Day on June 21, 2019 at the institute campus.

Important Meetings/Activities

Independence Day

The 73rd Independence Day' was celebrated on August 15, 2019 in the Institute premises with great gaiety and fervor. Different cultural events were organized for the staff and family members and program was concluded with distribution of prizes to the winners.

Hindi Pakhwada

Government of India encourages its organizations and the employees to participate in Hindi Pakhwada celebrations to promote and spread the use of Hindi as a common medium of language throughout the country. Accordingly, Hindi Pakhwada was celebrated in the Institute during September 14-28, 2019. Several competitions such as Debate, Quiz, Hindi vocabulary (Shabda Gyan), Typing were conducted in the Institute premises during the fortnight in which majority of staff members participated. The Director, ICAR-IISS distributed prizes to the winners of different competitions.

Swachch Bharat Mission

Institute, throughout the year, has kept the campus, labs, corridors, office rooms, roads, toilets and farm premises, neat and clean as well as plastic free. It also participated in the nationwide program of "Swachh Bharat Mission" launched by Government of India. During 11th September -2nd October 2019, different activities under Swachch Bharat Mission (SBM) and 150th Birth anniversary of Mahatma Gandhi were taken up at the Institute. Vaious activities namely essay and quiz competition, awareness of single use plastics and self disposal and management of plastic material were conducted by the Swachhta Committee and teams in different dates in the Institute involving all the staff and students. Nodal Officer, Dr RS Chaudhary delivered the lecture on "Safe Disposal and Management of Single Use Plastics". Another Swachhta Pakhwada was celebrated during December 16-31, 2019. Date wise action plan for Swachhta Pakhwada was under taken across all ICAR Institutes/ Establishments. This was followed by voluntary cleaning of the Institute premises by the staff members. Afterwards, an intensive campaign was started with finalization of weekly plan and timely execution for keeping of the surrounding of the Institute premises clean.

Vigilance Awareness Week

The ICAR-Indian Institute of Soil Science, Bhopal celebrated The Vigilance Awareness Week from October 28 to November 2, 2019, with the theme 'Integrity - A Way of Life'' as per direction of Central Vigilance Commission. Dr Ashok K Patra, Director of the Institute administered the pledge on 28 November at 11.00 AM among the employees of the Institute in the presence of Dr JK Saha, Vigilance Officer and Shri SK Gupta, Senior Administrative Officer of the Institute. Dr AK Patra stressed on fighting the menace of corruption, and maintaining highest standards of integrity, transparency and accountability in their functioning. During the week-long celebration various activities such as debate, quiz, essay writing competitions were organised. The staff of the institute participated actively in the week long programmes. Various posters, banners etc were also displayed to sensitize the people about vigilance, corruption, honesty etc. A guest lecture was organized on 29 Nov in CIAE auditorium, wherein Shri S. K. Sinha, Ex-Under Secretary (Vigilance) spoke about importance of vigilance in Govt. departments and integrity among officials. Vigilance Officer Dr. J.K. Saha attended a workshop on "CBI-Vigilance Department-CVC coordination" organized by CBI, Bhopal branch at Central Bank of India on 30 Nov. On the concluding day, Shri Ashutosh Kumar, Dy. Superintendent of Police (CBI), Bhopal was invited as the Chief Guest. He explained the role of CBI in curbing corruption in the society. Finally, he appreciated the efforts initiated by our Institute in creating awareness and sensitizing the people about corruption in the society.

Sports activities

Sport contingent from ICAR-IISS Bhopal participated in the ICAR central zonal sports tournament during November 8-10 2019 at ICAR-NBSS&LUP, Nagpur.In the mens event Mr. Sanjay Katenga secured first position in Chess and Mr. P.K. Raut secured second position in Carrom.

Soil Health Awareness Week

The ICAR- Indian Institute of Soil Science, Bhopal (Madhya Pradesh, India) celebrated 'Soil health awareness week' with great fervour and enthusiasm in the premises of the Institute, school and villages. The Institute organized a one-week long 'Soil Health Awareness' programme during 1st -7th December 2019.

World Soil Day

A massive campaign for preserving "SOIL – Our Mother Earth", was organised on World Soil Day. A March – Past was organized from the Institute campus to the city of Bhopal. This was followed by a farmer-scientist interaction meet at village-Parawalia Sadak, District-Bhopal, where, the renowned Soil Scientist Prof. N. N. Goswami, Ex-Vice Chancellor, CSAUAT, Kanpur, New Delhi was present along with Prof. D.K. Das (New Delhi), Prof. HK Senapati (Bhubaneswar), Dr. JC Tarafdar (Jodhpur). Prof. N.N. Goswami emphasized the role of soil in the survival of the mankind and called for a national movement to protect this precious natural resource for the future generations. He reiterated that with imbalanced and unscientific use of agro-chemicals, there is degradation in soil health and occurrence of multi-nutrient deficiencies in soil. As per the latest study by the Indian Institute of Soil Science, Indian soils are deficient in sulphur 28%, zinc 36% and boron 23% which needs immediate attention for balanced application of fertilizers. In the program, progressive farmers were distributed soil health cards. During the events, scientists, officials, students and about 300 farmers from nearby villages participated in this awareness program. Dr Ashok K Patra, Director of the Institute welcomed all experts and participants and called for wholehearted action for the cause of conserving soil and water for the prosperity of the nation.

Agriculture Education Day

The Institute organized the soil health awareness programme for about 100 school children of Sardar Patel Govt School, Bhopal. The scientist briefed keypoints on importance of Agriculture Education Day', agriculture science, Soil Science, importance of soil health and its management for achieving higher crop productivity and soil sustenance. In addition to this, a quiz competition was organized on the theme 'Soil health and agriculture education day. A session on 'Scientists-student-interaction' was also conducted in which students participated enthusiastically and satisfied their queries related to soil health.


Agriculture Education Day oraganised at Sardar Patel Govt Secondary School, Bhopal

An exposure visit-cum-expert session on 'Soil health for sustaining soil productivity' was organized for B. Sc. students of Bhopal School of Social Sciences (BSSS), Bhopal at ICAR-IISS on 2nd December 2019. The faculty presented their views on 'soil health its impact on human health'. The faculty and students participated in the interaction session. A field visit to vermicomposting pit as well as organic farming field demonstrations was arranged in the Institute premises for the field exposure. Dr Ashok K Patra, Director, ICAR-IISS, Bhopal elaborated several issues and the importance of Agriculture Education Day, soil health in context to crop production, food security and human health in particular.

Dr Ashok K Patra addreessing the students from College of BSSS, Bhopal

B.Sc. Student from BSSS participated in the session on 'Soil health for sustaining soil productivity'

Training Programme during Soil Health Awareness Week

A training programme on soil health management under SCSP at ICAR-IISS was organized on December 6, 2019 under the 'Soil Health Awareness Week' with the aim to create awareness about the importance of soil health and its prime significance for sustaining crop productivity. A training was imparted to about 50 SC farmers from different villages. Dr. Ashok K. Patra, Director, ICAR-IISS Bhopal emphasized the balance nutrient management for improvement of soil health to enhance soil productivity. He also mentioned the role of organic input for improving soil and crop quality for sustaining food and nutritional quality for the future generation. In this training programme scientist delivered lectures on different topics related the soil health and crop productivity namely best agriculture management practices, organic farming, composting technologies, soil quality, agro-techniques etc. On this occasion, field visits to the field experiments and composting unit at IISS, Bhopal were also organized for the farmers.

A Training on soil health management at ICAR-IISS

Training-cum-farmer-Scientist-interactive meet was organised at Khamkheda village (Dist Bhopal) on December 7, 2019 under the umbrella of "Soil Health Awareness Week". About 100 farmers from Khamkheda as well as nearby village sparticipated in this training cum interactive meet with a focus on soil health. A series of discussions were conducted by scientists/experts from ICAR- Indian Institute of Soil Science, Bhopal, ICAR-Central Institute on Agriculture Engineering, Bhopal and State department of agriculture. Some farmers pointed out the problems related to agriculture which were adequately addressed by the experts. On this occasion, soil health cards were distributed to the farmers. Experts elaborated parameters mentioned on soil health cards including critical ranges and suggested the nutrient application strategies. The remedial measures were suggested based on the symptoms of plant samples brought in by a farmer. The activities on 'Soil health awareness week' organised by ICAR- Indian Institute of Soil Science, Bhopal were highlighted in newspaper and other media.

Training-cum-Farmer-Scientist interaction organised at Khamkheda village

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

Name	Programme	Venue	Period
Dr AK Patra	Experts Meet on Soil and Use Policy	NAAS, New Delhi.	April 13, 2019
Dr AK Patra	Nano-tech and advanced instrumentation facilities for project proposal/sharing facilities.	CIFE/CIRCOT Mumbai	April 17-19, 2019
Dr AK Patra	Meeting on STCR equations with JS (INM)	New Delhi	April 29-30, 2019
Dr Pramod Jha	Editorial Board Meeting of Book on Soil Analysis	NASC Complex, New Delhi	May 4, 2019
Dr AB Singh	Live telecast programme on "Hari Khad ki upyogita"	Doordarshan Kendra Bhopal, Madhya Pradesh	May 10, 2019
Dr AK Patra	10th working session of the intergovernmental Technical Panel on Soils (ITPS) and Global Symposium on Soil Erosion (GSER19)	FAO, Rome, Italy	May 13-17, 2019
Dr Pradip Dey	Working group meeting for review and finalization of NCERT Textbook for Class XII	PSSCIVE, Bhopal	May 20-22, 2019
Dr Pradip Dey	Global Soil Week 2019 creating environmentl for sustainable and climate resilient agriculture	ICRAF, Nairobi, Kenya	May 25-31, 2019
Dr NK Lenka	Consultation meeting of stakeholders of Mandla district, Madhya Pradesh	Mandla, MP	May26-27, 2019
Dr AK Patra	28th AGM of NAAS	Krishi Bhawan, New Delhi	June 10-11, 2019
Dr AK Patra	World Day to Combat Desertification (WDCD)" and programme related to forthcoming UNCCD-14 and National Workshop on Land Degradation Neutrality - Target Setting Programme (LDN-TSP) organized by the Ministry of Environment, Forest and Climate Change, New Delhi	ICAR-IARI, New Delhi	June 13-18, 2019
Dr NK Lenka	Methodology Workshop for finalizing the soil sustainability indicators	ICAR-NCAP, New Delhi	June 18, 2019
Dr RS Chaudhary	State level "Stakeholders Consultative Meeting" on "Rejuvenation of Narmada River and DPR Preparation"	Indra Nikunj, Bhopal	June 19, 2019
Dr Muneshwar Singh	Workshop on "Strategy to increase carbon in soil" organized by UPCAR and Department of Agriculture, Government of U.P.	Lucknow	June 28-29, 2019
Dr AK Patra	Meeting on soil related issues in the region and development of institutional linkages	ICAR Research Complex for Eastern Region, Patna	July 2-6, 2019

Name	Programme	Venue	Period
Drs AK Patra and Pradip Dey	FAI-IPI Round Table as an invited speaker on Potassium in Balanced Fertilization-Emerging Issues	FAI House New Delhi	July 10-11, 2019
Dr AK Patra	ICAR Foundation Day and to receive Sardar Patel outstanding ICAR Institution Award 2018	New Auditorium of ICAR Convention centre, NASC Complex, Pusa New Delhi	July 15-16, 2019
Drs AK Patra and Pradip Dey	Directors Conference under the Chairmanship of Hon'ble Dr. Trilochan Mohapatra, Secretary, DARE& DG,ICAR	New Delhi	July 17, 2019
Drs SR Mohanty, KM Hati and M Mohanty	Review meeting of foreign aided projects	ICAR-CSSRI, Karnal	July 18, 2019
Drs AK Patra and Pradip Dey	ICAR Regional Committee-VII	ICAR-NBSS&LUP, Nagpur	August 9-10, 2019
Dr Sanjay Srivastava	Pre bid meeting of evaluation of impact of soil health card (SHC)	KrishiBhavan New Delhi	August 9, 2019
Dr KM Hati	Workshop on "Conservation Agriculture" organized by the Centre of Advanced Agricultural Science and Technology (CAAST) on Conservation Agriculture, BCKV, Mohanpur (WB)	BCKV, Kalyani	August 13-14, 2019.
Dr Pradip Dey	Workshop on Joint Working of ICAR & MSME to promote and develop Agro and Rural Enterprises	New Delhi	August 21, 2019
Dr Sanjay Srivastava	Presentation of soil testing laboratories by Acharya Balachandra before Hon'ble Minister of Agriculture	Krishi Bhavan New Delhi	August 21, 2019
Dr AB Singh	Workshop on Kharif crops	Gulab Garden, Bhopal	August 22, 2019
Dr AK Patra	Brainstorming session on 'Technological Innovations and Strategies for Farmers'Prosperity in Madhya Pradesh & Chhattisgarh'	C. Subramaniam Hall, New Auditorium, NASC complex, New Delhi	August 26-27, 2019
Dr KM Hati	Science Seminar on "Soil health assessment through MIR" organized by South Asia Regional Centre, ICRAF, New Delhi	NASC Complex, Pusa, New Delhi	August 27, 2019
Drs AK Patra and SR Mohanty	Annual Review Workshop-AMAAS	NASC Complex, New Delhi	August 29-30, 2019
Dr J Somasundaram	Workshop on GHG emissions studies and future planning	ICAR-NRRI, Cuttack	August 29, 2019
Dr Pradip Dey	Global Micronutrient Summit 2019	New Delhi	September 5-6, 2019
Dr Sanjay Srivastava	Meeting by Farmers Association of India organized by ADG (S&WM)	NASC Complex, New Delhi	September 11, 2019

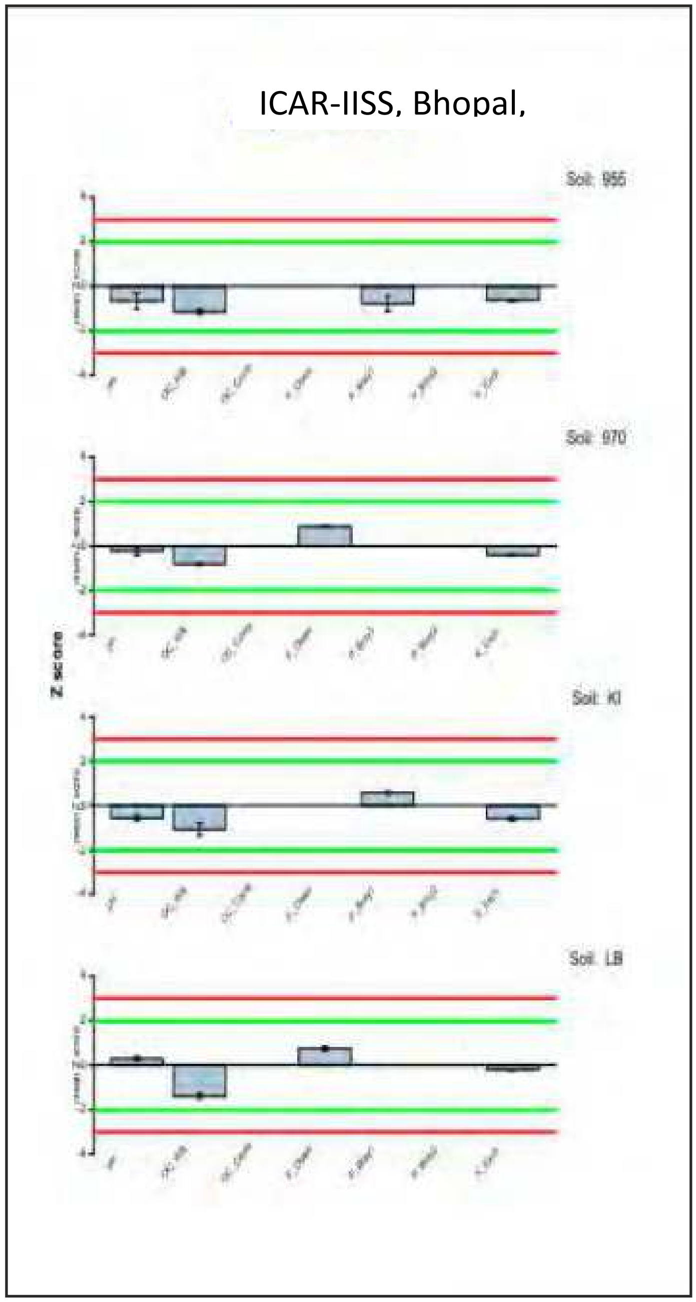
Name	Programme	Venue	Period
Drs AB Singh, RH Wanjari and Asha Sahu	Global Organic Conference 2019 on “Natural Resource Management for Sustainable Agriculture, Soil Health and Quality Food”	Nagpur	September 15-17, 2019
Dr Sanjay Srivastava,	Third meeting of the South East Asia Laboratory Network (SEALNET) of FAO	Bureau of Soil and Water Management (BSWM), Quezon city, Philippines	September 23-27, 2019.
Dr R Elanchezhian	11th NABS Conference on Climate Change-Driven Challenges on Indian Biodiversity:Innovative Solutions for SustainableDevelopment	Pondicherry University, Pondicherry	September 25-27, 2019
Dr AK Patra	Meeting on FAD 22/Panel Formulation of Indian Standard(s) for Labeling, Packaging & Traceability in Agriculture Produce	NRM Division, KAB–II & ICAR Hq.	September 25-27, 2019
Dr Pradip Dey	CAFT on “Current Challenges and strategies for management of soil health and sustainable productivity”	JNKVV, Jabalpur	29 September, 2019
All Scientists of ICAR-IISS	Workshop on “Improving Soybean Yield in Central India-Potential Strategies”	ICAR-IISS, Bhopal	October 1, 2019
Dr Pradip Dey	The International Workshop on “Legal Governance for Sustainable Soil Management to achieve Land Degradation Neutrality”	New Delhi	October15-16, 2019
Drs J Somasundaram and Sangeeta Lenka	Workshop on ‘Carbon Management in Soil through Resource Conservation Technologies: Issues and Strategies	BCKV, Kalyani, West Bengal	November 1-2, 2019
Dr AB Singh	Workshop on Rabi crops	ICAR-CIAE	November 7, 2019
Dr Pradip Dey	International Conference on “Soil and Water Resource Management for Climate –Smart Agriculture, Global Food and Livelihood Security”	New Delhi	November 7, 2019
ICAR-IISS sports contingent	ICAR Central Zone Sports Meet 2019	ICAR-NBSS&LUP, Nagpur	November 8-10, 2019
Dr AB Singh	14th Annual Group Meeting of AI-NPOF	ICAR-CIARI, Port Blair	November 12-14, 2019
Drs RH Wanjari, Ankush L Kamble and Mr Deepak Kaul	Exhibition on Science Fiesta 2019	Regional Science Centre, Bhopal	November 13-14, 2019
Drs AK Patra, MC Manna, RS Chaudhary, AB Singh, NK Lenka, M Mohanty, Asha Sahu, S Bhattacharjya and Madhumonti Saha	84th Annual National Seminar on Developments in Soil Science-2019	BHU, Varanasi	November, 15-18, 2019
Dr RS Chaudhary	State Working Committee on National Food Security Mission	State Secretariat, Bhopal	November 15, 2019

Name	Programme	Venue	Period
Drs AK Biswas, AK Shukla, Pradip Dey,R Elanchezhian,K.M. Hati, R.H. Wanjari	Meeting on SFC/EFC	NASC Complex, New Delhi	November 18, 2019
Dr AK Patra	11th Session of Inter-Governmental Panel on Soil (IGPS)	FAO, Rome	November 19-24, 2019
Dr SR Mohanty	Fulbright Enrichment Program	USPTO, San Jose state university and Intel, CA, USA	November 19, 2019
Dr Pradip Dey	Workshop on “Impact Assessment of ICAR Technologies”	ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi	November 28, 2019
Drs AB Singh, AK Tripathi, Sanjay Srivastava, KC Shinogi, RH Wanjari, Hiranmoy Das, Asha Sahu, Seema Bhardwaj, Madhumonti Saha	Kisaan Sangosthi on "Soil Health Card"	KVK, Betul (M.P.)	29 November, 2019
Dr Madhumonti Saha	International conference on “Global Perspective in Agricultural and Applied Sciences for Food and Environmental Security (GAAFES-2019)	Nainital, Uttarakhand	December 1-2, 2019
Dr AK Vishwakarma	Management Development Programme on Leadership Development	ICAR- NAARM, Hyderabad	December 2-13, 2019
All Scietists of ICAR-IISS	Workshop on Bio-waste Resource Management for Sustainable Agriculture	ICAR-IISS, Bhopal	December 10, 2019
Mrs Seema Bhardwaj	Workshop on “Energy Conservation 2019” organised by green energy club, SoEEM, BEE-GOI, MPUVN-Govt of M.P,	RGPV, Bhopal	Decmber 17, 2019
Dr R Elanchezhian	National Conference of Plant Physiology on Plant Productivity and Stress Management	KAU, Thrissur	December 19-21, 2019
Dr Pradip Dey	Zonal Monitoring Committee	NICRA KVKs of M.P.	December 19-22, 2019
Dr AK Patra	National Conference on "Climate change and agriculture Impacts, resilience & Adaptations for sustainable food security"	New Delhi	December 20-21, 2019
Dr Pradip Dey	Assessment Committee Meeting of scientist	ICAR-IISR, Lucknow	December 25-28, 2019

ICAR-IISS participated in the Proficiency Testing Programme of Food and Agriculture Organization (FAO)

ICAR-IISS has been participating the proficiency testing (PT) programme of FAO. PT programme was launched in 2018 by FAO under the framework of pillar 5 of Global Soil Partnership (GSP). Global Soil and regions comparable, interpretable; Build a set of agreed harmonization principles; Improve quality assurance and control (QA/QC) of soil analyses; and Promote information and experience exchange. An activity under GLOSOLAN is Proficiency Testing of participating Laboratory network (GLOSOLAN), the pillar 5 of GSP Make soil information across labs, countries laboratories for the analysis of soil parameters. PT programme identifies any systemic error in a laboratory and seeks to correct that error. It also seeks to ensure uniformity in the analytical methods among the laboratories so that the results emanating from different laboratories can be interpreted uniformly. ICAR-IISS is associated with this programme of FAO by being an active partner of South East Asia Laboratory Network (SEALNET) since inception. In the year 2018 and 2019, India participated in the PT for the parameters soil pH, Organic C, Available P (Olsen and Bray 1) and Exchangeable K. The results for all the five parameters were within +/- 2 Z score, showing a satisfactory laboratory performance. The scientists executed the PT programme were Drs. Ashok K Patra, Sanjay Srivastava, Pramod Jha and Abhay Shirale.


Food and Agriculture Organization of the United Nations
CERTIFICATE
We certify that the
ICAR-Indian Institute of Soil Science
Bhopal, India
participated in the
First proficiency test of the Asian Soil Laboratory Network (SEALNET)
SEALNET



Demonstration of Mridaparikshak mini-lab during UNEP innovation summit

Dr. Sanjay Srivastava demonstrated the Mridaparikshak mini-lab in United Nations Environment Programme (UNEP) Innovation Summit at Dr. Ambedkar International Centre, New Delhi on September 10 and 11, 2019. The Mridaparikshak mini-lab was listed as prominent technology in their compendium.

The 3rd SEALNET Meeting of FAO

Sixteen south east Asian countries viz., Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Vietnam participated in the 3rd SEALNET meeting. Besides, there was representation from France and Australia as resource persons. The meeting was sponsored by FAO (Rome) and Philippines. During the meeting, Dr Srivastava, presented the Proficiency Testing Plan of India, and participated in the development of Standard Operating Procedures (SOP) for the estimation of soil parameters. Dr. S. Srivastava was also elected as Vice-Chairman, SEALNET.

ICAR-IISS Participated in Exhibition on 'Science Fiesta 2019':

The ICAR-IISS participated in the exhibition on 'Science Fiesta 2019 at Regional Science Centre, Bhopal during 13-14 November 2019. The Institute's technologies including 'Mridaparikshak' were displayed in the exhibition. The students and teachers from different schools actively participated and interacted in this exhibition.

ICAR-IISS participated in Exhibition on 'Science Fiesta 2019

13. Workshops, Seminars and Trainings Organized

Training/Short Courses Conducted

Short Course/Winter School/Summer School/MTC

Programme	Course Directors/ Coordinators	Duration	Sponsored by
MTC on Balanced Nutrient Management for Sustainable Crop Production and Soil Health	Drs RH Wanjari, Mueshwar Singh, Pramod Jha	September 23-30, 2019	Directorate of Extension, Ministry of Agriculture and Farmers Welfare (Department of Agriculture, Cooperation & Farmers Welfare), Govt. of India, New Delhi
Short Course on Recent advances in Soil carbon sequestration and stabilization for soil health improvement and climate change mitigation	Drs Pramod Jha, BL Lakaria, NK Lenka	December 10-19, 2019	ICAR, New Delhi

Other training

Programme	Course Directors/ Coordinators	Duration	Sponsored by
Review Meeting of the ICAR-IISS-ICRAF Collaborative Project on “Assessment of important soil properties of India using Mid-Infrared Spectroscopy”	Dr KM Hati	December 17, 2019	ICAR-IISS, Bhopal

Farmers’ training/Student training

Programme	Course Directors/ Coordinators	Duration	Sponsored by
A training on "‘Soil Testing and Nutritional Recommendation for Kharif and Rabi Crops’	Drs RH Wanjari, AB Singh, AK Vishwakarma	July 2-6, 2019	SIAET, Bhopal and ICAR-Indian Institute of Soil Science, Bhopal
Farmers’ trainings organized at ICAR-IISS, Bhopal for 150 SC Farmers from Khamkheda, Karond Khurd, Kanera, Bhaironpura, Parawalia Sadak, Mungaliahat villages in Bhopal district (M.P.)	Drs. AK Patra, AB Singh, AK Vishwakarma, BP Meena	November 6, December 6, December 18, 2019	ICAR-IISS, Bhopal
Training for tribal farmers at KVK Betul, MP	Drs KC Shinogi, Sanjay Srivastava, AK Tripathi, AB Singh and RH Wanjari	November 26-28, 2019	Betul, MP

Training-cum-farmer-Scientist interaction meet under the umbrella of "Soil Health Awareness Week" for 100 farmers at Khamkheda.	Drs AB Singh, BP Meena, Prabhat Tripathi and Vasudev Meena	December 7, 2019	ICAR-IISS, Bhopal

Workshop/Seminar/Conference

Programme	Course Directors/Coordinators	Duration	Sponsored by
Review Workshop of the ICAR-IISS-ICRAF collaborative project on "Assessment of important soil properties of India using Mid-Infrared Spectroscopy"	Drs KM Hati, M Mohanty, NK Sinha and RS Chaudhary	May 29, 2019	ICAR-IISS, Bhopal
ICAR-ICARDA sponsored one day workshop on "Simulation Modelling approaches in natural resource management"	Drs M Mohanty, NK Sinha and RS Chaudhary	September 23, 2019	ICAR-IISS, Bhopal
Brainstorming Session on 'Biochar: Potential Availability, Usefulness and Limitation in the Context of Indian Agriculture'	Drs BL Lakaria, Pramod Jha and AK Biswas	November 27, 2019	ICAR-IISS, Bhopal
Farmers' Seminar (Kisan Sangoshti) on Soil Health Card	Drs. Shinogi KC, Sanjay Srivastava, AB Singh, AK Tripathi, RH Wanjari, Asha Sahu, H Das, Seema Bhardwaj, M Saha	November 29, 2019	ICAR-IISS Bhopal and KVK, Betul

Model Training Course: MTC on "Balanced Nutrient Management for Sustainable Crop Production and Soil Health" was organised at ICAR-Indian Institute of Soil Science, Bhopal during 23rd - 30th September, 2019. This MTC was sponsored by Directorate of Extension, Ministry of Agriculture and Farmers Welfare (Department of Agriculture, Cooperation & Farmers Welfare), Govt. of India, New Delhi. The training programme was attended by 24 participants representing States of Punjab, Himachal Pradesh, Odisha, Nagaland, Uttar Pradesh, Bihar, Telangana, Kerala, Maharashtra and Madhya Pradesh and Puducherry. This training course gave comprehensive coverage on balance nutrient management for improvement of soil health for enhancing soil productivity and preparation of soil health card. The valedictory function was graced by Dr AK Singh, Secretary, NAAS & Former DDG (NRM) on 30th September 2019. This programme was coordinated by Drs RH Wanjari, Muneshwar Singh and Pramod Jha.

Field Visit: The entrepreneurs of 'Diploma in Agriculture Extension and Services for Input Dealers' facilitated by Directorate of Extension, Indore (M.P.) sponsored by Ministry of Agriculture & Farmers Welfare, Govt. of India visited the ICAR-IISS Research Farm on October 14, 2019 (Training Coordinators: Drs RH Wanjari and AK Vishwakarma).

Training conducted/organized under SCSP

Farmers' trainings programmes were organized for 150 SC Farmers at Khamkheda, Karond Khurd, Kanera, Bhaironpura, Parawalia Sadak, Mungaliahat villages in Bhopal district (M.P.) on November 6, December 6 and December 18, 2019, respectively. During this programme farm implements such as cono-weeder, manual peg type dry land weeder and maize sheller were distributed to SC farmers under the SCSP programme at ICAR-IISS, Bhopal,

Kisan Diwas (Farmers' Day) was organized) on December 23, 2019 at ICAR-IISS, Bhopal. In this programme farmers as well as civil society officials were invited under Swachhta Pakhwada.

Brainstorming Session on 'Biochar: Potential Availability, Usefulness and Limitation in the Context of Indian Agriculture'

The programme was organized at ICAR-IISS, Bhopal on November 27, 2019. Professor Dinesh Mohan from the School of Environmental Sciences, JNU, New Delhi made a presentation on "Biochar Research in Global Perspective". He primarily emphasized on origin, production technology, characterization and its role in soil amendment, climate change mitigation and remediation of polluted soil, water and environment. He, however,put a remark that biochar technology being a carbon negative may be deployed in variety of application in agriculture. Dr. A. Subba Rao, Former Director, ICAR-IISS, Bhopal emphasized the need for popularization and adoption of biochar amongst the farmers. Dr. Brij Lakaria (Pr Scientist and Programme Co-ordinator) emphasized on usefulness and limitations of biochar in context to Indian Agriculture. and its impact on soil properties. In this program, officers from key organizations like ICAR-CRIDA, Hyderabad;TNAU, Madurai, ICAR-CIAE, Bhopal and representatives from Anant Urja, a private undertaking also deliberated on biochar use in agriculture. Some of the recommendations emerged from this deliberation are (i) Biochar being a carbon negative material it should be promoted for use in agriculture for soil health improvement (ii) Technological interventions to reduce biochar production cost (iii) Biochar application in soil brings out favorable changes in soil especially for acid and degraded lands and thus may be a good material for some crops and ecological regions. Therefore, niche areas for biochar application need be explored.

Short Course on Recent advances in soil carbon sequestration and stabilization for soil health improvement and climate change mitigation

In this programme, abouts 22 participants from 8 states successfully attended the training programme. This training comprised of theory and practicals viz., Newer concepts and mechanisms of soil carbon stabilization, carbon sequestration for mitigation of climate change, management practices for soil carbon storage, practical exposure to determination of soil C pools and use of C simulation models, estimation of soil carbon fractions, carbon mineralization study, partitioning of carbon through chemical and statistical approach, determination of water stable aggregates and aggregate associated carbon, substrate induced respiration technique for soil microbial biomass determination and particulate organic matter, black carbon and glomalin determination in soil. The trainees were also exposed to DNDC and APSIM models for soil carbon prediction under different cropping systems. The trainees were also exposed to handling of MIR spectroscopy, TOC analyzer, CHN Analyzer and Gas Chromatography.

Workshop on Infrared Spectroscopy Use in Soil Health Assessment

Institute organized workshop under the ICAR-IISS-ICRAF Collaboration Project held on May 29, 2019.

Workshop on ICAR-IISS in the service of farmers

Institute organized one-day Workshop "ICAR-IISS in the service of farmers" on July 22, 2019. During the event, Dr. S.K. Chaudhari, ADG (SWM), ICAR, New Delhi, Dr. M. Din, Director, ICAR-CIAE, Bhopal, Dr. A.K. Patra, Director, ICAR- IISS, Bhopal, Dr. Rajesh Sharma, DG, MPCOST, Bhopal graced the occasion. During the inaugural session, Dr. Ashok K. Patra welcome the dignitaries and highlighted the institute activities and research accomplishments. The program was coordinated by Dr. R. Elanchezhian.

Institute organized NAAS Workshop and launched NAAS, Bhopal Chapter

Keeping in view the concerns of climate change and risks associated with soybean production in central India, a one-day workshop was organized under the aegis of the National Academy of Agricultural Sciences (NAAS) - Bhopal chapter at the ICAR-Indian Institute of Soil Science. Dr. Anil K. Singh, Secretary, NAAS and former Vice Chancellor, RVSKVV, Gwalior graced the occasion as Chief Guest. In his address, he highlighted the policy implications of stagnation in soybean yield on the farm economy, soil health and overall economy of the country. On this occasion, the NAAS-Bhopal Chapter was formally launched. Other dignitaries who graced the function were Dr SK Rao, Vice Chancellor, RVSKVV, Gwalior; Dr A Subba Rao, former Director, ICAR-IISS. Similarly, Fellows and Associates of the NAAS of Bhopal Chapter , progressive farmers , officials from Madhya Pradesh, researchers and policy makers from ICAR Institutes and SAUs also actively participated in this programme.

The workshop also witnessed technical presentations by Dr Sanjay Gupta and Dr AN Sharma from ICAR-Indian Institute of Soybean Research, Indore; Dr AK Tiwari from Directorate of Pulse Mission, Govt. of India and Dr Pradip Dey from the Institute. A brainstorming session was also held where the progressive farmers and the State Government officials expressed their views on current constraints and strategies to improve soybean production.

At the outset, Dr Ashok K Patra, Director, ICAR-IISS and Convener of the NAAS-Bhopal Chapter welcomed the guests and dignitaries and briefed about the objectives of the technical workshop. The program was coordinated by Dr Narendra K Lenka, Principal Scientist, with Dr Sangeeta Lenka, Dr Asit Mandal, Dr Asha Sahu and Dr Sudeshna Bhattacharjya as rapporteurs of different technical sessions.

14. Distinguished Visitors

- Dr RJ Rao, Vice-Chancellor, Barkatullah University, Bhopal, Dr Pankaj Srivastava, Director, Indian Institute of Forest Management, Bhopal; Dr PC Sharma, Director, Central Soil Salinity Research Institute, Karnal and Dr Nachiketa Kotwaliwale, I/c Director, Central Institute of Agricultural Engineering, Bhopal visited on April 16, 2019.
- Dr. S.K. Chaudhari, ADG (SWM), ICAR, New Delhi, Dr. S.K. Dhyani, Former Director, ICAR-CAFRI, Jhansi, Dr. Sunil Londhe, Soil Health and Geo-informatics Scientist, South Asia Regional Centre, International Centre for Agroforestry Research, and Dr. R.N. Sahu, ICAR-IARI, New Delhi visited the institute on May 29, 2019.
- Dr. Alagusundaram, DDG (Agri. Engineering & NRM) visited ICAR-IISS, Bhopal on July 20, 2019 and November 2, 2019.

- Dr SK Chaudhari, ADG (SWM), ICAR, New Delhi, Dr M Din, Director, ICAR-CIAE, Bhopal and Dr Rajesh Sharma, DG, MPCOST, Bhopal visited on July 21, 2019.

- Dr Anil K Singh, Secretary, NAAS and former VC, RVSKVV, Gwalior and Dr SK Rao, VC, RVSKVV, Gwalior visited on October 1, 2019
- Shri Ashutosh Kumar, Dy. Superintendent of Police (CBI), Bhopal visited on November 2, 2019.
- Professor Dinesh Mohan from the School of Environmental Sciences, JNU, New Delhi visited on November 27, 2019.
- Dr SS Khanna, Former Advisor, Planning Commission, GoI and Vice-Chancellor of NDAU&T, Ayodhya (UP) visited on December 10, 2019.
- Dr Javed Rizvi, Regional Director, South Asia Regional Program, ICRAF (International Centre for Research in Agroforestry), Dr Keith Shepherd, Principal Scientist and theme leader of Soil Spectroscopy at ICRAF, Kenya, Dr Rabi N Sahoo, Principal Scientist, ICAR-IARI, New Delhi and Dr Shiv Kumar Dhyani, former Director, ICAR-CAFRI, Jhansi and Senior Agroforestry Specialist visited onDecember 17, 2019.

15. Infrastructure Development

Instrument/Equipment Purchased

During the year, Water Tanker (1), Glassware Dryer Oven (1), Desktop Computer (1), Air Conditioner (4), Automatic N Distillation (1), Fabrication/Accel Comp Composting Machine & Heavy Duty Accel- Comp Shredder (2), Real Time PCR-Machine (1), Gel Documentation System (1), Refrigerator (1), Free Air CO_2 Enrichment System (1), Multi-Parameter (1), Antivirus Bitdefender Gravity Zone Business Security 3 Year (112), Ultra-Pure Water Purification System (1), Intercom Cable (500 Mtrs), PCR Thermal Cyclers (1), Weighing Balance (1), Wet Sieving Apparatus (1), Spares ICP-OES Instrument (1) were purchased.

Library

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

Documents	Addition during 2019	Total
Books	Nil	2591
Bound Journals	Nil	3064
Annual Reports	184	2610
Foreign and Indian Journals	Nil	Nil

Farm Activities

- Revenue of Rs. 14.33 lakhs was generated through sale of farm produce.
- Resource conservation based farming activities were promoted in general research farm& promosing results were obtained in teams of productivity & resource use.
- One slit till drill was procured under FFP.
- About 30 quintals of seed was produced in the farm.

16. Scientific, Technical, Administrative Personnel

Details of manpower

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
DIRECTOR'S CELL				
Dr Ashok K Patra	Director	Soil Chemistry/Fertility/ Microbiology	05.10.1989	01.05.2014
Mr Thomas Joseph	Private Secretary	Office Staff	18.09.1989	18.09.1989
Mrs Yojana Meshram	Personal Assistant	Office Staff	12.05.1997	12.05.1997
Mr Bhoi Lal Uikey	Lab Attendant	Skilled Supporting Staff	13.11.1995	13.11.1995
Mr Darashram	Lab attendant	Skilled Supporting Staff	15.03.1990	15.03.1990
DIVISION OF SOIL PHYSICS				
Dr RS Chaudhary	Pr. Scientist & I/c Head	Soil Physics/Soil & Water Conservation	10.11.1993	09.12.1999
Dr KM Hati	Pr. Scientist	Soil Physics/Soil & Water Conservation	27.12.1996	27.12.1996
Dr RK Singh	Pr. Scientist	Soil Physics/Soil & Water Conservation	25.01.1993	16.10.2002
Dr Prabhat Tripathi	Pr. Scientist	Agronomy	19.09.1998	28.06.2017
Dr J Somasundaram	Pr. Scientist	Soil Physics/Soil & Water Conservation	12.11.2001	22.12.2008
Dr M Mohanty	Pr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1999	10.11.1999
Dr. N.K. Sinha	Scientist	Agriculture Physics	20.04.2010	27.08.2010
Mrs Seema Bhardwaj	Scientist	Soil Science	07.01.2008	07.07.2018
Ms Alka Rani	Scientist	Soil Science	04.01.2019	12.04.2019
Mr RK Mandloi	T-9	Chief Technical Officer	19.06.1989	19.06.1989
Mr PK Chouhan	T-5	Technical Officer	15.02.1993	15.02.1993
Mr Janak Singh Mehra	Khalasi	Skilled Supporting Staff	08.09.1997	08.09.1997
DIVISION OF SOIL CHEMISTRY AND FERTILITY				
Dr AK Biswas	Pr. Scientist & I/c Head	Soil Chemistry/Fertility/ Microbiology	21.01.1992	11.01.1993
Dr Sanjay Srivastava	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	22.03.1996	02.09.1996
Dr Brij Lal Lakaria	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	01.10.1997	15.01.2007

Dr R Elanchezhian	Pr. Scientist	Plant Physiology	09.11.1998	17.02.2012
Dr Narendra K Lenka	Pr. Scientist	Soil Physics/Soil & Water Conservation	30.11.2000	09.10.2009
Dr 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 AL Kamble	Scientist	Agricultural Economics	20.04.2010	09.10.2017
Dr Shinogi, KC	Scientist	Agricultural Extension	27.04.2011	05.09.2011
Dr BP Meena	Scientist	Agronomy	15.09.2011	22.12.2011
Dr AO Shirale	Scientist	Soil Chemistry/Fertility	01.01.2015	10.04.2015
Dr Gurav Priya Pandurang	Scientist	Soil Chemistry/Fertility	01.01.2016	11.04.2016
Dr Narayan Lal	Scientist	Fruit Science	01.01.2013	24.12.2019
Mr Deepak Kaul	T-9	Chief Technical Officer	29.12.1988	29.12.1988
Mr Jai Singh	T-6	Sr. Technical Officer	22.05.1990	22.05.1990
Mr Harish Kumar	Lab attendant	Skilled Supporting Staff	14.03.1990	14.03.1990
DIVISION OF SOIL BIOLOGY				
Dr MC Manna	Pr. Scientist & Head	Soil Chemistry/Fertility/ Microbiology	21.01.1992	11.01.1993
Dr AB 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 SR Mohanty	Pr. Scientist	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
Dr Kollah Bharati	Pr. Scientist	Microbiology - Plant Science	29.10.2009	05.04.2011
Dr Asit Mandal	Scientist	Soil Chemistry/Fertility	23.06.2009	30.10.2009
Dr J K Thakur	Scientist	Agricultural Microbiology	20.04.2010	27.08.2010
Dr Asha Sahu	Scientist	Soil Chemistry/Fertility	03.05.2010	03.05.2010
Dr Sudeshna Bhattacharjya	Scientist	Soil Chemistry/Fertility	01.01.2015	10.04.2015
Dr Dolamani Amat	Scientist	Microbiology	05.01.2017	15.04.2017
Mrs Seema Sahu	T-7-8	Asstt. Chief Technical Officer	14.04.1987	24.01.1989
Mr Sant Kumar Rai	T-3	Technical Asstt.	15.06.1989	15.06.1989
Mrs K.S. Chaturvedi	Personal Assistant	Office Staff	05.05.1997	18.02.2002
Mr. Kalicharan	Lab attendant	Skilled Supporting Staff	10.06.1999	10.06.1999

DIVISION OF ENVIRONMENTAL SOIL SCIENCE				
Dr JK 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 S 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	Scientist	Soil Chemistry/Fertility	04.11.2009	15.03.2010
Dr VD Meena	Scientist	Agronomy	15.09.2011	23.12.2011
Dr Utkarsh Tiwari	Scientist	Agricultural Economics	05.07.2017	12.10.2017
Dr Abhijit Sarkar	Scientist	Soil Science	05.07.2016	29.06.2018
Dr Madhumonti Saha	Scientist	Soil Science	05.07.2017	29.06.2018
Dr Nisha Sahu	Scientist	Soil Science	23.01.2012	30.11.2019
Mr Vinod Babu Pal	T-7-8	Asstt. Chief Tech. Officer	15.02.1993	15.02.1993
Mr Vinod Choudhary	T-4	Sr. Tech. Assistant	14.06.1989	14.06.1989
Mr Ram Bharose	Lab attendant	Skilled Supporting Staff	20.03.1990	20.03.1990
AICRP-LTFE				
Dr Muneshwar Singh	Pr. Scientist & PC (LTFE)	Soil Chemistry/Fertility/ Microbiology	11.07.1989	11.07.1989
Dr RH Wanjari	Pr. Scientist	Agronomy	07.01.1999	07.01.1999
Mr Sunny Kumar	Steno. Gr.-III	Office Staff	21.12.2011	21.12.2011
Mr Jagannath Gaur	Lab attendant	Skilled Supporting Staff	20.07.1992	20.07.1992
AICRP-MSPE				
Dr AK Shukla	Pr. Scientist & I/c PC (MSPE)	Soil Chemistry/Fertility/ Microbiology	05.07.1996	31.03.2011
Dr SK Behera	Sr. Scientist	Soil Chemistry/Fertility/ Microbiology	08.01.2007	27.06.2017
Mr Shahab Siddiqui	T-7-8	Asstt. Chief Technical Officer	05.10.1992	05.10.1992
Mr Venny Joy	Personal Assistant	Office Staff	14.02.1991	23.03.1998
Mr Khilan Singh Raghuvanshi	T-5	Technical Officer	29.12.1988	29.12.1988
Mr Bhanwar Singh Yadav	Messenger	Skilled Supporting Staff	01.09.1993	23.01.1999

AICRP-STCR				
Dr Pradip dey	Pr. Scientist & I/c PC (STCR)	Soil Chemistry/Fertility/ Microbiology	03.06.1993	01.02.2012
Mr Abhishek Rathore*	Scientist	Agricultural Statistics	16.12.2002	16.12.2002
Dr Hironmay Das	Scientist	Agriculture Statistics	15.09.2011	23.12.2011
Mrs Geeta Yadav	Private Secretary	Office Staff	26.12.1995	26.12.1995
Mrs Kavita Bai	Safaiwala	Skilled Supporting Staff	20.12.1988	20.12.1988
AINP-BIOFERTILIZERS				
Dr SR Mohanty	Pr. Scientist & I/c Network Coordinator	Soil Chemistry/Fertility/ Microbiology	18.06.2009	18.06.2009
PME CELL				
Dr R Elanchezhian	Pr. Scientist & I/c PME Cell	Plant Physiology	09.11.1998	17.02.2012
Mr Sanjay Kumar Kori	Stenographer Grade-III	Office Staff	03.01.2012	03.01.2012
ITMU				
Dr Sanjay Srivastava	Pr. Scientist	Officer In-Charge	22.03.1996	02.09.1996
Mr Sanjay Kumar Parihar	T-3	Technical Assistant	29.06.2019	29.06.2019
AKMU				
Dr J Somasundaram	Pr. Scientist	Officer In-Charge	12.11.2001	22.12.2008
Remot Sensing & GIS Laboratory				
Dr M Mohanty	Pr. Scientist	Soil Physics/Soil & Water Conservation	10.11.1999	10.11.1999
Mr LN Chouksey	Messenger	Skilled Supporting Staff	17.12.1988	17.12.1988
LIBRARY SECTION				
Mrs Nirmala Mahajan	T-7-8	Asstt. Chief Tech. Officer	15.03.1993	15.03.1993
CENTRAL LAB				
Dr SR Mohanty	Pr. Scientist	Officer In-Charge	18.06.2009	18.06.2009
Mr Vinod Babu Pal	T-7-8	Asstt. Chief Tech. Officer	15.02.1993	15.02.1993
REFERRAL LAB				
Dr PradipDey	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 OP Shukla	T-5	Technical Officer (Tractor Mech.)	22.04.1989	22.04.1989
Mr CT Wankhede	T-5	Technical Officer (Electrucian)	03.08.1992	03.08.1992
Mr DR Darwai	T-5	Technical Officer (Field Assistant	23.01.1993	23.01.1993
Mr Hukum Singh	T-4	Sr. Technical Assistant	30.12.1988	30.12.1988
Mr Bhagwat Prasad	Beldar	Skilled Supporting Staff	24.01.1992	24.01.1992
Mr Lalaram Sahu	Beldar	Skilled Supporting Staff	24.07.1992	24.07.1992
Mr RK Sen	Beldar	Skilled Supporting Staff	08.09.1997	08.09.1997
VEHICLE SECTION				
Dr AO Shirale	Scientist	Soil Chemistry/Fertility	01.01.2015	10.04.2015
Mr Sukh Ram Sen	T-4	Sr. Tech. Asstt. (Driver)	25.01.1991	25.01.1991
ADMINISTRATION SECTION				
Mr SK Gupta	SAO	Administration	14.11.1986	01.04.2017
Mr Neeraj Tahiliani	FAO	Audit & account	12.06.2012	22.07.2014
Mr Rajesh Dubey	AF&AO	Audit & account	21.12.1988	26.11.1998
Mr AS Rajput	AAO	Establishment Section	14.03.1990	14.03.1990
Mrs Babita Tiwari	Assistant	Central store	30.05.1996	30.05.1996
Mr Bansilal Sarsodia	Assistant	Purchase section	10.09.1997	10.09.1997
Mr Hira Lal Gupta	Assistant	Bill section	23.12.1988	23.12.1988
Mr OP Yadav	UDC	Audit & Account	19.12.1988	19.12.1988
Mr Jineshwar Prasad	UDC	Cash Section	13.12.1988	13.12.1988
Mr Sanjay Katinga	LDC	Bill Section	20.06.1989	20.06.1989
Mrs Raksha Dixit	LDC	Bill Section	24.05.2013	24.05.2013
Mr Anurag	Security Supervisor	Security section	29.09.1997	29.09.1997
Mr PK Raut	Beldar	Skilled Supporting Staff	21.07.1992	21.07.1992
Mr Sanjay N Gharde	Lab attendant	Skilled Supporting Staff	15.06.1999	15.06.1999
Mr Dharam Raj Singh	Messenger	Skilled Supporting Staff	10.09.1993	14.06.1999
Mr AK Mishra	Lab attendant	Skilled Supporting Staff	01.09.1993	10.06.1999

*on deputation

Promotion

1. Mr RK Mandloi and Mr. Deepak Kaul promoted ACTO to CTO w.e.f. January 1, 2018.
2. Mr OP Yadav got MACP w.e.f. December 19, 2018.
3. Mrs. Kavita Bai got MACP w.e.f. December 20, 2018.
4. Mr Bhanwar Singh Yadav got MACP w.e.f. January 23, 2019.
5. Mr PS Sunil Kumar, Ex-AAO has been Promoted to AO & got transferred and joined ICAR-DFR, Pune on October 5, 2019.

Transfer

1. Mr PS Sunil Kumar, AAO transferred to ICAR-DFR, Pune on October 5, 2019
2. Dr AL Kamble, Scientist has been transferred to ICAR-ATARI, Pune on November 30, 2019.
3. Dr Utkarsh Tiwari, Scientist has been transferred to ICAR-IARI, New Delhi on November 30, 2019.

Deceased

Mr Vinod Babu Pal, Ex-ACTO departed to heavenly abode on October 5, 2019

Resignation

Mr Neeraj Tahiliani, F&AO resigned on July 31, 2019.

Joining

1. Ms Alka Rani, Scientist joined on April 12, 2019.

2. Mr Sanjay Kumar Parihar, Technical Assistant, joined on June 29, 2019.

3. Dr Nisha Sahu, Scientist joined on November 30, 2019.

4. Dr Narayan Lal, Scientist joined on December 24, 2019.


मृदा स्वास्थ्य जागरूकता सप्ताह
Soil Health Awareness Week


किसान - वैज्ञानिक परिचर्चा
Farmer-Scientist Interaction Meet
on
5th December 2019

स्वस्थ मृदा
स्वस्थ फसल
स्वस्थ जीवन

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