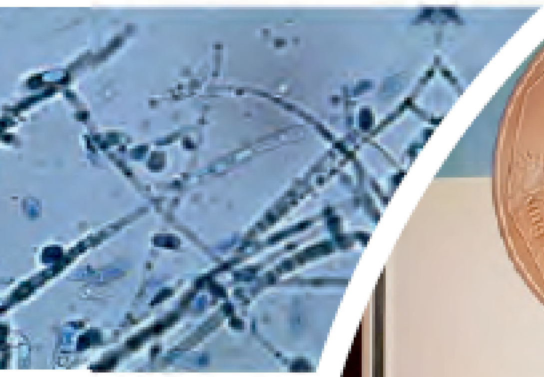
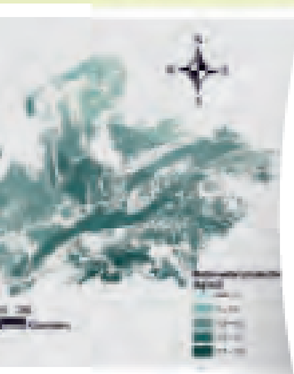
Annual Report
2020





भाकृअनुप- भारतीय मृदा विज्ञान संस्थान
ICAR - INDIAN INSTITUTE OF SOIL SCIENCE

Nabibagh, Berasia Road, Bhopal – 462 038 (M.P.)
https://iiss.icar.gov.in

ISO 9001:2015 Certified

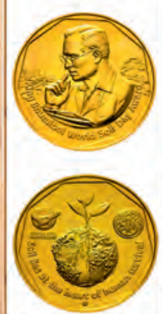
Sardar Patel Outstanding ICAR Institution

United Nations - FAO

King Bhumibol World Soil Day Award - 2020

Conferred to

ICAR-Indian Institute of Soil Science, Bhopal



OFFICE OF THE REPRESENTATIVE IN INDIA

联合国粮食及农业组织 | FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS | ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE | ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION | منظمة الأغذية والزراعة للأمم المتحدة

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Fax: 0091-11-24620115

Tomio Shichiri
FAO Representative in India

Re: LA 1/1

8 December 2020

Dear Dr. Mohapatra,

Congratulations to Indian Institute of Soil Science (IISS), ICAR for winning the King Bhumibol World Soil Day Award 2020

Greetings from the Food and Agriculture Organization of the United Nations (FAO)!

Since 2014, the World Soil Day (WSD) campaign has become one of the most influential FAO campaigns, with hundreds of events held worldwide and significant social media and digital impact. FAO's message on the importance of healthy soils for a healthy life is conveyed widely through this campaign.

From 2018, the King Bhumibol World Soil Day Award, hosted by the Global Soil Partnership (GSP) and supported by the Kingdom of Thailand has been recognizing individuals or institutions that organize successful and impactful WSD celebrations in accordance with the World Soil Day theme.

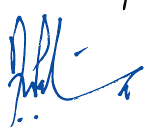
This prize is awarded annually on occasion of World Soil Day in Thailand. This year (2020), the Indian Institute of Soil Science, Indian Council for Agricultural Research, (IISS, ICAR), India has been conferred this award.

With best regards.

Your Sincerely,

(Tomio Shichiri)

With Best Compliments



(Ashok K. Patra)

Director

ICAR-Indian Institute of Soil Science

Nabi Bagh, Berasia Road, Bhopal – 462 038

ICAR-IISS Annual Report 2020

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Healthy soil for a healthy life

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PREFACE

It is now globally recognized that healthy soils are extremely important for numerous ecosystem services such as food production, nutrient supply, detoxification, water and nutrient retention, maintaining biodiversity, carbon sequestration and mitigating green house gas emission. To prevent decline in soil health and to improve agricultural productivity, an in-depth knowledge of soil is essential. This necessitates regular monitoring of our soil resources and providing appropriate technological interventions. ICAR-Indian Institute of Soil Science (ICAR-IISS), Bhopal is engaged in research with a mandate "to provide scientific basis for enhancing and sustaining productivity of soil resource with minimal environmental degradation". The institute has developed many technologies with field-level validation for improvement of soil health and to address the emerging issues and challenges. This annual report clearly illustrates the multi-scale approaches and work done in the area of soil health and input use efficiency, conservation agriculture (CA) and carbon (C) sequestration, greenhouse gas emission, soil microbial diversity and genomics, soil pollution, remediation and environmental security. The report also describes the work done on farmers' participatory research and demonstration of the technologies at farmers' fields across the length and breadth of the country through various AICRP/AINP/CRP centres.

During the year reported, some new technologies and methodologies were developed and refined by the institute, viz., Ion Selective Field Effect Transistors (ISFET) methodology for the estimation of soil pH, nitrate and potassium; use of modified glauconitic shale for supply of potassium to crops; delineation of soil management zones for ameliorating sulphur and micronutrients deficiencies in Narmada river basin; CA practices for improved soil health and C sequestration; abiotic stress responsive and zinc solubilizing microbial inoculants; organic management practices for wheat, mustard and chickpea; endophytic fungi for bioremediation of heavy metals, and use of fly ash for remediation of heavy metals pollution in soil. A rapid soil biological health kit has been developed which is based on the assessment of microbial activities in soil. Similarly, a new seed coating bioformulation is developed for improved delivery of microbial inoculants. Besides, on the basic research front, efficient wheat genotypes were assessed for nutrient use efficiency; developed fertilizer prescription equations under integrated plant nutrient supply systems; assessed methane consumption in response to different nitrogen sources in a tropical soil ecosystem, and evaluated the effect of long term use of FYM and inorganic fertilizers on soil microbial community and potential nitrification.

The institute plays a leadership role and highly committed to create awareness among people on the roles and functions of soil for the sustenance of humanity. In this endeavor, I am happy to share that the institute has been bestowed by the UN FAO "King Bhumibol World Soil Day 2020 Award" for its massive awareness program on soil health management across the country. The "King Bhumibol World Soil Day Award" by FAO acknowledges individuals or institutions that raise public awareness of soils by organizing successful and influential World Soil Day celebrations. The award, sponsored by the Kingdom of Thailand, is named after King Bhumibol Adulyadej of Thailand for his lifelong commitment for raising awareness of the importance of sustainable soil management and rehabilitation for food security, poverty alleviation and more. This award by FAO to ICAR-IISS, Bhopal, is an international recognition in view of excellent contribution in 'Soil Health Awareness' by the Institute during last year.

Further, this report presents glimpse of all the important activities undertaken by the institute during the difficult time of COVID 19 pandemic. It is thus, a great pleasure for me to bring out the Annual Report 2020 of the ICAR-Indian Institute of Soil Science.

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

I place on record, my sincere appreciation to Drs. R. Elanchezhian, S.R. Mohanty, Prabhat Tripathi, M. Vassanda Coumar, Asit Mandal, N.K. Sinha, B.P. Meena and H. Das for their dedicated efforts in compiling and editing the report. The service rendered by Mr. S.K. Kori and Mr. S.K. Parihar in collecting information and typesetting the manuscript is appreciated.

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

Bhopal
April 2021

Ashok K. Patra
(Director)

CONTENTS

कार्यकारी सारांश

विषयवस्तु 1: मृदा स्वास्थ्य एवं पोषक तत्व उपयोग दक्षता

मृदा उर्वरता

- विभिन्न नत्रजन तथा फॉस्फोरस के सामान्य, उप–इष्टतम एवं नियंत्रित उर्वरक स्तरों पर मूल्यांकन किए गए गेहूँ के विभिन्न जीनोटाइप्स में HI 1500 से क्रमशः 14.05, 12.69 व 10.51 टन प्रति हेक्टेयर कुल जैव पदार्थ तथा 5.81, 3.54 तथा 2.22 टन प्रति हेक्टेयर गेहूँ दाना की पैदावार प्राप्त हुई, जो कि अन्य की तुलना में सार्थक रूप से अधिक थी।

- दीर्घावधि (40 वर्षों) की बागवानी तथा कृषि बागवानी प्रणाली अपनाए जाने से मृदा का स्थूल घनत्व 1.14 मेगा ग्राम प्रति घनमीटर पाया गया जोकि बिना जुताई (नोटिल) प्रणाली (1.43 मेगा ग्राम प्रति घनमीटर) से कम था। फसल अवशेष को 90 प्रतिशत तक बनाए रखने से 0–10 सेमी मृदा में कुल जैविक कार्बन (1.74 प्रतिशत) में सुधार देखा गया। विभिन्न प्रकार की भूमि उपयोग प्रणालियों में कृषि बागवानी प्रणाली में कुल कार्बन की उच्चतम सान्द्रता (2.1 प्रतिशत) पाई गई, तथा 90 प्रतिशत फसल अवशेष के साथ NT (नोटिल) प्रणाली कुल कार्बन सान्द्रता में दूसरे स्थान पर पायी गयी।

- बिना जुताई (नो टिल) प्रणाली में फसल अवशेष बनाए रखने से वाक्ले एण्ड ब्लैक कार्बन (WBC) में बिना फसल अवशेष वाले उपचार की तुलना में 10 प्रतिशत तक सुधार देखा गया। कृषि बागवानी प्रणाली में उच्चतम WBC (1.59 प्रतिशत) था तत्पश्चात 90 प्रतिशत फसल अवशेष के साथ नोटिल में पाया गया। जबकि खेती की पारम्परिक प्रणाली में WBC की सान्द्रता न्यूनतम (0.76 प्रतिशत) पाई गई।

- मृदा में जल में घुलनशील पोटेशियम की सीमा 6 किग्रा से 1139 किग्रा प्रति हेक्टेयर के बीच पायी गयी। जल में घुलनशील पोटेशियम की अधिकतम मात्रा "सारोल" श्रेणी तथा इसके पश्चात "जलवाड़ा" श्रेणी में पायी गई। विनिमय योग्य पोटेशियम की मात्रा 193 किग्रा से 5365 किग्रा प्रति हेक्टेयर के बीच थी तथा इसका कुल पोटेशियम की मात्रा में योगदान 5 से 7 प्रतिशत था। यदि फसलों के लिए 125 किग्रा प्रति हेक्टेयर को सामान्य क्रांतिक सीमा मान लिया जाय, जो सम्पूर्ण गहराई में सभी मृदाओं में विनिमय योग्य पोटेशियम की मात्रा अधिक पायी गयी।

- वर्टिसोल में मक्का–चना फसल प्रणाली के लिए दीर्घावधि उर्वरक प्रयोग में एकीकृत पोषण प्रबंधन (INM) प्रक्रियाओं को अपनाने से प्रणाली की उत्पादकता, स्थायी उपज सूचकांक (SYI) तथा मृदा के गुणों में सुधार देखा गया। एन पी के की संस्तुति मात्रा व 100 प्रतिशत एस टी सी आर आधारित एन पी के से तुलना करने पर मक्का और चना की औसत उपज तथा प्रणाली की उत्पादकता सार्थक रूप से एस टी सी आर आधारित 75 प्रतिशत एन पी के + 5 मेगा ग्राम गोबर की खाद प्रति हेक्टेयर उपचार में अधिक पायी गयी इसके बाद एस टी सी आर आधारित 75 प्रतिशत एन पी के + 1 मेगा ग्राम मुर्गी की खाद प्रति हेक्टेयर उपचार में पायी गयी।

- ग्लूकोनाईट/उपचारित ग्लूकोनाईट के एकल प्रयोग की तुलना में इनका गोबर की खाद के साथ प्रयोग अधिक लाभदायक पाया गाया। विभिन्न उपचारों की तुलना में जब कैल्कलाइन्ड ग्लूकोनाइट का प्रयोग जब मृदा के वजन का 0.5 प्रतिशत की दर से गोबर की खाद के साथ किया गया तब मक्का के जैव पदार्थ की उपज, पोटेशियम अवशोषण की मात्रा तथा मक्के की कटाई के पश्चात अवशेष पोटेशियम के उच्च मान प्राप्त हुए।

- कृषि पर्यावरणीय प्रणाली में प्राकृतिक जल संसाधनों की प्रचुरता है। परन्तु जनजातीय किसान वर्षा आधारित खेती करते हैं अतः उनकी कृषि में जल संसाधनों का उपयोग बहुत ही कम था। अधिकांश जनजातीय खेतों में जैविक कार्बन की प्रचुरता थी तथा अन्य पोषक तत्व सीमित मात्रा में उपलब्ध पाये गये। तथापि इन अधिकांश खेतों में सल्फर तथा बोरोन की कमी देखी गयी। इसी क्रम में जनजातीय खेती की भूमि में पोषक तत्वों की कमी को दूर करने के लिए मृदा परीक्षण के आधार पर मृदा स्वास्थ्य कार्ड तैयार किए गये।

जलवायु परिवर्तन

- फसलों को दो वायुमण्डलीय CO_2 (एम्बिएन्ट तथा 550 ppmv) तथा वायु तापमान (एम्बिएन्ट, 2.0^{0}C एम्बिएन्ट से

ऊपर) स्तरों पर उगाया गया। CO_2 में वृद्धि से एम्बिएन्ट की तुलना में 43 प्रतिशत उच्च AEN देखा गया, जबकि तापमान में वृद्धि से AEN में 18.6 प्रतिशत की कमी देखी गई। CO_2 तथा तापमान दोनों में वृद्धि से AEN 8 प्रतिशत उच्च पाया गया।

- डाटासेट की भिन्नता गुणांक के आधार पर प्रधान कारक विश्लेषण (पी सी ए) से ज्ञात हुआ कि मृदा का स्थूल घनत्व एक महत्वपूर्ण भौतिक गुण है जो न्यूनतम डाटासेट (एम एस डी) में सूचक का कार्य करता है। यह अध्ययन के उप क्षेत्रों के छः कृषि पर्यावरणीय क्षेत्रों में से पांच का सूचक पाया गया।

- ए ई एस आर 4.1 तथा ए ई एस आर 9.1 जो कि पंजाब, हरियाणा, उत्तर प्रदेश तथा पूर्वी राजस्थान का प्रतिनिधित्व करते है। उनमें उपलब्ध फॉस्फोरस की मात्रा 60 प्रतिशत से अधिक नमूनों में उच्च पाई गई। इसी प्रकार ए ई एस आर 18.4 (पूर्वी तटीय धान वाले क्षेत्र) में उच्च फॉस्फोरस 46 प्रतिशत नमूनों में, ए ई एस आर 6.1 में 44 प्रतिशत नमूनों में, ए ई एस आर 4.3 में 23 प्रतिशत, ए ई एस आर 9.2 में 18 प्रतिशत नमूनों में अधिक फॉस्फोरस की मात्रा देखी गई। जबकि ए ई एस आर 4.1 में 11 प्रतिशत नमूने, ए ई एस आर 4.3 में 29 प्रतिशत नमूने, ए ई एस आर 6.1 में 26 प्रतिशत तथा ए ई एस आर 18.4 में 27 प्रतिशत नमूनों में उपलब्ध फॉस्फोरस की कमी पायी गयी।

- मृदा की पीएच, नाइट्रेट तथा पोटेशियम का आंकलन करने के लिए आयन सिलेक्टिव फील्ड इफेक्ट ट्रांजिस्टर्स (आई एस एफ ई टी) का परीक्षण किया गया। आई एस एफ ई टी एक फील्ड इफेक्ट ट्रांजिस्टर है जिसे विलियन में आयन सान्द्रता मापने के लिए उपयोग किया जाता है। जब आयन सान्द्रता में परिवर्तन होता है तो ट्रांजिस्टर के माध्यम से प्रवाहित होने वाली विद्युत धारा में भी तदानुसार बदलाव देखा जाता है।

- आई एस एफ ई टी के प्रयोग से मृदा नाइट्रेट का आंकलन करने के लिए सोडियम नाइट्रेट के साथ–साथ पोटेशियम क्लोरोइड अंश शोधन ग्राफ (कैलिब्रेशन कर्व) के प्रयोग से जो परिणाम प्राप्त हुआ वह पारम्परिक मृदा परीक्षण (2M KCL निष्कर्षण का ऑटोएनालाइजर की सहायता से कैलोरीमीट्रिक आंकलन) से तुलनात्मक था।

अखिल भारतीय समन्वित अनुसंधान परियोजनाएँ (ए आई सी आर पी)

- गोबर की खाद व अकार्बनिक उर्वरक दोनों के प्रयोग वाले उपचार में सूक्ष्मजीवी जैवपदार्थ कार्बन (एम बी सी) काफी अधिक था। जबकि जैविक खाद, व चूना के साथ मिलाकर अकार्बनिक उर्वरक का प्रयोग करने से क्यारियों में एम बी एन तथा एम बी पी की मात्रा अधिक पाई गई।

- जैविक खाद के साथ दीर्घावधि उर्वरक के प्रयोग से ($P<0.05$) एस एम बी सी तथा एम बी एन में नियंत्रित उपचार की तुलना में वृद्धि देखी गई। धान–गेहूँ फसलीय प्रणाली के अड़तालीसवी फसलीय चक्र के अंत में एकीकृत पोषण प्रबंधन के तहत मृदा सूक्ष्मजीवी जनसंख्या सार्थक रूप से प्रभावित हुई।

- सघन खेती वाले गंगा के मैदानी क्षेत्र (आई जी पी) में उपलब्ध सूक्ष्मपोषक तत्वों (जिंक, बोरोन, आयरन, मैग्नीज तथा कॉपर) उपलब्ध गंधक और मृदा गुणों (पीएच, विद्युत चालकता तथा मृदा कार्बनिक कार्बन) का स्थानिक वितरण का स्वरूप तैयार किया गया। साथ ही मृदा पोषक तत्वों के दक्षतापूर्ण प्रबंधन हेतु मृदा प्रबंधन क्षेत्र (एमजेड़) को चित्रित किया गया।

- भू–सांख्यिकीय विश्लेषण से मृदा के विभिन्न मापदण्डों के लिए घातीय प्रारूप के साथ सेमी–वैरियौग्राम प्राप्त हुआ। एन आर बी के लगभग 41.2, 78.6, 10.1, 2.70 तथा 32.6 प्रतिशत क्षेत्र में क्रमशः सल्फर, जिंक, मैग्नीज तथा बोरोन की पौधों को उपलब्धता में कमी देखी गई। प्रमुख अवयव के विश्लेषण तथा फजी सी क्लस्टरिंग से पांच प्रबंधन क्षेत्र प्राप्त हुए।

- अरहर के विभिन्न जिनोटाइप्स की बीज उपज दक्षता सूचकांक (SYEI) तथा जिंक अवशोषण दक्षता सूचकांक (ZUEI) क्रमशः 67.0 से 92.5 तथा 47.0 से 69.9 के बीच थी। SYEI तथा ZUEI के आधार पर जीनोटाइप्स का वर्गीकरण दक्ष एवं अनुक्रियाशील (विरसा अरहर–1 जीटी–1, जीटी– 101, एस के एन पी 05–05 बी डी एन–2, ए ए यू टी 2007–04, बी एस एम आर 853, टी 15–15, डी टी 23, पूसा 9) दक्ष एवं गैर अनुक्रियाशील (आई सी पी एल 87119, पी के वी ट्राम्बे) तथा दक्षताहीन एवं अनुक्रियाशील (ए के टी 8811, हिसार पारस दक्षताहीन व गैर अनुक्रियाशील (ए ए यूटी 2007–10 जे के एम 7, 10 हिसार मानक, सी–11, हिसार HO 2–60 जी ए यू टी 93–17)

- मृदा, उर्वरक तथा जैविक स्त्रोत (गोबर की खाद, हरी खाद, कम्पोस्ट फसल अवशेष तथा जैव उर्वरक जैसे ऐजोस्पाइरिलम तथा फॉस्फोबैक्टीरिया) सहित विभिन्न स्त्रोतों से पोषक तत्वों के योगदान पर आधारित एस टी सी आर – आई पी एन एस उर्वरक समीकरण विकसित किए गए।

- अरहर में पौधे के विकास में वृद्धि कारक तथा जिंक विलेयीकरण तथा नाइट्रोजन स्थिरीकरण के लिए बीज आवरण जैवउर्वरक का मूल्यांकन ए आइ एन पी एस बी बी (वी एन एम के वी परभणी केन्द्र) में किया गया। जिंक की घुलनशीलता बढ़ाने वाले स्यूडोमोनास स्ट्रेंटा तथा पौधों की वृद्धि में सहायक बेसिलस मेगाटेरियम तथा ट्राइकोडर्मा विरिडी को बीज आवरण जैवउर्वरक के रूप में प्रयोग किया गया।

- इन्डो–यूके नाइट्रोजन स्थरीकरण केन्द्र में दक्ष राइजोबियम स्ट्रेन्स को पृथक करके स्थानीय स्ट्रेन्स के साथ परभनी केन्द्र में इनका मूल्यांकन किया गया। फसल वृद्धि, नॉड्यूलेशन, पैदावार, मृदा उर्वरता तथा सूक्ष्मजैविक विविधता के सदर्भ में BRP-6 तथा BRP-20 स्ट्रेन्स स्थानीय स्ट्रेन्स एम के वी–1 की तुलना में अधिक कार्यदक्ष पाए गए।

विषयवस्तु 2 : संरक्षित कृषि, कार्बन पृथक्करण एवं जलवायु परिवर्तन

- फसल अवशेष के 30 तथा 60 प्रतिशत की तुलना में सोयाबीन–गेहूँ एवं मक्का–चना फसलीय प्रणाली में 90 प्रतिशत फसल अवशेष में उच्च फसल उपज मापदण्ड प्राप्त किए गये।

- विभिन्न जोताई उपचारों तथा फसलीय प्रणाली के तहत मृदा की कुल हानि 2.57 से 6.77 टन प्रति हेक्टेयर थी। तथापि कुल वर्षा में से जल का अपवाह 21.42 से 34.59 प्रतिशत था।

- सतह के पास (0–5 सेमी गहराई) दैनिक आयतनिक मृदा नमी के आंकड़ों (1980 से 2019) से ज्ञात हुआ कि खरीफ मौसम में सतह के समीप मृदा नमी 0.25 से 0.34 घनमीटर/घनमीटर थी जिसका औसत मान 0.29 घनमीटर/घनमीटर था। रबी मौसम में यह 0.15 से 0.24 घनमीटर/घनमीटर के बीच था जिसका औसत मान 0.19 घनमीटर/घनमीटर था।

- मृदा द्रव चालकता (एस एच सी) पर कर्षण और नत्रजन प्रबंधन का प्रभाव दस वर्ष तक निरन्तर प्रचलन के पश्चात यह पाया गया कि बिना जुताई वाले उपचार में मृदा द्रव चालकता पारम्परिक कर्षण उपचार से अधिक थी।

- अरहर की फसल की पैदावार अंतर के अखिल भारतीय स्तर पर विश्लेषण से ज्ञात हुआ की सबसे अधिक पैदावार में अंतर हरियाणा में (1350 किग्रा प्रति हेक्टेयर) था जिसके पश्चात राजस्थान तथा हिमाचल प्रदेश थे। तमिलनाडू में सबसे कम पैदावार अंतर (300 किग्रा प्रति हेक्टेयर) पाया गया।

- मध्यप्रदेश में मक्का तथा गेहूँ की फसल में फसल जल उत्पादकता (WP) में स्थानिक भिन्नता में सार्थक अंतर पाया गया। मक्के के लिए जल उत्पादकता 0.6 से 1.90 किग्रा प्रति घनमीटर थी तथा गेहूँ के लिए यह 0.65 से 1.2 किग्रा प्रति घनमीटर पायी गयी।

- विभिन्न दीर्घाकालिक नत्रजन प्रबंधन परिदृश्य के अंतर्गत मक्का की पैदावार तथा जैव पदार्थ पर वर्तमान एवं भविष्य की जलवायु प्रभाव के अध्ययन में देखा गया कि मक्का की पैदावार 100 प्रतिशत जैविक उपचारों में RCP 4.5 (2050_S) RCP 4.5 (2080_S), RCP 8.5 (2050_S) तथा RCP 8.5 (2080_S) के तहत क्रमशः 21.8 प्रतिशत, 23.2 प्रतिशत, 22.3 प्रतिशत तथा 23.8 प्रतिशत कम हुई।

- संरक्षण खेती की दीर्घकालिक प्रक्रियाओं में यह देखा गया कि 0–5 सेमी मृदा सतह में पारम्परिक जुताई (0.69 प्रतिशत) की तुलना में बिना जुताई के उपचार में मृदा कार्बनिक कार्बन (0.83 प्रतिशत) उच्च था। इसी प्रकार 5–15 सेमी मिट्टी की परत में मृदा कार्बनिक कार्बन की मात्रा पारम्परिक जुताई की तुलना में बिना जुताई के उपचार में उल्लेखनीय रूप से अधिक थी।

- संरक्षित खेती की दीर्घकालिक प्रक्रियाओं के तहत एग्रीगेट कार्बन की मात्रा एग्रीगेट के आकार के साथ बढ़ गई। इसमें इस प्रकार क्रम की श्रृंखला देखी गई बड़े मैक्रो एग्रीगेट (LM)> छोटे मैक्रो एग्रीगेट (SM) > माइक्रो एग्रीगेट (M)>सिल्ट + क्ले (S+C)

- सिंचाई उपचारों में गेहूँ की उच्चतम पैदावार टपक सिंचाई में (5965 किग्रा प्रति हेक्टेयर) प्राप्त की गई। इसके पश्चात छिड़काव सिंचाई में (5621 किग्रा प्रति हेक्टेयर) तथा न्यूनतम (5490 किग्रा प्रति हेक्टेयर) बहाव सिंचाई

में देखी गई। जोताई के विभिन्न उपचारों का अनाज व जैवपदार्थ की पैदावार पर विशेष प्रभाव नही देखा गया।

- भारत के इन्सेप्टिसॉल तथा अल्फिसॉल्स में मिड इन्फ्रारेड सॉइल स्पेक्ट्रा का प्रयोग कर उनमें मृदा जैविक कार्बन सान्द्रता, pH, रेत, सिल्ट (गाद) तथा क्ले की मात्रा, खेत में मृदा की जल संग्रहण क्षमता एवं स्थायी विल्टिंग पाइंट का पूर्वानुमान अच्छी सटीकता (R^2>0.7) के साथ किया गया।

विषयवस्तु 3: सूक्ष्मजीवी विविधता और जैव प्रोद्यौगिकी

- गेहूँ, सरसों, चना तथा अलसी की उच्चतम बीज पैदावार 75 प्रतिशत जैविक + 25 प्रतिशत अकार्बनिक उर्वरक के साथ प्राप्त की गई। इसके पश्चात शत प्रतिशत (100 प्रतिशत) जैविक उपचार विधियों > (100 प्रतिशत) अकार्बनिक > राज्य की अनुशंसाओं के उपचार में प्राप्त किया गया।

- फ्लूरेसिन डाई–एसीटेट हाइड्रॉलिसिस, डिहाड्रॉजिनेस गतिविधि, एल्कालाइन फॉस्फेटेज तथा बीटा ग्लूकोसाइडेज जैसी एंजाइम गतिविधि निम्नलिखित क्रम में पाई गई शतप्रतिशत जैविक > 75 प्रतिशत जैविक + 25 प्रतिशत अकार्बनिक > 75 प्रतिशत जैविक + नवोन्मेषी उपचार जिनसे मृदा के सूक्ष्मजीवों पर जैविकों का लाभदायक पाया गया।

- गेहूँ तथा चने की बारह किस्मों का भाकृअनुप–भारतीय मृदा विज्ञान संस्थान, भोपाल में परीक्षण किया गया, जिन्हें जैविक पोषण प्रबंधन प्रक्रियाओं के तहत उगाया गया था। गेहूँ की किस्म GW-366 का प्रदर्शन सर्वश्रेष्ठ था जिसके पश्चात मालवा शक्ति तथा HI 8498 पायी गई। इसी प्रकार चना की किस्म JG-130 की उच्चतम पैदावार थी जिसके पश्चात JG-63 की पैदावार दूसरे स्थान पर देखी गई।

- नगर निगम के ठोस अपशिष्ट पदार्थ युक्त स्थलों पर प्राकृतिक रूप से उगे पौधों की जड़ो से कुल 14 अंतः पादपी कवक (एन्डोफाइटिक फंगी) को अलग कर भारी धातुओं की सहनशीलता के लिए उनका मूल्यांकन किया गया। विभिन्न भारी धातुओं (कैडमियम, लैड, निकिल तथा पारा) के विरूद्ध यह काफी प्रभावी पाया गया।

- राइजोबियल स्ट्रेन जो ब्रेडिरिजोवियम के समान थे उनसे सोयाबीन (JS 9560) की वृद्धि एवं पैदावार में उल्लेखनीय सुधार आया। अधिक सूखा, उच्च तापमान तथा लवण सहनशीलता के प्रभाव की स्थिति में आइसेलेट्स में सीइड्रोफोर तथा IAA उत्पादन की क्षमता देखी गई। जो अनकल्चर्ण बैक्टीरियम स्ट्रेन के समान थे उनसे असंक्रमित कन्ट्रोल की तुलना में अनाज की पैदावार, जड़ों का घनत्व तथा नोड्यूल काउन्ट में सुधार देखा गया।

- उष्णकटिबंधीय मृदा पर्यावरणीय प्रणाली में विभिन्न नाइट्रोजन स्त्रोतों की प्रतिक्रिया में मीथेन उपयोग से ज्ञात हुआ कि N_2 से Nif तथा pmoA जीन्स दोनों की बहुलता में वृद्धि होने से मीथेन की खपत में वृद्धि हुई। नत्रजन जो कि NO_3 तथा NH_3 के रूप में प्रचुरता सें बढ़ता है वह उष्णकटिबंधीय वर्टीसोल में मीथेन की खपत को अवरूद्ध करता है। NO_3-N की तुलना में NH_4-N द्वारा संशोधित मृदा में मिथेनोट्रॉफ्स, pmoA जीन एवं नाइट्रिफायर्स, amoA जीन की बढ़ोत्तरी अधिक पायी गया। उपलब्ध नाइट्रेट नाइट्रोजन की मात्रा ने मीथेन के साथ 9 से 30 प्रतिशत तक नत्रजन स्थिरीकरण को बढ़ाया।

- मृदा सुधारक के साथ 1 प्रतिशत w/w फसल अवशेष (मक्का, गेहूँ, चना तथा सोयाबीन) का मूल्यांकन मीथेन गतिकी के अध्ययन के लिए जलमग्न दशा में किया गया। मीथेन की खपत दर (नैनो ग्राम प्रति ग्राम मृदा प्रति दिन) गेहूँ में सर्वाधिक (0.79) व चने में निम्नतम (0.53) पायी गयी। सर्वाधिक उत्पादन दर गेहूँ के अवशेष के साथ व सबसे कम चने में पायी गयी। मीथेन उत्पादक एवं मीथेन उपभोक्ता मृदाओं में जैव कार्बन व उपलब्ध नाइट्रेट की मात्रा में नियंत्रित उपचार की तुलना में सार्थक वृद्धि प्राप्त हुई। फसल अवशेष की उपस्थिति में मीथेन उत्सर्जक की संख्या में सार्थक वृद्धि पायी गयी।

- विभिन्न अपशिष्टों से तैयार कम्पोस्ट में भारी धातुओं जैसे कैडमियम, निकल, तथा जिंक का गुणवत्ता मूल्यांकन किया गया। सभी कम्पोस्ट में भारी धातुओं की सान्द्रता एफ सी ओ द्वारा तय मानकों के अनुसार निर्धारित सीमा में ही पायी गयी।

- विभिन्न जैविक अपशिष्टों से तैयार कम्पोस्ट का नेमाटोड की संख्या के लिए परीक्षण किया गया। कम्पोस्ट निलम्बन में कोई नेमाटोड नहीं पाया गया जबकि जड़ो की मृदा निलम्बन में सक्रिय नेमाटोड की उपस्थिति देखी गई। कम्पोस्ट में एम पी एन विधि का प्रयोग करते हुए कुल कोलीफॉर्म वैक्टीरिया तथा ई कोली का भी परीक्षण किया गया। क्रमशः जल द्वारा तनु कम्पोस्ट नमूनों को लेक्टोज ब्रॉथ में एकल तथा दोगुनी क्षमता के साथ प्रेषित किया गया। इनके 48 घण्टों तक 37^0 सेन्टीग्रेड पर इन्क्यूवेशन किए जाने पर किसी प्रकार का रंग में परिवर्तन अथवा गैस उत्पादन नहीं देखा गया।

- उप शुष्क से उप आद्रतायुक्त मध्य भारत में प्राकृतिक चारागाह प्रणाली की तुलना में मानवजनित प्रबंधनयुक्त चारागाह प्रणाली में (0–15 तथा 15–30 सेमी) मृदा की गहराई पर RuBisCo एन्जाइम गतिविधि अधिक थी। एकीकृत पोषण प्रबंधन उपचार (100 प्रतिशत NPK + गोबर की खाद) में फिनॉल ऑक्सीडेज की मात्रा असंतुलित उर्वरक 100 प्रतिशत N व NP उपचारों की तुलना में अधिक था। (एल टी एफ ई, रायपुर) इसी प्रकार बागवानी तथा चारागाह प्रणाली में मिट्टी की ऊपरी पटल में फिनॉल आक्सीडेज गतिविधि के कारण कार्बन पृथककरण की क्षमता अधिक थी। कृषि वानिकी तथा पलाश आधारित जंगल की काली मिट्टी में कार्बन पृथक्करण क्षमता अधिक गहराई पर ज्यादा थी।

- शत प्रतिशत NPK + गोबर की खाद में कुल सूक्ष्मजीवी तथा यूकेरियोट जैवपदार्थ सर्वाधिक था तथा परभक्षी/जीव का अनुपात कम था। साइक्लो/मोनोअनसेचुरेटेड प्रिकरसर का अनुपात कंट्रोल में उच्च तत्पश्चात 100 प्रतिशत N, 100 प्रतिशत NP में था। इसी प्रकार एकीकृत पोषक तत्व प्रबंधन में ग्राम पॉजीटिव से ग्राम निगेटिव बैक्टीरिया अनुपात उच्चतम था। मृदा नाइट्रिफिकेशन सर्वाधिक ऑटोट्रोफिक नाइट्रिफिकेशन गतिविधि (ANM) से हुआ। तथापि अध्ययन से ज्ञात हुआ कि हेटरोट्रॉपिक नाइट्रिफिकेशन में उल्लेखनीय वृद्धि हुई। कुल नाइट्रीफिकेशन में 55 से 80 प्रतिशत ए एन ए व 19.6 –49.6 प्रतिशत एच एन ए का योगदान था। एकीकृत उपचार (100 प्रतिशत NPK + गोबर की खाद) में NA कंट्रोल की तुलना में उल्लेखनीय रूप से अधिक था।

- एल टी एफ ई, बैरकपुर की मृदा के विभिन्न पोटेशियम हिस्सों के विश्लेषण से ज्ञात हुआ कि निरन्तर संतुलित फर्टिलाइजेशन तथा एकीकृत पोषक तत्व प्रबंधन से मृदा में विनिमय तथा गैर विनिमय–पोटेशियम की मात्रा में उल्लेखनीय वृद्धि हुई। सूक्ष्मजीवी जैवपदार्थ पोटेशियम (MBK) का विनिमय योग्य पोटेशियम (r=0.72), गैर विनिमय पोटेशियम (r=0.684) तथा जल में घुलनशील पोटेशियम (डब्यूलू एस के) (r=0.617) से सकारात्मक संबंध था। उच्चतम सूक्ष्मजीवी जैवपदार्थ पोटेशियम पड़ती भूमि में पाया गया उसके उपरान्त MBK 100 प्रतिशत NPK+ गोबर की खाद में पाया गया।

विषयवस्तु 4: मृदा प्रदूषण एवं उपचार

- ताप ऊर्जा संयंत्र की फ्लाई ऐश का प्रयोग करने से पौधों को सोडियम को छोड़कर सभी आवश्यकता पोषक तत्व प्राप्त होते है। भारी धातुएं जैसे निकल, कॉपर, कोबाल्ट तथा कैडमियम 6.7–7.5 की pH श्रेणी में घुलनशील नही है। अतः उनकी सान्द्रता बहुत कम थी। भारी धातुओं में केवल क्रोमियम (Cr) को पानी की सहायता से निकाला गया (0.06 ppm) जो पर्यावरण के लिए घातक था।

- क्षार संशोधित फ्लाई ऐश (AIMFA) द्वारा घोल से कैडमियम तथा लैड को पूर्णतया हटा दिया गया क्योंकि अम्ल संशोधित मॉडिफाईड फ्लाई एश (AcMFA:2.4 तुल्यांकप्रति 100ग्रा) तथा अनुपचारित एश (यू एफ ए 3.4 तुल्यांक प्रति 100ग्रा) की तुलना में CEC में 113 तुल्यांक प्रति 100ग्रा तक बढ़ोत्तरी देखी गई। जिसके कारण Cd व Pb को हटाया जा सका।

- परिवर्तित/संशोधित फ्लाई ऐश के 5 प्रतिशत की दर से प्रयोग से न केवल कैडमियम का विषैलापन दूर हुआ बल्कि पालक के जैवपदार्थ की वृद्धि (15 प्रतिशत) में सुधार आया। DTPA से निकलने योग्य कैडमियम (>28 प्रतिशत) में कमी आई तथा असंशोधित मृदा की तुलना में पालक पत्ती Cd (45प्रतिशत) में भी कमी आई।

- जब भारी धातुओं से युक्त नगर निगम ठोस अपशिष्ट को 3 से 60 दिन तक इन्क्यूवेट किया गया तो यह पाया गया कि कार्बन डाई आक्साइड के उत्सर्जन में क्रमशः कमी आयी। सभी भारी धातुओं के संयुक्त रूप से उपस्थित के कारण दूषित कार्बन डाई आक्साइड उत्सर्जन, एकल धातु से दूषित की तुलना में सार्थक रूप से कम था।

- कोयले की खदान के पानी का पी.एच. 5.7 से 6.0 था। आक्सीकरण–अवकरण क्षमता 162–300 मिली वोल्ट, घुलनशील आक्सीजन 4.14 से 7.25 पी पी एम के बीच थी। विद्युत चालकता व घुलनशील ठोस पदार्थ क्रमशः 1.10 – 4.47 डेसी सीमेन्स प्रति मीटर तथा 0.15–2.25 पी पी टी पाए गये।

- प्रदूषित चम्बल नदी के पानी का नागदा शहर में सिंचाई के लिए उपयोग करने से मृदा स्वास्थ्य तथा गेहूँ, चने आदि की फसलों की गुणवत्ता पर प्रतिकूल प्रभाव पाया गया। प्लास्टिक मल्च, ड्रिप सिंचाई तथा जैविक खाद को संयुक्त प्रयोग से इस प्रदूषित नदी जल को प्रयोग में लाकर फसल उत्पादकता तथा मृदा स्वास्थ्य में सुधार लाया जा सकता है।

EXECUTIVE SUMMARY

Theme I : Soil Health and Nutrient Use Efficiency

Soil Fertility

- Among wheat genotypes evaluated under varying N and P gradient, HI1500 exhibited significantly higher plant biomass of 14.05 t ha^{-1}, 12.69 t ha^{-1} and 10.51 t ha^{-1} under normal, sub-optimal and control fertilizer levels, respectively. The same genotype also recorded significantly higher grain yield of 5.81 t ha^{-1}, 3.54 t ha^{-1} and 2.22 t ha^{-1} under normal, reduced and control fertilizer levels, respectively.

- Adoption of long term (40 years) horticulture & agri-horticulture system 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 organic carbon (1.74%) in 0-10 cm of soil depth. Among the different land use systems, agri-horticulture system maintained a highest concentration of total carbon (2.1%) followed by NT system with 90% of residue retention.

- Retention of residue under NT system improved Walkley and Black Carbon (WBC) by 10% in comparison to no residue retained plot. Agri-horticulture system had highest WBC (1.59%) followed by NT with 90% of residue retention. The lowest concentration of WBC (0.76%) was recorded in conventional agriculture system.

- The water soluble K in the soil ranged between 6 kg ha^{-1} to 1139 kg ha^{-1}. Maximum value of water soluble K was found in Sarol series followed by Jalawara series. Exchangeable K content varied from 193 kg ha^{-1} to 5365 kg ha^{-1} and its contribution of exchangeable K towards total K was 5 to 7%. Considering 125 kg ha^{-1} as general critical limits for crops, all the soils were high in exchangeable K throughout the depths.

- The integrated nutrient management (INM) practices under long term fertilizer experiment for maize-chickpea system in vertisol improved system productivity, sustainable yield index (SYI) and soil properties. The average grain yield of maize and chickpea and system productivity was considerably higher with STCR based 75% NPK along with FYM at 5 Mg ha−1 followed by STCR based 75%NPK + poultry manure (PM) at 1 Mg ha−1 as compared to recommended dose of NPK (RDF) and 100% STCR based NPK.

- The application of glauconite/treated glauconite along with FYM was more beneficial rather than their sole application. Among the different treatments the application of calcined glauconite along with FYM @ 0.5% of soil weight recorded highest values of biomass yield of maize, K uptake and residual K after harvest of maize.

- The agro-ecosystem is endowed with abundant natural water resources and the utilization of these water resources for agriculture is very low as tribal farmers practice rainfed farming. Mostly tribal farmlands are rich in organic carbon with moderate availability of other plant nutrients. However, most of these farmland soils are deficient in sulphur and boron. In order to rectify the nutrient deficiencies in these tribal farmlands 'Soil Health Cards' were prepared based on the soil test results.

Climate Change

- The crops were grown under two atmospheric CO_2 (ambient and 550 ppmv) and air temperature (ambient, 2.0 °C above ambient) levels. Elevation in CO_2 showed 43% higher AEN as compared to ambient, whereas, elevation of temperature decreased the AEN by 18.6%. The co-elevation of CO_2 and temperature showed 8% higher AEN.

- The Principal Component Analysis (PCA) based on the variance of the dataset indicated that soil bulk density an important physical property served as an indicator in the minimum dataset (MDS) in five out of the six agro-ecological sub-regions covered in the study.

- Available P in AESR 4.1 and AESR 9.1 representing the states of Punjab, Haryana, UP and eastern Rajasthan was found to be high in more than 60% samples. Similarly, high P content was observed in 46% of samples in AESR 18.4 (east coast rice belt), 44% in AESR 6.1, 23% in AESR 4.3 and 18% in AESR 9.2. However, 11% samples in AESR 4.1, 29% in AESR 4.3, 26% in AESR 6.1 and 27% in AESR 18.4 were deficient in available P.

- Ion Selective Field Effect Transistors (ISFETs) were tested for the estimation of soil pH, nitrate and potassium. An ISFET is a field-effect transistor used for measuring ion concentrations in solution; when the ion concentration changes, the current through the transistor will change accordingly.

- For soil nitrate estimation using ISFET, the sodium nitrate + potassium chloride calibration curve was used and result obtained was comparable to conventional soil estimation (2 M KCl extraction followed by calorimetric estimation with the help of Autoanalyzer).

AICRPs

- Microbial biomass carbon (MBC) was significantly higher in plots receiving both FYM and inorganic fertilizers. The MBN and MBP content in soil was found to be higher in the plots receiving organic manure and lime combined with mineral fertilizer.
- The long term fertilizer application along with organic manure significantly increased ($P<0.05$) SMBC and SMBN over control. Soil microbial population was significantly influenced under integrated nutrient management at the end of 48th cropping cycles of rice-wheat cropping system.
- Spatial distribution pattern of available micronutrients (Zn, B, Fe, Mn and Cu), available sulphur (S), and soil properties (pH, EC and SOC content) of intensively cultivated Indo-Gangetic Plain (IGP) of India were prepared and delineated soil management zones (MZs) for efficient management of soil nutrients.
- Geostatistical analysis resulted in semi-variogram with exponential model for different soil parameters. About 41.2, 78.6, 10.1, 2.70, and 32.6% area of NRB exhibited deficiency (including acute deficient, deficient and latent deficient areas) in phyto-available S, Zn, Fe, Mn, and B, respectively. The principal component analysis and fuzzy c-means clustering produced five MZs.
- The seed yield efficiency index (SYEI) and Zn uptake efficiency index (ZUEI) of pigeonpea genotypes varied from 67.0 to 92.5 and 47.0 to 69.9, respectively. Based on SYEI and ZUEI, the genotypes were classified as efficient and responsive (Virsa Arhar-1, GT-1, GT-101, SKNP 05-05, BDN-2, AAUT 2007-04, BSMR 853, T 15-15, DT 23, Pusa 9), efficient and non-responsive (ICPL 87119, PKV Trombay), inefficient and responsive (AKT 8811, Hisar Paras), and inefficient and non-responsive (AAUT 2007-10, JKM 7, Hisar Manak, C 11, Hisar HO2-60, GAUT 93-17).
- The STCR-IPNS fertilizer equations were developed based on nutrient contribution from various sources including soil, fertilizers and organic sources (FYM, green manure, compost, crop residues and bio-fertilizers like Azospirillum and Phosphobacteria).
- A seed coating biofertilizer for Zn solubilisation, nitrogen fixation and plant growth promotion for pigeon pea was evaluated at the VNMKV, Parbhani centre of AINP SBB. The Zn solubilizer, Pseudomonas striata and the plant growth promoters Bacillus megaterium and Trichoderma viride were applied as seed coating biofertilizers.
- The efficient rhizobium strains isolated under Indo-UK Nitrogen Fixation Centre were evaluated along with local strains by the Parbhani centre. The strains (BRP-6 and BRP-20) performed well as compared to the local strain MKV-1 with respect to crop growth, nodulation, yield, soil fertility and microbial diversity.

Theme II : Conservation Agriculture, Carbon Sequestration and Climate Change

- The 90% residue retention in soybean - wheat and maize-chickpea cropping system recorded higher crop yield parameters compared to 30%, and 60% residue retention.
- Under the different tillage treatments and cropping system, total soil loss ranged from 3.10 to 6.86 t/ha; however, runoff ranged from 22.32 to 29.70 % of total rainfall.
- The daily near-surface (0-5 cm depth) volumetric soil moisture data (1980 to 2019) showed that near-surface soil moisture in the kharif season ranged from 0.25 to 0.34 m^3/m^3 with a mean value of 0.29 m^3/m^3; whereas, it ranged from 0.15 to 0.24 m^3/m^3 with a mean value of 0.19 m^3/m^3 during rabi season.
- Tillage and nitrogen management effect on soil hydraulic conductivity (SHC) showed higher SHC under the no-tillage (NT) than (CT) after ten years of continuous treatment imposition.
- Pan India yield gap analysis of pigeon pea showed highest yield gap in Haryana state (1350 kg ha^{-1}), followed by Rajasthan and Himachal Pradesh. The lowest yield gap was found in the Tamil Nadu state (300 kg ha^{-1}).

- Spatial variation in crop water productivity (WP) of maize and wheat crop in Madhya Pradesh state showed significant variation. The WP ranged from 0.6 to 1.9 kg m^{-3} for maize and 0.65 to 1.2 kg m^{-3} for wheat.

- The impact of present and future climates on maize grain yield and biomass under different long term N management scenarios showed that the maize grain yield decreased by 21.8%, 23.2%, 22.3% and 23.8% under RCP 4.5 (2050s), RCP 4.5 (2080s),RCP 8.5 (2050s) and RCP 8.5 (2080s), respectively in100% organic treatments compared to baseline scenarios.

- The long-term imposition of conservation agriculture practices showed NT system recorded significantly higher SOC content (0.83%) than CT (0.69%) at 0-5 cm soil layer. Similarly, in the 5-15cm soil layer, the SOC content was significantly higher in the NT than CT.

- Under the long-term imposition of conservation agricultural practices, aggregate-associated C content increased with aggregate size, and followed order of large macro aggregate (LM) > small macro-aggregate (SM) > micro-aggregate (M) > silt+clay (S+C).

- Among the irrigation treatment, highest wheat yield was recorded in drip irrigation (5965 kg ha^{-1}) followed by sprinkler irrigation (5621 kg ha^{-1}), and the yield was the minimum (5490 kg ha^{-1}) in flood irrigation. Among the tillages, grain and biomass yield did not vary significantly.

- Among the different properties evaluated, soil organic carbon concentration, pH, sand, silt and clay content, soil water retention capacity at field capacity and permanent wilting point were predicted with reasonably good accuracy (R^2>0.7) using the mid infrared soil spectra in Inceptisols and Alfisols of India.

Theme III : Microbial Diversity and Biotechnology

- The highest seed yield of wheat, mustard, chickpea and linseed were recorded with 75% organic + 25% inorganic followed by 100% organic treatment practices > 100% inorganic > state recommendation.

- Enzyme activity in terms of fluorescein di-acetate hydrolysis, dehydrogenase activity, alkaline phosphatase and β glucosidase were found in following order: 100% organic > 75% organic + 25% inorganic > 75% organic + innovative treatment, indicating beneficial effect of organics on soil microorganisms.

- Twelve varieties of wheat and chickpea grown under organic nutrient management practices were tested at ICAR-IISS Bhopal Centre. The wheat variety, GW-366 performed best followed by Malwa shakti and HI8498, whereas, chickpea variety, JG-130 recorded highest yield followed by JG-63 under organic management practice.

- A total of 14 endophytic fungi were isolated from plant roots of naturally grown on the municipal solid waste dumping sites and assessed for heavy metal tolerance. It was found to be very effective against the multiple heavy metals (Cd, Pb, Ni and Hg).

- Rhizobial strains homologous to Bradyrhizobium sp improved the growth and yield of soybean (JS 9560) significantly. The isolates also showed potential of siderophore production and IAA production under stress (high drought, temperature and salt tolerant), homologous to uncultured bacterium strain improved grain yield, root mass and nodule count over uninoculated control.

- CH_4 consumption in response to different nitrogen sources in a tropical soil ecosystem revealed that N_2 stimulated the abundance of both nif and pmoA genes which leads to more CH_4 consumption while N in the form of NO_3 and NH_4 inhibits CH_4 consumption in tropical vertisol. The abundance of methanotrophs, pmoA gene copies and nitrifiers, amoA gene copies were more in NH_4-N amended soil than NO_3-N. Available NO_3 content in soil increased 9 to 30% with CH_4 driven N_2 fixation.

- Soil amendment with crop residue (maize, wheat, chickpea, and soybean) at 1% w/w were evaluated under flooded condition to study the methane dynamics. The rate of CH_4 production (ng CH_4 produced g^{-1} soil d^{-1}) varied from 0.068 to 0.107 with highest in wheat and lowest in chickpea. CH_4 consumption rate (ng CH_4 consumed g^{-1} soil d^{-1}) was highest in wheat (0.79) and lowest in chickpea (0.53). In both CH_4 producing and consuming soils, the organic C and the available NO_3 increased significantly ($p<0.05$) over control. The abundance of methanogens was found to be increased significantly due to crop biomass.

- Quality assessment for heavy metals was carried out for Cd, Ni, Cu and Zn in mature compost prepared from different wastes. The concentrations of heavy metals in all the composts were within permissible limit as compared to the standard given by FCO.

- Compost prepared from different organic wastes were tested for presence of nematode population. No nematode was observed in the compost suspension whereas rhizospheric soil suspension showed presence of active nematodes. Mature compost also tested for total coliform bacteria. and E. coli using MPN method. Serially diluted compost samples were inoculated in single and double strength lactose broth. No colour change and gas production were observed after 48 hrs of incubation at 37^0C.

- RuBisCO enzyme activity in anthropogenically managed grassland system was higher at both soil depths (0-15 and 15-30 cm) than natural grassland system in semi-arid to sub-humid central India. Phenol oxidase in integrated nutrient management treatment (100% NPK + FYM) was higher than imbalanced fertilizer application (100% N, 100% NP) in LTFE Raipur. Similarly, phenol oxidase activity in horticulture and grassland system had more C sequestration potential in upper soil depth; whereas, agro-forestry and palash based black forest soil had higher C sequestration potential in lower depth.

- Total microbial and eukaryote biomass were highest in 100% NPK+FYM with lower ratio of Predator/Pray. The ratio of Cyclo/Mono-unsaturated precursor was high in control, 100% N, 100% NP. Likewise, the Gram-positive to Gram-negative bacterial ratio was highest in INM. The major contributor of soil nitrification was from autotrophic nitrification activity (ANA), however the study indicated that heterotrophic nitrification activity (HNA) significantly contributed to nitrification. ANA contributed 55-80% of total NA; whereas, HNA contributed 19.6-49.6% of total NA. The INM treatment (100% NPK+FYM) had significantly higher NA as compared to control, 100 % N and 100% NP treatment.

- Analysis of different K fractions in LTFE Barrackpore soil revealed that continuous balanced fertilization and INM significantly increased Exch-K and Non Exch-K content in soil. Microbial biomass K (MBK) positively correlated with Exch-K (r = 0.72**), Non Exch-K (r = 0.684**) and WSK (r = 0.617**). Highest MBK was found in fallow followed by 100% NPK+FYM.

Theme IV: Soil Pollution and Remediation

- Application of weathered fly ash from ash-pond of a Thermal Power Plant may supply essential plant nutrients (except Na). Heavy metals such as Ni, Cu, Co and Cd were practically insoluble at a pH range of 6.7-7.5 and therefore their concentration is very low. Among the heavy metals, only Cr was extracted by water (0.06 ppm) which can be of environmental concern.

- Alkaline modified fly ash (AlMFA) completely removed Cd and Pb from solution due to significant increase in CEC to an extent of 113 meq/100g as compared to acid modified fly ash (AcMFA: 2.4 meq/100g) and untreated ash (UFA:3.4 meq/100g).

- Application of modified fly ash (@ 5%) not only countered the Cd toxicity but also improved the spinach biomass growth (15%), reduced DTPA extractable Cd (>28%) and spinach leaf Cd (45%) as compared to unamended soil.

- CO_2 evolution gradually decreased over the period of incubation from 3 to 60 days in all the heavy metal loaded (upto 50 ppm Cd, 1500 ppm Pb, 800 ppm Cr and 500 ppm Ni) municipal solid waste (MSW). It was significantly lower in the MSW contaminated with all the heavy metals (combined effect) as compared to individual heavy metal effect (sole effect).

- The coal mine water pH ranged from 5.7 to 6.0; oxidation-reduction potential varied between 162-300 mV; dissolved oxygen was 4.14 to 7.25 ppm; electrical conductivity and total dissolved solids were in the range of 1.10 - 4.47 dS m^{-1} and 0.15 - 2.25 ppt, respectively.

- The use of contaminated Chambal river water for irrigation purpose in the downstream area of Nagda had resulted in poor soil health and crop (wheat, chick pea, etc.) quality. The combined use of plastic mulch, drip irrigation and organic manure application could be an effective strategy to use contaminated Chambal river water for maintaining crop productivity and improving soil health.

1. INTRODUCTION

Intensive agriculture with unprecedented exploitation oIntensive agriculture with unprecedented exploitation of scarce soil resources worldwide has produced more food grain, but soil health has declined significantly due to high rates of soil erosion, environmental pollution, loss of soil biota, reduced nutrient use efficiency and declining factor productivity. Soil health is crucial for the quantity and quality of the food produce to sustain the present and future generations and also in achieving Sustainable Development Goals (SDG1 - end poverty, SDG2 - zero hunger, SDG3 - good health and wellbeing, SDG11 - sustainable cities and communities, SDG12 - responsible consumption and production, SDG13 - climate action and SDG15 - life on land) of United Nations by 2030. Hence, it is essential to understand the properties and processes of soil at regional, national and global scales to realize these SDGs. During the last few decades, Soil science research has significantly contributed to food and nutritional security, human wellbeing, nature conservancy, and global peace and harmony. Several researchers and policy makers have also made considerable efforts to address soil quality issues for sustainable development. To achieve the demand of food grain production (405 MT) by 2050 when the population is estimated to be 1.7 billion, the most suitable strategies are to be the improvement in crop productivity, increasing cropping intensity, adoption of best soil and water management practices along with preservation of prime agricultural lands, water and biodiversity resources.

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". Presently, the institute activity has been strengthened further by the scientific and extension activities of three All India Coordinated Research Projects, one All India Network Project on Soil Biodiversity & Biofertilizers and one Consortia Research Platform on Conservation Agriculture. 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, provide access to the diverse soils, agro-ecosystems across the agro-ecological zones of the country for effective implementation of various programs of the institute at national level. Since its inception, the institute has made concerted efforts to attain its mission and received several national and international recognitions. In 2020, the UN FAO has conferred the prestigious King Bhumibol World Soil Day Award to the institute for its massive outreach and awareness program on soil health management across the country. During the year under report the institute has made significant scientific contributions in the frontier areas of soil science, such as input use efficiency; carbon sequestration and climate change; integrated nutrient supply system (IPNS); nutrient transformation and dynamics in soil-plant systems; organic matter recycling and management; soil biodiversity and genomics; environmental impact on agricultural production; utilization of solid wastes and waste water; bio-remediation, etc. The salient research achievements, infrastructural development, technology transfer, human resource development, awards and recognitions, linkages and collaborations, etc. are briefly highlighted in this annual report.

1.1 Mission and Mandate

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

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

b). Advanced technologies for sustainable soil health and quality

c). Coordinate the network research with State Agricultural Universities, National, International and other Research Organizations

1.2 Priorities and Thrust Areas

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

Programme 1: Soil Health and Input Use Efficiency

- Integrated nutrient management: Indigenous mineral and by-product sources
- Nano-technology
- Precision agriculture
- Fertilizer fortification
- Resilience of degraded soils
- Developing a workable index of soil quality assessment imbibing influence of different physical, chemical and biological soil attributes
- Organic farming and produce quality

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

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

Programme 3: Microbial Diversity and Genomics

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

Programme 4: Soil Pollution, Remediation and Environmental Security

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

1.3 Organization Set-Up

Divisions

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 (AI-CRPs)/ AINP/ CRP

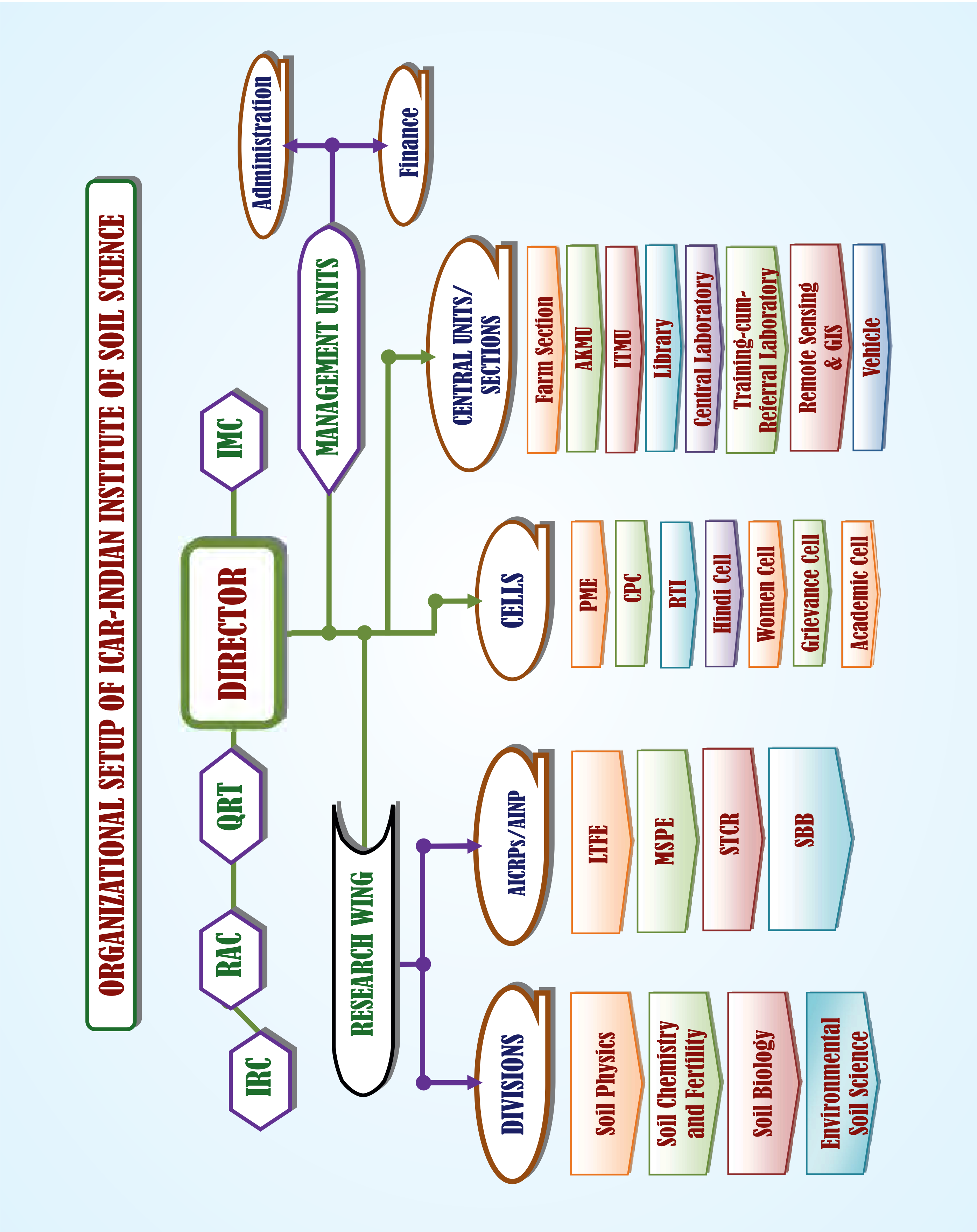
i. AICRP on Long-Term Fertilizer Experiments to Study Changes in Soil Quality, Crop Productivity and Sustainability (LTFE)

ii. AICRP on Soil Test Crop Response (STCR)

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

iv. AINP on Soil Biodiversity and Biofertilizers (SBB)

v. CRP on Conservation Agriculture


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

1.4 Manpower

a) Scientific

S. No.	Discipline	Sanctioned				In Position			
		PS	SS	S	Total	PS	SS	S	Total
1	Agricultural Chemicals	0	0	1	1	0	0	1	1
2	Agricultural Economics	0	0	2	2	0	0	0	0
3	Agricultural Extension	0	0	1	1	0	0	1	1
4	Agricultural Microbiology	0	1	2	3	0	1	2	3
5	Agricultural Physics	0	1	0	1	0	0W	0	0
6	Agricultural Statistics	0	0	1	1	0	0	1	1
7	Agronomy	0	1	4	5	0	1	3	4
8	Electronics & Instrumentation	0	1	0	1	0	0	0	0
9	Fruit Science	0	0	1	1	0	0	1	1
10	Plant Biochemistry	0	1	0	1	0	1	0	1
11	Plant Physiology	1	1	1	3	7	1	1	3
12	Soil Science	0	4	27	31	8	6	20	33
	Total	**1**	**10**	**40**	**51**	**0**	**10**	**30**	**48**
13	HODs	4	0	0	4	0	0	0	0
14	Project Coordinators	0	0	0	0	0	0	0	0
15	RMP	1	0	0	1	1	0	0	1
	GRAND TOTAL	**6**	**10**	**40**	**56**	**9**	**10**	**30**	**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	2
8	Stenographer Gr-III	2	2
9	Security Supervisor	1	1
10	Upper Division Clerk	2	2
11	Lower Division Clerk	3	3
12	Skilled Supporting Staff	17	17
	Total	**42**	**35**
	Grand Total	**117**	**101**

1.5 Finance: Budget statement (Lakhs) during 1 January to 31 Dec 2020

S. No.	Designation	Budget	Expenditure
1	ICAR-IISS	2014.15	2106.86
2	AICRP-LTFE	480.51	455.20
3	AICRP-STCR	710.32	544.94
4	AICRP-MSPE	709.42	604.58
5	AINP on SBB	228.37	150.05
6	CRP on CA	218.41	184.74
	Total	**4361.18**	**4046.37**

1.6 Resource Generation

S. No.	Head of Account	Amount (In Rupees)
1	Sale of farm produce	1249040
2	Sale of publication and advertisement	5882
3	Royalty of Mridaparikshak	6625355
4	Licence fee	396734
5	Interest earned on loans and advances	2340993
6	Receipts from schemes	3920082
7	Analytical and testing fee	13053
8	Interest earned on short term deposits	2778846
9	Recovery of loans and advances	2540993
10	Miscellaneous Receipts	646177
	Total	**20517155**

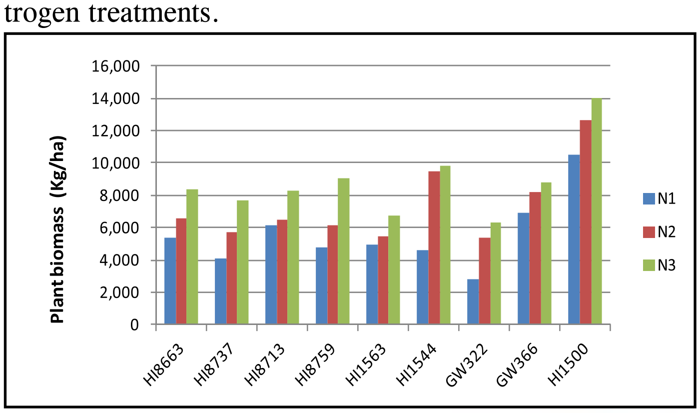
2. RESEARCH ACHIEVEMENTS

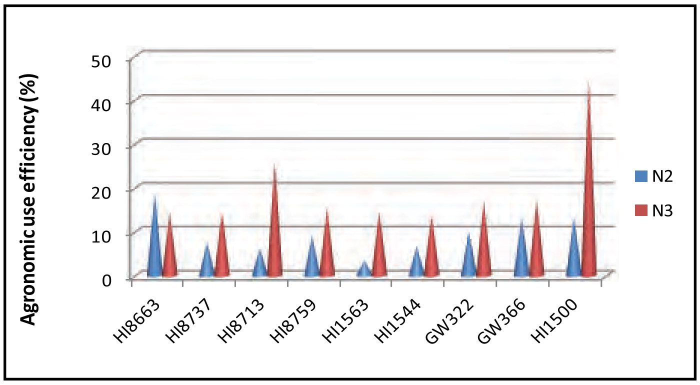
Theme - I: Soil Health and Nutrient Use Efficiency

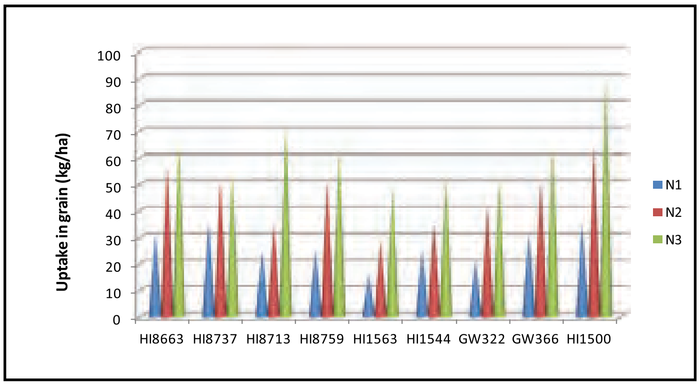
2.1 Improving Input Use Efficiency

2.1.1 Evaluation of wheat genotypes for nutrient use efficiency (NUE) and improved crop productivity

A field experiment was conducted to evaluate 121 genotype of wheat for NUE and crop productivity during rabi 2019-20. Among them, promising nine genotypes of wheat viz. HI8663, HI8737, HI8713, HI8759, HI1563, HI1544, GW322, GW366 and HI1500 were evaluated for NUE under three different levels of nitrogen viz. control (N1), sub-optimal N (N2; 60 kg ha^{-1}) and normal N (N3; 120 kg ha^{-1}). The results indicated that increasing the level of N significantly increased the growth and yield attributes of the crop viz. plant biomass, grain yield, uptake, use efficiencies, harvest index and nitrogen harvest index when compared to control (Fig. 2.1.1). Among all the genotypes HI1500 exhibited significantly higher plant biomass of 14,050 kg ha^{-1}, 12,687.5 kg ha^{-1} and 10,507.8 kg ha^{-1} under normal, sub-optimal and control fertilizer levels, respectively. The same genotype also recorded significantly higher grain yield of 5,808.3 kg ha^{-1}, 3,536.9 kg ha^{-1} and 2,222.3 kg ha^{-1} under normal, reduced and control fertilizer levels, respectively. The interactive effect of N levels and genotypes was not significant on the grain and straw N content of the genotypes. The N concentration in the grain of selected genotypes ranged from 1.5 to 2%. N uptake was higher in the variety HI1500 (85.10 kg ha^{-1}) followed by GW366 (61.71 kg ha^{-1}) among all the nine genotypes. There were no significant differences in soil pH and EC, soil organic carbon, soil N, P and K status across the nitrogen treatments.







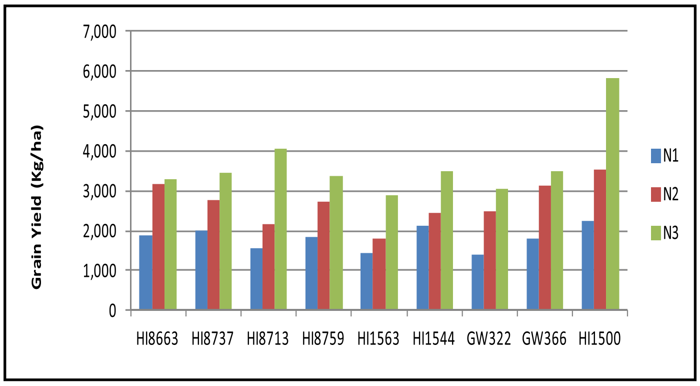


Fig. 2.1.1 Plant biomass, grain yield, uptake of N and Agronomic efficiency of wheat

2.1.2 Impact of Conservation agricultural practices on soil health, carbon Sequestration and GHG emissions in different production systems

A study was undertaken to evaluate the effect of residue retention (0 and 90%) vis a vis land use impact on soil properties in a six year no-till (NT) system in Vertisol of central India. Adoption of long term (40 years) horticulture & agri-horticulture system 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 organic carbon (1.74%) in 0-10 cm of soil depth. Among the different land use systems, agri-horticulture system maintained a highest concentration of total carbon (2.1%) followed by NT system with 90% of residue retention. Retention of residue under NT system improved Walkley and Black Carbon (WBC) by 10% in comparison to no residue retained plot. Agri-horticulture system had highest WBC (1.59%) followed by NT with 90% of residue retention. The lowest concentration of WBC (0.76%) was recorded in conventional agriculture organic system. There was 64% improvement in particulate organic carbon (POC) concentration in 90% residue retained plot than no residue retention plot. In comparison to conventional agriculture system (0.18%), there was a two fold increase in POC concentration in 90% of residue retained plot. Six years of residue retention under no till plot resulted in 17% improvement in water soluble carbon in soil, which is even greater than the WSC content of organic amended treatments. Retention of residue resulted in 80% improvement in easily extractable glomalin related soil protein (EEGRSP) concentration than no residue retained plot (Fig.2.1.2a). Nitrogen mineralization capacity of soils under different land use systems were assessed 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 (Fig. 2.1.2b).

Retention of residue under no till system resulted in higher proportion of carbon in active pool (very labile and labile pools) whereas proportion of carbon in passive pool was decreased; however, reverse trend was recorded under the conventional agriculture. Conventional agriculture had the highest concentration of carbon in passive pool although it contained lowest concentration of soil total carbon. A correlation matrix developed to identify the factors affecting N mineralization. N mineralization potential of soil as estimated by anaerobic method 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) (Fig.2.1.2c).

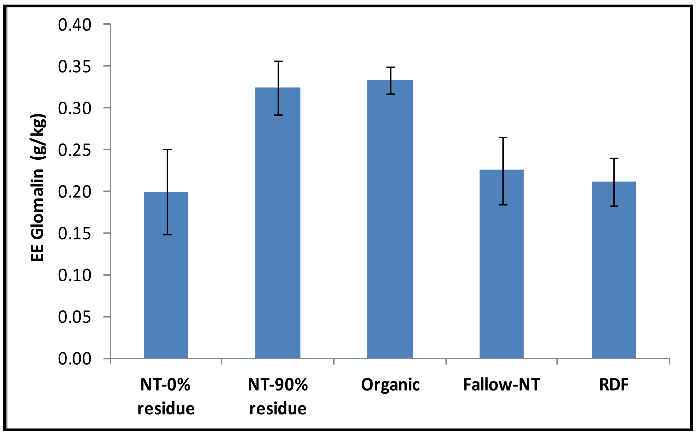


Fig. 2.1.2a Extractable glomalin concentration as affected by cropping systems

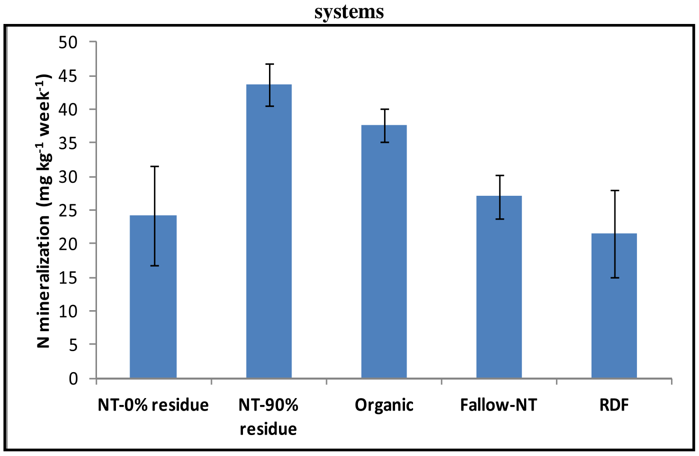


Fig. 2.1.2b Nitrogen mineralization (anaerobic method) as affected by cropping

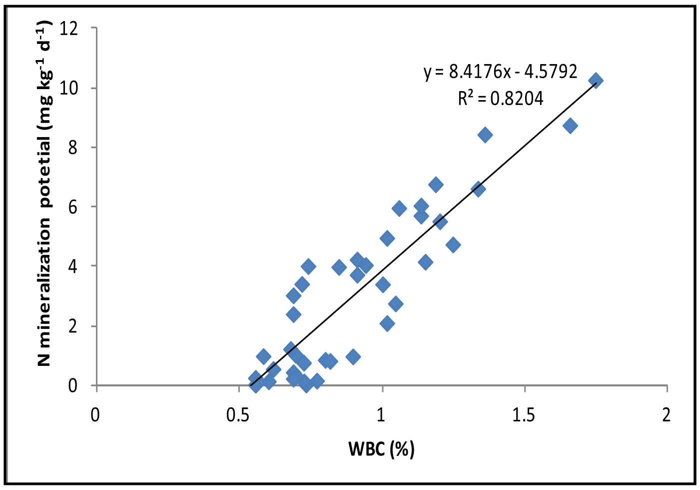


Fig. 2.1.2c Relationship between N mineralization and oxidizable carbon concentration

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

Soil chemical properties and K fractions were analysed for selected benchmark sites of the Vertisols (Table 2.1.3a Fig. 2.1.3). The results showed that the pH of the soils (1:2 soil water suspensions) ranged between 7.7 to 8.4 i.e. slightly alkaline to strongly alkaline (Fig.2.1.3b), which increased with depth in all sites. Higher pH values in soils may be due to basalt as parent material. The water soluble K in the soil ranged between 6 kg ha^{-1} to 1139 kg ha^{-1}. Maximum value of water soluble K was found in Sarol series followed by Jalawara series (Fig. 2.1.3c). Exchangeable K content varied from 193 kg ha^{-1} to 5365 kg ha^{-1} and its contribution of exchangeable K towards total K was 5 to 7 %. Considering 125 kg ha^{-1} as general critical limits for crops, all the soils were high in exchangeable K throughout the depths. Samples from Sarol series contained higher amount of exchangeable K followed by Nabibagh series. The exchangeable K determined by the method of Hanway & Heidel (1952) (shaking time - 5 minute) released slightly higher K from soil as compared to the method of Khudsen *et al*. (1982) (Shaking time–30 minute) (Fig. 2.1.3d). The non-exchangeable K content of soil ranged from 286 kg ha^{-1} to 6433 kg ha^{-1}. The highest non-exchangeable K content was found in the soils of Sarol series followed by Nabibagh series. The soils of Junagad, Gujarat are low in all fractions of K content. In all the soil series, pristine soils contain high amount of K in all fractions analyzed by using different methods.

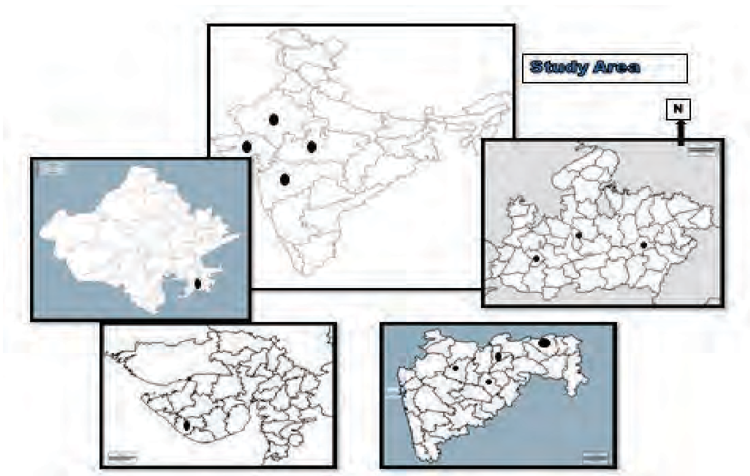


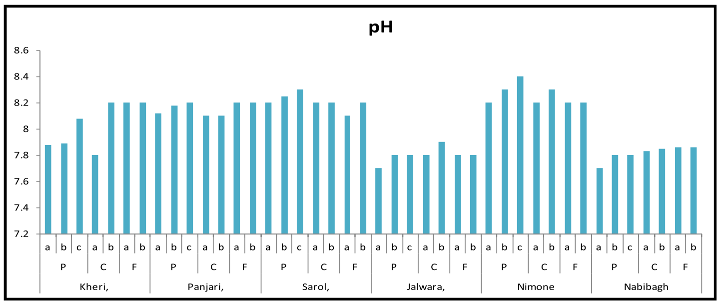
Fig. 2.1.3a Location of soil sampling sites

Table 2.1.3 Site location and classification of the soil sample

Site	Name	Location	Climate
Site -1	Nimone series, Rahuri, Maharashtra (Clayey, smectitic, isohyperthermic Sodic *Haplusterts*)	19^{0} 22’ 0.02” N 74^{0} 39’ 0.41” E	Arid (Rainfall- 520 mm)
Site -2	Panjari series, Nagpur, Maharashtra (Fine, smectitic, hyperthermic Typic, *Haplusterts*)	21^{0} 01’ 58.6” N 79^{0} 03’ 29.4” E	Sub-humid (moist) (Rainfall- 1127 mm)
Site -3	Wanirambhapur series, Akola, Maharashtra(Very fine, smectitic, hyperthermic Typic *Haplusterts*)	20^{0} 41’ 0.784” N 77^{0} 04’ 0.011” E	Semi-arid (dry) (Rainfall- 886 mm)
Site -4	Kheri series, Jabalpur, Madhya Pradesh (Very fine, smectitic, hyperthermic Typic *Haplusterts*)	23^{0} 14’ 0.023” N 79^{0} 56’ 0.609” E	Sub-humid (moist) (Rainfall- 1448 mm)

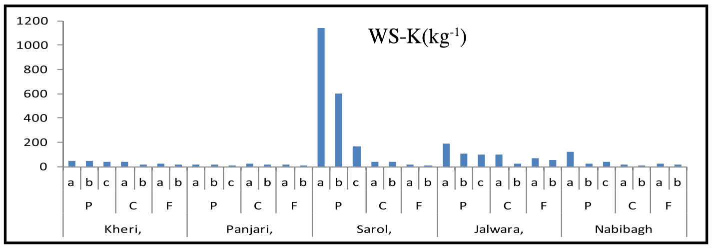
Site	Name	Location	Climate
Site -5	Sarol Series, Indore, Madhya Pradesh (Fine, smectitic, hyperthermic, Typic *Haplusterts*)	22^0 41' 58" N 75^0 52' 36.5" E	Sub-humid (dry) (Rainfall- 1100 mm)
Site -6	Jalwara series, Baran, Rajasthan (Fine, smectitic, hyperthermic Typic *Haplusterts*).	24^0 58' 00" N 76^0 41' 00" E	Humid (Rainfall – 900-1000mm)
Site – 7	Jintur series, village Wadachiwadi tehsil Jintur, Parbhani; Maharashtra (Fine, smectitic (cal), isohyperthermic Typic *Haplusterts*).	19^0 34' 00" N 76^0 44' 30" E	Semi-arid (Rainfall- 840 mm)
Site -8	STCR Farm, Junagadh Agriculture University, Gujarat	21^0 31' N, 70^0 27' E	Arid (Rainfall- 900 mm)
Site -9	Nabibagh series, Bhopal, Madhya Pradesh (Fine, smectitic, Hyperthermic, Typic Haplusterts)	23^0 308' N 77^0 407' E	Sub-humid (moist) (Rainfall- 1209 mm)
Site -10	Sokhda series, Morki, Rajkot, Gujarat (Fine, smectitic(calcareous) hyperthermic Leptic Haplusterts)	23^0 02' 22" N 70^0 47' 14" E	Arid (Rainfall – 533 mm)

Plate 2.1.3 Soil sample collection from the study area



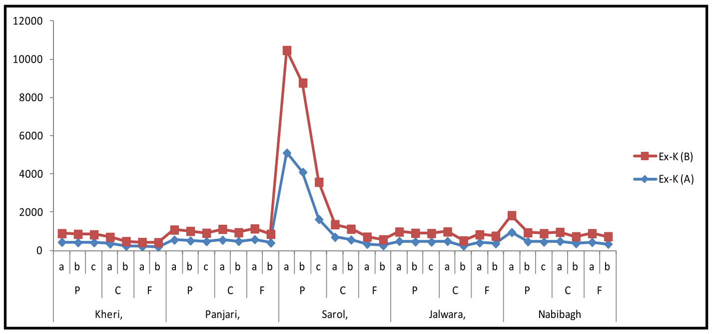
**P- Pristine, C- Control, F-Fertilized, a-0-15 cm depth, b-15-30cm, c- 30-60 cm*

Fig. 2.1.3b Depth wise pH of the studied soils.



**P- Pristine, C- Control, F-Fertilized, a-0-15 cm depth, b-15-30cm, c- 30-60 cm*

Fig. 2.1.3c Depth wise water soluble potassium of the studied soils.



Ex-K (A)– Khudsen et al. 1982; Ex-K (B) – Hanway & Heidel, 1952
**P- Pristine, C- Control, F-Fertilized, a-0-15 cm depth, b-15-30cm, c- 30-60 cm*

Fig. 2.1.3d Depth wise distribution of exchangeable potassium of the studied soils.

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

The integrated nutrient management (INM) practices under long term fertilizer experiment for maize-chickpea system in vertisol improved system productivity, sustainable yield index (SYI) and soil properties. The average grain yield of maize and chickpea and system productivity was considerably higher with STCR based 75% NPK along with FYM at 5 Mg ha^{-1} followed by STCR based 75%NPK + poultry manure (PM) at 1 Mg ha^{-1} as compared to recommended dose of NPK (RDF) and 100% STCR based NPK (Table 2.1.4a & Table 2.1.4b). Whereas, application of organic modules (the integration urban compost (UC), maize residue (MR) and Gliricidia loppings) did not influence the maize yields. The application of 5 Mg ha^{-1} FYM to chickpea and residual fertility of 20 Mg ha^{-1} FYM (every season) increased the chickpea yields. Increase in chickpea yield might be due to residual fertility effect of long term use of organic manures. The application of organic modules maintained the soil properties but could not achieve the targeted yield of maize. However there in no problem in sustaining chickpea yield. Apparent nutrient balance (Table 2.1.4c) was negative for N and K in all treatments except higher level of FYM (FYM at 20 Mg ha^{-1}) while P balance was positive under balanced and complete nutrition through organic and inorganic treatments. Significant increase in total organic carbon (TOC) content and N concentration were observed under FYM at 20 Mg ha^{-1} and STCR based 75% NPK + FYM at 5 Mg ha^{-1} (Fig. 2.1.4a). Similarly, application of INM modules enhanced the micronutrients (Zn, Mn, Fe, and Cu) concentration in soil than chemically mediated modules and initial levels (Fig. 2.1.4b). Application of FYM based INM modules significantly reduced the bulk density in surface soil as compared to RDF (Fig. 2.1.4c).

Table 2.1.4a Treatment details

Designation	Maize	Chickpea
T1 Control	No Fertilizer/ Manure	No Fertilizer/ Manure
T2 GRD	120- 60- 30	20-60-20
T3 RD (STCR)	135-55-50 (Target- 5 t maize)	0-0-0 (1.5 t chickpea)
T4	75% NPK of T3	100% P only
T5	75% NPK of T3 + 5 t FYM	100% P only
T6	75% NPK of T3 + 1 t PM	100% P only

Designation	Maize	Chickpea
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 STCR-soil test crop response equation, GRD-general recommended dose, MR-Maize residue, **UC**- Urban compost, **PM-** Poultry manure, **FYM-** Farmyard manure, and **Gly-***Glyricidia* loppings

Table 2.1.4b System Productivity and SYI influenced by the different INM modules

Treatments	Maize (t/ha)	Chickpea (t/ha)	System productivity (MEY) (t/ha)	Sustainable yield index (SYI)	
				Maize	Chickpea
T1	2.08	1.18	5.23	0.23	0.52
T2	4.62	1.76	9.31	0.70	0.78
T3	4.90	1.71	9.44	0.73	0.77
T4	4.19	1.54	8.28	0.60	0.68
T5	5.77	1.93	10.89	0.84	0.93
T6	5.36	1.89	10.37	0.80	0.90
T7	4.64	1.82	9.49	0.67	0.81
T8	4.30	1.59	8.52	0.59	0.75
T9	3.37	1.89	8.40	0.42	0.85
T10	3.45	1.71	7.99	0.41	0.76
T11	4.47	2.08	10.01	0.66	0.86
T12	4.83	1.90	9.89	0.67	0.89
LSD	0.40	0.21	0.62	-	-

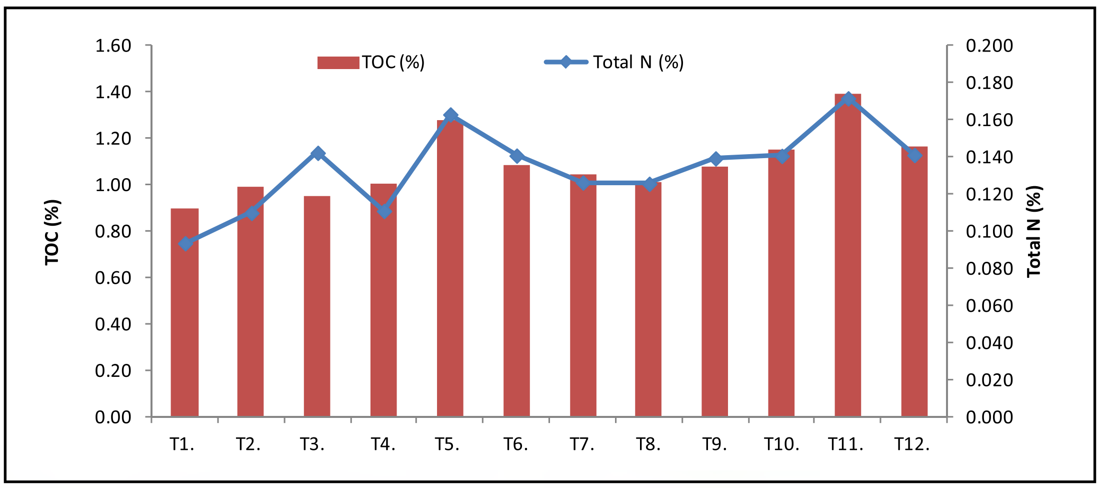


Fig. 2.1.4a Total organic carbon content and total N content in soil influenced by INM modules (0-15cm)

Table 2.1.4c Apparent nutrient balance (kg ha^{-1}) in maize – chickpea system

Treatment	Apparent N Balance	Apparent P Balance	Apparent K Balance
T1	-71.4	-19.9	-60.2
T2	-5.0	78.1	-68.3
T3	-3.8	11.0	-72.7
T4	-17.4	1.6	-65.1
T5	-35.7	10.0	-69.3
T6	-0.2	7.5	-74.0
T7	3.9	18.8	-7.1
T8	4.4	16.5	-29.1
T9	-38.9	-19.3	-43.4
T10	-35.4	-11.6	-32.4
T11	22.3	17.9	46.9
T12	-4.4	16.9	-49.3

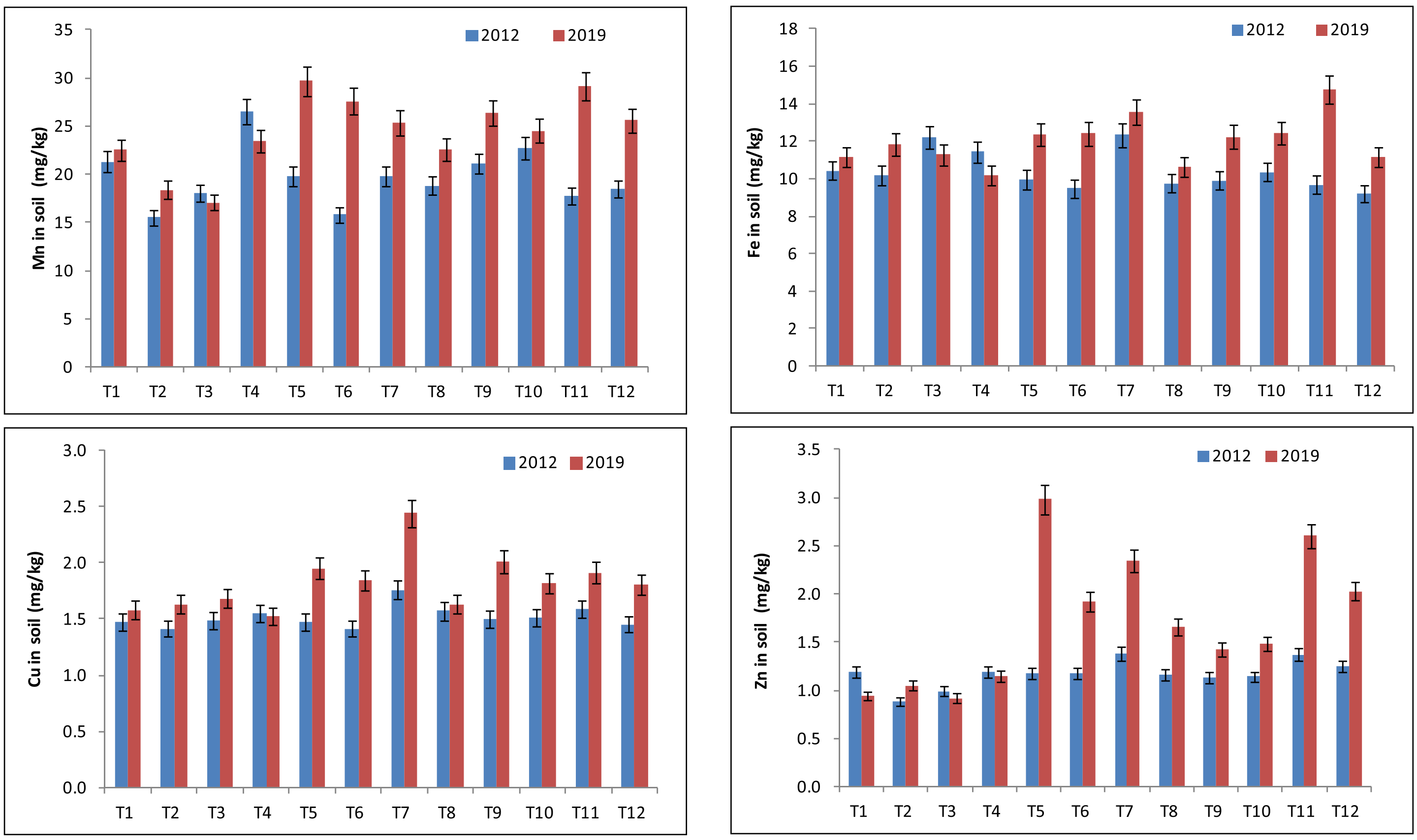


Fig. 2.1.4b Micronutrient status in soil profile (0-15cm) under different INM modules

Plate 2.1.4 Performance of maize and chickpea crop.

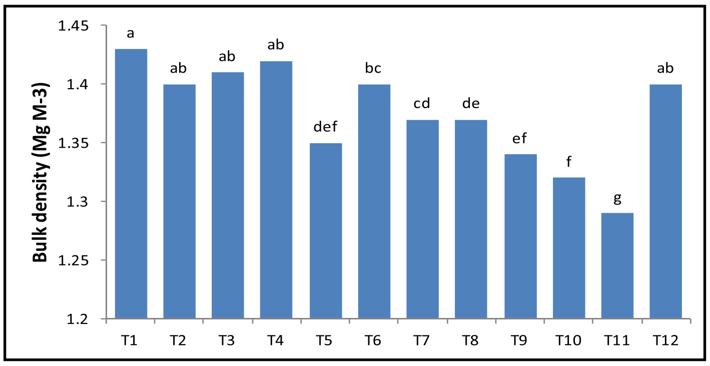


Fig. 2.1.4c Bulk density of soil as influenced by different INM modules

2.1.5 Evaluation of modified glauconitic shale for supply of potassium to crops

The glauconitic shale collected from Singrauli district of Madhya Pradesh contains 10.8% K_2O. The X-ray diffraction analysis of glauconitic (Fig. 2.1.5a) shale revealed that the prominent basal reflection at 10.04 Å (001), 4.5 Å (020) and 3.3 Å (003) are the characteristic of glauconite. The peaks are unmoved after glycol treatment and heating at 110 ^{0}C, 300 ^{0}C and 500 ^{0}C indicating minimal inter-stratification between expandable and non-expandable layers. A peak of illite at 5.0 Å coexist in all modes of scanning. The other mineral constituent present in the glauconite are presented in Table 2.1.5a.

Table 2.1.5a Mineral constituents of glauconite sample

d spacing (Å)	Mineral
5	Illite (002 refection)
4.26	Quartz
3.79	Albite
3.63	Serpentine
3.57	Chlorite (003 refection)
3.23	Feldspar
3.09	Calcite

Pot experiments in Alfisols and Vertisols were also conducted to study the effect of gluaconite and treated glauconitic shale application on K supply and performance of maize crop. The application of glauconite more particularly clacined glauconite (glauconite and $CaCl_2$ $2H_2O$ heated at 900 ^{0}C for 1 hr) and acidulated glauconite (acidulation of glauconite with 10M H_2SO_4 in 2:1 ratio) showed higher growth and K uptake by maize. The calcined glauconite was found superior over acidulated glauconite and glauconite. This was due to the fact that calcinations treatment to glauconite resulted into production of sylvite, which releases more K (Table 2.1.5b). The SEM analysis of glauconite and treated glauconite (calcined) showed more disintegration of rock material resulted in to smoothening at the edges and breaking of mineral structure into smaller particles (Fig. 2.1.5b) resulted into more release of K in soil as compare to untreated glauconite.

Table 2.1.5b Effect of calcinations on K extraction from glauconite

Parameter	Glauconite	Calcined Glauconite
Total K_2O (%)	10.8	10.8
Water soluble K (mg kg^{-1})	24.2	837
NH_4OAc extractable K (mg kg^{-1})	350	1175

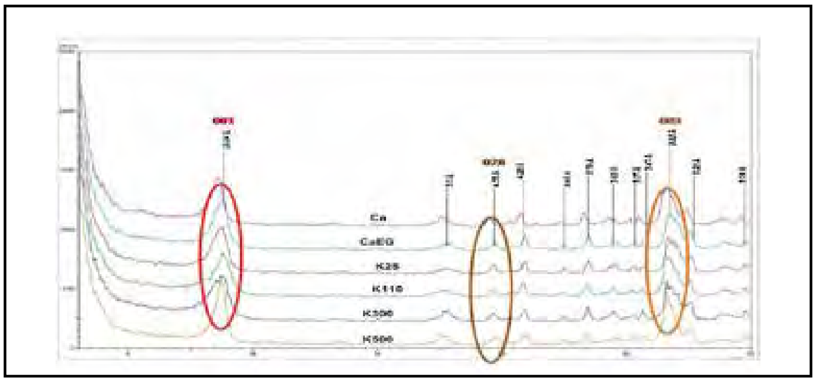


Fig 2.1.5a X-Ray diffraction analysis of glauconite

A. Glauconite **B. Calcined glauconite**

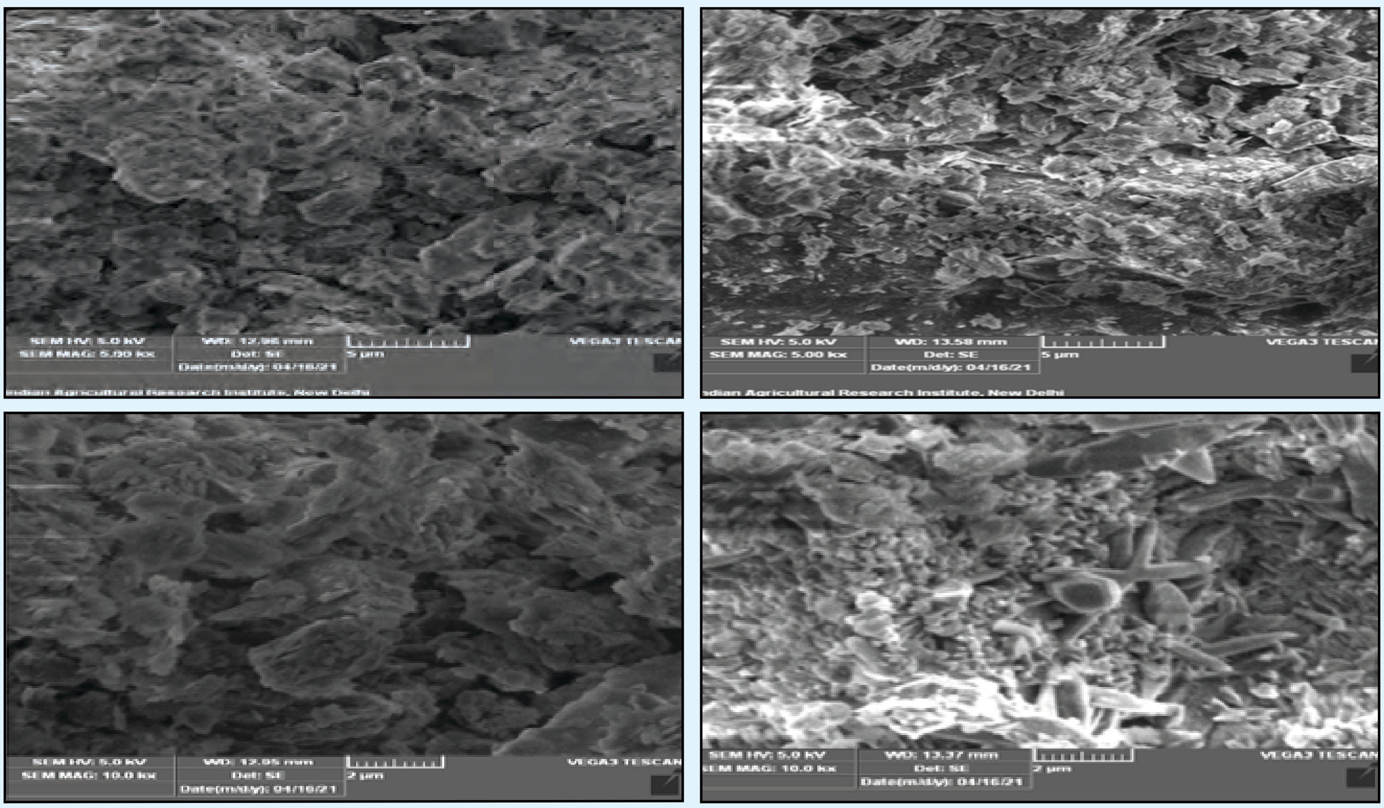


Fig. 2.1.5b SEM analysis of glauconite and treated glauconite

The application of glauconite/treated glauconite along with FYM was more beneficial rather than their sole application. Among the different treatments the application of calcined glauconite along with FYM @ 0.5% of soil weight recorded highest values of biomass yield of maize, K uptake and residual K (Fig. 2.1.5c, 2.1.5d and 2.1.5e) after harvest of maize (Table 2.1.5c). Similarly, the application of acidulated glauconite along with FYM and glauconite along with FYM also showed similar kind of results. The response of maize to glauconite application was not much in Vertisol as compare to Alfisol.

Table 2.1.5c Treatment details

T.No.	Treatments
T1	No glauconite (Control)
T2	Glauconite
T3	FYM 0.5% of soil weight
T4	Acidulated glauconite
T5	Calcined glauconite
T6	Glauconite along with FYM 0.5% of soil weight
T7	Acidulated glauconite along with FYM 0.5% of soil weight
T8	Calcined glauconite along with FYM 0.5% of soil weight
T9	Acidulated calcined glauconite
T10	Acidulated calcined glauconite along with FYM 0.5% of soil weight
T11	Muriate of potassium
T12	Waste mica

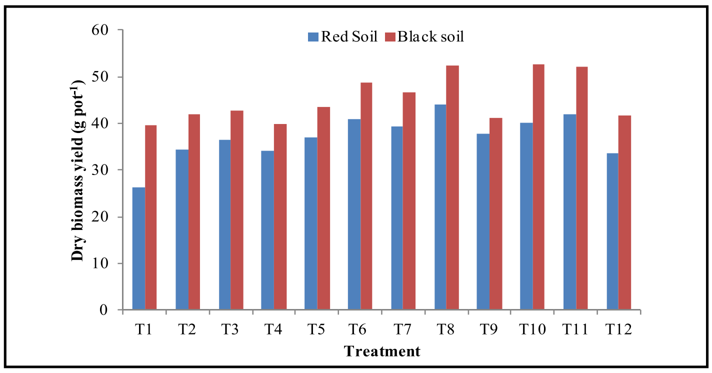


Fig. 2.1.5c Effect of glauconite application on dry biomass yield of maize

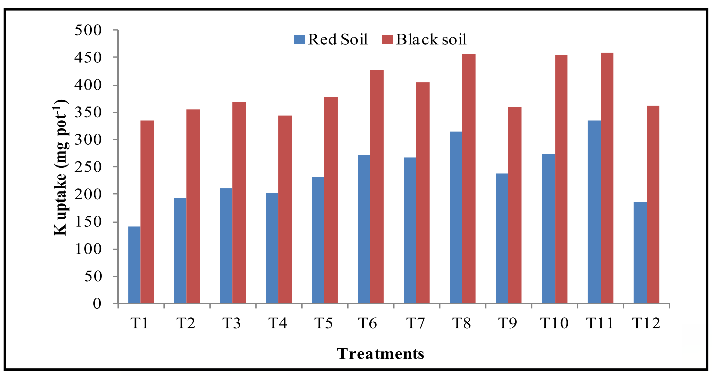


Fig. 2.1.5d Effect of glauconite application on K status in soil

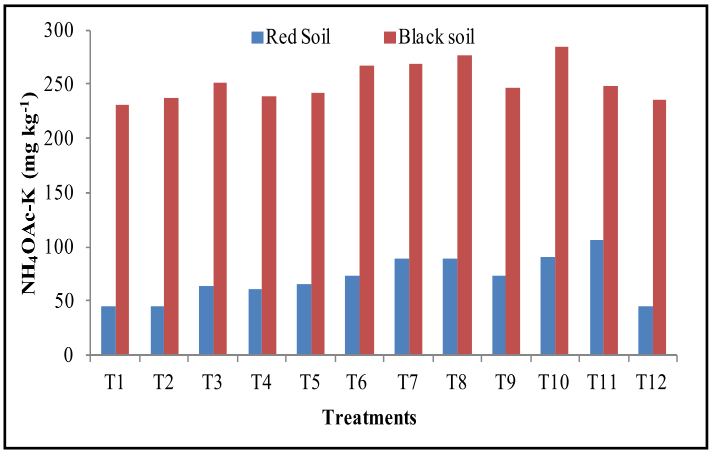


Fig. 2.1.5e Effect of glauconite application on available K

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

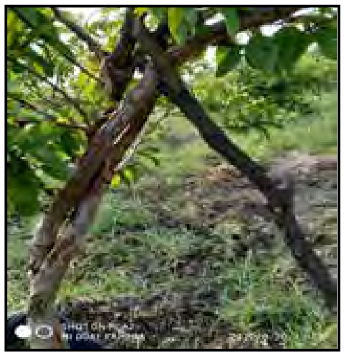
The assessment of system productivity and stability of the agroecosystem (rice-fallow system) located inside the Balaghat forest range of Madhya Pradesh was carried out by quantifying soil and water resources. The agro-ecosystem is endowed with abundant natural water resources and the utilization of these water resources for agriculture is very low as tribal farmers practice rainfed farming. However, soil loss from farmlands was visible in the form of shallow rills, pedestals and exposure of tree roots in many sloppy areas (Plate 2.1.6a). Analysis of soil samples collected from 80 locations (Plate 2.1.6b) showed that mostly tribal farmlands (with no external inputs) are rich in organic carbon with moderate availability of other plant nutrients like nitrogen, phosphorus, potassium, zinc, iron, manganese and copper. However, most of these farmland soils are deficient in sulphur and boron. In order to rectify the nutrient deficiencies in these tribal farmlands 'Soil Health Cards' were prepared based on the soil test results. These soil health cards contain nutrient recommendation for rice-fallow systems using low cost locally available organic inputs like farmyard manure, azolla, green leaves like gliricidia, compost and steamed bone meal.

Plate 2.1.6a Extent of soil loss (slops) in the Kulpa village of Balaghat district

Plate 2.1.6b Soil sample collection from tribal farmlands of Balaghat district

Rejuvenation of agri-horticultural system for improving soil health, productivity and produce quality

Management practice like pruning, weeding and pest control for guava and citrus plantation crops were done for rejuvenation and proper growth. Plants are being trained in such way that could sustain their fruit load without extra support by bamboos (Plate 2.1.6c). As a result stem borer infected plants are rejuvenated (Plate 2.1.6d) and new growth emerged on the main trunk. Similarly, weed problem in mango plantation was managed with ploughing and base cleaning. Unwanted branches are also removed and plants are trained with scaffold branches in all directions (Plate 2.1.6e). Fertilizer management was followed in Citrus and Bordeaux paste has been applied on the trunk to avoids fungal infection.



Plant with unwanted branch

Removed unwanted branch

Plate 2.1.6c Corrective heavy pruning and weed management in guava field

Infestation of stem borer

Dehoarding of the trunk

New sprout in main trunk

Plate 2.1.6d Rejuvenation of borer affected guava plant

Weed problem   Present Clean Plantation

Unwanted branches   Removed unwanted branches

Plate 2.1.6e View of mango field before and after implementation of project

2.1.7 Climate change effect on Nutrient Use Efficiency in wheat

The effect of climate change on NUE, in wheat crop was investigated for three consecutive cropping seasons under elevated CO_2 and temperature conditions in Open Top Field Chambers (OTC) in the Vertisols of Bhopal. The crops were grown under two atmospheric CO_2 (ambient and 550 ppmv) and air temperature (ambient, 2.0 °C above ambient) levels. Elevation in CO_2 showed 43% higher AEN as compared to ambient, whereas, elevation of temperature decreased the AEN by 18.6%. The co-elevation of CO_2 and temperature showed 8% higher AEN (Fig. 2.1.7a).

Similar to AEN, effect of climate was significant on recovery of applied N (REN). The N-recovery values varied from 0.52 to 0.80 kg increase in uptake kg N applied under climate change treatments. Elevation in CO_2 showed 39% higher recovery as compared to ambient, whereas, elevation of temperature decreased the N-recovery by 9%. The co-elevation of CO_2 and temperature showed 12% higher recovery. (Fig. 2.1.7b).

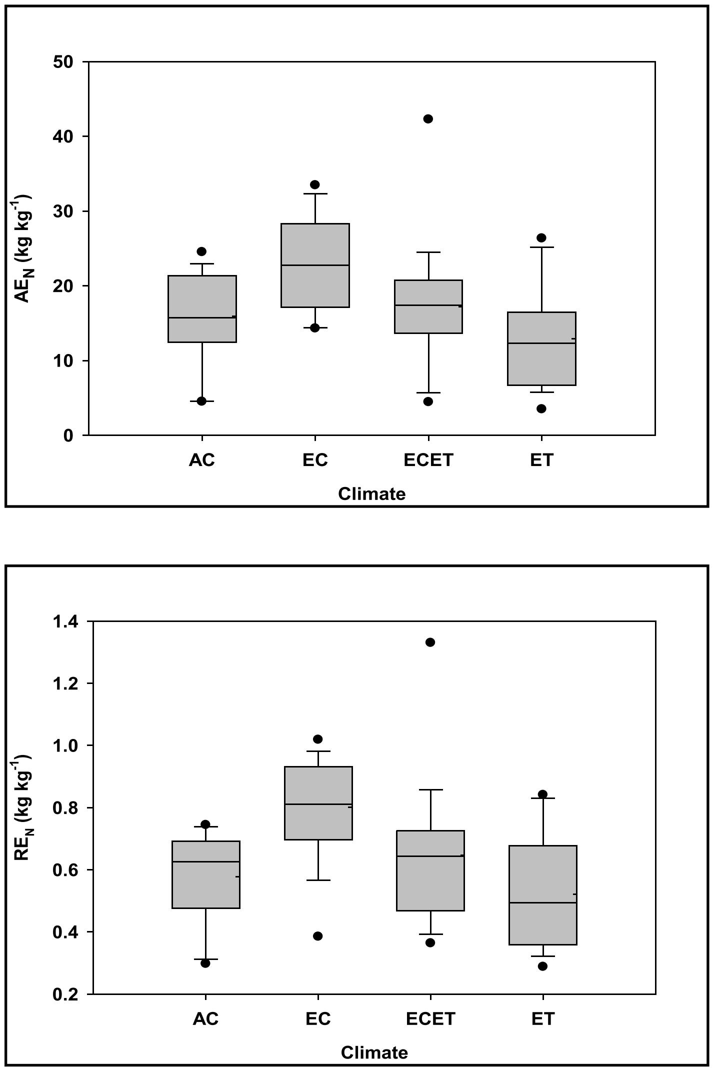


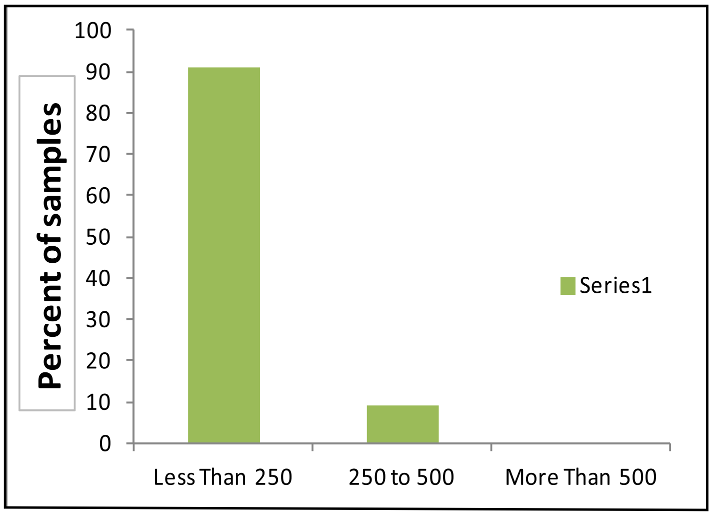
Fig.2.1.7a Climate change impact on agronomic use efficiency and recovery of applied N

Soil bulk density and labile carbon fraction as indicators for soil health monitoring

The Principal Component Analysis (PCA) based on the variance of the dataset indicated that soil bulk density an important physical property served as an indicator in the minimum dataset (MDS) in five out of the six agro-ecological sub-regions (AESRs 4.1, 4.3, 6.1, 9.1, 9.2, 18.4) covered in the study. In other words, in major food production regions of the country, variation in soil bulk density is being observed and thus the soil bulk density should be included as a physical parameter in routine soil health assessment programs. In 50% of the AESRs covered under this study, active soil carbon fraction was observed to be an important parameter contributing to the total variance in the dataset. Thus, active C fraction can also be included as an important parameter in the MDS in place of total soil organic carbon (TOC) for long term monitoring of soil health.

High available P content in major food production zones of India

Available P in AESR 4.1 and AESR 9.1 representing the states of Punjab, Haryana, UP and eastern Rajasthan was found to be high in more than 60% samples. Similarly, high P content was observed in 46% of samples in AESR 18.4 (east coast rice belt), 44% in AESR 6.1, 23% in AESR 4.3 and 18% in AESR 9.2. However, 11% samples in AESR 4.1, 29% in AESR 4.3, 26% in AESR 6.1 and 27% in AESR 18.4 were deficient in available P. Thus, nutrient recommendation should take care of the particular trend in available P distribution in soils of the major food production region of the country.



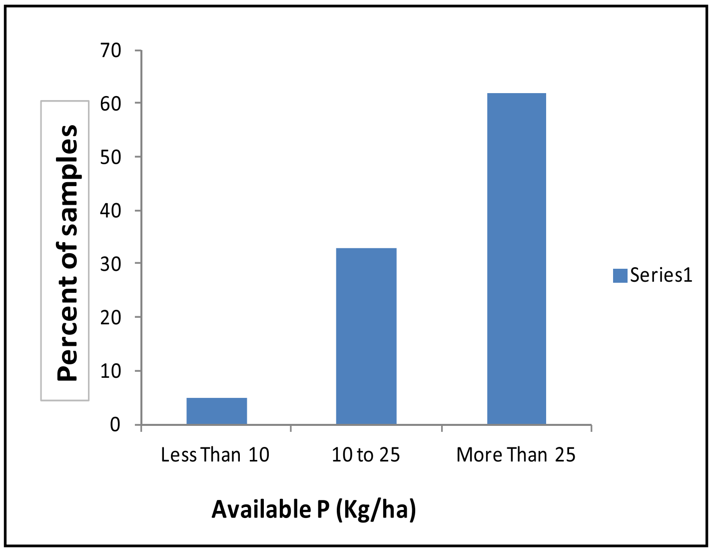


Fig.2.1.7b Frequency diagram showing distribution of soil samples in different categories of N and P availability

2.1.8 Ion Selective Field Effect Transistors (ISFETs) for the estimation of soil fertility parameters

Ion Selective Field Effect Transistors (ISFETs)were tested for the estimation of soil pH, nitrate and potassium. An ISFET is a field-effect transistor used for measuring ion concentrations in solution; when the ion concentration changes, the current through the transistor will change accordingly. The ISFET assembly, nitrate ISFET and reference electrode is shown in Plate 2.1.8a, b and c.

Plate 2.1.8a Assembly of ISFET

Plate 2.18b Nitrate ISFET

Plate 2.1.8c Reference Electrode

Standard curve for pH with standard buffers and soil pH

Standard curve was obtained by using pH ISFET with three-point calibrations (Fig. 2.1.8a). A perfect correlation is obtained for pH with the sensitivity of 56 mV per decade. The response time was 15 minutes for each reading. Soil pH was measured for fifteen soil samples in a soil water suspension of 1:2.5 ratio using pH meter and ISFET. The paired t test at P=0.05 showed that there is no significant difference in the mean pH values of ISFET and pH meter (Fig. 2.1.8b).

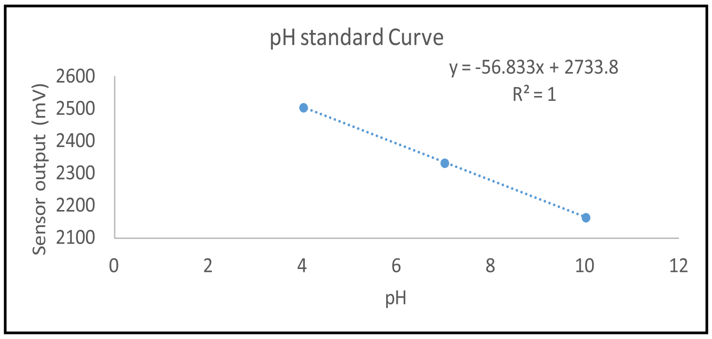


Fig. 2.1.8a Standard curve for pH using buffer solution of pH 4, 7 and 10

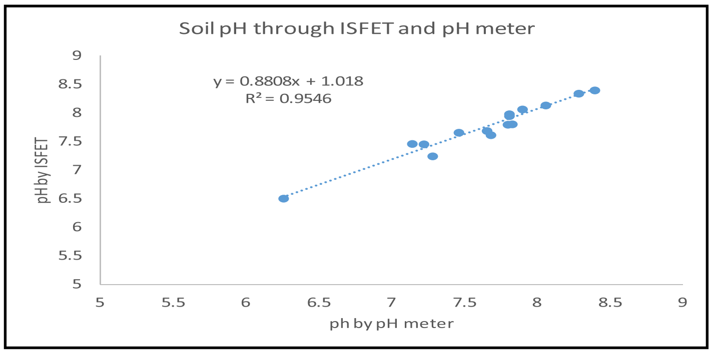


Fig. 2.1.8b Soil pH estimation through ISFET and pH meter

Nitrate standard curve

A fairly high coefficient of determination (R^2) was obtained in sodium nitrate and sodium nitrate + potassium chloride and acceptable results are obtained in sodium nitrate + sodium chloride medium showing that these calibrations could be used to determine nitrates in soil. The sensitivity of nitrate was -34.5, -25.5 and -24.0 mV per decade for calibrations prepared in sodium nitrate, sodium nitrate + sodium chloride and sodium nitrate+ potassium chloride, respectively. For soil nitrate estimation using ISFET, the sodium nitrate +potassium chloride calibration curve was used and result obtained was comparable to conventional soil estimation (2 M KCl extraction followed by calorimetric estimation with the help of Autoanalyzer) (Fig. 2.1.8c).

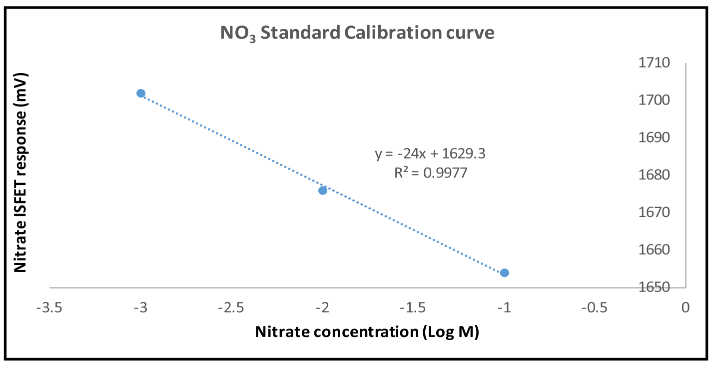


Fig. 2.1.8c Standard curves for nitrate prepared through sodium nitrate + potassium chloride

Potassium standard curve

The determination of potassium was estimated by ISFET through following standard of potassium chloride, potassium chloride + ammonium acetate and potassium chloride + sodium chloride. In the case of potassium chloride + sodium chloride and potassium chloride + ammonium acetate a good correlation (R^2) was obtained i.e. 0.99 and 0.99, respectively and acceptable results was also obtained in potassium chloride (R^2 = 0.98) medium showing that these calibrations could be used for the determination of potassium in soil. The sensitivity obtained through calibration was 23.5, 64.0 and 32.5 mV per decade for potassium chloride, potassium chloride + sodium chloride and potassium chloride + ammonium acetate respectively (Fig.2.1.8d).

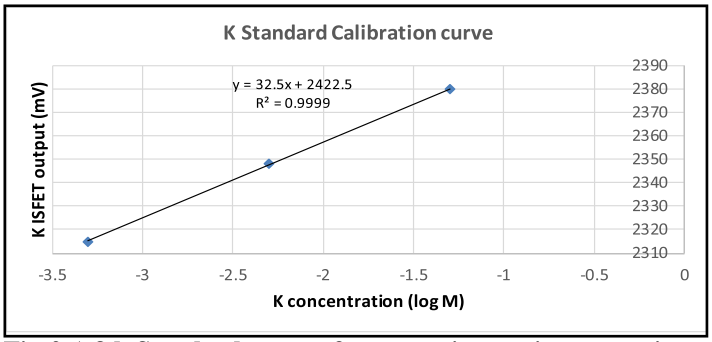


Fig.2.1.8d Standard curve for potassium using potassium chloride + ammonium chloride standard

The results obtained from ISFET were comparable to the results of conventional method (Flame photometer). The paired t test also indicated that there is no significant difference in the mean of two methods. The regression analysis showed that the fitting is poor (R^2=0.63) because of outliers which was probably due to potential drift, and interfering ions (Fig.2.1.8e).

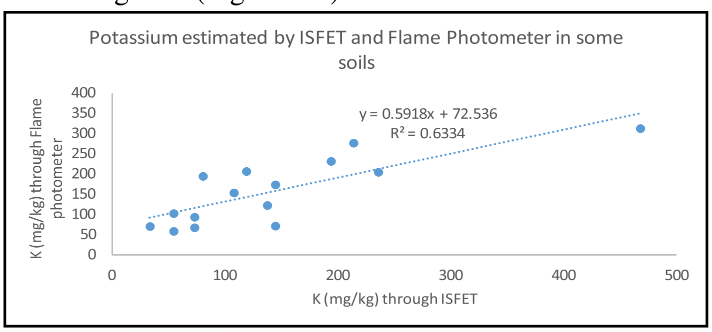


Fig. 2.1.8e Comparison between potassium estimated by ISFET and Flame Photometer in soils

2.2 AICRP on Long Term Fertilizer Experiments (LTFE)

2.2.1 Soil Biological Properties under Long Term Fertilizer Experiments

Studies undertaken at different LTFE centers across the country on impact assessment of different nutrient combination o n soil biological properties were presented.

Bhubaneswar

Microbial Population

Soil fungal population was in the range of 11.75×10^4 to 34.75×10^4 cfu/g (Table 2.2.1a) and the highest population was recorded under 100% NPK+FYM followed by 100% NPK+lime+FYM. Bacterial population varied from 9×10^6 to 27.50×10^6 cfu/g and the application of 100% NPK+lime+FYM recorded highest bacterial count. Actinomycetes population varied from 6.12×10^6 to 1.75×10^6 cfu/g and the application of FYM with or without lime showed highest actinomycetes population. The lime application caused an increase in actinomycetes population. Highest respiration rate was observed in 100% NPK+lime+FYM and optimal dose of nutrient along with FYM. These treatments increased respiration by about 50% and in case of balanced fertilization, respiration was increased by 16% over control.

Table 2.2.1a Effect of manurial treatments on microbial population (cfu g^{-1} s oil) and basal soil respiration (mgCO_2/g of soil) at Bhubaneswar

Treatment	Fungi ($\times10^4$)	Bacteria ($\times10^6$)	Actinomycetes ($\times10^6$)	Basal soil Respiration (mg CO_2 /g of soil)
Control	11.75	9.00	1.75	0.172
100% N	13.50	11.88	1.62	0.202
100% NP	14.50	12.00	2.62	0.217
100% PK	12.00	11.13	1.37	0.192
100% NPK	14.75	13.00	4.37	0.200
150% NPK	15.75	11.25	4.62	0.241
100% NPK+Zn	14.00	18.50	2.12	0.237
100% NPK+B+Zn	15.00	7.50	3.37	0.222
100% NPK+S+Zn	18.25	7.13	2.75	0.230
100% NPK+lime	15.50	18.63	6.25	0.233
100% NPK+FYM	34.75	18.75	5.00	0.255
100% NPK+lime+FYM	26.75	27.50	6.12	0.259
LSD (P=0.05)	3.48	2.60	1.21	0.02

Microbial biomass carbon, nitrogen and phosphorous

Microbial biomass carbon (MBC) was significantly higher in plots receiving both FYM and inorganic fertilizers (Fig.2.2.1a). The MBN and MBP content in soil was found to be higher in the plots receiving organic manure and lime combined with mineral fertilizer. Addition of micronutrient either Zn alone or in combination with B or S recorded significantly higher MBN content than 100% NPK

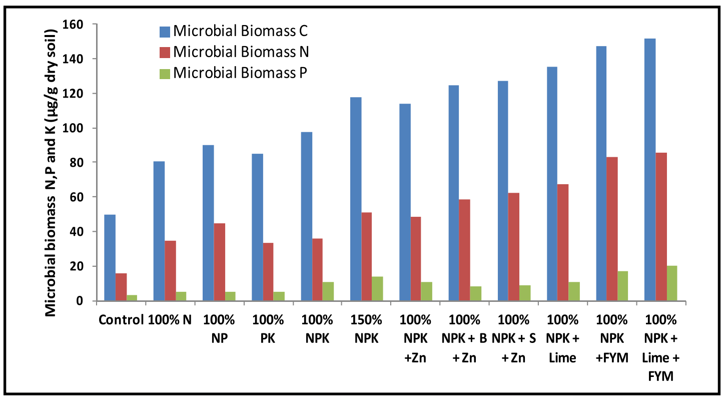


Fig.2.2.1a Effect of manurial treatments on Microbial properties of soil

Soil enzymatic activity

Dehydrogenase activity was maximum in 100% NPK+ FYM+ lime (59.20 mg of TPF kg^{-1} of soil 24 hr^{-1}) followed by 100 % NPK+FYM (58.53 mg of TPF kg^{-1} of soil 24 hr^{-1}) and 150% NPK (45.93 mg of TPF kg^{-1} of soil 24 hr^{-1}) (Table 2.2.1b). There was a significant increase in dehydrogenase activity in N only treatment over control and addition of P with N further increased significantly but addition of K with NP resulted no significant effect. However, additional 50% increase in NPK significantly improved dehydrogenase activity.

Urease activity was highest in 100% NPK+ FYM+ lime which were at par with 100% NPK+FYM. Application of 100% NPK significantly increased the urease activity over control but increasing NPK dose to 150% did not have any significant effect. Addition of Zn or Zn +B or Zn + S decreased the urease activity as compared to 100% NPK.

Table 2.2.1b Effect of long term fertilization on soil enzymatic activities

Treatment	Dehydrogenase activity (mg of TPF/ kg soil/24 hr)	Urease activity (mg NH_4^+-N/kg soil/2hr)
Control	12.16	34.27
100% N	26.47	53.47
100% NP	36.45	58.07
100% PK	24.73	45.27
100% NPK	35.25	69.67
150% NPK	45.93	72.07
100% NPK +Zn	23.25	66.13
100% NPK + B + Zn	33.47	66.47
100% NPK + S + Zn	36.08	56.20
100% NPK + Lime	43.47	65.40
100% NPK +FYM	58.53	79.67
100% NPK + Lime + FYM	59.20	80.47
LSD (P=0.05)	5.05	5.51

Coimbatore

The long term fertilizer application along with organic manure significantly increased ($P<0.05$) SMBC and SMBN over control (Fig. 2.2.1b and 2.2.1c). Irrespective of the treatments, INM (100+NPK + FYM @ 10 t ha^{-1}) showed higher SMBC (301 mg kg^{-1}) and SMBN (47.82 mg kg^{-1}) in finger millet grown plots. The highest biomass C (284 mg kg^{-1}) and biomass N (46.47 mg kg^{-1}) were observed under INM (100% NPK+FYM) treatment in post harvest soils of maize. Fertilization with inorganic NPK fertilizers registered biomass C (262 mg kg^{-1}) and N (398.05 mg kg^{-1}).

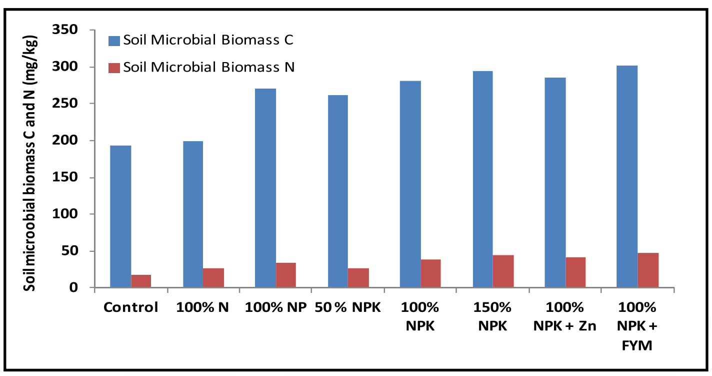


Fig. 2.2.1b SMBC and SMBN in post harvest soils of fingermillet

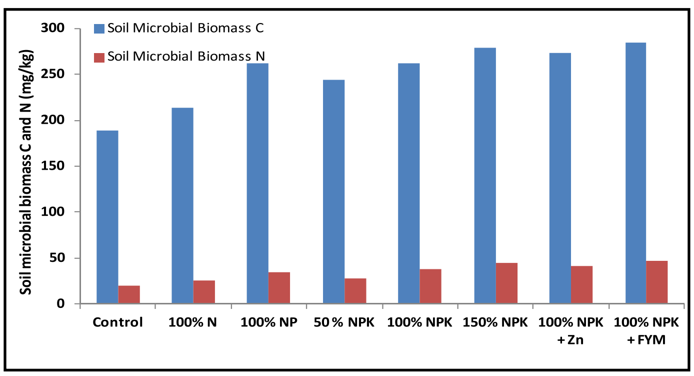


Fig. 2.2.1c SMBC and SMBN in post harvest soils of maize

Jabalpur

Higher microbial population was observed under 100% NPK+FYM indicating the beneficial effect of integrated fertilizer application with organic manure. Soil biomass C and N content in 100% NPK+FYM was 343.48 and 44.25 (μg g^{-1} soil), respectively (Table 2.2.1c).

Table 2.2.1c Effect of long term application of fertilizers and manure on microbial population and soil microbial biomass

Treatment	Population Count (cfu x 10^7 g^{-1} soil)			SMB (μg g^{-1} soil)	
	Bacterial	Fungi	Actinomycetes	SMBC	SMBN
Control	11.67	18.46	13.64	168.32	21.25
100% N	14.28	19.63	15.28	212.15	25.10
100% NP	18.32	23.55	16.32	238.22	26.89
50% NPK	19.77	24.44	17.22	234.12	27.72
100% NPK-S	23.31	32.44	25.22	285.47	33.18
100% NPK	23.85	33.22	26.18	292.21	35.21
150% NPK	25.09	37.86	29.03	314.46	40.49
100% NPK+HW	23.53	34.11	26.07	284.12	33.42
100% NPK+Zn	23.41	34.02	26.22	286.10	34.10
100% NPK+FYM	39.06	42.74	39.60	343.48	44.25
LSD (P=0.05)	2.315	1.580	1.692	15.99	2.711

Pantnagar

Microbial abundance

Soil microbial population was significantly influenced under integrated nutrient management at the end of 48th cropping cycles of rice-wheat cropping system (Table 2.2.1d). Fungal population at 0-15 cm was higher under NPK+FYM treatment followed by NPK+Zn and NP+Zn. Population of bacteria at 0-15 cm (2.32 x 106 cfu g^{-1}) and 15-30 cm (1.99 x 106 cfu g^{-1}) was highest in NPK+FYM treatment. Similarly, the azotobacter count (630 x 103 and 601x 103 cfu g^{-1}) was highest in NPK+FYM treatment at both the depths i.e. 0-15 and 15-30 cm) respectively.

Table 2.2.1d Long term effect of fertilizer and manure on microbial population in soil after 48th crop cycles

Treatment	Fungi (X 10^4) Fungi		Bacteria(X 10^6) SMBC		SMBN		Azotobacter (X10^3 cfu g^{-1})	
	0-15cm	15-30cm	0-15 cm	15-30cm	0-15 cm	15-30cm	0-15cm	15-30cm
Control	0.60	0.45	0.55	0.40	0.78	0.40	152	146
100% N+Zn	1.27	1.06	1.46	1.55	1.89	1.71	410	346
100% NP+Zn	1.66	1.29	1.68	1.53	1.00	1.52	476	338
50% NPK+Zn	1.06	0.85	1.60	1.51	1.59	1.31	236	218
100% NPK-S+Zn	1.40	1.31	1.79	1.63	1.81	1.75	422	380
100% NPK	1.48	1.18	1.80	1.75	1.71	1.67	286	208
150% NPK	1.48	1.27	1.87	1.77	1.76	1.70	256	204
100% NPK+Zn	1.91	1.29	2.19	1.92	1.84	1.55	336	216
100% NPK+HW+Zn	1.84	1.42	1.99	1.88	1.85	1.70	379	254
100% NPK+FYM	1.99	1.48	2.32	1.99	2.16	1.82	630	601
LSD (P=0.05)	0.11	0.14	0.17	0.26	0.31	0.27	43.88	38.47

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

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

The present study was undertaken to understand the spatial distribution pattern of available micronutrients (Zn, B, Fe, Mn and Cu), available sulphur (S), and soil properties (pH, EC and SOC content) of intensively cultivated Indo-Gangetic Plain (IGP) of India and to delineate soil management zones (MZs) for efficient management of soil nutrients. About 55101 soil samples from 0–15 cm depth were analysed from 167 districts of IGP during 2014 to 2017 for different soil parameters. Soil pH, EC and SOC content varied from 4.44 to 9.80, 0.02 to 2.13 dS m^{-1} and 0.10 to 1.99%, respectively. The concentration of available Zn, B, Fe, Mn, Cu and S varied from 0.01 to 3.27, 0.01 to 3.51, 0.19 to 55.7, 0.05 to 49.0, 0.01 to 5.29 and 1.01 to 108 mg kg^{-1}, respectively. Geostatistical analysis showed moderate to strong spatial dependence. The extent (% area) of nutrient deficiencies in IGP followed the order: S > Zn > B > Mn > Cu > Fe. Principal component analysis and fuzzy c-means clustering produced six distinctly different soil MZs for implementation of zone-specific soil nutrient management strategies for attaining sustainability in crop yield. The developed MZ maps could also be utilized for prioritization and rationalization of nutrients supply in IGP of India (Fig. 2.3.1a).

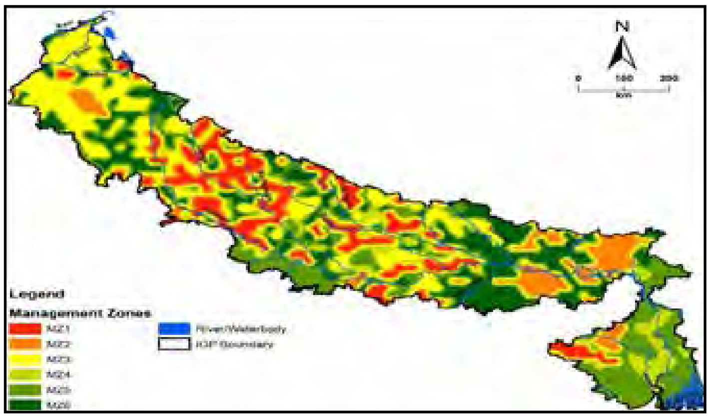


Fig. 2.3.1a Sulphur and micronutrient management zones of IGP, India

Delineation of soil management zones for ameliorating sulphur and micronutrients deficiencies in Narmada river basin

Geo-referenced soil samples (5984 nos.) from top layer (0-15 cm) were collected from Narmada river basin (NRB) of India, and analysed for pH, EC, SOC, available S, and micronutrients namely Zn, Cu, Mn, Fe, and B. The soils had acidic to alkaline pH, non-saline and wide SOC values. The values of phyto-available nutrients were 17.5±11.6 mg kg^{-1} S, 0.73±0.52 mg kg^{-1} Zn, 3.00±2.15 mg kg^{-1} Cu, 15.4±11.2 mg kg^{-1} Fe, 19.5±14.6 mg kg^{-1} Mn, and 1.39±0.80 mg kg^{-1} B. Geostatistical analysis resulted in semi-variogram with exponential model for different soil parameters. About 41.2, 78.6, 10.1, 2.70, and 32.6% area of NRB exhibited deficiency (including acute deficient, deficient and latent deficient areas) in phyto-available S, Zn, Fe, Mn, and B, respectively. The principal component analysis and fuzzy c-means clustering produced five MZs. (Fig. 2.3.1b).

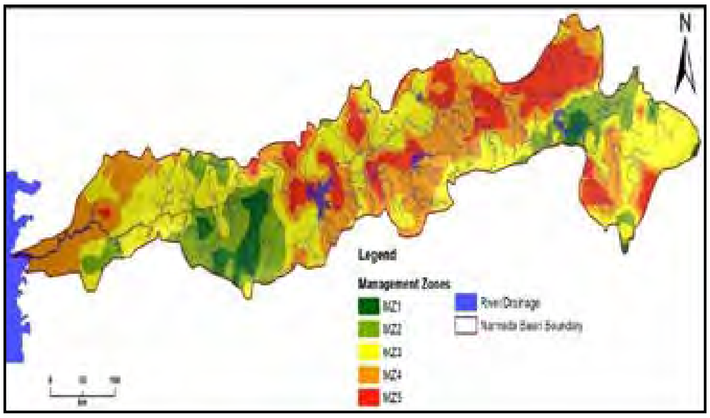


Fig.2.3.1b Sulphur and micronutrient management zones of Narmada river basin of India

Zinc efficiency of pigeonpea (*Cajanus cajan* (L.) Millsp.) genotypes grown on Vertisols of central India varies

A field experiment was conducted with twenty different pigeonpea genotypes and two levels of Zn application under a split-plot design to assess the Zn efficiency of pigeonpea genotypes based on seed yield and seed Zn uptake efficiency. The two levels of Zn (0 and 20 kg Zn ha^{-1} as $ZnSO_4.7H_2O$) were applied as basal soil application, in conjunction with three foliar sprays (@0.50% (w/v) with 0.25% lime as neutralizing agent) at flowering, pod formation and pod filling stages. Application of Zn significantly improved plant height, branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, and 100 seed weight of pigeonpea genotypes. The mean seed yield, seed Zn concentration, and seed Zn uptake of the genotypes increased from 1.71 to 2.12 t ha^{-1}, 32.4 to 43.0 mg kg^{-1}, and 54.9 to 90.6 g ha^{-1}, respectively, with application of Zn. The seed yield efficiency index (SYEI) and Zn uptake efficiency index (ZUEI) of pigeonpea genotypes varied from 67.0 to 92.5 and 47.0 to 69.9, respectively. Based on SYEI and ZUEI, the genotypes were classified as efficient and responsive (Virsa Arhar[1], GT-1, GT-101, SKNP 05-05, BDN-2, AAUT 2007-04, BSMR 853, T 15-15, DT 23, Pusa 9), efficient and non-responsive (ICPL 87119, PKV Trombay), inefficient and responsive (AKT 8811, Hisar Paras), and inefficient and non-responsive (AAUT 2007-10, JKM 7, Hisar Manak, C 11, Hisar HO2-60, GAUT 93-17). (Fig. 2.3.1c).

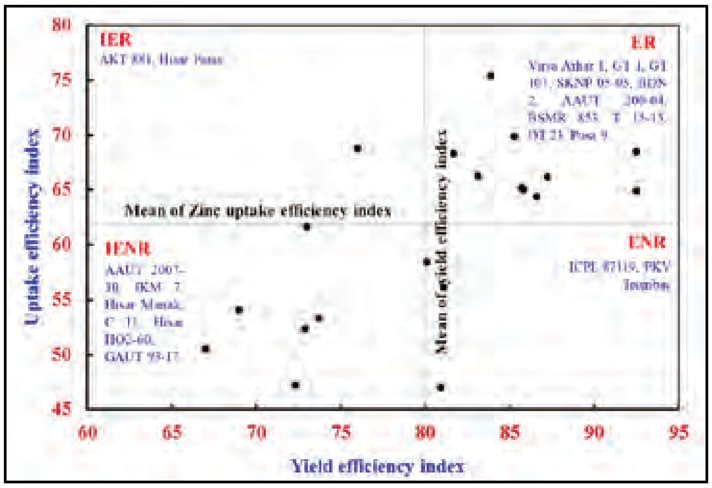


Fig. 2.3.1c Classification of pigeonpea genotypes for zinc efficiency. ER = efficient and responsive, ENR = efficient and non-responsive, IER = inefficient and responsive, IENR = inefficient and non-responsive

Monitoring of heavy metal toxicity in soil-plant-animal continuum in Punjab

Twenty blood samples of animals were collected from Machhiwara along with soil and fodder samples. The digested fodder and blood serum; and DTPA extractant from soil samples were analyzed for Zn, Cu, Fe, Mn, Cd and Ni. The content of DTPA-Zn, Cu, Fe, Mn, Cr, Cd, Ni, Pb and Co in soil varied form 0.4-1.5, 0.79-1.39, 3.1-9.5, 1.3-3.92, 0.27-0.37, 0.018-0.036, 0.022-0.056, 1.74-2.70 and 0.018-0.042 mg kg^{-1} soil with a mean of 0.93, 0.98, 6.3, 2.5, 0.31, 0.03, 0.036, 2.19 and 0.030 mg kg^{-1} soil, respectively. The mean concentration of Zn, Cu, Fe, Mn, Cr, Cd, Ni, Pb and Co in fodders were 30.5, 8.9, 258, 21, 2.54, 2.01, 0.67, 7.57 and 3.75 mg kg^{-1} dry matter, respectively. Overall, the content of Zn, Fe, Mn, Cd and Ni in blood serum of animals varied from 0.57-1.49, 3.81-8.43, 0.16-0.28, 0.22-0.33, and 0.09-0.15 mg l^{-1}, respectively. Only one blood serum sample was found to be be deficient in Zn (0.573 ppm). The Pb ($r=0.482^*$) and Ni ($r=0.525^*$) content in blood and fodder samples were significantly positively correlated.

2.4 AICRP on Soil Test Crop Response (STCR)

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

The STCR-IPNS fertilizer equations were developed based on nutrient contribution from various sources including soil, fertilizers and organic sources (FYM, green manure, compost, crop residues and bio-fertilizers like *azospirillum* and *phosphobacteria*). The work done by various centers for development of IPNS targeted yield equations has been detailed in the following Table 2.4.1.

Table 2.4.1 The list of STCR-IPNS equations for different crops with basic data

Name of the Centre	Crop/Variety	Basic Data					Targeted Yield Equations
		Nutrients	NR (kg q^{-1})	CS (%)	CF (%)	CO (%)	
Jorhat	Rice (Ranjit Sub-1)	N	2.01	46.63	41.76	49.91	FN = 4.82 T – 1.12 SN – 1.20 ON
		P_2O_5	0.26	48.19	29.13	4.19	FP^{2}O5= 0.90 T – 1.65 SP – 0.14 OP
		K_2O	1.30	57.37	47.66	32.47	FK_2O = 2.73 T – 1.20 SK – 0.68 OK
Pantnagar	Brinjal (Pant Samrat)	N	0.50	31.63	50.41	59.58	FN = 1.00 T – 0.63 SN – 0.59 ON
		P_2O_5	0.14	29.16	47.41	94.60	FP_2O_5= 0.68 T – 1.43 SP – 3.17 OP
		K_2O	0.25	13.82	65.12	81.10	FK_2O = 0.47 T – 0.26 SK – 0.75 OK

	Mustard (PR20)	N	8.03	113.61	15.16	26.88	FN = 52.96 T – 7.49 SN – 1.77 ON
		P_2O_5	1.29	26.87	28.21	36.45	FP_2O_5 = 10.54 T – 2.18 SP – 2.95 OP
		K_2O	3.49	22.91	60.88	7.40	FK_2O = 6.93 T – 0.46 SK – 0.12 OK
	Chilli (Teja)	N	3.82	70.85	44.12	7.01	FN = 7.12 T – 1.24 SN –0.15 ON
		P_2O_5	0.36	36.18	46.18	3.33	FP_2O_5 = 1.14 T –0.82 SP – 0.07 OP
		K_2O	3.06	66.43	75.48	10.02	FK_2O = 3.02 T – 0.26 SK – 0.12 OK
	Soybean (Basara)	N	5.53	32.00	98.00	12.00	FN = 4.48 T – 0.28 SN – 0.10 ON
		P_2O_5	0.67	33.00	33.00	4.00	FP_2O_5= 2.82 T –0.1.01 SP –0.11 OP
		K_2O	2.89	11.00	136.00	9.00	FK_2O = 2.12 T – 0.08 SK – 0.07 OK
	Sorghum (NTJ 5)	N	1.69	18.35	19.80	15.06	FN = 8.65 T – 0.50 SN – 0.20 ON
		P_2O_5	0.48	23.99	32.57	12.51	FP2O5= 1.98 T – 0.36 SP – 0.24 OP
		K_2O	1.24	13.00	38.14	15.42	FK_2O= 3.29 T – 0.16 SK – 0.18 OK
Ludhiana	Brinjal (Navkiran)	N	0.52	0.46	0.39	0.39	FN = 1.34 T – 1.16 SN – 0.99 ON
		P_2O_5	0.27	0.63	0.26	0.26	FP_2O_5 = 1.07 T – 2.42 SP – 0.99 OP
		K_2O	1.25	0.91	3.17	0.64	FK_2O = 0.40 T – 0.29 SK – 0.20 OK
	Maize (PMH1)	N	1.36	0.34	0.37	0.16	FN = 3.71 T – 0.97 SN – 0.42 ON
		P_2O_5	1.13	0.69	0.24	0.06	FP_2O_5 = 4.67 T – 2.86 SP – 0.26 OP
		K_2O	4.23	0.74	1.09	0.18	FK_2O = 1.49 T – 0.20 SK – 0.06 OK
Rahuri	Pigeon pea (Rajeshewari)	N	3.06	14.18	56.87	40.75	FN = 5.38 T – 0.25 SN – 3.58 ON
		P_2O_5	0.81	37.71	8.86	2.13	FP_2O_5 = 9.12 T – 4.26 SP – 0.72 OP
		K_2O	2.30	3.69	59.49	6.37	FK_2O = 3.87 T – 0.06 SK – 0.96 OK
Raipur	Rice (Rajeshwari)	N	1.53	30.65	24.06	9.09	FN = 5.00 T – 0.78 SN – 0.30 ON
		P_2O_5	0.29	20.80	57.86	5.59	FP_2O_5 = 1.40 T – 2.78 SP – 0.27 OP
		K_2O	1.78	113.40	11.07	10.47	FK_2O = 1.57 T – 0.10 SK – 0.09 OK
	Safflower (Chhattisgarh Kusum-1)	N	3.96	30.16	15.78	9.76	FN =13.13 T – 0.52 SN – 0.32 ON

		P_2O_5	0.92	19.61	54.07	6.29	FP_2O_5 = 4.69 T – 2.76 SP – 0.32 OP
		K_2O	6.32	134.55	11.32	9.00	FK_2O = 4.69 T – 0.08 SK – 0.07 OK
Coimbatore	Tuberose (Brijwal)	N	0.86	17.23	40.90	34.70	FN = 2.10 T – 0.42 SN – 0.85 ON
		P_2O_5	0.42	19.43	25.34	10.39	FP_2O_5 = 1.65 T – 1.76 SP – 0.94 OP
		K_2O	0.96	10.26	45.03	32.90	FK_2O = 2.14 T – 0.27 SK – 0.88 OK
Palampur	Soybean (Harit Soya Kharif)	N	6.10	40.49	56.32	13.95	FN = 10.84 T–0.72 SN – 0.25 ON
		P_2O_5	1.18	34.68	28.73	5.00	FP_2O_5 = 4.09 T– 1.21 SP – 0.17 OP
		K_2O	2.22	10.79	59.83	7.67	FK_2O = 3.71 T – 0.18 SK – 0.13 OK
Bangluru	Aerobic rice (MAS 946-1)	N	1.77	12.40	61.03	0.73	FN = 2.89T – 0.20SN– 0.73ON
		P_2O_5	1.09	6.72	96.58	0.49	FP_2O_5 = 1.13T – 0.07SP - 0.49 OP
		K_2O	2.88	40.43	191.57	0.42	FK_2O = 1.50T – 0.21 SK – 0.42 OK
Kalyani	Chilli (Bullet)	N	2.95	29.52	76.80	22.00	FN = 4.66 T – 0.38 SN – 0.38 ON
		P_2O_5	0.34	27.72	35.70	18.00	FP_2O_5 = 0.94 T – 0.78 SP – 0.22 OP
		K_2O	1.08	36.40	49.19	22.00	FK_2O = 2.19 T – 0.74 SK – 0.30 OK
Varanasi	Spinach (Pusa Jyoti)	N	0.75	24.74	51.22	3.76	FN = 1.46 T – 0.48 SN – 0.07 ON
		P_2O_5	0.08	33.96	45.08	1.99	FP_2O_5 = 0.19 T – 0.75 SP – 0.04 OP
		K_2O	0.70	29.95	138.51	2.15	FK_2O = 0.51 T – 0.22 SK – 0.02 OK
Bikaner	Dill (AD-2)	N	3.34	29.60	81.30	100.90	FN = 5.33 T– 0.36 SN – 1.24 ON
		P_2O_5	1.44	56.50	29.98	54.91	FP_2O_5 = 1.78 T –1.88 SP – 1.83 OP
		K_2O	7.13	39.34	147.21	177.59	FK_2O = 4.85 T – 0.27 SK –1.20 OK
	Quinoa (Chenopodium quinoa)	N	4.65	51.03	16.97	92.05	FN = 27.40 T– 3.01 SN – 5.43 ON
		P_2O_5	1.22	62.90	17.06	50.59	FP_2O_5 = 7.16 T – 3.68 SP – 2.96 OP
		K_2O	2.41	17.26	20.81	60.52	FK_2O = 11.57 T – 0.83 SK –2.91 OK
Puducherry	Chilli (hybrid-Ananya)	N	0.72	23.66	59.99	37.84	FN = 1.25 T – 0.42 SN – 0. 65 ON
		P_2O_5	0.24	59.74	27.57	10.51	FP_2O_5 = 0.84 T – 4.82 SP– 0.84 OP

		K_2O	0.62	19.08	80.66	47.95	FK_2O = 0.72 T – 0.29 SK – 0.77 OK
Pusa	Hybrid Rice (Arize-6444)	N	2.30	34.65	37.21	23.52	FN = 6.65 T – 1.07 SN – 0.68 ON
		P_2O_5	0.85	42.77	123.87	5.32	FP_2O_5 = 1.99 T – 2.90 SP – 0.12 OP
		K_2O	2.49	133.53	89.66	28.80	FK_2O = 1.86 T – 0.67 SK – 0.22 OK
New Delhi	Fenugreek (Pusa Early Branching)	N	4.48	15.54	73.84	4.18	FN = 6.06 T – 0.21 SN – 0.06 ON
		P_2O_5	0.88	35.72	23.89	2.12	FP_2O_5 = 3.70 T – 1.50 SP – 0.09 OP
		K_2O	2.92	9.59	133.38	2.15	FK_2O = 2.19 T – 0.07 SK – 0.02 OK
Junagadh	Soybean (GS-3)	N	5.65	35.03	65.25	74.50	FN = 7.87 T – 0.50 SN – 0.39 ON
		P_2O_5	0.91	55.13	22.49	27.60	FP_2O_5 = 3.10 T – 1.87 SP – 0.17 OP
		K_2O	2.53	10.36	43.89	51.60	FK_2O = 4.70 T – 0.20 SK – 0.19 OK

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

Theme II. Conservation Agriculture, Carbon Sequestration and Climate Change

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

Soybean- Wheat cropping system

The higher plant height (56.53 cm), maximum no. of pods/ plant (42.06) and straw yield (37.62 q/ha), were recorded with 90% residue retention (Table 2.5.1a). The soybean yield levels were very low due to infestation of stem fly during the pod formation stage.

Table 2.5.1a Effect of different residue level retention on growth and yield parameters of soybean at harvest

Treatment	Plant Height (cm)	Branches/ plant	Pods/ plant	Seed yield q/ha	Straw yield q/ha	HI (%)
T1 (Control)	52.87	4.67	36.89	6.49	**32.88**	**17.00**
T2 (30% residue)	53.93	5.10	41.00	6.85	29.82	19.04
T3 (60% residue)	54.97	5.57	42.00	6.99	37.60	15.70
T4 (90% residue)	56.53	5.53	42.06	6.96	37.62	15.61
SEm±	0.560	0.095	1.132	0.669	1.762	1.302
CD (P=0.05)	1.688	0.287	3.413	NS	5.312	NS

The higher plant height (110.67cm), earhead length (24.72 cm), number of grain per earhead (114.08) grain (90.50 q/ ha) and straw (131.16 q/ha) yield of wheat were recorded with 90% residue retention compared to control. (Table 2.5.1b).

Table 2.5.1b Effect of different residue level retention on growth and yield attributes of wheat

Treatment	Plant height (cm)	Earhead Length (cm)	Number of grains per earhead	Grain Yield (q/ha)	Straw yield
T1 (without residue)	(q/ha)	22.32	103.32	80.42	116.56
T2 (30% residue)	105.57	23.18	107.73	83.06	120.69
T3 (60% residue)	108.00	23.73	109.96	85.83	124.69
T4 (90% residue)	110.67	24.72	114.08	90.50	131.16
SEm±	0.770	0.130	0.516	3.291	4.845
CD (P=0.05)	2.320	0.39	1.56	9.920	14.60

Maize- Chickpea cropping system

Maize

Maximum plant height at harvest (194.97 cm) was recorded with T4 treatment (90% residue). Maximum grain and straw yield (73.96q/ha and 129.38 q/ha) was recorded under T3 (60% residue) treatment which was at par with rest of the treatments. (Table 2.5.1c).

Table 2.5.1c Effect of different residue level retention on growth and yield parameters of Maize

Treatment	Plant height (cm)	Grain yield (q/ha)	Straw yield (q/ha)
T1	179.20	67.71	113.54
T2	183.50	72.25	120.00
T3	187.63	73.96	129.38
T4	194.97	73.63	115.79
SEm±	1.443	3.368	6.699

CD (P=0.05)	4.349	NS	NS
CD (P=0.05)	4.349	NS	NS

Chickpea

Among different residue level treatments, maximum plant height (61.57 cm), branches at harvest (35.73), maximum no. of pods/plant (96.06) and maximum grain and straw yield (20.28q/ha and 38.14q/ha) were recorded with T4 treatment (90% residue) (Table 2.5.1d).

Table 2.5.1d Effect of different residue level retention on growth and yield parameters of chickpea at harvest

Treatment	Plant Height (cm)	Branches/ plant	Pods/ plant	Seed yield	Straw yield (q/ha)	HI (%)
T1 (Control)	54.27	27.23	63.50	18.13	33.67	35.15
T2 (30% residue)	55.70	29.47	79.56	18.52	35.46	34.34
T3 (60% residue)	58.57	32.20	87.06	20.26	37.97	34.83
T4 (90% residue)	61.57	35.73	96.06	20.28	38.14	34.81
SEm±	0.259	0.425	1.844	0.849	1.889	0.476
CD (P=0.05)	0.780	1.280	5.558	NS	NS	NS

2.5.2 Impacts of conservation agriculture on run-off and soil loss under different cropping system in Vertisols

Two cropping systems namely soybean-wheat and maize-chickpea were evaluated for various parameters under various tillage and crop residue levels; (i) Conventional tillage (ii) Reduced tillage + 30 % crop residue (iii) Reduced tillage + 60 % crop residue (iv) No-tillage + 30 % crop residue (v) No-tillage + 60 % crop residue. The soil bulk density, pH, EC and plant growth parameters showed non-significant variation among treatments at 0-5 cm and 5-10 cm, (Table 2.5.2 & Fig. 2.5.2). Total soil loss ranged from 2.57 to 6.77 t/ha among various tillage and crop residue levels; however, runoff ranged from 21.42 to 34. 59 % of total rainfall.

Plate 2.5.2 Overview of experimental field

Table 2.5.2 Wheat and Chickpea crop productivity and grain-straw ratio

Treatments	Wheat Yield ($t\ ha^{-1}$)	Grain/Straw	Chickpea Yield ($t\ ha^{-1}$)	Grain Straw ratio
Conventional Tillage	5.06±0.31	0.87±0.032	2.17±0.05	0.69±0.017
Reduced Tillage + 30% residue.	5.10±0.09	0.88±0.037	2.09±0.06	0.70±0.026
Reduced Tillage + 60 % residue	5.2±0.12	0.91±0.032	2.21±0.11	0.67±0.026
No Tillage + 30 % residue.	5.05±0.08	0.88±0.043	2.17±0.02	0.67±0.033
No Tillage + 60% Residue	5.18±0.01	0.92±0.023	2.13±0.02	0.68±0.050
LSD (P=0.05)	NS	NS	NS	NS

2.5.3 Variation in the near-surface soil moisture content of Madhya Pradesh state during last 40 years (1980-2019)

The daily near-surface (0-5 cm depth) volumetric soil moisture data (1980 to 2019) were acquired from the European Space Agency (ESA) Climate Change Initiative (CCI) for Madhya Pradesh. The average near-surface soil moisture content was computed for both *Kharif* and *Rabi* cropping seasons. The near-surface soil moisture in the *Kharif* season ranged from 0.25 to 0.34 m^3/m^3 with a mean value of 0.29 m^3/m^3; Whereas, it ranged from 0.15 to 0.24 m^3/m^3 with a mean value of 0.19 m^3/m^3 during *Rabi* season. The average near-surface soil moisture during the *Kharif* season was 54.6% higher than the *Rabi* season and the coefficient of variation (CV) was 5.81 and 10.28 % for *Kharif* and *Rabi* seasons, respectively (Fig. 2.5.3a).

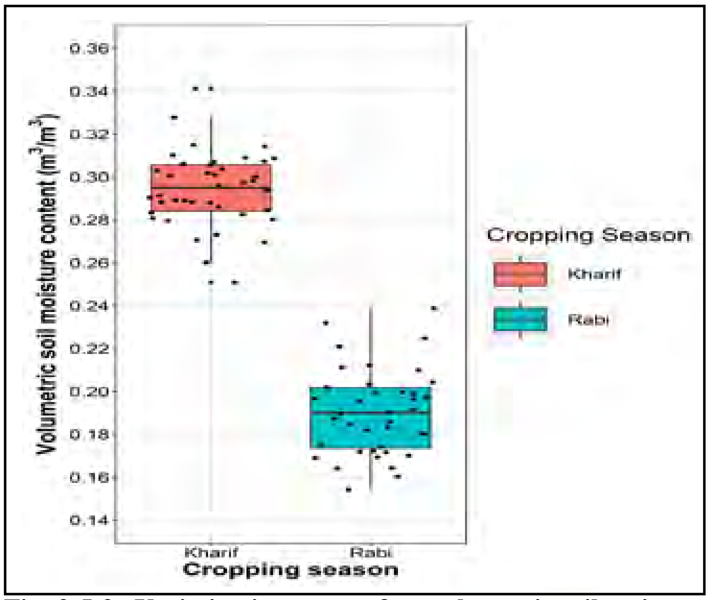


Fig. 2.5.3a Variation in near-surface volumetric soil moisture content (m^3/m^3) in Madhya Pradesh in Kharif and Rabi cropping seasons

During *Kharif* cropping season, the maximum near-surface volumetric soil moisture content (VSMC) was found in the year 2013 across all agro-climatic zones ranging from 0.29 m^3/m^3 (Bundelkhand zone) to 0.39 m^3/m^3 (Chhattisgarh plains). On the other hand, the lower near-surface VSMC in most of the agro-climatic zones during *Kharif* season was found in the year 1992, *i.e.* Northern hill region of Chhattisgarh (0.23 m^3/m^3), Kymore plateau & Satpura hills (0.23 m^3/m^3), Central Narmada valley (0.26 m^3/m^3), Vindhayan plateau (0.26 m^3/m^3), Satpura plateau (0.26 m^3/m^3), Malwa plateau (0.26 m^3/m^3) and Nimar plains (0.26 m^3/m^3). The near-surface VSMC during *Kharif* season for the period 1980 to 2019 under different agro-climatic zones are presented in figure 2.5.3b.

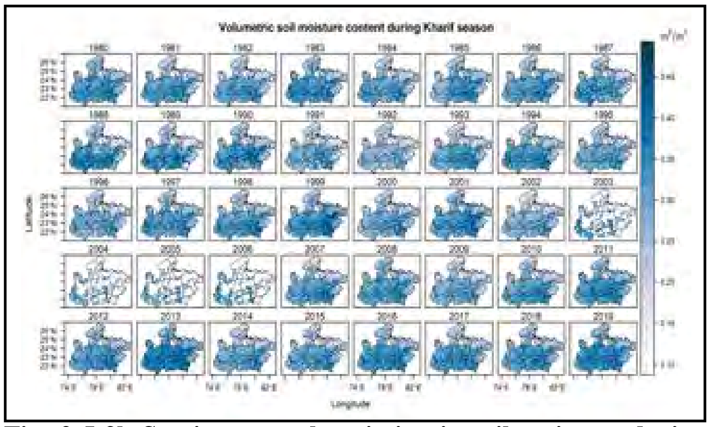


Fig. 2.5.3b Spatiotemporal variation in soil moisture during Kharif season in Madhya Pradesh

During the *Rabi* cropping season, the higher near-surface VSMC was found across most agro-climatic zones during 1982 and 1989, ranging from 0.20 m^3/m^3 (Bundelkhand zone) to 0.33 m^3/m^3 (Satpura plateau). However, the lower near-surface VSMC was found during the years 1992 and 2000, ranging from 0.13 m^3/m^3 (Northern hill region of Chhattisgarh, Kymore plateau & Satpura hills, and Bundelkhand zone) to 0.18 m^3/m^3 (Central Narmada valley). The near-surface VSMC during rabi season for the period 1980 to 2019 under different agro-climatic zones are shown figure 2.5.3c.

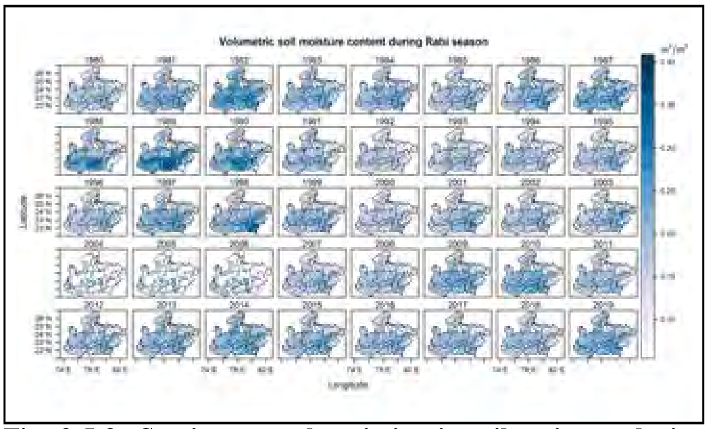


Fig. 2.5.3c Spatiotemporal variation in soil moisture during Rabi season in Madhya Pradesh

2.5.4 Tillage and nitrogen management effects on soil hydraulic conductivity (SHC) in maize based cropping systems in Vertisols

Tillage and nitrogen management effect on soil hydraulic conductivity (SHC) was studied after ten years of continuous treatment imposition. The SHC under the no-tillage (NT) was higher compared to conventional tillage (CT). Under both the tillage system, higher SHC was reported with a higher nitrogen application rate and decreases with increase in soil depths. This study further showed that tillage and nitrogen management significantly affected the SHC up to 20 cm of soil depth (Table2.5.4).

Table 2.5.4 Effect of tillage and Nitrogen application on saturated hydraulic conductivity (cm hr^{-1})

Tillage	Nitrogen	0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm
Conventional tillage (CT)						
	150%N	0.91	0.85	0.44	0.34	0.20
	100%N	0.87	0.73	0.38	0.28	0.24
	50%N	0.95	0.67	0.33	0.21	0.28
	0%N	0.74	0.58	0.35	0.15	0.35
No-tillage (NT)						
	150%N	1.32	1.10	1.21	0.42	0.40
	100%N	0.94	1.18	0.63	0.39	0.47
	50%N	0.79	0.53	0.53	0.32	0.42
	0%N	0.69	0.32	0.42	0.33	0.19
	LSD (P=0.05)	0.15	0.36	0.29	0.11	NS

Yield gap analysis of Pigeon pea in India

A well-validated APSIM crop growth model was employed to estimate pigeon pea potential yield, whereas actual yield was collected from state agriculture departments of 2017-19. The highest and lowest potential yield was obtained in Haryana (2500 kg ha^{-1}) and Andhra Pradesh (1870 kg ha^{-1}), respectively. However, the highest and lowest observed yield, i.e. state average yield, was reported in Chhattisgarh (2000 kg ha^{-1}) and Haryana (1150 kg ha^{-1}), respectively. The yield gap was highest in Haryana state (1350 kg ha^{-1}), followed by Rajasthan and Himachal Pradesh. The lowest yield gap was found in the Tamilnadu state (300 kg ha^{-1}) (Fig. 2.5.4).

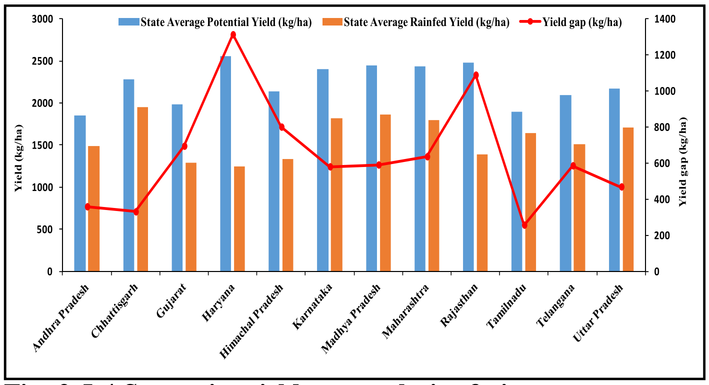
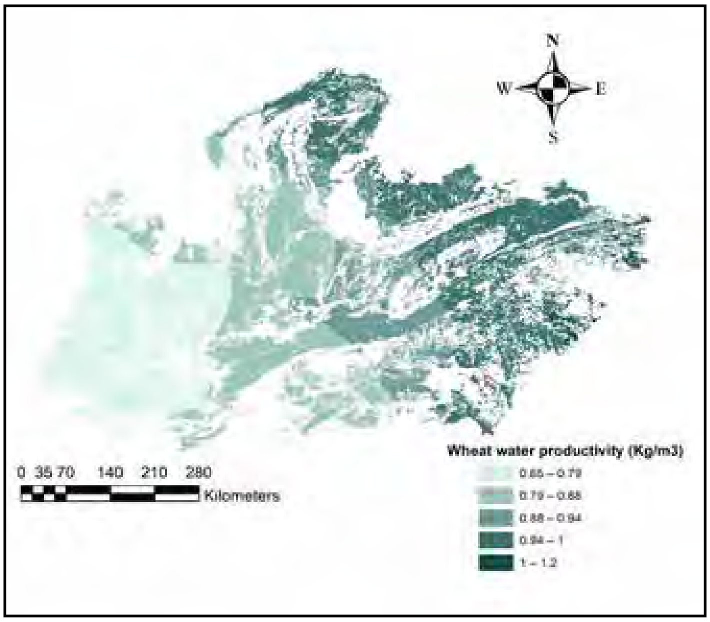


Fig. 2.5.4 State-wise yield gap analysis of pigeon pea

2.5.5 Characterization of spatial variation in crop water productivity in Madhya Pradesh state

The APSIM crop model was used to estimate daily evapotranspiration (ET) between sowing and physiological maturity, aggregated to derive seasonal ET. Daily ET is simulated based on evaporative demand, soil water content, and crop leaf area. Daily changes in soil water content are computed based on precipitation, ET and water losses through surface runoff and deep drainage. There is significant variation in WP of maize and wheat crop over the Madhya Pradesh state. The WP ranged from 0.6 to 1.9 kg m^{-3} for maize and 0.65 to 1.2 kg m^{-3} for wheat. Variation in WP is attributed not only to climate and soil but also to the management practices adopted during the crop growing season. Therefore, there is a need to prioritize areas for management interventions for enhancing crop yield and WP through the spatial distribution WP (Fig. 2.5.5).



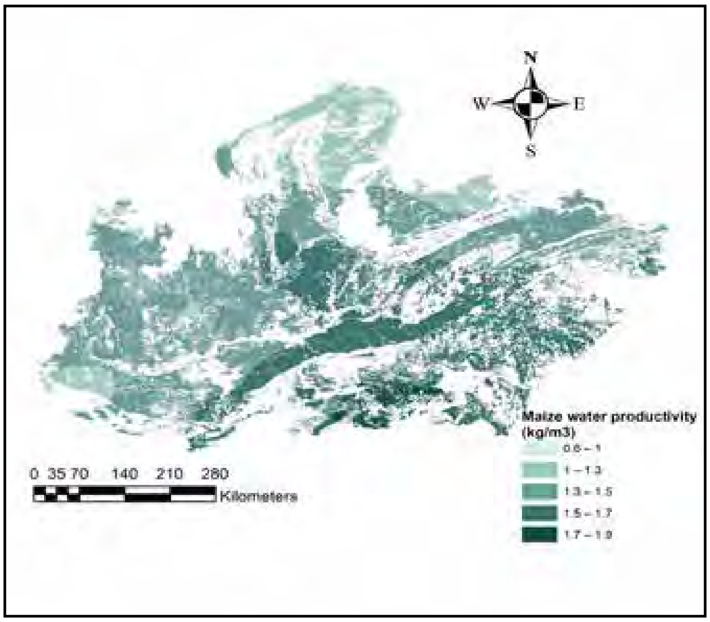


Fig. 2.5.5 Spatial variability of mean crop water productivity of (a) Maize and (b) wheat crop in Madhya Pradesh state

2.5.6 Climate change effects on maize productivity under different nitrogen (N) management strategies

The impact of present and future climates on maize grain yield and biomass under different long term N management scenarios was studied in Madhya Pradesh. The results showed that maize yield under different N management scenarios differs substantially. The N0%, N50%, N100%, N150% and 100% organic treatments have 50% chance of yield greater than 1.0, 3.40, 4.20, 4.45 and 3.84 t ha^{-1}, respectively (Fig.2.5.6). The results of climate change impact on maize grain and biomass yield showed that the maize grain yield decreased by -21.8%, -23.2%, -22.3% and -23.8% under RCP 4.5 (2050s), RCP 4.5 (2080s), RCP

8.5 (2050s) and RCP 8.5 (2080s), respectively in 100% organic treatments compared to baseline scenarios. The biomass yield reduction was observed in organic treatment was -15.9%, -16.9%, -16.6, and -17.7% for RCP 4.5 (2050s), RCP 4.5 (2080s), RCP 8.5 (2050s) and RCP 8.5 (2080s), respectively. For the 0% N, under different RCPs, a decrease in maize grain and biomass yield ranged from -16.6% to - 23.9% and -21.5% to -22.5%, respectively, compared to baseline. For the 50% N, the maize grain yield was decreased by -19.1%, -20.8%, -20.3% and -22.2%, while maize biomass yield was reduced by -14.9%, -15.9%, -15.8% and -16.9% under RCP 4.5 (2050s), RCP 4.5 (2080s), RCP 8.5 (2050s) and RCP 8.5 (2080s), respectively, compared to the baseline scenario. Similarly, the decrease in maize grain and biomass yield for 100% N treatment varied between -18.8% to -21.9% and -15.2% to -17.2%, respectively. However, for 150%N, the decline in maize grain and biomass yield was observed to be between -16.6 to -23.9%, and -14.0 to -17.7%, respectively (Table 2.5.6).

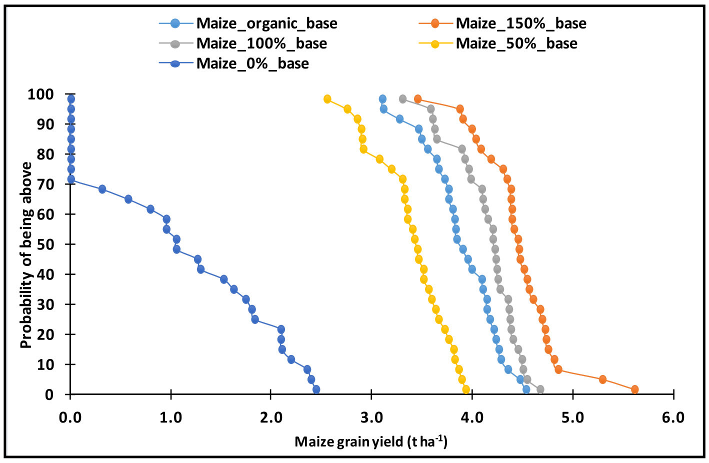


Fig. 2.5.6 Probability of exceedance of maize yield under different nitrogen management strategies for 30 years

Table 2.5.6 Maize grain and biomass yield under different nitrogen management strategies in response to climate change

		100 % Organic	150% N	100% N	50% N	0% N	100 % Organic	150% N	100% N	50% N	0% N
				Grain yield (t ha^{-1})					Biomass yield (t ha^{-1})		
Base (1980-2010)		3.9	4.5	4.1	3.4	1.1	8.5	9.1	8.8	8.0	3.3
RCP45	2050	3.0 (-21.8)	3.7 (-16.6)	3.4 (-8.8)	2.7 (-19.1)	0.6 (-48.5)	7.1 (-15.9)	7.9 (-14.0)	7.5 (-15.2)	6.8 (-14.9)	2.6 (-21.5)
	2080	3.0 (-23.2)	3.6 (-19.1)	3.3 (20.6)	2.7 (-20.8)	0.6 (-40.3)	7.0 (-16.9)	7.7 (-15.5)	7.4 (-16.3)	6.7 (-15.9)	2.6 (-19.4)
RCP85	2050	3.0 (-22.3)	3.7 (-17.4)	3.3 (-19.6)	2.7 (-20.3)	0.6 (-40.2)	7.1 (-16.6)	7.8 (-14.7)	7.4 (-15.8)	6.7 (-15.8)	2.6 (-21.3)
	2080	2.9 (-23.8)	3.4 (-23.9)	3.2 (-21.9)	2.6 (-22.2)	0.6 (-40.2)	7.0 (-17.7)	7.5 (-18.3)	7.3 (-17.2)	6.6 (-16.9)	2.5 (-22.5)

2.5.7 Impact of long-term imposition of conservation agriculture practices on soil organic carbon (SOC) and aggregate associated carbon content and system productivity

The SOC content was significantly affected by both the tillage and cropping systems (Fig. 2.5.7a). The NT system recorded significantly higher SOC content (0.83%) than CT (0.69%) at 0-5 cm soil layer. Similarly, in the 5-15 cm soil layer, the SOC content was significantly higher in the NT than CT. Among the cropping systems evaluated, maize-gram and maize-wheat recorded significantly higher SOC content (0.84%) followed by soybean-wheat (0.81%) under NT. Whereas under CT, SOC content (0.65%) at 0-5 cm depth was minimum in the maize-wheat system. The interactive effect of tillage × cropping system × soil depth was not significant for SOC. Higher SOC content in the surface soil was attributed to crop residue addition and relatively less soil disturbance by tillage operations under NT.

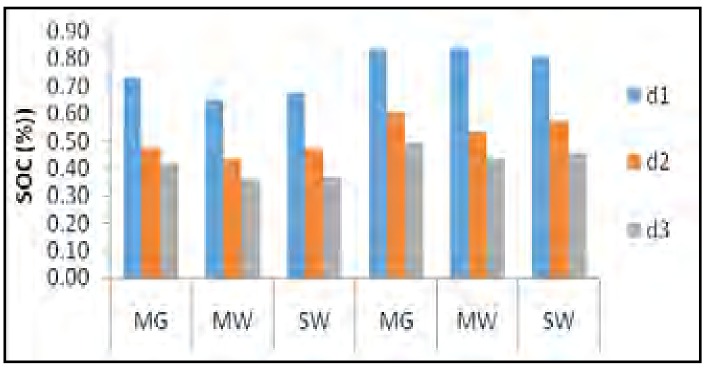


Fig. 2.5.7 Effect of tillage and cropping systems on soil organic carbon (SOC). (MG-Maize-Gram; MW-Maize-Wheat; SW-Soybean-Wheat; d1-0-5cm, d2-5-15cm, d3-15-30cm)

Aggregate associated carbon content: The aggregate-associated C content increased with aggregate size, and followed order of large macroaggregate (LM) > small macro-aggregate (SM) > micro-aggregate (M) > silt+clay (S+C). Tillage practices and cropping systems had a significant effect on large macro aggregate associated-C. Similarly, tillage had a significant effect on small macro-aggregate associated C. In contrast, cropping systems had a significant effect on micro-aggregate associated C and silt +clay fraction C. The interaction effect of cropping system × depth was significant for LM-C, but the interaction effect was not significant for the other aggregate associated C classes. The LM aggregate associated C for NT (0.93%) was significantly higher than that for CT (0.83) at 0-5 cm depth. The aggregate C in all the size fractions decreased at lower depths, i.e. 5-15 cm and 15-30 cm (Fig. 2.5.7).

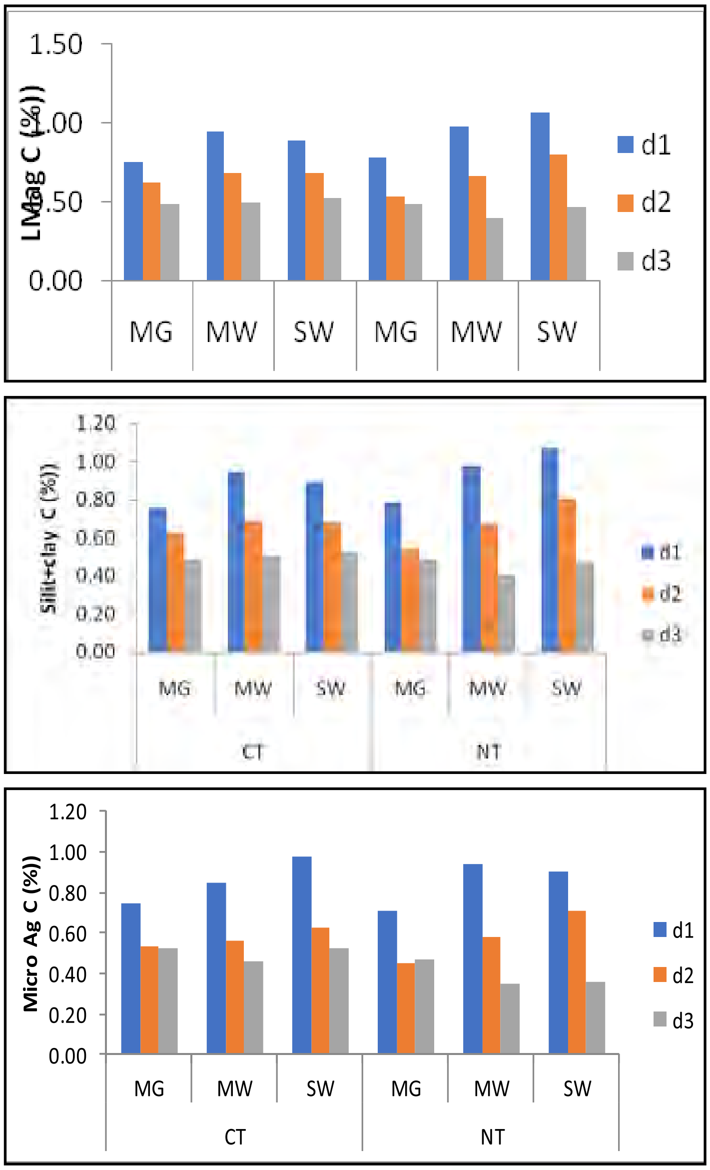


Fig 2.5.7b Effect of different tillage and cropping system on aggregate associa) Silt+Clay C

System productivity: Tillage practices showed no significant effect on the soybean grain equivalent yield (SGEY), whereas cropping system significantly affected the SGEY. Among various cropping system studied, maximum SGEY were recorded in maize-gram followed by maize-wheat cropping system. The minimum SGEY were recorded in soybean-wheat cropping system regardless of tillage practice. SGEY was slightly higher in NT than CT for all the cropping systems (Fig 2.5.7c).

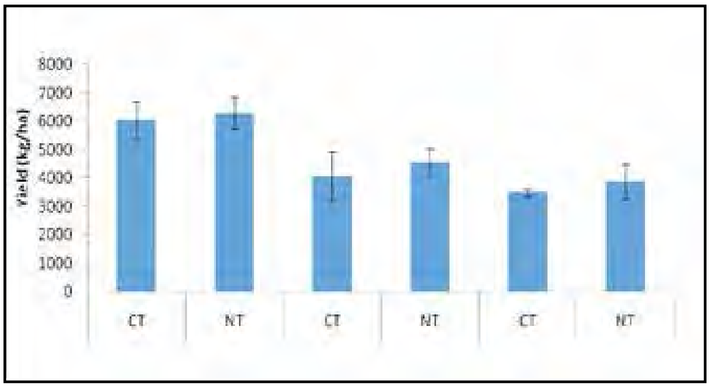


Fig. 2.5.7c Effect of different tillage and cropping system on soybean grain equivalent yield (kg ha^{-1})

2.5.8 Fine-tuning of Conservation Agricultural Practices for Vertisols of Central India

Field experiments on soybean-wheat and maize-chickpea cropping systems were initiated during Kharif 2015 with five tillage treatments as the main plot and three nutrient treatments as sub-plot with three replications following split-plot experimental design. In the new experimental setup, crops were raised with two different levels of residue retention i.e. 30 cm and 60 cm height residue retention, each under a reduced and no-tillage system (Fig. 2.5.8a).

Plate 2.5.8 Sowing and establishment of soybean crop under CA experiment

Impact on five years (2015-2020) average crop yield: Mean data of five years showed that the tillage system did not have a significant effect on crop yield (Soybean and Maize) (Fig. 2.5.8b and 2.5.8c) and Wheat yield. However, residue retention @30cm height treatment under both the NT and RT systems performed better in terms of crop establishment than 60cm height residue retention. On the other hand, the yield of maize was very low during 2019 as the crop suffered due to heavy rainfall. Mean data of soybean grain yield varied from 995 to 1150 kg/ha; maize grain yield varied from 2712 to 2948 kg/ha; wheat grain yield varied from 4245 to 4365 kg/ha.

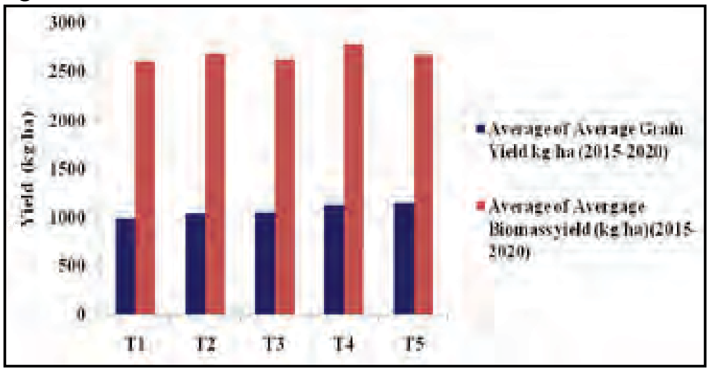


Fig. 2.5.8a Effect of different tillage on soybean yield (Average of five years- 2015-2020)

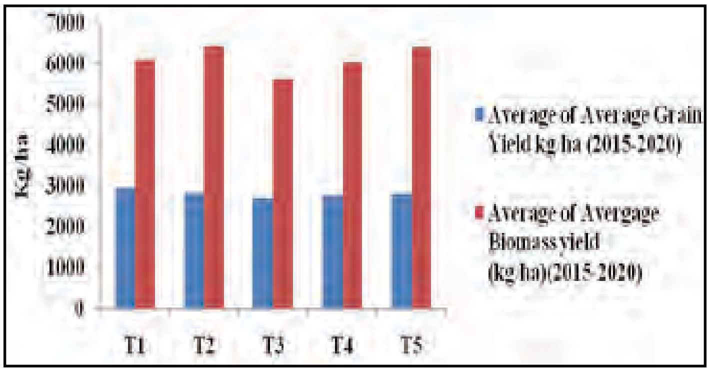


Fig. 2.5.8b Effect of different tillage on maize yield (Average of five years- 2015-2020)

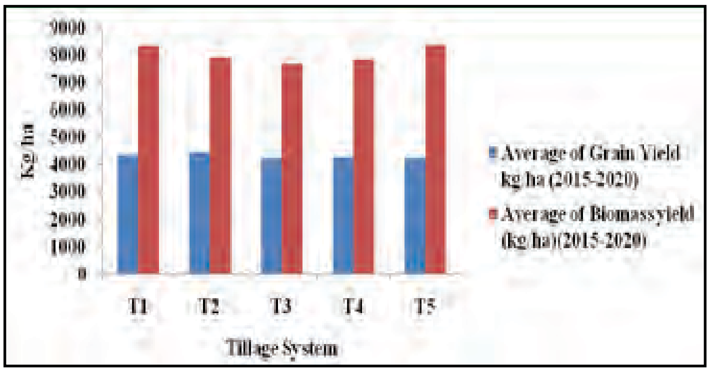


Fig. 2.5.8c Effect of different tillage on wheat yield (Average of five years- 2015-2020)

2.5.9 Effect of irrigation methods and nutrient management in Conservation Agriculture on crop yield and water use efficiency

During the rabi season of 2019-20, 60 and 80 per cent of the flood irrigation water were applied to the drip and sprinkler irrigation plots. Among the irrigation treatment, highest wheat yield was recorded in drip irrigation (5965 kg/ha) followed by sprinkler irrigation (5621 kg/ha), and the yield was the minimum (5490 kg/ha) in flood irrigation.

Among the tillages, grain and biomass yield did not vary significantly. The water use efficiency was significantly higher in drip and sprinkler irrigation than in flood irrigation. The sprinkler and drip irrigation system was found suitable for the efficient application of limited irrigation water under the conservation agricultural system with the concomitant saving of irrigation water and improvement in water productivity (Plate 2.5.9). Application of fertilizer at 75% recommended dose for fertilizer could maintain yield level of wheat similar to that of fertilizer application at 100% recommended dose indicating a probable saving of fertilizer under the CA system (Table 2.5.9).

Table 2.5.9 Effect of irrigation, tillage and fertilizer levels on grain, straw yield and water use efficiency of wheat

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	WUE (kg ha^{-1} mm^{-1})
	2019-20	2019-20	2019-20
Irrigation methods			
FI (Flood Irrigation)	5490	7604	13.9
SI (Sprinkler Irrigation)	5621	8061	16.5
DI (Drip Irrigation)	5965	8417	20.7
LSD (0.05)	NS	NS	1.66
Tillage systems			
CT	5943	8379	17.7
RT	5600	7725	16.9
NT	5533	7978	16.5
LSD (0.05)	NS	NS	NS
Nutrient Doses			
F1 (100% RDF)	5688	7589	17.0
F2 (75% RDF)	5576	7865	16.7
F3 (STCR Dose)	5770	8508	17.3
F4 (75% +25% LCC)	5733	8146	17.2
LSD (P=0.05)	NS	NS	NS


Plate 2.5.9 Wheat crop grown under different irrigation system and CA practices

2.5.10 Mid-Infrared Spectroscopic Technique for Rapid Assessment of Key Soil Health Parameters

More than a thousand geo-referenced soil samples from Inceptisols and Alfisols of India were used to develop robust MIR based chemometric prediction models. A spectral library of Indian soils was also created (Fig. 2.5.10a). MIR spectral regions, important for the prediction of some soil properties, were identified (Fig. 2.5.10b). Partial Least Squares Regression (PLSR), Support Vector Machine (SVM) and Random Forest

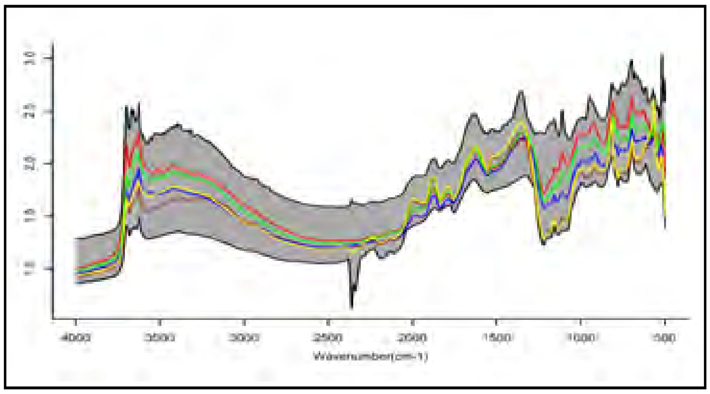


Fig. 2.5.10a Five representative raw mid-infrared absorption spectra of the samples. Grey spectral envelope encompasses the maximum and minimum MIR absorbance values of all the soil samples at each wave number

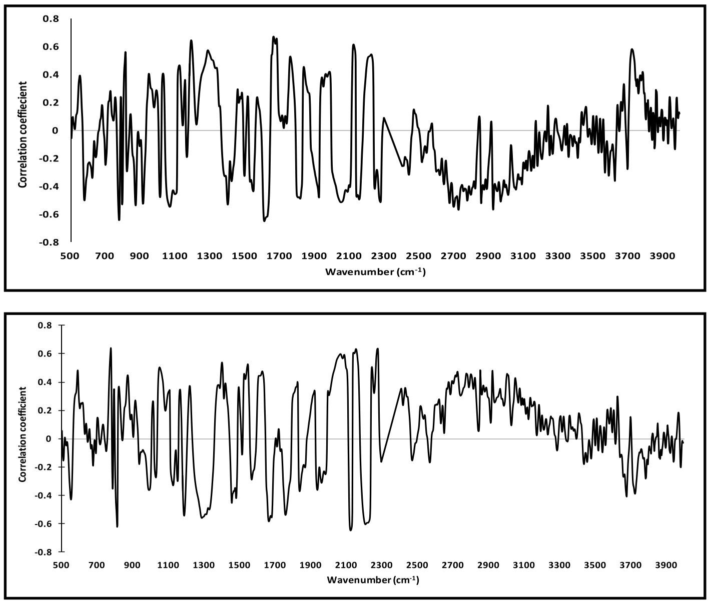


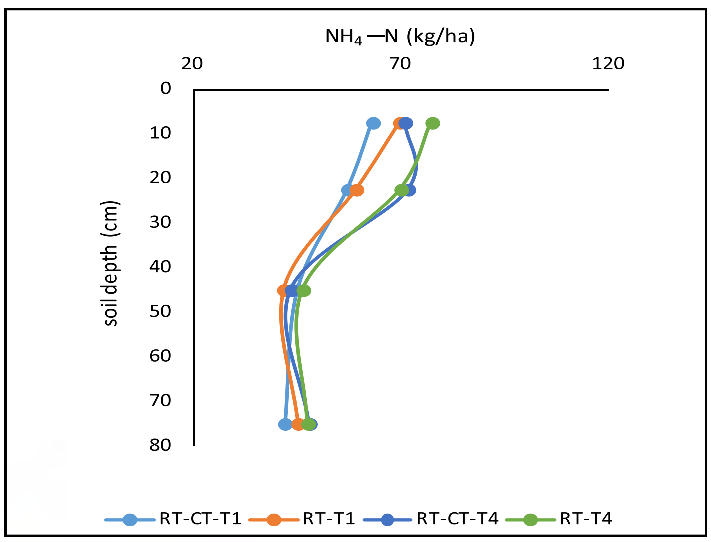
Fig. 2.5.10b Spectral distribution of correlation coefficients of the partial least-squares regression (PLSR) model for a. sand and b. clay percentage

Partial Least Squares Regression (PLSR), Support Vector Machine (SVM) and Random Forest Regression techniques in general performed better for estimation of most of the soil properties. Among the different properties evaluated, soil organic carbon concentration, pH, sand, silt and clay content, soil water retention capacity at field capacity and permanent wilting point were predicted with reasonably good accuracy (R^2>0.7). MIR spectroscopy showed good potential for simultaneous estimation of these properties for the Inceptisols and Alfisols of India.

2.5.11 Nutrient stoichiometry and utilization efficiency in soybean influenced by tillage and nutrient management in Vertisols of Central India

The effect of tillage and fertilizer management on dry matter distribution, nutrient uptake, stoichiometry and utilization efficiency in soybean was studied. The treatments were 100% NPK (T1), 100% NPK + FYM @ 1.0 Mg-C ha-1 (T2) and 100% NPK + FYM @ 2.0 Mg-C ha^{-1} (T3). After eight years the RT and NT treatments were subjected to conventional tillage. and thus the tillage treatments were RT-CT, RT, NT, and NT-CT. The highest soybean yield and nutrient uptake (N, P, K) was in NT-CT with 100% NPK + FYM @ 2.0 Mg-C ha $^{-1}$ (T3). The seed yield ranged from 845 to 1546 kg/ha. The N:P ranged from 5.5:1 to 12:1 and 8.5:1 to 10.4:1 in stem and seed, respectively. The N:K ranged from 1.4:1 to 2.6:1 and 3.4:1 to 4.3:1 in stem and seed, respectively. There was significant ($P<0.05$) negative correlation between N:P of stem and nitrogen harvest index. A positive correlation observed between phosphorus, potassium harvest index and their utilization efficiency. Integrated use of nutrients consistently increased the nutrient harvest index and utilization efficiency by 11% (NHI), 15% (NUE), 16% (PHI), 15% (PUE), 23% (KHI) and 15% (KUE) over 100% NPK fertilization. In tillage treatments, tillage operations with residue incorporation (NT-CT, RT-CT) were superior to no-tillage on nutrient utilization efficiency. Overall, nutrient uptake, utilization efficiency and soybean yield were highest in tilled plots with 30 percent residue return and integrated use of nutrients.

The vertical distribution of ammonical N was higher at the upper soil layer (0-15 cm) compared to the deep soil layer although there was an positive peak at the depth 60- 100 cm in the soil profile, irrespective of tillage, fertilizer and sampling dates. Averaged over the sampling dates, the profile distribution of soil nitrate -T1 and NT-CT-T1 (Fig. 2.5.11a and b). However, in the tillage treatments where FYM @ 2 Mg/ha was applied with 100% NPK fertilizer (T4) soil nitrate concentration was higher at 15-30 cm and 60-100 cm soil depth compared to 0-15 and 30-60 cm.



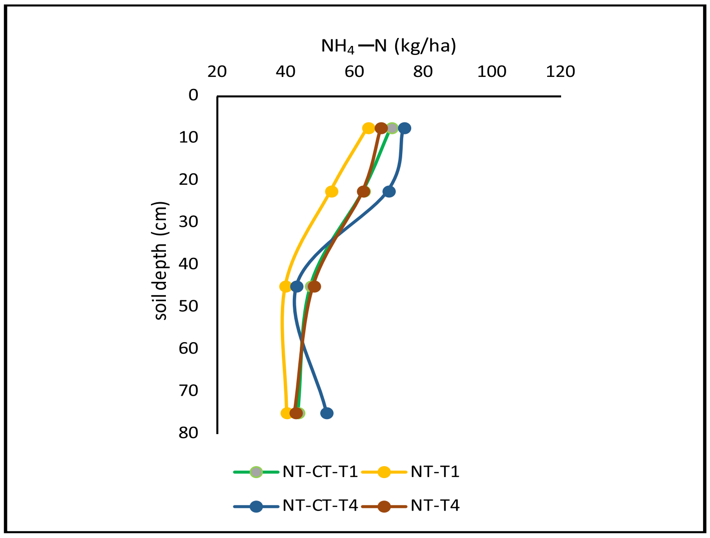


Fig.2.5.11a Profile distribution of ammo i cal N (averaged for sampling dates) under different tillage and fertilizer management

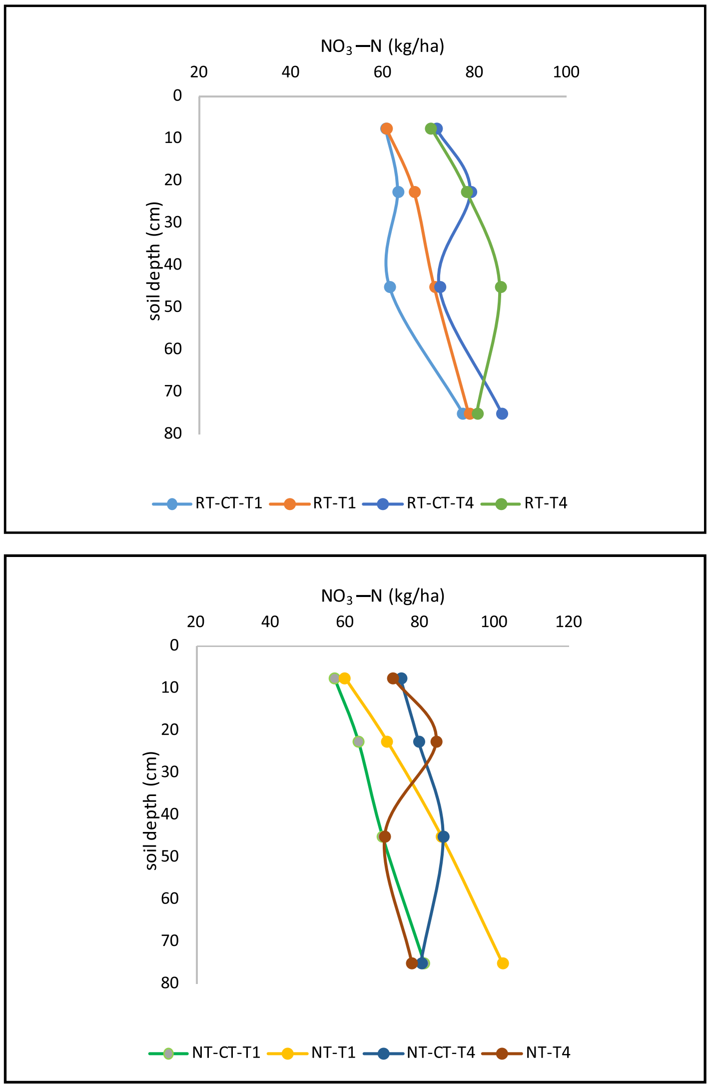


Fig. 2.5.11b Profile distribution of nitrate N (averaged for sampling dates) under different tillage and fertilizer management.

Crop yield under different nutrient management and tillage reversal in Vertisols

The main effects of tillage and fertilizer were significant ($P<0.05$) on wheat grain and biomass yield and higher was observed in NT-CT-T4. The mean wheat grain yield ranged from 4.03 (NT-T1) to 6.78 (NT-CT-T4) Mg ha-1. The NPK+FYM (T4) increased the yield by 17to 38% over NPK fertilization (T1). Irrespective of fertilizer application, NT-CT treatment had significantly increased the biomass (22%) and grain yield (31%) than NT (Fig. 2.5.11c).

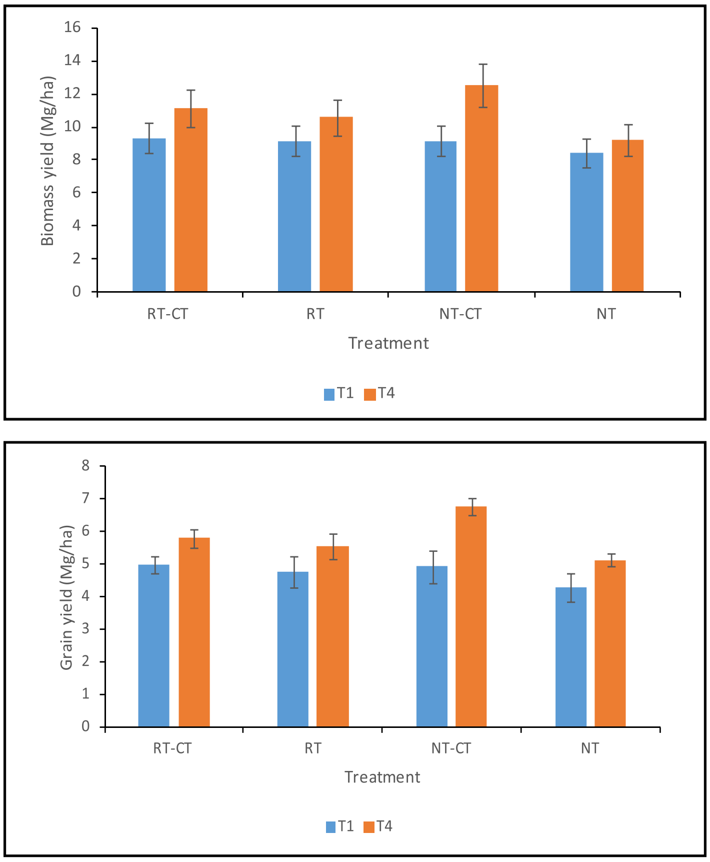


Fig. 2.5.11c Effect of tillage and fertilizer on wheat grain and biomass yield

2.5.12 Effect of climate, nutrient management and soil type on vertical distribution of carbon and nitrogen under long-term soybean-based cropping system

Long term soil management significantly influenced the vertical distribution of soil organic carbon (SOC), total nitrogen (TN) and nutrient cycling enzyme activity (C and N) in soybean-based cropping systems under different ACRs. The TOC and TN in the top 30 cm (relative to the total top 90 cm) averaged 65 and 76% (Vertisols of Bhopal), 71 and 68% (Vertisols of Jabalpur), 60 and 68%

(Vertisols of Indore); and 80 and 71%, (Alfisol of Ranchi), respectively. The result further revealed that profile distribution of SOC and TN content decreased with increase in temperature and precipitation (Fig. 2.5.12). A significant negative correlation was found between sand, maximum temperature and SOC. Reduced tillage together with 30% residue retention and application of 100% NPK + FYM @ 6 t/ha had the highest SOC sequestration (344 kg/ha/yr) for 0-15 cm soil depth. The order of SOC sequestration is soybean-wheat > soybean-chickpea > soybean-fallow cropping system. Further, the integrated use of nutrients (100% NPK+ FYM) increased SOC storage and enzyme activities over NPK fertilization.

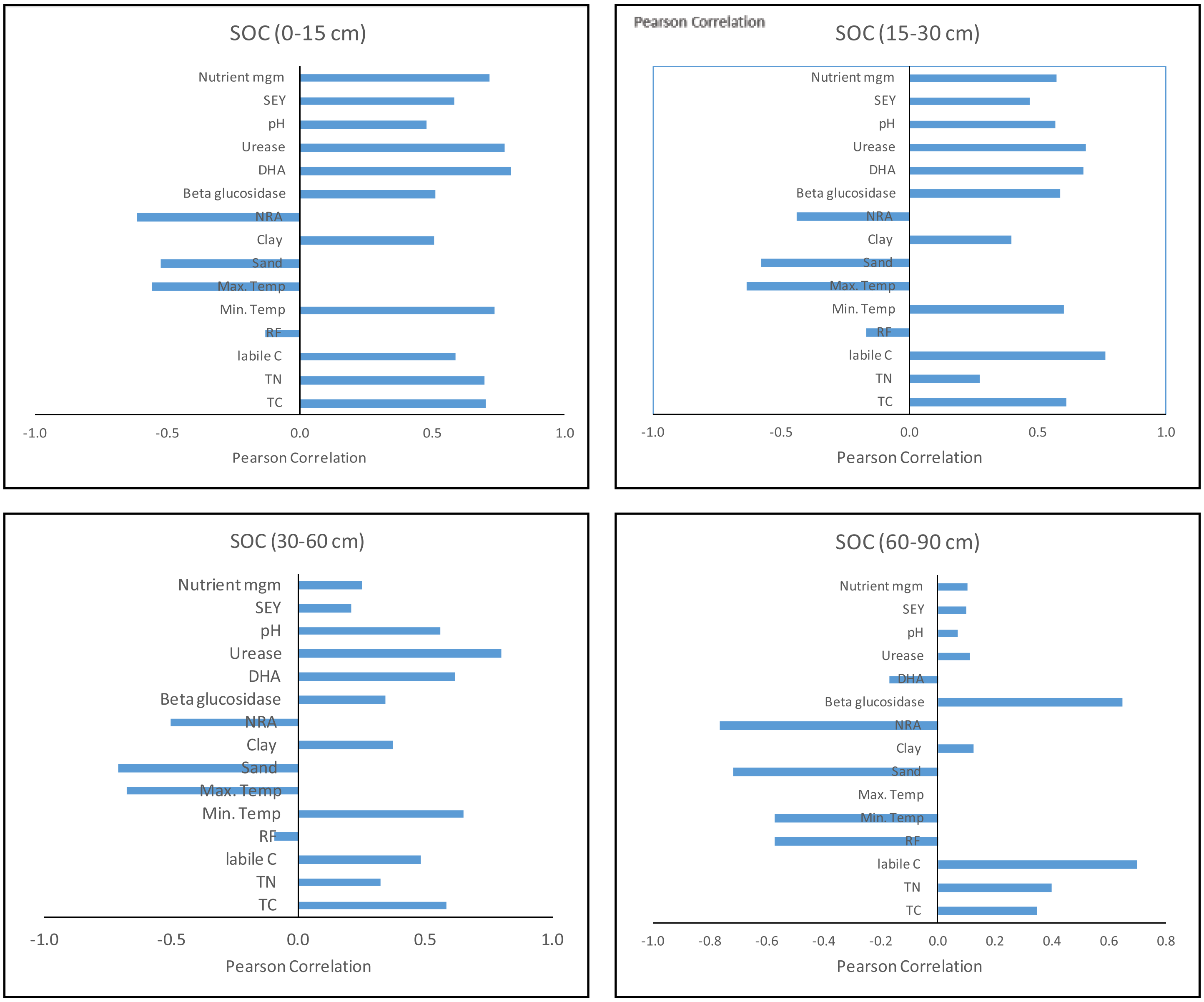


Fig. 2.5.12 Relative importance of climatic drivers, soybean equivalent yield, soil nutrient management and soil properties on vertical distribution of soil organic carbon. The relative importance was denoted by Pearson correlation coefficient. Nutrient mgm: nutrient management; SEY: soybean equivalent yield; DHA: Dehydrogenase activity; NRA: nitrate reductase activity; RF: rainfall; TN: total nitrogen; TC: total carbon

Theme -III: Microbial Diversity and Genomics

2.6 Microbial Diversity and Genomics

2.6.1 Evaluation of organic, inorganic and integrated crop management practices on different crops

The seed yield of wheat, mustard, chickpea and linseed significantly varied in different nutrient management systems. The highest seed yield of wheat, mustard, chickpea and linseed was recorded with 75 % organic + 25 % inorganic followed by 100% organic treatment practices, which were higher than 100% inorganic and state recommendation. In general, integrated management was better than sole organic and inorganic management systems. System productivity was found to be higher in the soybean–chickpea cropping system (Fig. 2.6.1).

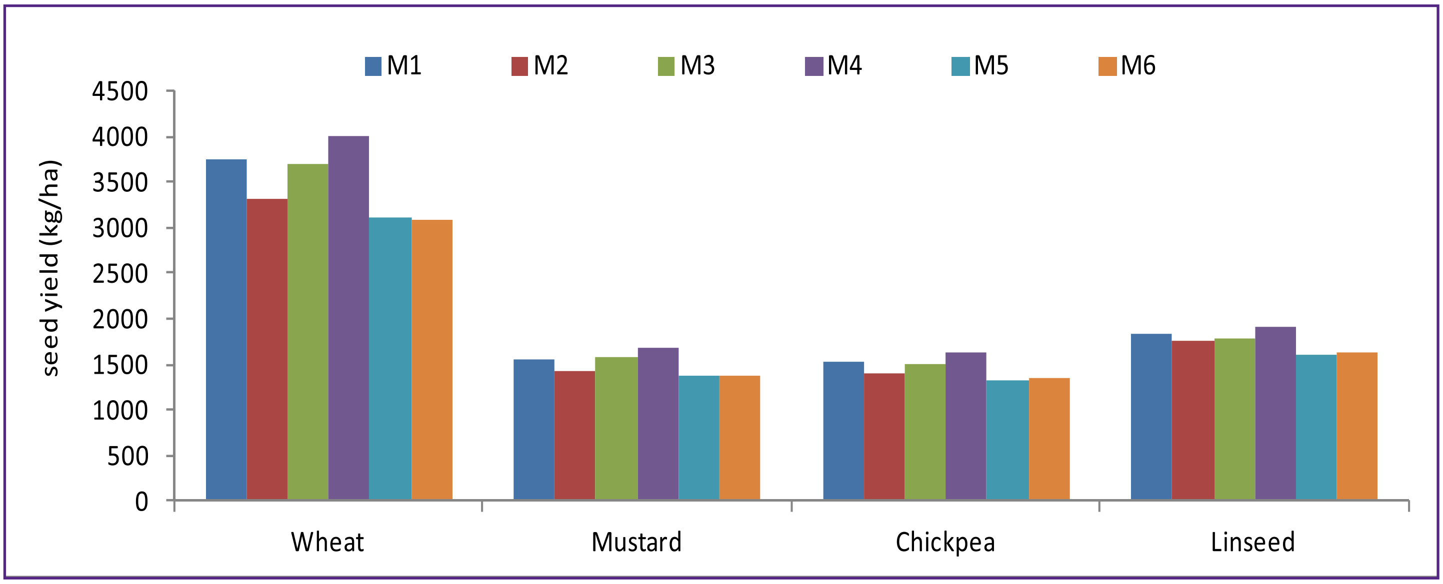


Fig. 2.6.1 Yield of wheat, mustard, chickpea and linseed (kg ha^{-1}) under different nutrient management practices Management practice: (M1) 100% organic (Organic manure equivalent to 100 % N requirement of the system),(M2) 75 % organic (Organic manure equivalent to 75 % N requirement of the system) +innovative practices (spray of cow urine and vermi-wash 10% each twice), (M3) 50 % Organic + 50 % inorganic, (M4) 75% Organic + 25 % inorganic, (M5) 100% inorganic package, (M6) State recommendations

2.6.2 Response of wheat and chickpea varieties under organic farming

Twelve varieties of wheat and chickpea were evaluated under organic nutrient management practices. Among the wheat varieties, higher grain yield was observed in GW-366 (4380 kg ha^{-1}) followed by GW-322 (3962 kg ha^{-1}) and Malwa shakti (3953 kg ha^{-1}). Among the different varieties of chickpea, JG-130 (1813 kg ha^{-1}) recorded highest grain yield (Fig. 2.6.2a and b).

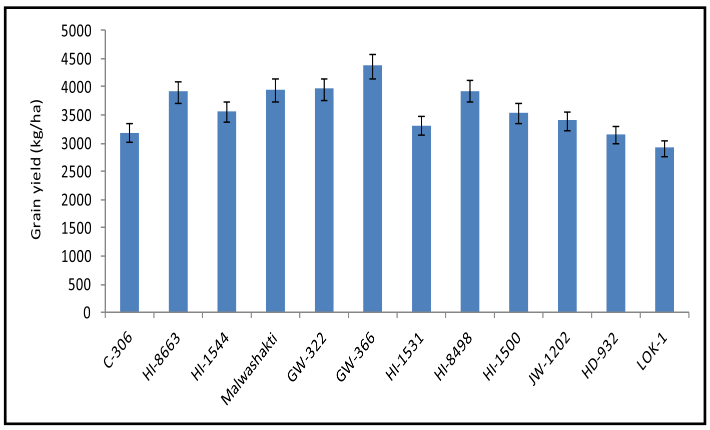


Fig. 2.6.2a Evaluation of different varieties of wheat crops under organic practices

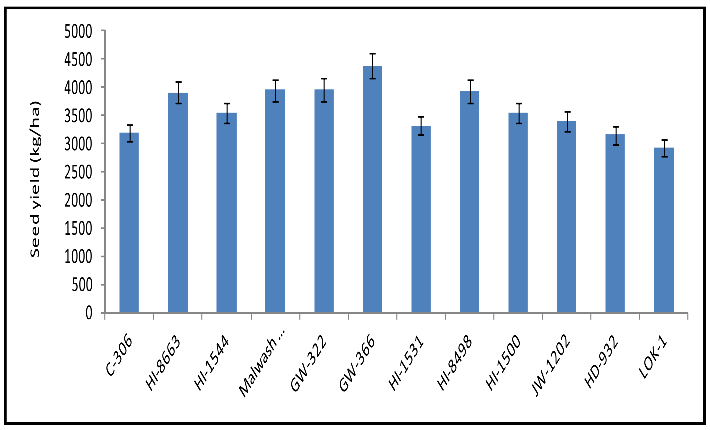


Fig. 2.6.2b Evaluation of different varieties of chickpea crops under organic practices

2.6.3 Assessment of soil biological properties under different nutrient management systems

The FDA, dehydrogenase, alkaline phosphatase and β Glucosidase enzymes activities were highest under 100% organic followed by 75% organic+ innovative, 75 % organic + 25 % inorganic and 100 % inorganic in soybean based cropping systems. Among the cropping systems, soybean-wheat recorded higher FDA followed by soybean-mustard and soybean-chickpea (Fig. 2.6.3a, b, c and d).

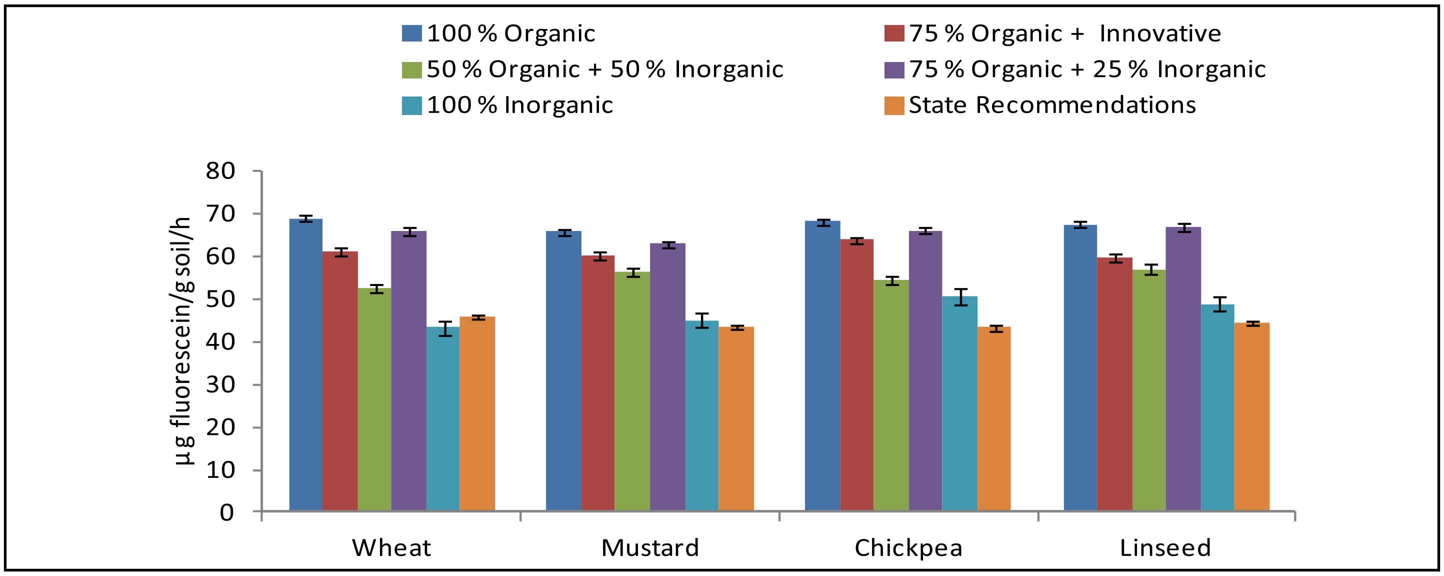


Fig. 2.6.3a Fluorescein diacetate (FDA) hydrolysis activity as affected by different nutrient sources in different crops

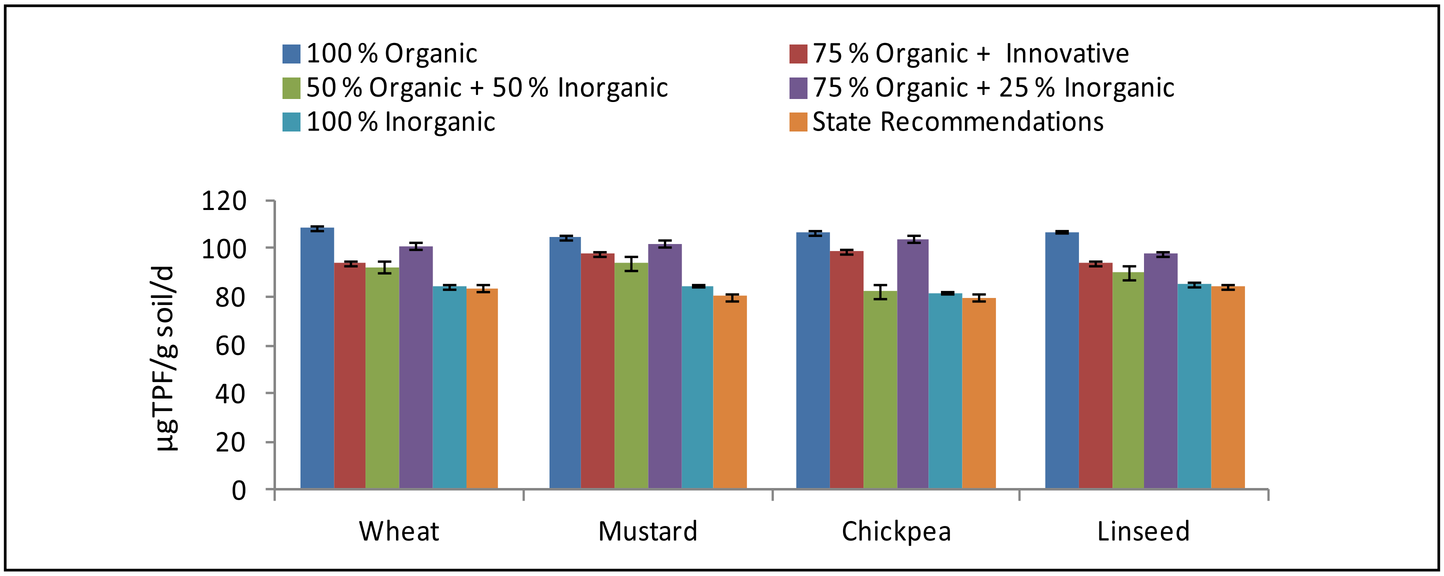


Fig. 2.6.3b Soil dehydrogenase activity as affected by different nutrient sources and crops

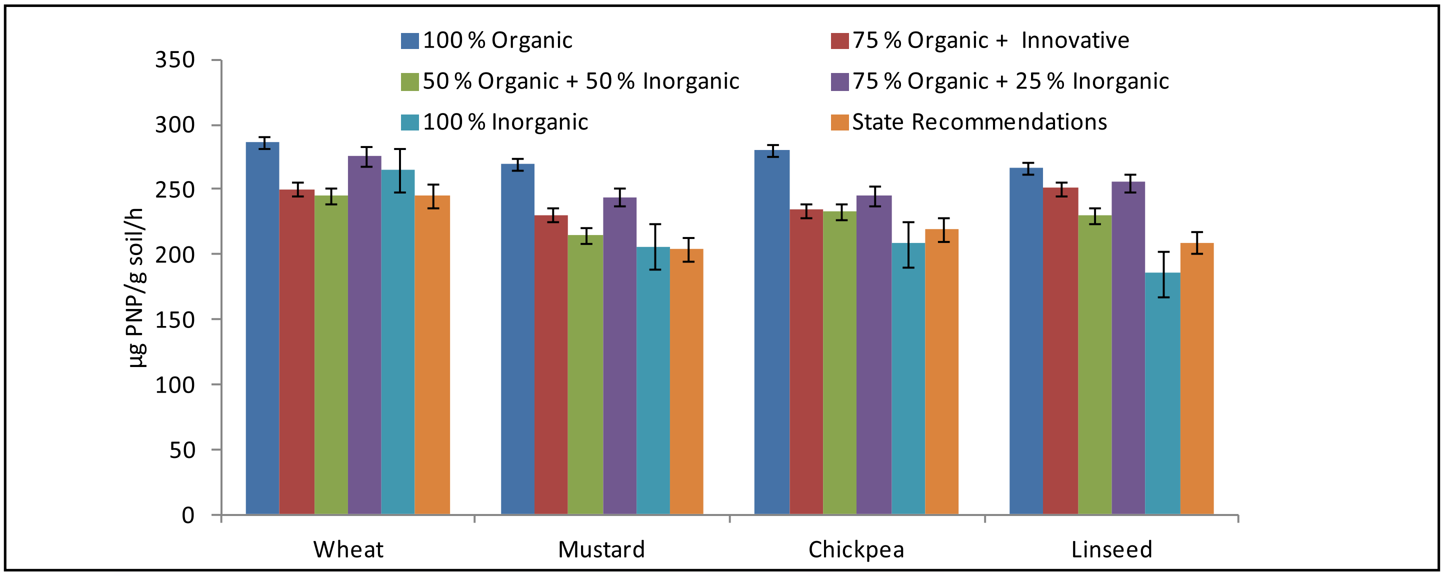


Fig. 2.6.3c Alkaline phosphatase activity as affected by different nutrient sources and different crops

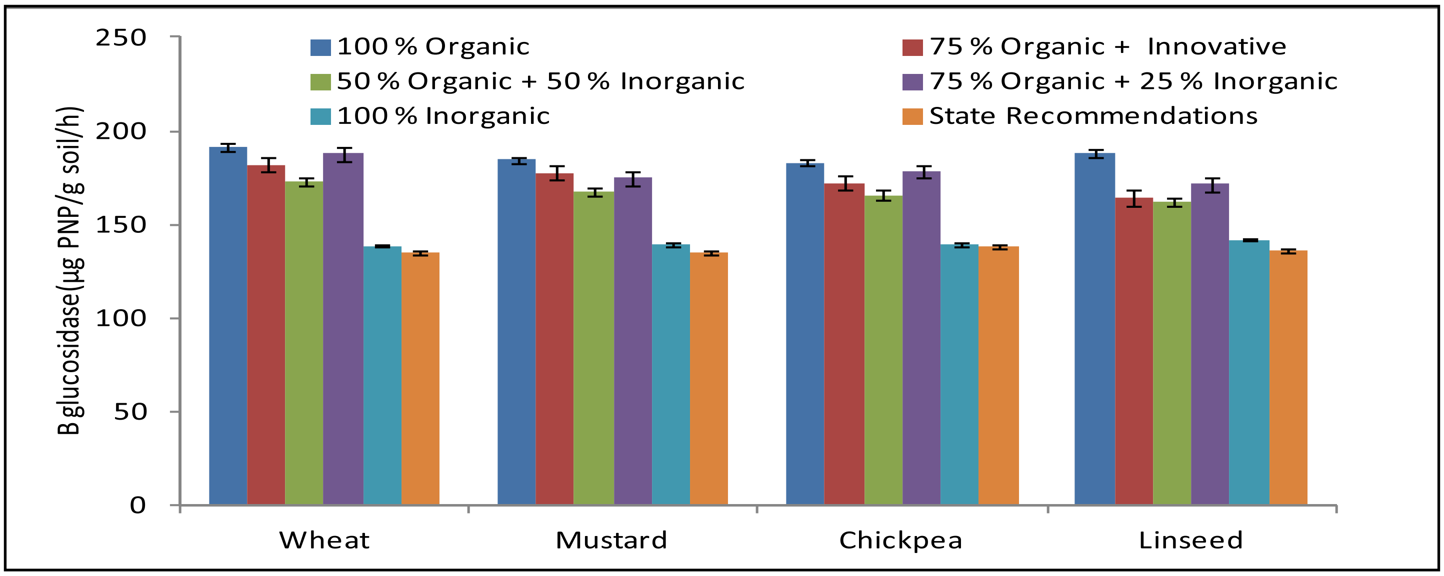


Fig. 2.6.3d β Glucosidase activity as affected by different nutrient sources and crops

2.6.4 Abiotic stress management using microbial inoculants

Bacterial strains isolated from vertisol were screened based on their abiotic stress tolerating and plant growth promoting properties. Sequences of 16S rRNA gene of these isolates were found to be homologous to *Bacillus*, *Microbacterium* and *Enterobacter* sp. Two rhizobial strains were also found to be homologous to Bradyrhizobium sp. A field experiment was undertaken to evaluate the effect of these isolates on the growth of soybean (JS 9560). Field application of non-rhizobial endophytes improved the yield of soybean significantly. Among the isolates, YOAR2 (moderate siderophore production and high IAA production under stress; high drought, temperature and salt tolerant), homologous to uncultured bacterium strain improved grain yield, root mass and nodule count by 60.59%, 48.81% and 103.65%, respectively over uninoculated. The isolates SOA1 (high siderophore production and IAA production under drought, moderate temperature and salt tolerant), was more efficient in improving the wheat yield (Plate 2.6.4 a and b).

Plate 2.6.4 a and b Evaluation of abiotic stress responsive microbial formulations on different crops

2.6.5 Methane consumption in response to different nitrogen sources in a tropical soil ecosystem

Experiments were carried out to evaluate CH_4 consumption under the influence of the three nitrogen sources comprising N_2 (+5%, +10%), NO_3-N and NH_4-N at 10 mM and 20 mM. Among the different N sources, N_2 stimulated CH_4 consumption potential by 1.11 to 1.71 times over control, while N in the form of both NO_3 and NH_4 inhibited CH_4 consumption by 1.14 to 2.18 times than control. CH_4 consumption rate increased with CH_4 feeding cycles. The effect of N sources on CH_4 consumption followed a similar trend irrespective of N sources. N_2 stimulated the abundance of both nif and pmoA genes. The abundance of methanotrophs pmoA gene copies and nitrifiers amoA gene copies were more in NH_4-N amended soil than NO_3-N. Available NO_3 content in soil increased 9 to 30% with CH_4 driven N_2 fixation. The study concludes that N_2 stimulates CH_4 consumption while nitrogen in the form of NO_3 and NH_4 inhibits CH_4 consumption in tropical vertisol (Table 2.6.5).

Table 2.6.5 CH_4 consumption rate of soil under the influence of different N sources CH_4

(ppm)	N source	Concentration	CH_4 consumption rate (ng CH_4 consumed g^{-1} soil d^{-1})		
			CH_4 feeding 1	CH_4 feeding 2	CH_4 feeding 3
1000	Control	Ambient	0.23±0.013j	0.47±0.040j	0.58±0.012j
	N_2 (%)	+5	0.28±0.003i	0.52±0.030i	0.64±0.009i
		+10	0.40±0.018h	0.61±0.031h	0.75±0.006h
	NO_3 (mM)	10	0.15±0.015m	0.37±0.036m	0.46±0.025m
		20	0.11±0.007n	0.24±0.031n	0.30±0.018n
	NH_4 (mM)	10	0.18±0.013l	0.39±0.023j	0.50±0.018j
		20	0.14±0.006k	0.29±0.023k	0.35±0.018k
10000	Control	Ambient	2.01±0.117c	4.28±0.067c	5.10±0.102c
	N_2 (%)	+5	2.24±0.080b	4.88±0.143b	5.71±0.041b
		+10	2.52±0.043a	5.86±0.154a	6.85±0.359a
	NO_3 (mM)	10	1.45±0.111g	4.07±0.071g	4.69±0.089g
		20	0.92±0.133f	3.83±0.135f	3.89±0.145f
	NH_4 (mM)	10	1.76±0.116d	4.10±0.071d	4.74±0.086d
		20	1.38±0.080e	3.98±0.092e	4.19±0.062e
		20	1.38±0.080e	3.98±0.092e	4.19±0.062e
Tukeys HSD ($p < 0.05$, df error 52)			0.031	0.086	0.036

2.6.6 Methane production and consumption under the influence of different crop biomass in a tropical Vertisol

Soil samples were amended with crop residue (maize, wheat, chickpea, and soybean) at 1% w/w and incubated under non-fooded and flooded condition to study the methane dynamics. The rate of CH_4 production (ng CH_4 produced g^{-1} soil d^{-1}) varied from 0.068 to 0.107 with highest in wheat and lowest in chickpea. CH_4 consumption rate (ng CH_4 consumed g^{-1} soil d^{-1}) was highest in wheat (0.79) and lowest in chickpea (0.53). In both CH_4 producing and consuming soils, the organic carbon (%) and the available NO_3 (mM) increased significantly ($p<0.05$) over control. The abundance of methanogens was found to be increased significantly due to crop biomass over control (Table 2.6.6). Linear models exhibited significant correlation among CH_4 production and CH_4 consumption with organic carbon, available nitrate and microbial abundance. The study concluded that carbon content of crop biomass influenced CH_4 cycling and the biomass of cereals stimulated both CH_4 production and consumption at a higher rate than the biomass of legumes (Fig. 2.6.6.)

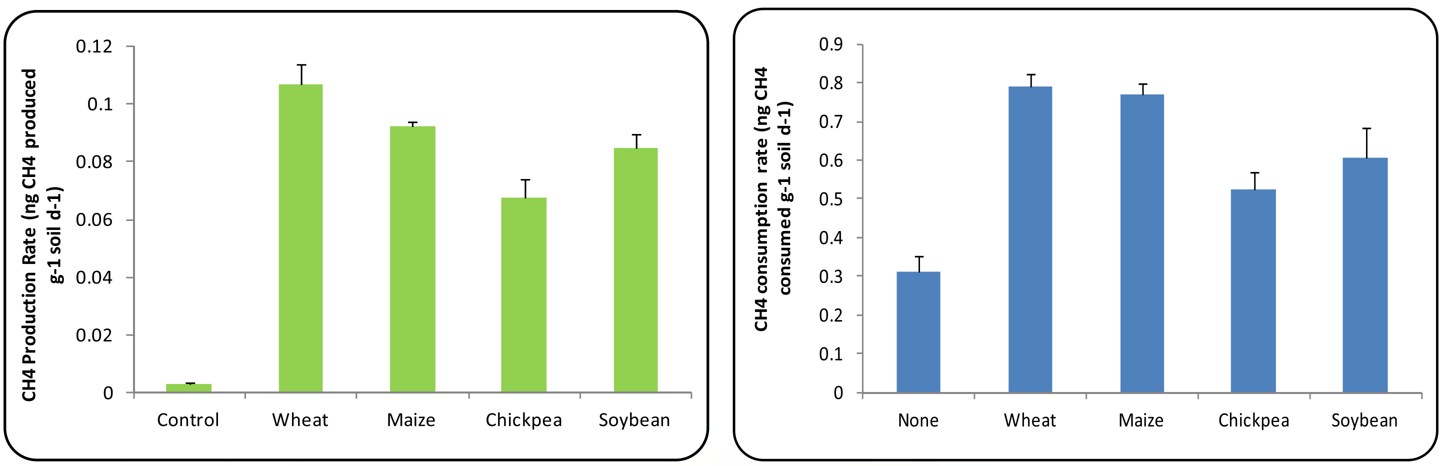


Fig. 2.6.6 CH_4 production and consumption in soil under the influence of biomass of different crops

Table 2.6.6 Abundances of methanogens and methanotrophs in soil amended with different crop biomass

Crop biomass	Abundance of methanogens (mcr gene copies 10^3 g^{-1} soil)	Abundances of Methanotrophs (pmoA gene copies x 10^4 g^{-1} soil)
Control	11±2.45e	15±2.87d
Wheat	84±3.70a	49±5.62a
Maize	68±4.55b	36±4.27b
Chickpea	27±4.65d	18±3.10d
Soybean	40±4.27c	26±4.27c
Tukeys HSD (P =0.05, df error 12)	2.53	3.11

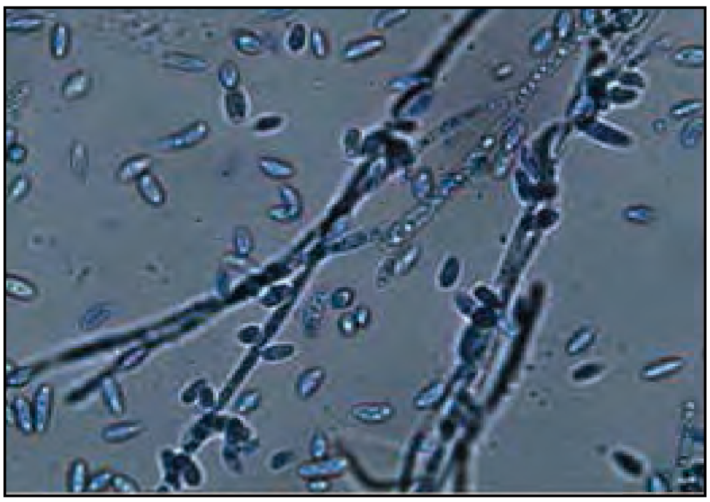
2.6.7 Isolation of endophytic fungi for bioremediation of heavy metal

Endophytic fungi were isolated from the plant roots growing on the municipal solid waste dumping sites by following standard protocol of surface sterilization of roots with 70% alcohol, followed by 2.5% of sodium hypochlorite solution. The roots cut into small pieces and placed over sterilized Potato dextrose agar (PDA) plate containing (50 $\mu g\ ml^{-1}$) antibiotic solutions (Penicillin, Streptomycin and Chloramphenicol) for bacterial growth inhibition. Incubate the plates at 28°C in dark for three to five days. The fungal hyphae emerging from the root segment was purified in fresh PDA plates and identified through using genomic approaches. The sequence of ribosomal DNA is deposited in NCBI genebank and accession number is obtained (Plate 2.6.7).

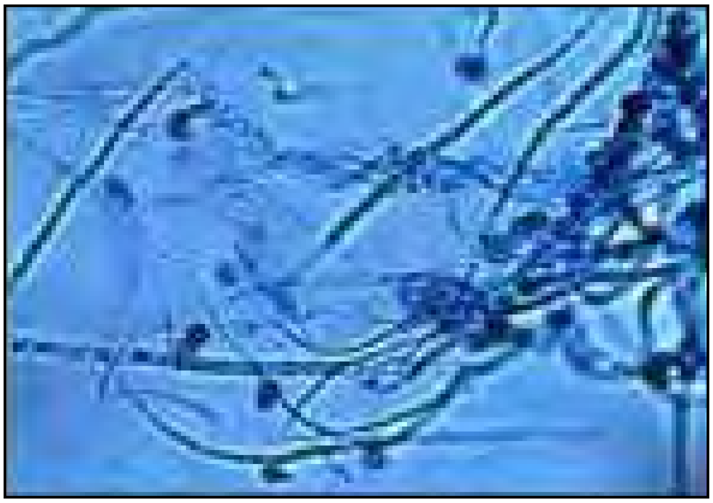
Aspergillus flavus **(MW081853)**

Paecilomyces maximus **(MW081855)**

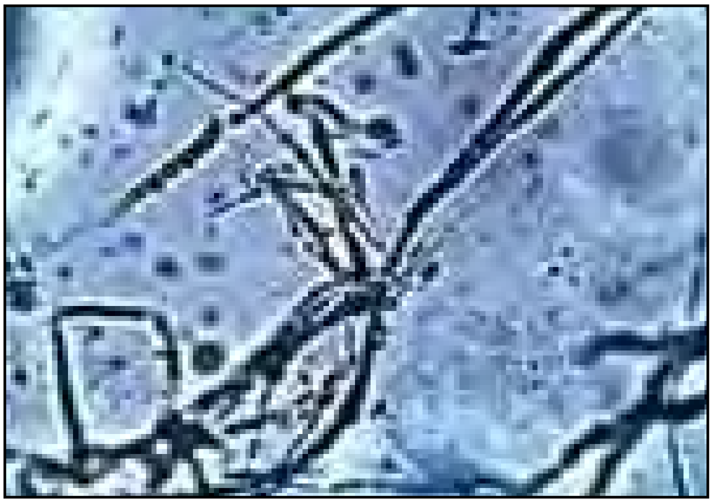
Alternaria alstroemeriae **(MW081854)**



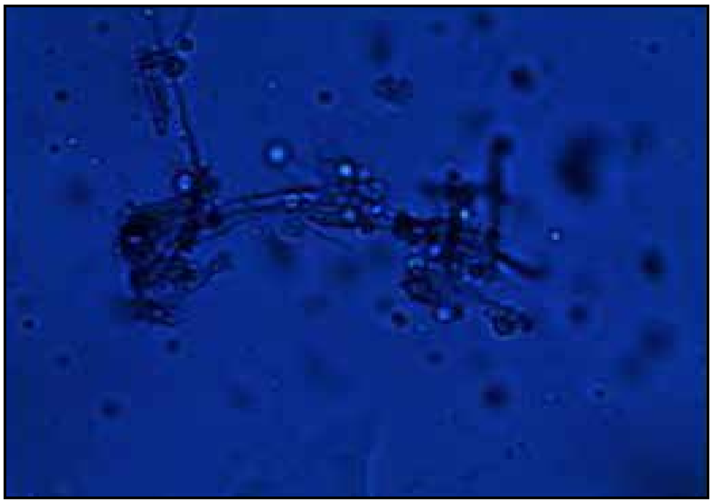
Fusarium falciforme (MW081856)



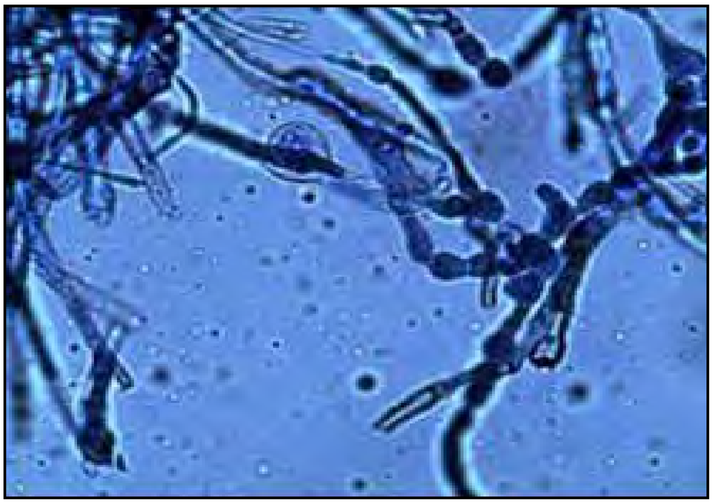
Aspergillus versicolor **(MW081857)**



Fusarium concentricum **(MW045440)**

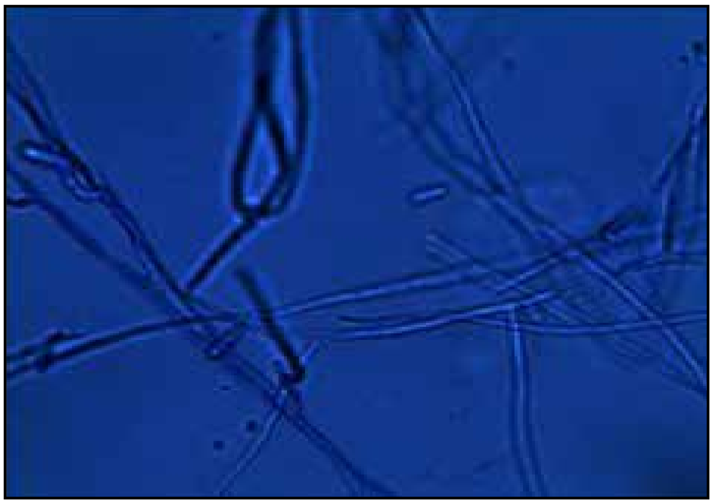


Ectophoma multirostrata **(MW081859)**

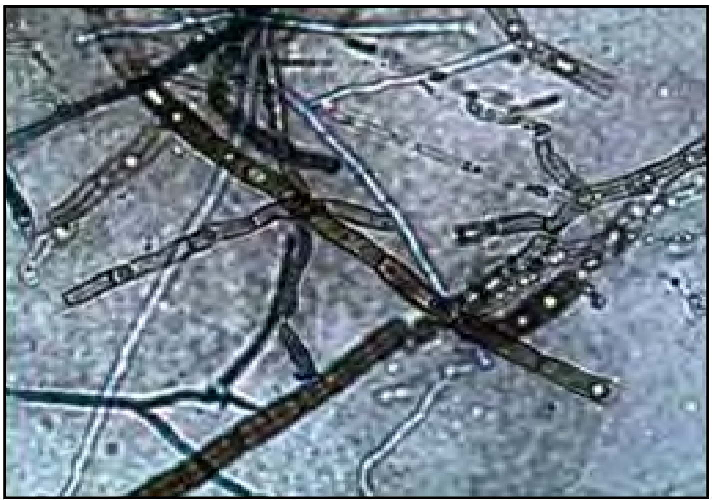


Epicoccum thailandicum **(MW081858)**

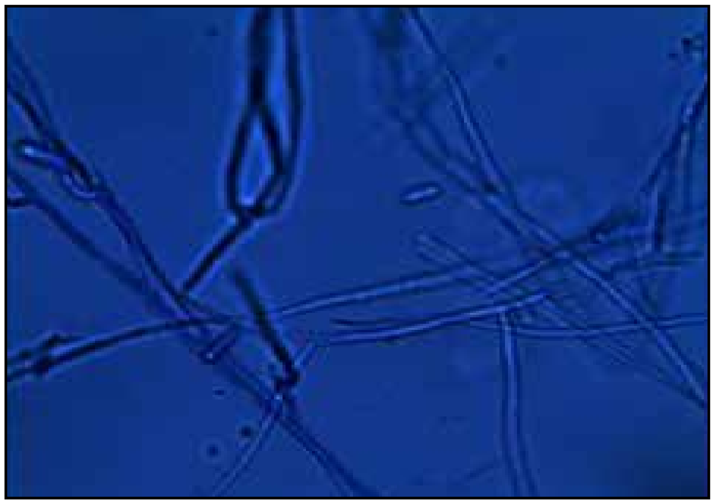
Fusarium keratoplasticum **(MW081861)**



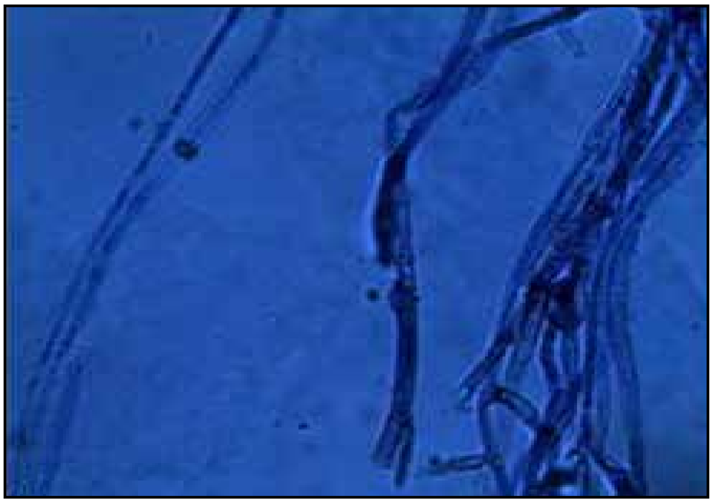
Aspergillus flavus **(MW081860)**



Curvularia buchloes (MW045439)



Aspergillus flavus (MT635198)



Ectophoma multirostrata (MT635196)

Ectophoma multirostrata (MT635199)

Plate 2.6.7 Endophytic fungal isolates used for bioremediation of heavy metal

2.6.8 Identificaton of fungal isolates

Isolation of DNA from fungal mycelium is performed by grinding under liquid nitrogen (N_2) to a fine powder followed by DNA extraction using Favor Prep Kit. PCR Amplification of Internal Transcribe Spacers, ITS-1 and ITS-4 region were carried out using universal primer (ITS-1 -5'-TCCG-TAGGTGAACCTGCGG-3' and ITS-4-5'-TCCTCCGCT-TATTGATATGC-3'). The amplified PCR products were sequenced. All ITS-1 and ITS-4 partial sequences were aligned with those of the related reference microorganisms available in the Gene Bank database by using BLAST program (Table 2.6.8).

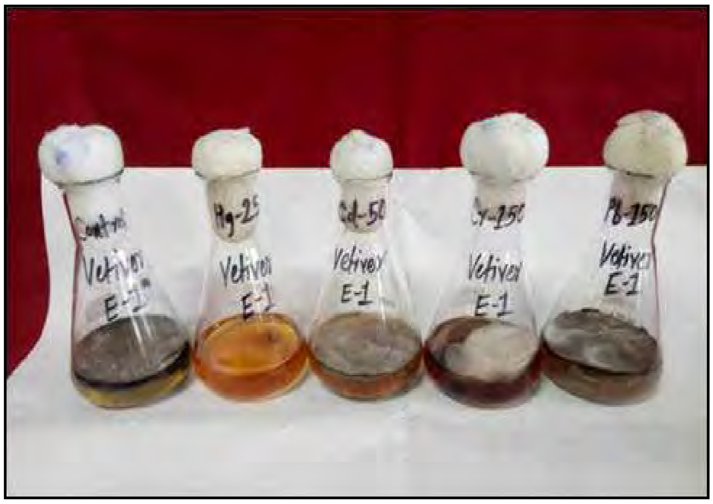
Table 2.6.8 Molecular Identification of Endophytic fungi (ITS-1 and ITS-4)

S. No.	Plant names	Identified fungal isolates
1	*Parthenium hysterophorus*	*Paecilomyces maximus*
2	*Xanthium strumarium*	*Alternaria alstroemeriae*
3	*Alternanthera calico*	*Fusarium falciforme*
4	*Solanum lycopersicum*	*Aspergillus oryzae*
5	*Chrysopogon zizanioides*	*Curvularia buchloes*
6	*Chrysopogon zizanioides*	*Fusarium fujikuroi*

7	*Sesbanea aculeata*	*Aspergillus flavus*
8	*Sesbanea aculeata*	*Ectophoma multirostrata*
9	*Corchorus trilocularis*	*Epicoccum thailandicum*
10	*Corchorus trilocularis*	*Ectophoma multirostrata*
11	*Cassia tora*	*Aspergillus flavus*
12	*Cassia tora*	*Fusarium keratoplasticum*
13	*Datura stramonium*	*Aspergillus sydowii*
14	*Calotropis gigantea*	*Ectophoma multirostrata*

2.6.9 Screening of heavy metal tolerant endophytic fungi

A study was conducted with increasing heavy metal concentration (0, 50, 100, 150, 200 ppm) of Cr, Hg, Cd and Pb in PDB containing (50 ug ml^{-1}) antibiotic solutions (Penicillin, Streptomycin and Chloramphenicol). PDB was inoculated with mycelia disc of four days old colonies and incubated at 30 ^{o}C for 120 hr (Plate 2.6.9).



Curvularia buchloes (C. zizanioides)

Fusarium fujikuroi (C. zizanioides)

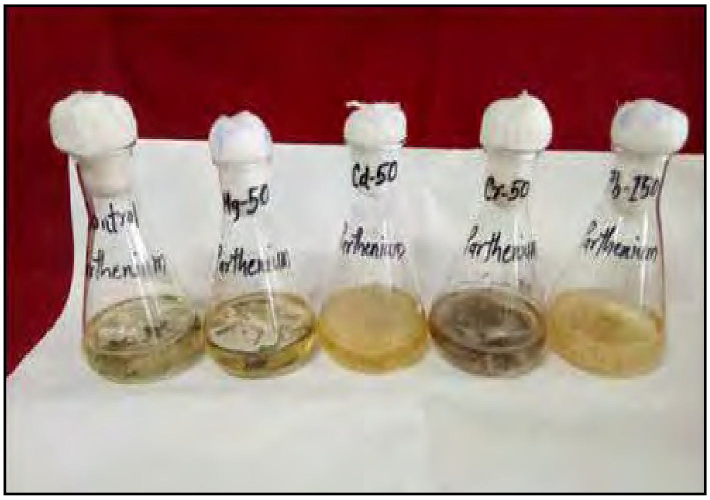
Epicoccum thailandicum (C. Tricularis)

Ectophoma multirostrata (Calotropis gigantea)

Aspergillus oryzae (S. Lycopersicum)

Aspergillus flavus (S. Aculeata)

Ectophoma multirostrata (S. aculeata)



Paecilomyces maximus (P. hysterophorus)

Aspergillus flavus (Cassia tora)

Fusarium keratoplasticum (Cassia tora)

Plate 2.6.9 Heavy metal tolerant screened endophytic fungi

2.6.10 Heavy metal tolerant endophytic fungal biomass

Estimation of dry weight of fungal biomass grown on highest concentration of selected heavy metals was carried out Fig. 2.6.10.

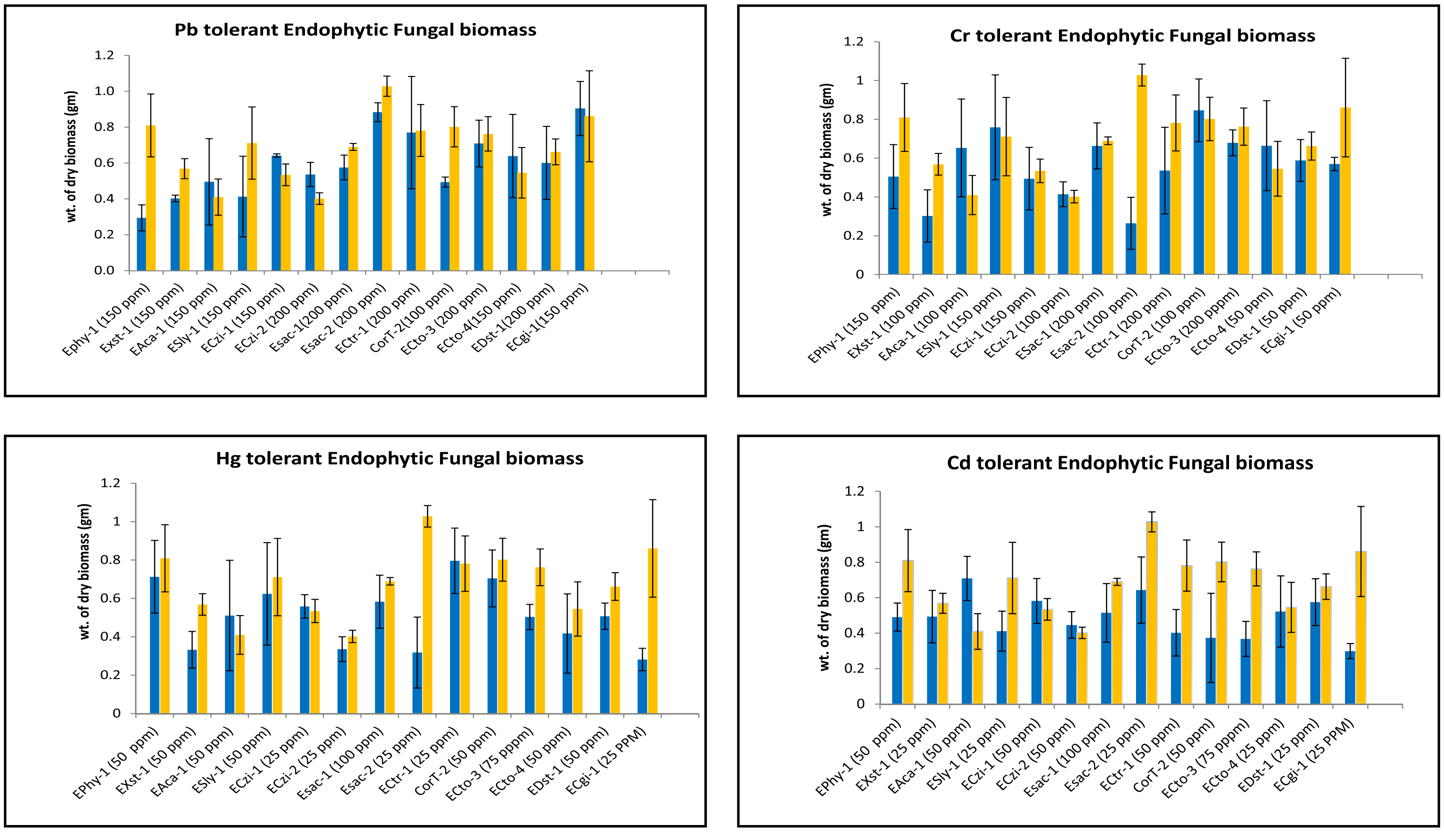


Fig. 2.6.10 Dry weight of the endophytic fungi biomass in relation to different concentration of Pb, Cr, Hg and Cd

2.6.11 Thermophiles isolates from hot springs of Central India

Samples of soil, water and green mat were collected from two hot water springs of Central India i.e. Choti Anhoni (CA) (22˚38‘42‘‘longitude,78˚21‘26‘‘latitude) hot water spring and Badi Anhoni (BA) (22˚35‘3‘‘longitude,78˚36‘16‘‘latitude) hot water spring (Plate 2.6.11a and b).

(a) (b)

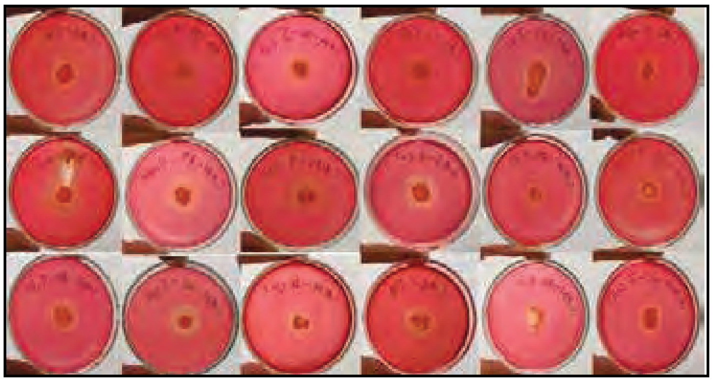
Plate 2.6.11a and b Sample collection from Anhoni hot springs (a) Chhoti Anhoni (b) Badi Anhoni

Physiochemical properties of the samples like colour, odour pH, EC, redox potential (ORP), dissolved oxygen (DO), total dissolved solid (TDS), salinity, and temperature using hand held multiparameter probe (Hanna make) were estimated (Table 2.6.11).

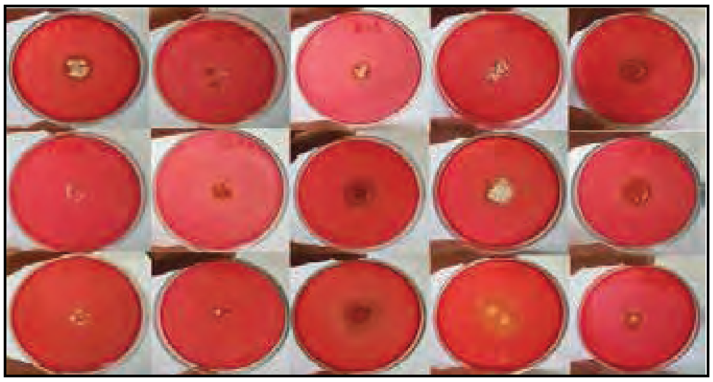
Table 2.6.11 Physiochemical properties of Anhoni hot spring water

S.No.	Parameter	Normal water	Choti Anhoni	Badi Anhoni
1.	Colour	Transparent	Transparent	Transparent
2.	Odour	Nil	Sulphurous and flammable	Sulphurous and flammable
3.	pH	6.5-7.5	7.96	8.5
4.	EC	400μS/cm	880μS/cm	913μS/cm
5.	ORP	300-500mV	36.3mV	176mV
6.	DO	80-120%	51.6%	11.2%
7.	TDS	200-400 ppm	439 ppm	457 ppm
8.	Salinity	<0.05%	0.042%	0.042%
9.	Temperature	13 ^{O}C	45 ^{O}C	55 ^{O}C

Hydrolytic activities of pure cultures were tested qualitatively on modified carboxy methyl cellulose (CMC) agar plates containing the CMC as substrate and congo red as dye (Plate 2.6.11c and d).



(c)



(d)

Plate 2.6.11c and d Qualitative assay of pure cultures for cellulolytic activity (c) CA isolates (d) BA isolates

2.6.12 Enhancing decomposition rate and quality of bio-waste through microbial consortia for improving soil health

Quality assessment for heavy metals was carried outfor cadmium (Cd), nickel (Ni), copper (Cu) and zinc (Zn) in mature compost prepared from different wastes (Table 2.6.12). The concentrations of heavy metals in all the composts were within permissible limit as compared to the standards given by FCO.

Table 2.6.12 Assessment of heavy metals in mature compost prepared from different wastes

Compost sample	Cd (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)
VW	0	0.495	0.77	1.351
HW	0.4	0.117	0.673	1.6
FW	0.125	0.111	0.294	0.798
KW	0	0.451	0.686	1.259
FYM	0	0.157	0.854	1.678
Maximum permissible limits	5.0	50.0	300.0	500.0

(Vegetable waste compost –VW, Horticulture waste compost-HW, Farm waste compost-FW, Kitchen waste compost- KW, and Farm Yard Manure-FYM)

Further, the compost prepared from different organic wastes were tested for presence of nematode by Baermann funnel method. The rhizosphere soil was taken as positive control. The soil and compost suspension were observed under microscope (Plate 2.6.12). No nematode was observed in the samples of compost suspension whereas rhizospheric soil suspension showed presence of active nematode population.

(a) (b) (c)

Plate 2.6.12 Microscopic observation (a) Nematode in rhizosphere soil (positive control) (b) No Nematode in compost sample (c) Coliform test

Total coliform bacteria and *Escherichia coli* in the mature composts were evaluated using most probable number (MPN) count method. Serially diluted compost samples were inoculated in single and double strength lactose broth. No colour change and gas production were observed in the Durham tubes after 48 hrs of incubation at 37^{0}C (Plate 2.6.12c).

2.6.13 Microbial autotrophy and C- cycling enzymes under different land use systems of semiarid-sub humid Central India

RuBisCO enzyme activity in anthropogenically managed grassland system was higher at both soil depths (0-15 and 15-30 cm) than natural grassland system in semi-arid to sub-humid central India (Fig. 2.6.13a).Phenol oxidase in integrated nutrient management treatment (100% NPK + FYM) was higher than imbalanced fertilizer application (100% N, 100% NP) in LTFE Raipur. Similarly, phenol oxidase activity in horticulture and grassland system had more carbon sequestration potential in upper soil depth; whereas, agro-forestry and Palash based black forest soil had higher carbon sequestration potential in lower depth. These findings corroborated with the TOC content. (Fig. 2.6.13b).

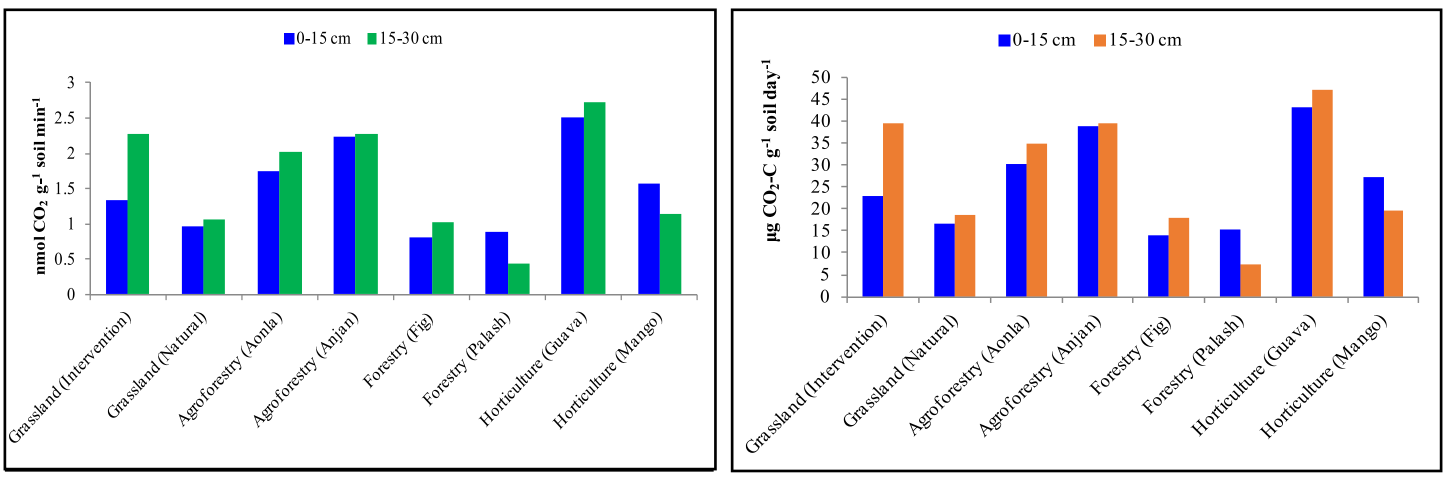


Fig. 2.6.13a RuBisCO enzyme activity and autotrophic C fixation potential of soil under different land use systems of semiarid-sub humid Central India

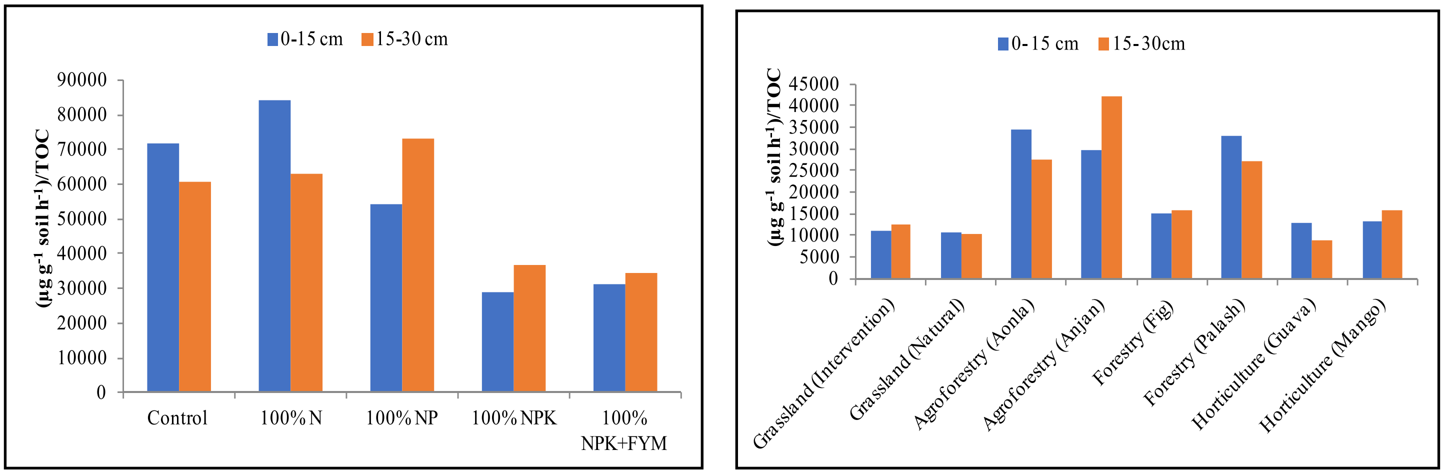
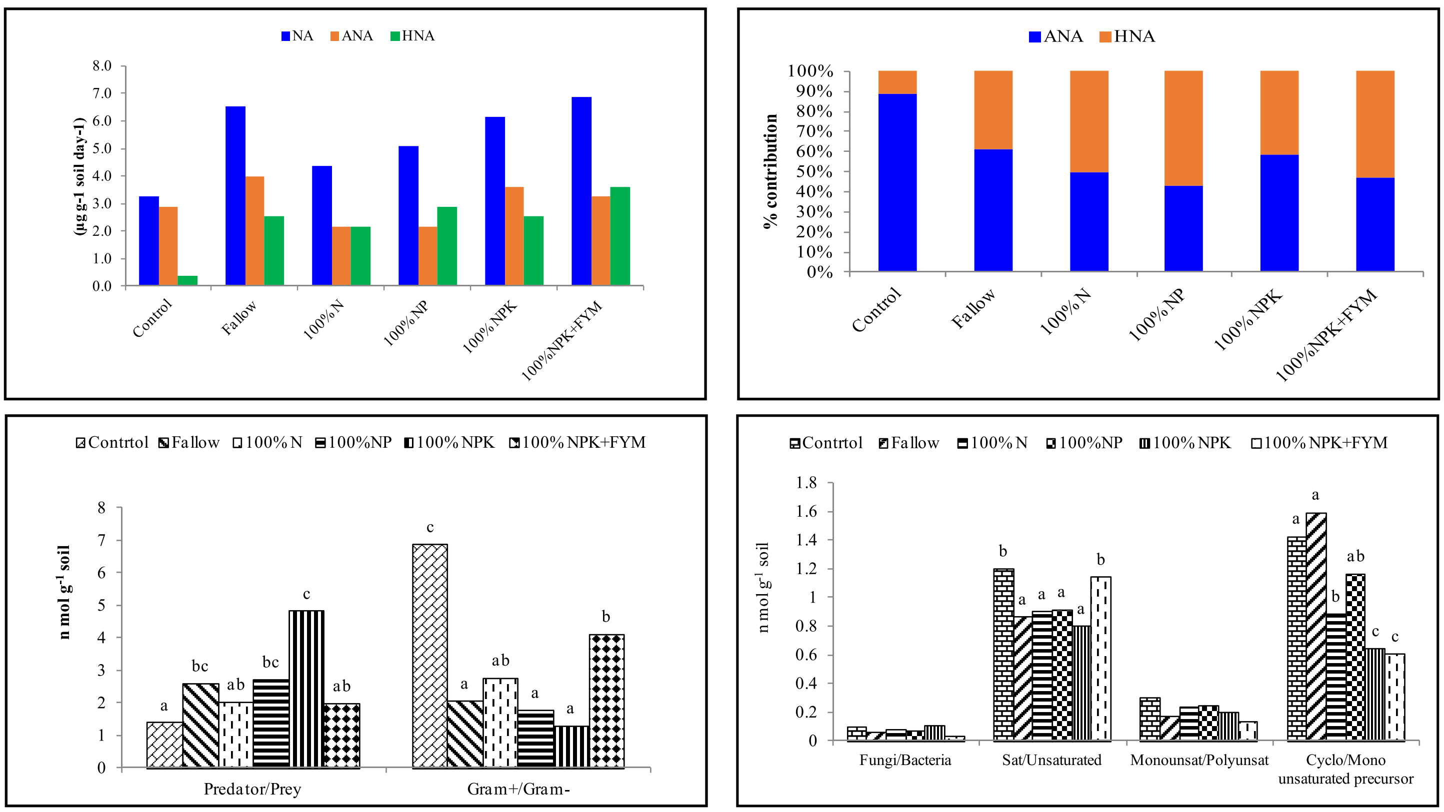


Fig. 2.6.13b Specific activity of phenol oxidase under different land use systems of semiarid-sub humid Central India

2.6.14 Effect of long term use of FYM and inorganic fertilizer on soil microbial community and potential nitrification in LTFE Barrackpore

Total microbial and eukaryote biomass were highest in 100% NPK +FYM with lower ratio of Predator/Pray. The ratio of Cyclo/Monounsaturated precursor was high in control, 100% N, 100% NP. Likewise, the Gram-positive to Gram-negative bacterial ratio was highest in INM. The major contributor of soil nitrification was from autotrophic nitrification activity (ANA), however the present study indiated that heterotrophic nitrification activity (HNA) significantly contributed to nitrification. ANA contributed 42.8 – 88.9 % of total NA whereas; HNA contributed 11.1 – 57.1 % of total NA. The INM treatment (100% NPK+-FYM) had significantly higher NA as compared to control, 100 % N and 100% NP treatment. ANA ranged from 2.2-4.0 μg g^{-1} soil day^{-1} whereas the HNA ranged from 0.4-3.6 μg g^{-1} soil day^{-1} (Fig 2.6.14).



2.6.14 Effect of long term use of FYM and inorganic fertilizer on soil microbial community and potential nitrification in LTFE Barrackpore

2.6.15 Potassium fractions in Long Term Fertilizer Experiment of Barrackpore

Analysis of different K fractions in LTFE Barrackpore soil revealed that continuous balanced fertilization (100% NPK) and INM (100% NPK + FYM) significantly increased Exch-K and NonExch-K content in soil. Microbial biomass K (MBK) positively correlated with Exch-K (r = 0.72**), NonExch-K (r = 0.684**) and WSK (r = 0.617**). Highest MBK was found in fallow followed by 100% NPK+FYM (Table 2.6.15).

Table 2.6.15 Potassium fractions in LTFE Barrackpore soil

Treatment	Water soluble K (mg kg^{-1})	Exchangeable K (mg kg^{-1})	Non exchangeable K (mg kg^{-1})	Microbial biomass K (mg kg^{-1})
Control	10.50 a	83.50 a	591.20 a	21.43 a
Fallow	27.17 b	221.00 b	880.53 c	161.91 b
100% N	13.67 a	69.50 a	568.53 a	25.39 a
100% NP	17.17 a	87.33 a	612.53 a	45.24 a
100% NPK	13.00 a	94.67 a	728.53 b	49.21 a
100% NPK+FYM	14.83 a	117.50 a	747.20 b	65.87 a

2.7 AINP on Soil Biodiversity and Biofertilizer

2.7.1 Zinc solubilizer microbial inoculants

A seed coating biofertilizer for Zn solubilisation, nitrogen fixation and plant growth promotion for pigeon pea was evaluated at the VNMKV, Parbhani centre of AINP SBB. The Zn solubilizer, *Pseudomonas striata* and the plant growth promoters *Bacillus megaterium* and *Trichoderma viride* were applied as seed coating biofertilizers. Zn was applied at 0, 10, 20 and 30 kg $ZnSO_4$ ha^{-1}. Zn mobilizing culture *Pseudomonas* striata was applied at 100 ml / 10 kg grain (CFU x10^8 / ml), where as other cultures were applied at 100 ml / 10 kg seed. Seed coating of the formulation improved the yield of the crop (Table 2.7.1).

The positive effect was in the trend of *P striata* > *B megaterium* > *T viride*.

Table 2.7.1 Effect of seed coating microbial formulation on pigeon pea seed yield (kg ha^{-1})

Treatment	0 kg Zn ha^{-1}	10 kg Zn ha^{-1}	20 kg Zn ha^{-1}	30 kg Zn ha^{-1}
Control	1066.4	1092.86	1364.02	1615.34
Pseudomonas striata	1312.57	1676.33	1934.26	2238.5
Trichoderma viride	1152.38	1430.16	1648.41	1674.87
Bacillus megaterium	1178.84	1522.75	1760.85	1992.33
	Strains (S)	Zn	S xX Zn	
SEm±	28.85	28.85	57.7	
CD at P=0.05	83.31	83.31	166.63	

- **Microbial inoculants developed under Indo UK project:** The efficient rhizobium strains isolated under Indo-UK Nitrogen Fixation Centre were evaluated along with local strains by the Parbhani centre. The strains (BRP-6 and BRP-20) performed well as compared to the local strain MKV-1 with respect to crop growth, nodulation, yield, soil fertility and microbial diversity. Thus, the strains of can be used as microbial inoculants for pigeon pea in Parbhani, Maharashtra.
- **Chickpea Microbiome:** The influence of soil type and genotype on metabolic potential of soil microorganisms associated with chickpea (BG 372 and BG 256) was investigated. The microbial biomass analyzed by PLFA (Phospho Lipid Fatty Acid) varied significantly. BG 372 variety had a pronounced effect on soils microbiome, collected from Dharwad, Jharkhand, New Delhi and Pune site. The ratio of Gram positive to Gram negative bacteria was influenced both by soil types and genotypes with most rhizosphere soils cor-

responding to higher ratios. BIOLOG study revealed that the average substrate utilization pattern was higher for rhizosphere soils than bulk soils. The gene copy numbers of eubacterial (16S rDNA) and diazotrophic (*nifH*) population were also higher in rhizosphere soil and these microbial gene abundances were influenced by both soil types and genotype. Study signified that the interaction between soil type and genotype jointly had more influence on soil metabolic diversity than the individual variables.

- **Diversity of *amoA* and arch *amoA* gene in the nodule of soybean:** The community of ammonia oxidizing prokaryotes was examined in nodular region of soybean (*Glycine max*) grown in soil of central India. Clone libraries were constructed using TOPO vector system with the amoA genes of archaea (AOA) and bacteria (AOB). Majority of the amoA sequences of Archaea were homologus to Nitrososphaera gargensis, belonging-group.

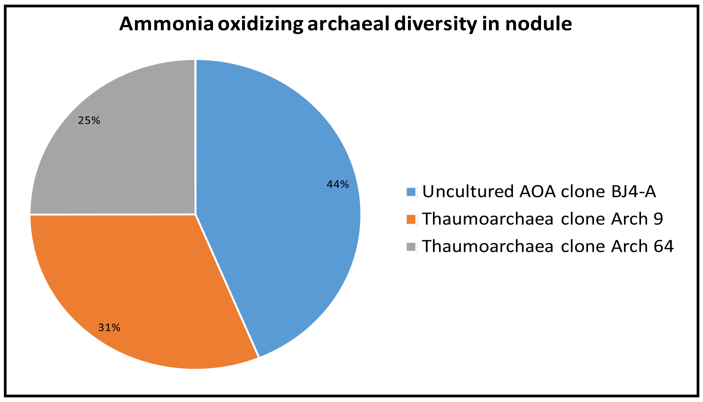


Fig.2.7.1a Archaea in soybean nodule (clone library of Archaeal amoA gene) - Uncultured AOA clone BJ4-A (blue), Thaumoarchaea clone Arch 9 (red), Thaumoarchaea clone Arch 64 (green)

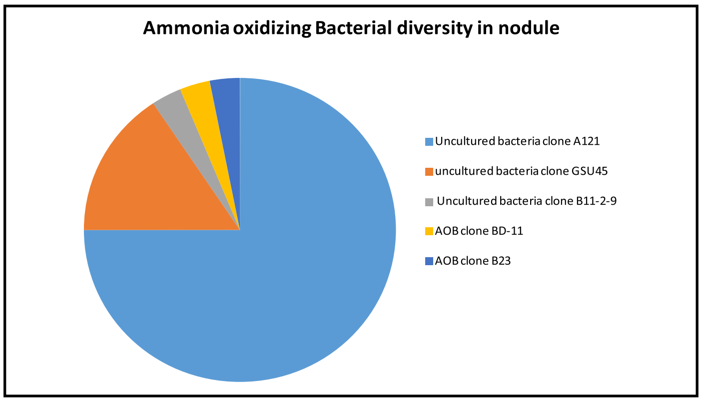


Fig.2.7.1b Clone library of bacterial amoA gene- Uncultured bacteria clone A121 (blue), uncultured bacteria clone GSU45 (red), Uncultured bacteria clone B11-2-9 (green), clone BD-11 (purple), B23-AOB (light blue)

Sequences of AOB were homologus to uncultured clones of *Nitrosomonas* sp., Nitrosospira sp. and Nitrosolobus sp (Fig.2.7.1a and b). The ratio of AOA/AOB was higher in the nodule than bulk soil. which indicated that abundance of AOA was greater than AOB. The copy number of archeal amoA gene was 7.98 x 105+ 0.39 and bacterial amoA gene was 0.02 x 102 + 0.32 per gram of nodule. Diversity indices suggested that AOA were more diverse than AOB.

- Effect of Methylotrophs on crops: The effect of methylotrophs (*Methylobacter radiotolerans*) on maize was evaluated in a field experiment conducted at the ICAR-IISS, Bhopal. The strain was also compared with *Burkholderia* sp and a consortia (*Bradyrhizobium* sp. BRP2+ *Burkholderia* + *Arthobacter* + *Bacillus* sp. JR5). The strains were isolated from soil and plant samples growing in the location. The treatments were C: control (un-inoculated), T1: *Methylobacter radiotolerans* seed inoculated, T2: *M. radiotolerans* foliar spray, T3: *Burkholderia* sp T4: consortia. In maize the number of cob, seeds, and weight were improved by the strains in the following order T2 > T3> T4 > control. Weight of seeds was 48.7 g of 100 seeds in T2.

Theme - IV: Soil Pollution, Remediation and Environmental Pollution

2.8.1 Use of fly ash for remediation of heavy metals pollution in soil

Solubility of elements from fly ash

Weathered fly ash from ash-pond of a Thermal Power Plant at Singrauli had high pH buffering capacity. About 82-99.9% of H+ from HCl (pH 1.52 to 3.12) and 90-99.9% OH- from NaOH solution were neutralized by weathered fly ash, resulting in solubilizaton of several elements. The extractability of Fe, Al and Ca was high (< 480 $\mu g\ g^{-1}$) at pH 2.2. The concentrations of Fe and Ca decreased progressively with increase in pH up to 11.05, whereas, Al concentration decreased upto pH 7.45 and increased thereafter with increase in pH. Among other elements, extractable Mg, Zn, Sr, Ni, Cr, Co and Li decreased progressively with increase in pH of the extracting solution.

The concentration of Mn, K, Ba, Ga and Cd decrease drastically with increase in pH of the extractant upto pH 7.45 or pH 8.93 and increased slightly at higher pH of 11.05. B and Se were not detected at the lowest pH of 2.27 and were detected at higher pH of extractions. Their concentration increased progressively with the increase in pH of extractions. Only Ca, Mg, K and Na were detected in the water extract of fly ash at concentration > 1.0 μg g^{-1}. It indicates that essential plant nutrients (except Na) may be supplied after land application. Heavy metals such as Ni, Cu, Co, and Cd were practically insoluble at a pH range of 6.7-7.5 and therefore their concentration potential is very low. Among the heavy metals, only Cr was extracted by water at concentration of 0.06 ppm which can be of environmental concern. Among the anionic elements, both B and Se were present in significant amount in water extract of fly ash (Fig. 2.8.1a).

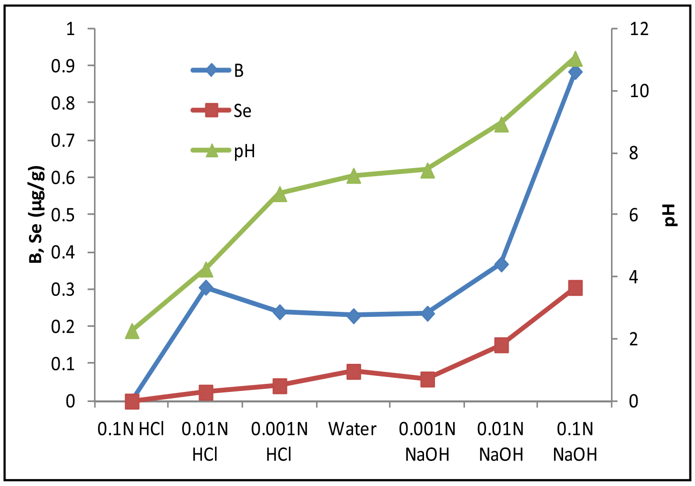


Fig. 2.8.1a Extractability of B and Se by acid and alkali at various concentrations

Metals adsorption by hydrothermally modified fly ash product

Weathered fly ash samples were hydrothermally modified in two ways: ash sample was treated with 3N HCl at 90-95°C for 48 hrs with occasional stirring followed by washing with distilled water (AcMFA) and ash sample was treated with 3N NaOH at 90-95°C for 48 hrs with occasional stirring followed by washing with distilled water (AlMFA). Cation exchange capacity (CEC) of AlMFA increased considerably (113 meq/100g) as compared to AcMFA (2.4 meq/100g) and untreated ash (UFA: 3.4 meq/100g). The sorption of heavy metals increased with pH of the solution. AlMFA completely removed Cd and Pb from solution due to significant increase in CEC. On the other hand, acid treatment reduced sorption of Cd and Pb at pH 5 and 7 (Table 2.8.1a). The XRD and FTIR results showed that mineralogical changes occurred during alkali/NaOH treatment might have helped cadmium and lead adsorption. The alkali/NaOH treated fly ash exihibited structural changes in Si-O-Fe bonding and allophane mineral formation (Fig. 2.8.1b).

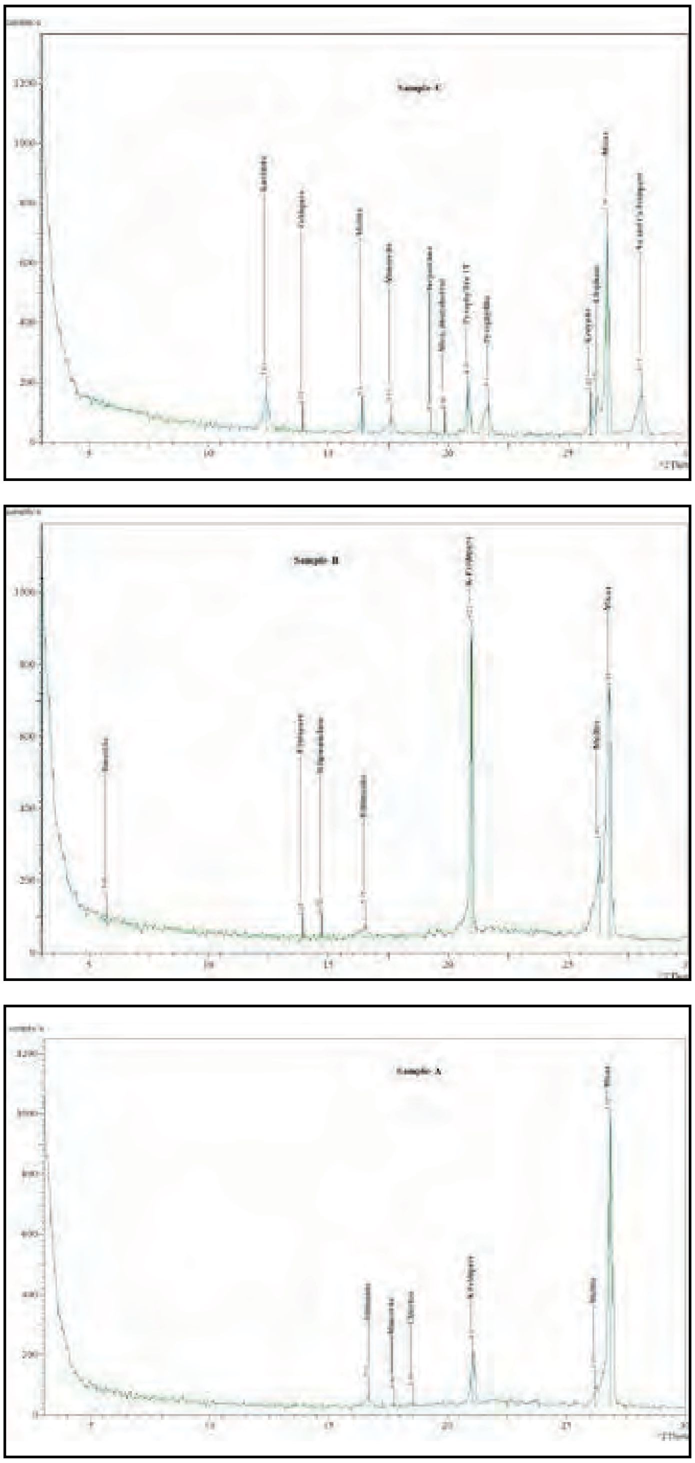


Fig. 2.8.1b XRD analysis of fly ash and modified fly ash material

Table 2.8.1a Effect of pH on adsorption of Cd and Pb on modified fly ash

	Cd adsorbed (%)			Pb adsorbed (%)		
	pH 5	pH 7	pH 9	pH 5	pH 7	pH 9
UFA	4.1	66.6	84.6	88.3	97.0	99.0
AcMFA	3.7	5.0	99.7	23.4	25.2	99.9
AlMFA	95.5	99.6	99.7	99.9	99.9	99.9

Remediation technology for minimizing Cd toxicity using modified fly ash product

A pot culture experiment was conducted using spinach as a test crop to investigate the capacity of the alkali modified fly ash (AlMFA) to minimize Cd toxicity (Fig. 2.8.1c). Biomass of spinach reduced 30% under 100 mg Cd kg^{-1} soil. The application of modified fly ash (@ 5%) not only countered the Cd toxicity but also improved the spinach biomass growth by more than 15% compared to uncontaminated soil. Application of AIMFA resulted in reduction in DTPA extractable Cd (>28%) and spinach leaf Cd (45%) (Table 2.8.1b and Plate 2.8.1).

Table 2.8.1b Effect of fly ash and modified fly ash addition on spinach leaf dry weight

Treatments	Relative change in Leaf Dry Matter Yield*	Relative change in plant available Cd in soil**	Relative change in Cd conc. in leaf**
Cd contaminated soil	-30%	-	-
Cd contaminated soil amended with fly ash	-12%	-13.5%	-27.3%
Cd contaminated soil amended with modified fly ash	+15%	-28.2%	-44.9%
AlMFA	95.5	99.6	99.7

*change with respect to uncontaminated soil; **change with respect to Cd contaminated soil

Plate 2.8.1 Effect of fly ash on spinach grown with spiked cadmium

2.8.2 Risk assessment of heavy metal loaded municipal solid waste on microbial toxicity and compost quality

A laboratory experiment was conducted to evaluate the effect of heavy metals (Cd, Pb, Cr and Ni) loaded municipal solid waste (MSW) on microbial toxicity through CO_2 evolution method. The result indicated that the CO_2 evolution gradually decreased over the period of incubation from 3 to 60 days in all the heavy metal loaded (upto 50 ppm Cd, 1500 ppm Pb, 800 ppm Cr and 500 ppm Ni) MSW. Among the heavy metals, the CO_2 evolution was significantly reduced at the highest level of Cd (50 ppm), Cr (800 ppm) and Ni (500) contaminated MSW. The CO_2 evolution was significantly lower in the MSW contaminated with all the heavy metals (combined effect) as compared to individual heavy metal effect (sole effect). The compost maturity index results also indicated that at the highest level of heavy metal contaminated MSW, the decomposition is reduced and the final compost quality had wider C/N ratio and higher TOC as compared to uncontaminated MSW (Fig. 2.8.2).

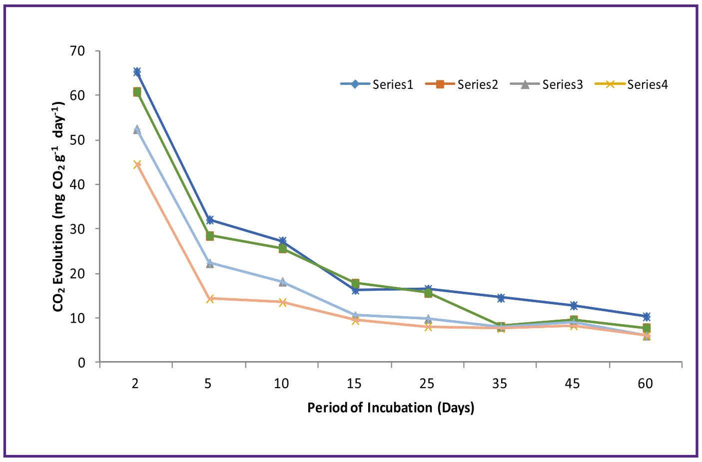


Fig. 2.8.2 CO_2 Evolution from heavy metal loaded MSW

T1: Uncontaminated MSW; T2: MSW contaminated with Cd (5ppm), Pb (100 ppm), Cr (100 ppm) and Ni (25ppm); T3: MSW contaminated with Cd (20ppm), Pb (500 ppm), Cr (300 ppm) and Ni (100ppm); T4: MSW contaminated with Cd (50ppm), Pb (1500 ppm),Cr (800 ppm) and Ni (500ppm)

2.8.3 Water quality parameters in drainage water of coal mine area

Water sampling was carried out at selected georeferenced locations near Sharda Coal Mine, Amlai (Fig 2.8.3a). The sampling sites were located along waste dump leachates, discharge pond, mine effluents and tailing dam reservoir of mine area. The water samples were also collected from handpump and canal sites of nearby Bargaon and Kelauhri villages. The pH of coal mine water was in the range of 5.7 to 6.0; whereas in the villages, it varied from 4.0 to 6.4. Oxidation-reduction potential varied between 162-300 mV; dissolved oxygen was 4.14 to 7.25 ppm; electrical conductivity and total dissolved solids were in the range of 1.10 - 4.47 dS m^{-1} and 0.15 - 2.25 ppt, respectively (Fig 2.8.3b).

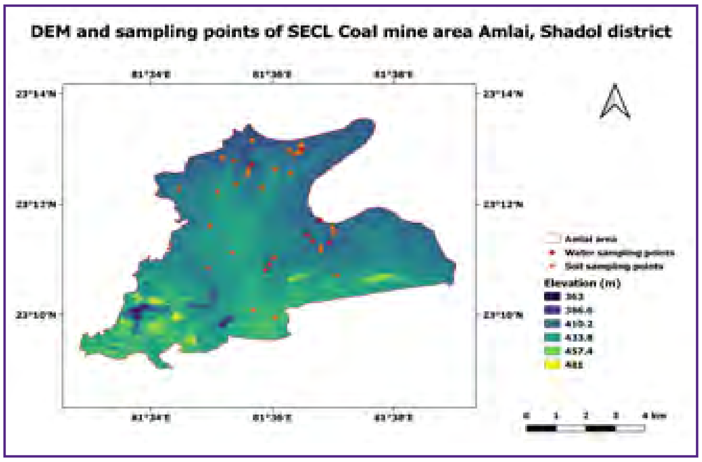


Fig 2.8.3a DEM and sampling points of coal mine area, Amlai

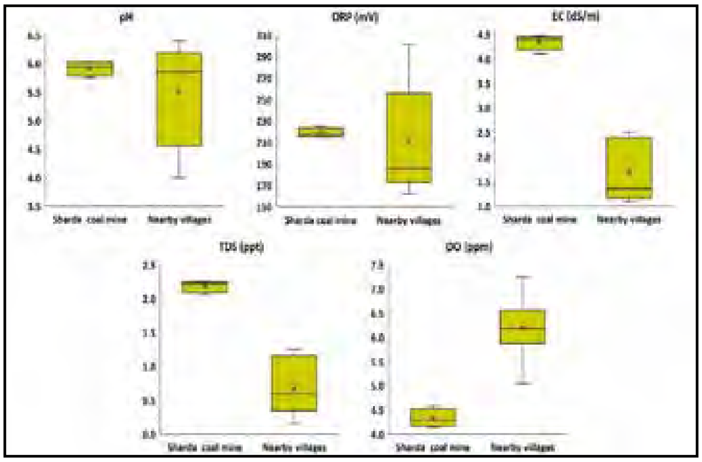


Fig. 2.8.3b Box-plot diagram to show different water quality parameters of Amlai

2.8.4 Impact of industrial effluent on Chambal river water and wheat crop quality

The effluent from industries and municipal domestic sewage water discharged in the Chambal river near Nagda. The farmers of surrounding area utilized the contaminated river water for irrigation. The EC and pH of the river water of downstream area was 6.982 dS/m and 7.12, respectively; whereas in the upstream area the values were 0.45 dS/m and 6.95, respectively. The color of the Chambal river water in the downstream area was red. The farmers in the downstream area using the contaminated water has resulted into poor soil health and crop (wheat, chick pea etc.) quality. (**Plate 2.8.4a)**.

Technological intervention for wheat production using contaminated Chambal river water

Field experiment was conducted to investigate the effect of contaminated Chambal river water, Nagda, M.P. on wheat (Triticum aestivum L.) crop production and its management through plastic mulch, drip irrigation and organic manure application. Application of FYM @ 20 t ha^{-1} increased the SOC and moisture content in soil; and lowered the salt content in root zone of contaminated water irrigated field. Under the same treatment, the yield of wheat crop was also enhanced by 2% in comparison to control. The combined use of plastic mulch, drip irrigation and organic manure application could be an effective strategy to use contaminated Chambal river water for maintaining crop productivity and improving soil health (Plate 2.8.4a).

Plate 2.8.4a Field preparation using drip plastic mulch for wheat crop at Atlawda village, Nagda

3. TRANSFER OF TECHNOLOGY

3.1 Capacity Building Programmme

3.1.1 ICAR-IISS, Bhopal

Capacity building under Farmer FIRST Programmme

Particulars	No. of training	No. of villages covered	No. of farmers benefited
Webinar on farmers need and preparedness for Kharif season 2020 under COVID-19 situations.	1	6	75
Training programme for rural farm women on vermicomposting and soil health management on the occasion of "Mahila Kisan Divas."	1	3	30


Webinar on farmers need and preparedness for Kharif season 2020 under COVID-19 situations on June 1, 2020


Training programme for rural farm women on the occasion of "Mahila Kisan Divas" on October 15, 2020

Extension activities under Farmers FIRST

Name of extension activities	No. of villages covered	No. of farmers attended
Interaction meeting was organized at the village Khamkheda	1	30
Field Day and Farmers Scientist Interaction Meet was organized on the occasion of soil health awareness week at village Bhairopur	1	50

Name of extension activities	No. of villages covered	No. of farmers attended
Field Day and Farmers Scientist Interaction Meet was organized on the occasion of soil health awareness week at village Khamkheda.	1	50
Field Visit and Farmers Scientist Interaction Meet was organized at ICAR-IISS, Bhopal	2	20




Interaction meeting at the village Khamkheda on November 2, 2020


Field Day and Farmers Scientist Interaction Meet on December 2, 2020 at village Bhairopur


Farmers Scientist Interaction Meet on December 25, 2020 at ICAR-IISS, Bhopal

Radio Talk/TV Programme

- Dr. Pradip Dey gave a talk on queries of the farmers related to Soil Health on February 13, 2020 during DD Kisan programme.
- Dr. A. B. Singh had given Radio talk on "Kenchua Khad Kheti Keliye Vardan" dated March 13, 2020 at Prasar Bharati, All India Radio, Bhopal.
- Dr. A.B. Singh gave a talk on Importance of Vermicompost under Organic farming on December 5, 2020 on Doordarshan Kendra, Bhopal.

Other training imparted to the Farmers/Extension Officers/Students/visits

Name of Scientist	Topic	Date	Venue	Participants
Dr Asha Sahu	Exposure visit on Composting techniques	January 4, 2020	ICAR-IISS, Bhopal	30 students from GH School Palasi
Dr Asha Sahu	Exposure visit on Composting techniques	January 23, 2020	ICAR-IISS, Bhopal	30 students from Eastern Public School, Bhopal
Dr. Sudeshna Bhattacharjya, Narayan Lal, Abhay O Shirale, AB Singh, AK Patra	One-day skill development training on organic manure production technique and soil health	February 4, 2020	ICAR-IISS, Bhopal	50 Farmers participated

Showcasing different technologies of ICAR-IISS in the farmers' fair

Farmers' fair at ICAR-IIPR, Phanda on February 10, 2020

Farmers' fair at ICAR-CIAE Bhopal on February 14, 2020

Farmers' fair at ICAR-IARI, New Delhi during March 1-3, 2020

3.2 Demonstrations/FLDs

3.2.1 ICAR-IISS, Bhopal

Demonstration trials under Farmers FIRST Programme

Conservation agriculture (CA) based 80 demonstrations were conducted during rabi season 2019-20 (60 in wheat and 20 in chickpea). The performance of crop under CA based demonstrations was found to be better as compared to farmers practice both in terms of yield as well as cost of cultivation besides resource conservation which resulted in increased water productivity.

Performance of crops under CA

Parameters	Chickpea		Wheat	
	Farmers practice	CA Intervention	Farmers practice	CA Intervention
Grain yield (q/ha)	14.52	16.67	48.03	52.25
Straw yield (q/ha)	20.12	26.52	71.98	78
Water productivity (kg grain m^{-3})	0.91	1.04	1.20	1.63
Cost of cultivation (Rs./ha)	21500	18000	42000	38000
Net income (Rs./ha)	40936	53681	50457	62581
B:C ratio	2.90	3.98	2.20	2.64

Chickpea and wheat crop performance under zero tillage

Wheat and chickpea crop performance under zero tillage

Crop based Module (Kharif season 2020-21)

Conservation agriculture based 70 demonstrations were conducted during Kharif season 2020-21 (70 in Soybean and 10 in Rice). Soybean productivity ranged between 10.88 to 12.96 q/ha in different villages with an average of 12.16 q/ha. Similarly,rice crop also recorded seed yield varied between 38.19 to 42.50 q/ha with an average of 40.29 q/ha under farmers field condition in the selected villages.

Conservation agriculture for improving crop productivity

Villages covered	Name of crop	Number of House-holds covered	Area covered (ha)	Yield (q/ha)
Bhairopur	Rice	4	1.61	42.50
	Soybean	17	6.88	12.53
Kanchvabli	Rice	---	---	---
	Soybean	4	1.61	10.88
Khamkheda	Rice	4	1.61	40.20
	Soybean	40	16.19	12.30
Kalyanpur	Rice	2	0.81	38.19
	Soybean	9	3.64	12.96

Soyabean crop performance under zero tillage

Paddy crop performance under DSR

Horticultural Based Module

Improved package of practices (POPs) were demonstrated in 60 farmers' field for enhancing vegetable (Tomato, Brinjal and Cabbage) production. The vegetable yield was increased under demonstrations as compared to farmer's practices due to balanced nutrient application, control of weed and insect-pest. Tomato, Brinjal and Cabbage productivity ranged between 37.00 to 38.44 t ha^{-1}, 36.41 to 43.18 t/ha and 38.75 to 42.41 t ha^{-1}, respectively.

Improved packages of pratices for tomato cutivation

Scientific brinjal tomato cultivation

Scientific cabbage cultivation

Horticultural plantations

Four hundred saplings each of mango and guava were planted in farmer's field in the village cluster. The survival percentage recorded was 75% for mango and 78% in case of guava.

Conservation agriculture for improving crop productivity

SN	Name of Farmer	Village	Mango (Nos.)		Guava (Nos.)	
			Plantation	Survival	Plantation	Survival
1	Sh. Ram CharanSilawat	Khamkheda	---	---	60	50
2	Sh. Deepak Mali	Bhairopur	---	---	---	---
3	Sh. Abdul Rashid Khan	Khamkheda	---	---	50	45
4	Sh. Parvat Singh	Khamkheda	---	---	40	30
5	Sh. Ramsevak Mali	Bhairopur	50	40	---	---
6	Sh. Prabhulal Meena	Kalyanpur	60	45	60	45
7	Sh. Vijay Kumar Sowne	Bhairopur	---	---	50	35
8	Sh. Santoshmeena	Kalyanpur	30	20	---	---
9	Sh. Amaan Singh	Khamkheda	50	40	60	45
10	Sh. Man Singh	Khamkheda	50	40	---	---
11	Sh. Mahesh Silavat	Khamkheda	70	50	40	32
12	Sh. Batlo Bai	Bhairopur	40	30	40	30
13	Sh. Omprakash Rajput	Khamkheda	50	35	---	---
	Total		400	300	400	312

Growth parameters of new orchard plants

Plant Type (Fruit)	Age (month)	Average plant height (cm)	Average girth (cm)
Guava	12	230.15	25.30
Mango	14	125.40	20.65

Intercropping paddy onion with guava


Intercropping onion with mango

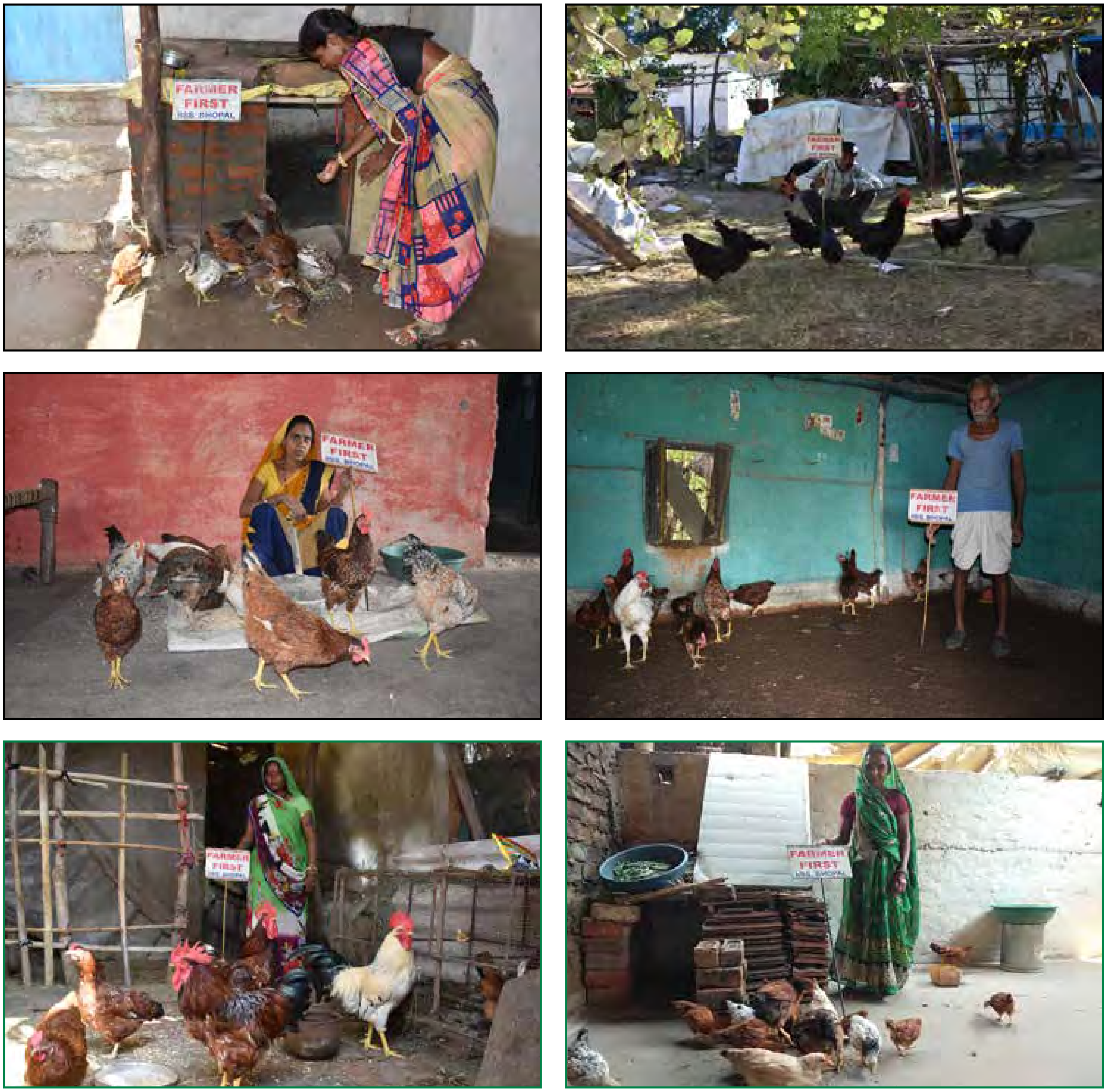

Guava plantation at fruiting stage

Livestock based module

Backyard Poultry : 25 chicks of Narmada breed along with feed were distributed to 24 farm families

Parameters	Farmers practice	Intervention
Average body weight (kg)	1.10	1.4
Average egg production /month	8 egg production / month (960 egg per year)	12 egg production /month (1440 egg per year)

Parameters	Farmers practice	Intervention
Economic indicators		
Cost of cultivation (Rs/year)	2200	2800
Net income (Rs.)	4520	8720
B:C ratio	3.05	4.11



Dual purpose backyard poultry rearing at Khamkheda, Bhairopur, Kalyanpur and Kanchvabli Villages

Mineral nutrient supplementation

One hundred farm families were distributed with mineral mixture feed for balanced nutrition of milch animals. It was found that the balanced nutrition with mineral mixture supplementation increased milk production to the extent of 300-500 ml per animal per day.

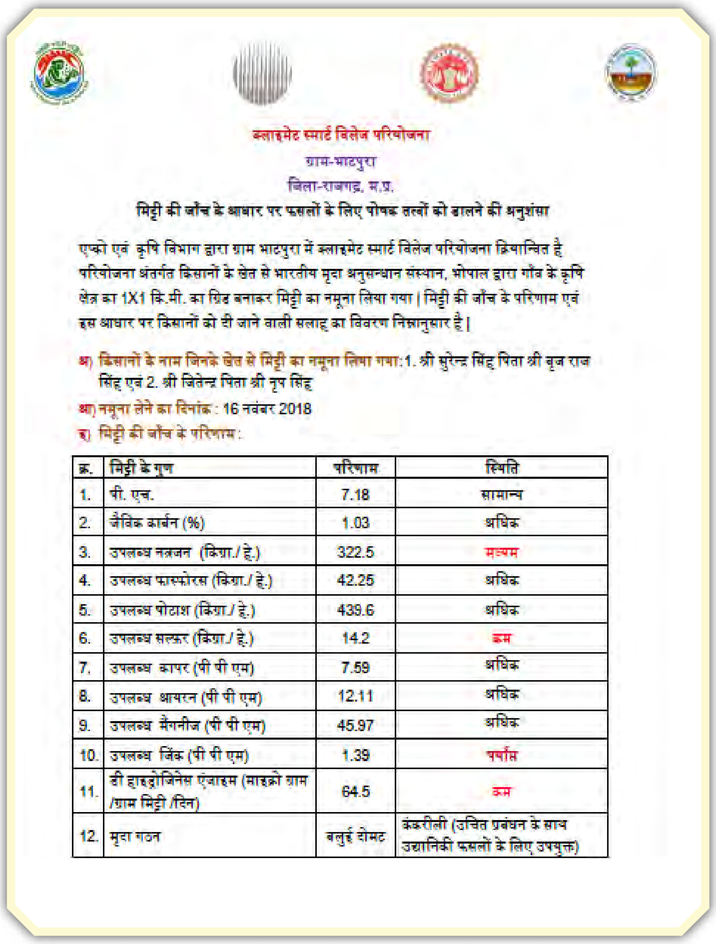
Vermicomposting

Fifty farmers were trained in vermicompost preparation and fifty vermibeds were distributed to the progressive farmers.Three to four cycles of composting per year were harvested by the farmers.

Release of earthworm and visit of Scientist's at Vermicompost unit

Soil health card distribution in climate smart villages in vulnerable districts of Madhya Pradesh

To understand the spatial variability of soil properties using GIS and a Geostatistical Model,Grid based (1 X 1 Km) soil and plant samples were collected from 20 climate smart villages in vulnerable districts of Sehore, Rajgarh and Satna district. Soils were low to medium in soil organic carbon and nitrogen, low in Sulphur, zinc and boron. Soil health cards in Hindi were distributed to the farmers.



क्लाइमेट स्मार्ट विलेज परियोजना
ग्राम-भाटपुरा
जिला-राजगढ़, म.प्र.
मिट्टी की जाँच के आधार पर फसलों के लिए पोषक तत्वों को डालने की अनुशंसा

एप्को एवं कृषि विभाग द्वारा ग्राम भाटपुरा में क्लाइमेट स्मार्ट विलेज परियोजना क्रियान्वित है परियोजना अंतर्गत किसानों के खेत से भारतीय मृदा अनुसन्धान संस्थान, भोपाल द्वारा गाँव के कृषि क्षेत्र का 1X1 कि.मी. का ग्रिड बनाकर मिट्टी का नमूना लिया गया | मिट्टी की जाँच के परिणाम एवं इस आधार पर किसानों को दी जाने वाली सलाह का विवरण निम्नानुसार है |

अ) किसानों के नाम जिनके खेत से मिट्टी का नमूना लिया गया: 1. श्री सुरेन्द्र सिंह पिता श्री बृज राज सिंह एवं 2. श्री जितेन्द्र पिता श्री नृप सिंह

आ) नमूना लेने का दिनांक : 16 नवंबर 2018

इ) मिट्टी की जाँच के परिणाम :

क्र.	मिट्टी के गुण	परिणाम	स्थिति
1.	पी. एच.	7.18	सामान्य
2.	जैविक कार्बन (%)	1.03	अधिक
3.	उपलब्ध नत्रजन (किग्रा./ हे.)	322.5	मध्यम
4.	उपलब्ध फास्फोरस (किग्रा./ हे.)	42.25	अधिक
5.	उपलब्ध पोटाश (किग्रा./ हे.)	439.6	अधिक
6.	उपलब्ध सल्फर (किग्रा./ हे.)	14.2	कम
7.	उपलब्ध कापर (पी पी एम)	7.59	अधिक
8.	उपलब्ध आयरन (पी पी एम)	12.11	अधिक
9.	उपलब्ध मैंगनीज (पी पी एम)	45.97	अधिक
10.	उपलब्ध जिंक (पी पी एम)	1.39	पर्याप्त
11.	डी हाइड्रोजिनेस एंजाइम (माइक्रो ग्राम /ग्राम मिट्टी /दिन)	64.5	कम
12.	मृदा गठन	बलुई दोमट	कंकरीली (उचित प्रबंधन के साथ उद्यानिकी फसलों के लिए उपयुक्त)

ई) किसान भाइयों के लिए सलाह:

1. मक्का एवं गेहूं में प्रति हेक्टर 120 किलोग्राम नाइट्रोजन, 45 किलोग्राम फास्फोरस एवं 30 किलोग्राम पोटाश डाले तथा सोयाबीन एवं लहसुन में प्रति हेक्टर NPK 20:45:23 किलोग्राम के अनुपात में डाले | मिट्टी में सल्फर की कमी को पूरा करने एवं विपुल उत्पादन के लिए 40-50 किलोग्राम सल्फर प्रति हेक्टर डालने की भी अनुशंसा की जाती है |
2. कुल पोषक तत्वों की मात्रा का 75 प्रतिशत हिस्सा रासायनिक उर्वरकों से एवं 25 प्रतिशत जैविक खाद (5-8 टन गोबर की खाद) से पूर्ति कर डाले |
3. गाँव के अधिकतर किसान मक्का के बाद गेहूँ की बुवाई करते है जिसमे नाइट्रोजन की पूर्ति के लिए केवल यूरिया का प्रयोग करते है गाँव के किसानो का औसत यूरिया उपयोग 85 से 123 कि.ग्रा./हे. है | किसानो द्वारा नाइट्रोजन के अलावा अन्य पोषक तत्वों की पूर्ति नहीं की जाती है अतः मिट्टी के स्वास्थ्य में सुधार के लिए गोबर की खाद, वर्मी कम्पोस्ट के साथ साथ सुपर फास्फेट, म्यूरेट आफ पोटाश एवं जिंक सल्फेट के संतुलित उपयोग के द्वारा पोषक तत्वों की पूर्ति करे
4. मिट्टी में उपस्थित पोषक तत्वों की मात्रा की उपलब्धता बढ़ाने के लिए जैव उर्वरकों का उपयोग बीज उपचार एवं मृदा में भुरकाव के रूप में करे | दलहनी फसलों में राइजोबियम, पी.एस.बी.एवं अनाज वाली फसलों में एजेटोबेक्टर, एजोस्पिरिलम, पी.एस.बी., ट्राईकोडरमा कल्चर को अवश्य डाला जावे |
5. नाइट्रोजन की उपयोगिता बढ़ाने एवं यूरिया के नुकसान को कम करने के लिए फसल में उपयोग की जाने वाली मात्रा को एक बार में नहीं डाले हुये हिस्सों में विभाजित कर फसल में 2-3 बार में उपयोग किया जावे |
6. फसलों में आवश्यकता से अधिक यूरिया का प्रयोग न करे क्लाइमेट स्मार्ट विलेज परियोजना के अंतर्गत वितरित किये मक्का एवं गेहूँ के लीफ कलर चार्ट के आधार पर यूरिया की मात्र निर्धारित कर डाले |
7. भाटपुरा की मिट्टी की गहराई कम है एवं पथरीली होने के कारण वर्षा एवं सिंचाई द्वारा मिट्टी का अधिक कटाव होता है इसे रोकने के लिए सभी किसान अपने खेतो की मेड़ पर कृषि वानिकी के अंतर्गत बांस, लेमनग्रास एवं खस को बड़े स्तर पर उगावे एवं अतिरिक्त आय प्राप्त करे |
8. अधिक जानकारी के लिए कृषि विभाग जिला कार्यालय एवं क्लाइमेट स्मार्ट विलेज परियोजना के एस. आर. एफ. श्री नरेन्द्र सिंह सोलंकी से संपर्क करे |

नोट: किसानों की सुविधा के लिए नाइट्रोजन N को, फास्फोरस को P_2O_5 एवं पोटाश को K_2O के रूप में मात्रा का अनुमोदन की गयी है |

Soil health cards distributed to the farmers

Demonstrated the use of Family Net Vessel Compost Technology and Ekcel shredder and composter at Krishi Vigyan Kendra, Sujani, Deoghar, Jharkhand.

Demonstration of Best-Bet Conservation Agriculture Practices on Farmers' Fields

Twelve demonstrations were conducted with wheat crop and eight demonstrations were conducted with chickpea crop in the farmer's field under zero and reduced tillage and were compared with farmers practice (conventional). No significant differences in grain yield, straw yield and harvest index was observed in both the crops among different tillage systems.

Famers field trial data under ZT, RT and CT of wheat crop

Name of Farmers	Straw yield (q/ha)	Grain yield (q/ha)	HI (%)	Straw yield (q/ha)	Grain yield (q/ha)	HI (%)	Straw yield (q/ha)	Grain yield (q/ha)	HI (%)
Wheat		**ZT**			**RT**			**CT**	
Sh. Nandlal Yadav	85.23	56.81	40.00	88.80	55.96	38.66	83.88	54.34	39.32
Sh. Parvat Yadav	85.36	54.34	38.90	79.48	49.40	38.33	80.00	51.87	39.33
Sh. Hemraj Yadav	94.55	52.85	35.85	78.75	51.37	39.48	78.25	50.63	39.28
Sh. Santosh Yadav	75.38	47.56	38.69	81.28	49.65	37.92	77.40	48.19	38.37
Sh. Karan Singh Yadav	85.75	55.57	39.32	83.38	57.30	40.73	87.78	55.32	38.66
Sh. Deepak Yadav	77.68	50.88	39.58	77.58	48.16	38.30	78.10	50.14	39.10
Sh. Naval Singh Yadav	75.13	46.23	38.09	77.35	51.12	39.79	77.25	51.40	39.95
Sh. Jagjeevan Ahirwar	70.28	45.00	39.04	74.50	46.00	38.17	63.85	44.00	40.80
Sh. Himmat Singh Lodhi	61.55	37.05	37.58	62.00	40.20	39.33	72.45	40.45	35.83
Sh. Naval Singh Lodhi	70.20	39.20	35.83	71.55	39.90	35.80	66.00	41.25	38.46
Sh. Ram Singh Lodhi	69.60	43.58	38.51	76.50	45.23	37.16	66.00	42.12	38.96
Sh. Azad Singh	61.60	38.65	38.55	68.85	40.50	37.04	63.50	41.63	39.60
Mean	**76.02**	**47.31**	**38.36**	**76.67**	**47.90**	**38.45**	**74.54**	**47.61**	**38.98**
Chickpea									
Sh. Jeevan Singh Jat	12.75	11.00	46.32	11.20	11.80	51.30	13.00	12.50	49.02
Sh. Badam Singh Jat	11.00	9.00	45.00	13.33	8.30	38.38	12.60	9.20	42.20
Sh. Chain Singh Jat	11.75	9.50	44.71	11.80	8.70	42.44	11.70	9.80	45.58
Sh. Rajnarayan Yadav	11.63	9.63	45.29	11.60	8.40	42.00	12.00	9.00	42.86
Sh. Ram Singh Jat	13.80	11.20	44.80	11.20	11.80	51.30	14.15	12.60	47.10
Sh. Vijay Malviya	12.50	10.00	44.44	12.55	8.90	41.49	12.65	9.60	43.15
Sh. Phul Singh	10.98	10.40	48.65	10.85	10.90	50.11	10.78	11.60	51.84
Sh. Goverdhan	9.8	10.2	48.00	12.80	11.50	47.33	11.95	12.30	50.72
Mean	**11.15**	**10.11**	**45.88**	**11.92**	**10.04**	**45.72**	**12.35**	**10.83**	**46.70**

Twenty field demonstrations under zero tillage and reduced tillage were conducted during kharif 2020 with soybean crop. Conventional tillage recorded higher plant height and number of pods per plant. However, higher grain yield was recorded under zero till condition.

Famers field trial data under ZT, RT and CT of soybean crop

	Plant height (cm)			No of pods/plant			Grain yield (q/ha)		
Name of Farmer's	**ZT**	**RT**	**CT**	**ZT**	**RT**	**CT**	**ZT**	**RT**	**CT**
Sh. Parvat Yadav	51.67	53.67	57.40	31.67	24.33	27.40	12.00	10.00	10.50
Sh. Nandlal Yadav	50.33	56.33	66.20	25.00	20.67	19.80	10.00	8.50	9.00
Sh. Karan Singh Yadav	63.00	67.67	64.00	25.33	18.33	17.00	13.00	12.00	12.40
Sh. Hemraj Yadav	59.67	58.33	63.40	21.00	21.33	18.40	10.20	7.80	8.65
Sh. Naval Singh Yadav	54.33	63.00	65.80	13.33	13.00	16.40	8.00	6.20	6.90

	Plant height (cm)			No of pods/plant			Grain yield (q/ha)		
Sh. Deepak Yadav	64.33	62.33	66.40	15.33	18.00	15.00	5.00	3.11	3.56
Sh. Rajnarayan Yadav	45.67	51.00	51.00	17.33	19.67	21.20	6.00	5.30	5.75
Sh. Santosh Yadav	58.33	47.00	64.60	12.00	11.67	15.00	5.67	4.45	3.82
Sh. Chain Singh Jat	52.33	55.33	62.00	9.67	13.67	13.00	4.35	3.28	3.10
Sh. Jeevan Singh Jat	55.33	64.00	59.60	17.00	11.00	12.80	8.65	6.29	5.96
Sh. Badam Singh Jat	45.00	57.67	63.80	17.33	14.33	13.40	4.68	3.36	3.20
Sh. Ram Singh Jat	57.00	61.33	60.40	9.67	13.67	14.60	5.80	4.25	3.40
Sh. Jagjeevan Ahirwar	49.00	54.33	56.80	17.33	14.33	12.00	6.47	4.24	4.00
Sh. Vijay Malviya	49.33	53.00	60.60	17.33	15.33	43.20	7.00	5.00	5.45
Sh. Ram Singh Lodhi	51.67	59.67	61.40	14.67	13.00	12.80	3.00	2.50	2.10
Sh. Himmat Singh Lodhi	60.67	52.00	59.20	11.00	13.00	16.60	4.00	3.00	2.65
Sh. Naval Singh Lodhi	47.67	53.33	58.80	12.67	14.00	13.40	5.85	4.20	3.60
Sh. Azad Singh	51.33	63.00	59.40	10.00	10.33	10.80	6.00	5.40	4.50
Sh. Phul Singh	53.00	47.33	50.80	13.33	13.00	13.00	8.00	6.25	5.65
Sh. Goverdhan	62.33	50.00	64.60	12.00	13.67	14.00	7.40	6.52	5.20
Mean	**54.10**	**56.52**	**60.81**	**16.15**	**15.32**	**16.99**	**7.05**	**5.58**	**5.47**



Sowing of soyabean crop at zero tillage and the crop performance under zero tillage

Farmers' Field demonstration on conservation agriculture practices

Demonstration on resource conservation technologies (RCT)

To popularize resource conservation technologies among farmers, different packages of RCTs viz, (a) Reduced tillage (RT) + Broad Bed furrow (BBF) + Maize-chickpea; (b) No-tillage (NT) + BBF + Maize-chickpea; (c) RT + BBF + Soybean-Wheat; (d) NT + BBF + Soybean-Wheat; (e) RT + BBF + soybean-chickpea (intercropping, 3:2) and (f) NT + BBF + soybean-chickpea (intercropping, 3:2) were demonstrated. After the eight year of the continuous treatments impositions, 13% in chickpea yield and 8% in wheat yield improvement were observed under NT than RT on the BBF system.

RCT demonstration on wheat and chickpea

Demonstration of in-situ rice residue decomposition technology

In-situ rice residue decomposition was demonstrated using lignocelluoytic microbial consortia developed by ICAR-IISS, at Karod Khurd village, Bhopal on 25th Nov. 2020.

Demonstration of in-situ crop residue decomposition technology at Karod Khurd village, Bhopal

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

Effect of foliar spray of zinc and boron on wheat crop in Uttarakhand

Frontline demonstration (FLD) trials were conducted to examine the effect of Zn and B foliar fertilization on wheat (cv. PBW 343) on farmer's fields (3) in Pindari village, Sitarganj of District U.S. Nagar, Uttarakhand. Single foliar Spray of 0.5% $ZnSO_4$ + 0.2% Borax at 30 DAS (T1) increased the grain yield of wheat by 3.7 to 18.1 percent and straw yield by 0.0 to 11.1 percent over farmer's practice, respectively. Two foliar Spray of 0.5% $ZnSO_4$ + 0.2% Borax at 30 and 60 DAS (T2) increased the grain yield of wheat by 12.5 and 24.5 percent and straw yield by 4.3 to 24.1 percent over farmer's practice, respectively. Higher response of foliar spray of Zn at Site 1 could be attributed to lower content of DTPA extractable Zn (0.95 mg Zn/kg soil) and hot water-soluble B (0.36 mg B/kg soil) in comparison to Site 2 and 3. The second foliar spray done at 60 DAS was more effective in increasing the concentration of Zn in grains. Therefore, two foliar sprays of Zn and B are recommended to wheat crop for achieving higher yields as well as Zn fortification of cereals in the region.

Effect of foliar spray of B and Zn on grain and straw yields and nutrient concentration of wheat

Site	Soil properties	Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Grain Zn Conc.	Straw Zn Conc.	Grain B Conc.	Straw B Conc.
1	Texture loam, pH 7.5, E.C. 0.335 dS m-1, O.C. 6.8 g C/kg soil, DTPA extr. 0.95 mg Zn and 0.36 mg hot water-soluble B/kg	Farmer's Practice	4.16	6.22	14.9	2.9	4.9	7.0
		T1	4.91	6.22	16.8	2.7	5.3	6.0
		T2	5.18	6.49	21.3	5.1	6.6	7.4
2	Texture loam, pH 7.6, E.C. 0.355 dS m-1, O.C. 8.2 g C/kg soil, DTPA extr. 1.67 mg Zn and 0.48 mg hot water-soluble B/kg soil	Farmer's Practice	5.04	6.15	18.1	5.4	4.5	7.0
		T1	5.23	6.40	19.9	5.5	5.0	7.8
		T2	5.67	6.50	20.9	4.8	6.2	9.3
3	Texture loam, pH 7.9, E.C. 0.448 dS m-1, O.C. 9.8 g C/kg soil, DTPA extr. 1.57 mg Zn and 0.42mg hot water-soluble B/kg soil	Farmer's Practice	4.45	5.20	17.1	3.2	3.4	6.6
		T1	4.89	5.78	17.3	3.6	3.8	8.0
		T2	5.25	6.45	28.8	3.4	4.4	8.3

3.3 Tribal Sub-Plan/Scheduled Tribe Component

3.3.1 ICAR-IISS, Bhopal

Enhancement of Soil Health and Livelihood of Tribal Farmers

Training cum Farmers-Scientist Interaction meet at Rajnandgaon, Chhattisgarh

Training cum farmers-Scientist interaction meet and field days were organized on January 29, 2020 in collaboration with KVK, Surghi at Kodikasa and Pateli village of Ambagarh Chowki Block, Rajnandgaon. Training programme on soil health and crop productivity was organised on January 30, 2020 and 154 kg seed of summer moong and 40 bags of DAP (Fertilizer) were distributed among 75 tribal farmers of Pateli, Devvavadi and Mangatola Villages of Ambagarh Chowki Block in Rajnandgaon to create awareness among farmers about short duration moong bean.

Agri input distribution and interaction with tribal farmers of Kodikasa and Pateli Village

Training cum farmers- scientist interaction meets, farmers' days were organized at tribal villages (Boirdi and Ladijog villages) and KVK, Surghi, Rajnandgaon on March 5, 2020. Soil samples were collected and water samples were drawn from village ponds, handpumps and tube wells of the tribal villages. An introductory orientation regarding soil health was also carried out at anganwadi and primary schools of Boirdi village to create awareness among school children about the importance of soil health.

Awarness Creation at School and Villages of Boirdi and Ladijog

Kisan Mela at Rajnandgaon, Chhattisgarh

A Kisan Mela was jointly organised by ICAR-IISS, Bhopal and AICRP on MULLaRP, Raipur at KVK Rajnandgaon on March 6, 2020 in which about 385 tribal farmers participated. District collector Shri Jaipraksh Maurya and Superintendent of Police Shri B.S. Dhruve, Sub Divisional Magistrate Shri Mukesh Rawte, Dean College of agriculture Dr. V.K. Dubey and other state agriculture officers of Rajnandgaon graced the occasion and distributed agriculture inputs to the tribal farmers. Agri-inputs (60 q paddy seed, 100 bags urea and 100 bags NPK complex fertilizers) were distributed to 125 selected tribal farmers.

किसान मेला सह कृषक संगोष्ठी कार्यक्रम का हुआ आयोजन

उपरवा @ पत्रिका. शुक्रवार को कृषि विज्ञान केन्द्र राजनांदगांव टीएसपी, क्रिप मुलार्प रायपुर एवं भारतीय मृदा विज्ञान संस्थान भोपाल के संयुक्त तत्वाधान में एक दिवसीय किसान मेला सह कृषक संगोष्ठी कार्यक्रम का आयोजन किया गया। कार्यक्रम का मुख्य उद्देश्य आदिवासी कृषकों को दलहनी फसल एवं मृदा स्वास्थ्य परीक्षण के प्रति जागरूकता लाना है। कार्यक्रम के मुख्य अतिथि कलेक्टर जयप्रकाश मौर्य अध्यक्षता जिला पुलिस अधीक्षक बीएस धुर्वे, विशिष्ठ अतिथि एसडीएम मुकेश रावटे, डॉ.वीके दुबे, डॉ.बीएस राजपूत, डॉ.डीके चंद्राकर, गोविंद सिंह दुबे, आरएल अंबादे, डॉ.प्रभात त्रिपाठी, डॉ.आर ईलनचेलीयन, डॉ.एम वसुंधा कुमार, डॉ.वासुदेव मीना, सरपंच आंनद साहू, पितांबर कतलम, शिव देवांगन, प्रमुख मां बम्लेश्वरी किसान उत्पादक कंपनी की उपस्थिति में संपन्न हुआ।

इस दौरान डॉ.बीएस राजपूत के द्वारा कार्यक्रम के विभिन्न गतिविधियों का संक्षिप्त विवरण दिया गया। जिलाधीश जयप्रकाश मौर्य द्वारा कृषकों को शासन के द्वारा संचालित योजनाएं कृषि, शिक्षा एवं स्वास्थ्य का समुचित उपयोग कर अधिक से अधिक लाभ लेकर अपने जीवन स्तर को सुधारने के लिए जागरूक किया गया।

Input distribution at Kisan Mela at KVK Rajnandgaon

On field demonstration on soil health and HYV of paddy and chickpea

During Kharif season, ICAR-IISS in collaboration with KVK Rajnandgaon conducted training cum rice seed distribution programme at village Khadkhadi, Ambagarh Chowki Block of Rajnandgaon district. In this training programme 60 q seed of HYV of rice (MTU 1010) was distributed among 65 tribal women farmers.


Paddy at village Khadkhadi

Field demonstration on soil health and HYV of paddy at village Khadkhadi

During rabi season, training cum chickpea seed distribution programme was conducted at village Mogara, Ambagarh chowki block of Rajnandgaon district. Padam shri Phulvasahan Devi Yadav, President Maa Bamleshwari Janhit Karya Samiti, graced the occasion and motivated the farmers to maintain soil health. In this training programme, 25 q seed of chickpea variety RVG202 was distributed among 65 tribal women farmers.


Awarness creation and input distribution for ravi season at Mogra village

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

The Training -Cum -Workshop Programme on Soil Health and Nutrient Management was organized at KVK Barwani during February 24-25, 2020. About 200 tribal farmers were participated in the training programme. During the kharif season, the agricultural inputs like vermicompost, chilli and tomato seedlings and fruit plantation material like drumstick and custard apples were distributed to the tribal farmers. Similarly, in rabi season, the wheat and chickpea seeds and fertilizer (Urea, DAP and MOP) were also distributed to the 50 tribal farmers.


Training program and input distribution at KVK Barwani

Farmer Field School (FFS)

Three farmer field school on "Use of organic inputs based Soil Health Card recommendations" were organized in Kaweli, Kulpa and Sarra villages of the Balaghat during January 22-24, 2020. Soil Health Cards were also distributed to eight farmers along with instruction leaflets. In addition, vegetable seed packets were also distributed to 30 tribal farmers to prepare nutrition gardens at the backyard.

Distribution of Soil Health Cards in the Kaweli and Kulpa villages of Balaghat

Farmer Field School and distribution of vegetable seeds at Sarra village of Balaghat

3.3.2 AICRP on STCR

Trainings cum field days under STC

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

State	District	Village/Block	Date	Total participants	No. of women farmers
Uttar Pradesh	Chandauli	Persiya	01.02.2020	25	15
	Chandauli	Persiya, Majhagawan and Jhariyawan	02.02.2020	60	35
	Chandauli	Jhariyawan and Persiya	09.02.2020	54	32
	Chandauli	Jhariyawan and Persiya	02.08.2020	20	12
Andhra Pradesh	YSR district	Utukur/CK Dinne	29.01.2020	25	5
Telangana	Rangareddy	Sherguda Bhadraipalli/Kothur	19.02.2020	58	12
	Rangareddy	Burjugadda Thanda/Shamshabad	16.10.2020	25	10
	Rangareddy	Sherguda Bhadraipalli/Kothur	29.10.2020	35	5

State	District	Village/Block	Date	Total partici-pants	No. of women farmers
Chhattisgarh	Uttar Bastar Kanker	Dumali	20.10.2020	25	02
	Kondagaon	Lanjoda	23.10.2020	35	6
Uttarakhand	U. S. Nagar	Indrapur	21.02.2020	56	18
	U. S. Nagar	Pratapur	19.11.2020	49	13
Kerala	Thrissur	Mathilakam	17.08.2020	40	20
	Thrissur	Edathuruthy	12.10.2020	25	12
	Thrissur	Sree Narayanapuram	10.11.2020	22	13
Odisha	Gajapati	Phatachanchada/R. Udaygiri	16.03.2020	50	21
	Deogarh	Reamal	16.10.2020	50	26
West Bengal	Nadia	Gayeshpur	01.09.2020	78	13
	Nadia	Gotra	24.09.2020	54	50
	Nadia	Gayeshpur	05.12.2020	90	34



Frontline demonstrations (FLDs) on farmers' field by different centres of STCR

Crop/variety	Village/Block	District	No. of FLDs	Yield (q ha^{-1}) Farmers' practice	Yield (q ha^{-1}) STCR based	Increased yield (%)
Chhattisgarh						
Rice (MTU 1001)	Kapsi	Kanker	20	44.23	54.94	24.21
Rice (Bamleshwari)	Jhartarai and Kondaloor	Bastar	20	31.53	39.32	24.71
Wheat (JW-3382)	Arjuni	Kanker	10	25.11	28.92	15.17
Maize (900 M Gold)	Retawand	Bastar	10	44.72	59.12	32.20
Odisha						
Lady's finger	Rukunapur	Keonjhar	10	96.40	137.80	42.95
Brinjal	Phatachanchada	Gajapati	15	163.50	221.30	35.35
Kerala						
Bhindi (Arka anamika)	Parakulambu and Van-dithavalam	Palakkad and Thrissur	4	134.20	156.10	16.32
Amaranthus (Arun)	Parakulambu	Palakkad and Thrissur	4	107.30	195.20	81.92
Ginger (Himachal)	Edayankolumbu and Van-dithavalam	Palakkad and Thrissur	4	163.00	191.10	17.24
Himachal Pradesh						
Soybean (PK 472)	Dadh, Ghughar, Biara and Garla	Kangra	9	11.90	24.00	101.68

Crop/variety	Village/Block	District	No. of FLDs	Yield (q ha^{-1}) Farmers' practice	Yield (q ha^{-1}) STCR based	Increased yield (%)
Toria (Bhawani)	Charatgarh, Biara, and Sasan	Una	10	7.80	14.90	91.03
Uttar Pradesh						
Rice (Beena-11)	Jharigawan	Chandauli	10	32.49	44.16	35.92
Maize (Herra BSNM-21)	Naugarh/Pathraur	Chandauli	5	25.52	34.30	34.40
Wheat (HUW-37)	Parsiya and Jharigawan	Chandauli	10	38.21	50.07	31.04
Mustard (Ashirwad)	Hadahi and Jharigawan	Chandauli	10	15.41	20.36	32.12
Tamil Nadu						
Little Millet	Noolathukombai and Samakuttapatti	Salem	4	11.00	17.28	57.09
Bhendi (NS-7772-TNAU Hybrid CO-4)	Pattiarkoilpathy	Coimbatore	3	89.50	149.30	66.82
Aggregatum Onion (Local)	Pattiarkoilpathy	Coimbatore	3	127.00	201.00	58.27
Tomato (Hybrid Aish-warya)	Alangandi, Ukkaiyanur and Kunnur	Coimbatore and Salem	6	454.15	788.90	73.71
Brinjal (Local)	Pattiarkoilpathy	Coimbatore	2	241.00	346.00	43.57
Sorghum (Local)	Ukkaiyanur	Coimbatore	1	210.00	345.00	64.29
Radish (Ural)	Pattiarkoilpathy	Coimbatore	2	309.00	489.00	58.25
Rice (IR20)	Pattiarkoilpathy	Coimbatore	5	382.00	598.00	56.54
Rainfed tapioca (Mullu-vadi)	Kaikkanvalavu & Kunnur	Salem	25	185.00	294.90	59.41
Sugarcane (CO-86032)	Kunnur	Salem	2	780.00	1242.00	59.23
Chilli (VS 344)	Kunnur	Salem	3	143.00	198.00	38.46
Cabbage (Harirani)	Pethakurichi	Salem	2	440.00	694.50	57.84
Carrot (Carota)	Pethakurichi	Salem	1	260.00	397.00	52.69
Ragi	Mottiyur/Karamadai	Coimbatore	1	23.60	36.80	55.93
Gingelly	Mottiyur/Karamadai	Coimbatore	2	6.40	9.40	46.88
Groundnut	Pottapathy/Thondamuthur	Coimbatore	1	18.00	23.10	28.33
West Bengal						
Cabbage (Green Express)	Saguna/Kalyani	Nadia	5	517.70	560.50	8.27
Broccoli (CSH-1)	Saguna/Kalyani	Nadia	3	414.70	464.40	11.98
Tomato (Amlic)	Saguna/Kalyani	Nadia	3	314.50	345.00	9.7
Mustard (B9)	Saguna/Kalyani	Nadia	2	13.10	15.10	15.27
Onion (Sukhsagar)	Saguna/Kalyani	Nadia	1	140.00	169.40	21
Potato (Kufri jyoti)	Saguna/Kalyani	Nadia	1	211.10	256.40	21.46
Assam						
Winter Rice (Ranjit Sub-1)	Danichapari, Dubigaon, Koilaghat, Nepaligaon and Birinagaon	Golaghat	10	37.12	52.66	41.86

Crop/variety	Village/Block	District	No. of FLDs	Yield (q ha^{-1}) Farmers' practice	STCR based	Increased yield (%)
Gujarat						
Wheat (GW 366)	Badalpur, Rabhatpur, Rajavad, Ishapur, Udakiya, Dudhala Gir and Lasva	Junagadh and Rajkot	15	40.40	49.36	22.18
Bihar						
Rice (Arize-6444)	Pusa	Samastipur	03	30.50	44.50	45.90
Wheat (2733)	Pusa	Samastipur	01	24.00	44.50	85.42
Maize (Shaktiman-5)	Pusa	Samastipur	01	52.00	91.50	75.96
Mustard (Rajendra Suphlam)	Pusa	Samastipur	01	12.25	27.00	120.41

3.4 Scheduled Caste Sub-Plan (SCSP)

3.4.1 Enhancing livelihood security of SC farming community

Twenty farmers from SC community from four villages namely, Tarasewania, Pipalia Chapparband, Bagoniya and Jhapadia of Bhopal district were supplied with seed (40 kg chick pea and 60 kg for wheat) and fertilizer (75 kg NPK: 12:32:16; 90 kg Urea). For INM, fertilizer recommendation for chickpea and wheat were 75% RDF and FYM @10 t/ha. Apart from this 150 farmers were also supplied with seed (40 kg chickpea and 60 kg for wheat) and fertilizer (75 Kg NPK complex : 12:32:16; 90 Kg Urea).

3.4.2 Input distribution to SC farming community by MGMG groups

MGMG Group	Trainings/Farmers-Scientist Interaction Meet (No)	Input distributed	No. of Farmers
1	7 (March 5, 2020, September 14, October 7, 8, 12, 15 and 21, 2020)	Manual peg type dry weeder (122), maize sheller (122), vermibed (20), fertilizers (360 bags) and plant of mango (360), lemon (90) and guava (90)	122
2	2 (September 26, and October 28, 2020)	Manual peg type dry weeder (40), maize sheller (50), vermibed (20), fertilizers (160 bags), mango (80), lemon (100) and guava (80)	50
3	1 (November 6, 2020)	Manual peg type dry weeder (17), maize sheller (140), vermibed (30), fertilizers (80 bags Urea & 80 bags Gromore), mango (nil), lemon (160 saplings) and guava (106 saplings)	110
4	3 (October 13, 15 and 19, 2020)	Manual peg type dry weeder (38), maize sheller (38), vermibed (20), fertilizers (152 bags), mango (152), lemon (152) and guava (152)	38
5	1 (October 23, 2020)	Fertilizer (52), maize sheller (26), wheel hoe type manual weeder (26), lemon (104), guava (52) and mango saplings (26)	26
6	2 (October 19, 2020 and November 10, 2020)	Manual peg type dry weeder (51), maize sheller (51), vermibed (20), fertilizers (204 bags), mango (51), lemon (51) and guava (51)	51
7	3 (September 22, 23, 29, 2020)	Manual peg type dry weeder (17), maize sheller (50), vermibed (17), fertilizers (68 bags), mango (150), lemon (100) and guava (150)	17

MGMG Group	Trainings/Farmers-Scientist Interaction Meet (No)	Input distributed	No. of Farmers
8	1 (September 29, 2020)	Manual peg type dry weeder(43), maize sheller(43),fertilizers (129 bag)	43
9	1 (October 31, 2020)	Manual peg type dry weeder (10), maize sheller (30), vermibed (20), fertilizers (120bags), guava (60), lemon (150)	31
10	1 (October 31, 2020)	Manual peg type dry weeder (30), maize sheller (30), vermibed (30), fertilizers (120 bags), mango (60), lemon (150)	30
11	2 (October 13 and November 10, 2020)	Manual peg type dry weeder (28), vermibed (10), fertilizers (200 bags), mango (40), lemon (32) and guava (42)	90

Distribution of farm inputs to the SC farmers

3.5 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.

Table : Adopted Villages under MGMG by the Institute

Group	Members	Name of five villages adopted by Group Leader
1	Dr. A.K. Patra, Director, ICAR-IISS Dr. A.B. Singh, PS, & Nodal Officer, MGMG Dr. A.O. Shirale, Scientist, SC&F Dr. Sudeshna Bhattacharjya, Scientist, SBD Dr. Narayan Lal, Scientist, SC&F	Dobra, Khejra, Perwalia Sadak, Badarkha Sadak, Mubarakpur
2	Dr. M.C. Manna, HOD, SBD Dr. P. Tripathi PS & Co-Nodal officer Dr. N.K. Sinha, Scientist, SPD Dr. Dolamani Amat Scientist, SBD	Acharpura, Parewakheda, Arwali, Hazampura and Parewalia sahani
3	Dr. Muneshwar Singh, PC, LTFE Dr. S.R. Mohanty, PS & I/c BNF Dr. R.H. Wanjari, PS, LTFE Mrs. Seema Bhardwaj, Scientist, SPD	Choupdakala, Ghatkheri, Sayyaid Semara, Emaliya Chopra and Amoni
4	Dr. J.K. Saha, HOD, ESS Dr. Hiranmoy Das, Scientist (STCR) Dr. Vasudev Meena, Scientist, ESS Dr. Madhumounti Saha, Scientist, ESS	Islam Nagar, Dewalkhedi, Bharonpura, Kalyanpura, Puraman Bhavan
5	Dr. K.M. Hati, PS, SPD Dr. Sanjay Srivastava, PS, SC &F Dr. Sanjib Kumar Behera, SS, MSN Dr. K.C. Shinogi, Scientist, ITMU Dr Gurav Priya Pandurang, Scientist SC & F	Bankhedi, Baroda, Sojna, Amaravadi and Kuravadi
6	Dr. A.K. Shukla, PC, MSN Dr. R. Elanchezhian, PS, SC&F Dr. R.K. Singh, PS, SPD Dr. J.K. Thakur, Scientist, SBD Dr. Nisha Sahu, Scientist, ESS	Sagoni, Munirgarh, Gudawal, Chhattarpura, Chiklodkhurd
7	Dr. A. K. Biswas, HOD, SC&F Dr. Brij Lal Lakaria, PS, SC&F Dr. Asha Sahu, Scientist, SBD Dr. Bharat P. Meena, Scientist, SC&F Ms Alka Rani, Scientist, SPD	Golkhedi, Binapur, Kanchbavli, Khamkheda and Raslakhedi
8	Dr. R.S. Choudhary, HOD, SPD Dr. P. Jha, PS, SC&F Dr. A.K. Vishwakarma, PS, SPD Dr. K. Bharati, PS, SBD Dr Abhijit Sarkar, Scientist, ESS	Raipur, Kanera, Momanpur, Kadhaiya and Karod khurd
9	Dr. P. Dey, PC, STCR Dr. N.K. Lenka, PS, SC&F Dr. M. Mohanty, PS, SPD Dr. M. Vassanda Coumar, SS, ESS	Ratibad, Rasuliya Pathar, Mugaliahat, Ratanpur Sadak, Chandukhedi
10	Dr. A.K. Tripathi, PS, SBD Dr. S. Ramana, PS, ESS Dr. J. Somasundaram, PS, SPD Dr. Asit Mandal, Scientist, SBD	Dobra Jagir, Kolua Khurd, Sagoni Kalan, Chor Sagoni, Adampur Chhawni
11	Dr. Ajay, PS, ESS Dr. Tapan Adhikari, PS, ESS Dr. Sangeeta Lenka, SS, ESS Dr. Jitendra Kumar, Scientist, SPD	Shahpur, Devpur, Kasi Barkeda, Sagoni, and Barkedi Hajam

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 January to December 2020
1	Scientist	17
2	Technical	0
3	Administrative & Finance	1
4	Skilled Supporting Staff	0
	Total	**18**

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

S. No.	RE for HRD 2020	Actual Expenditure 2020 for HRD
1.	2.44	2.43

c. Training attended during January to December 2020

Category: Scientific staff

S.No	Name of employee	Title	Organizer	Duration
1	Mrs M Saha	Winter School Training Programme on 'Data Analysis in agriculture using Statistical Software Packages'	ICAR-IASRI, New Delhi	January 16 to February 5,
2	Dr NK Lenka	Geospatial analysis using QGIS and R"	ICAR-NAARM, Hyderabad	February 27 to March 3, 2020
3	Miss Alka Rani	ICAR-NICRA sponsored Training Programme on Crop Simulation Modelling and Impacts of Climate Change on Agricultural Production Systems: Multi-model Training	ICAR-IISS, Bhopal	March 16-21, 2020
4	Drs M Mohanty, NK Sinha, Hiranmoy Das	Training on e-file module of e-office	ICAR-IASRI, New Delhi Online through Microsoft-teams platform	May 1, 2020
5	Dr R Elanchezhian	MDP on "Access and benefit sharing"	ICAR-NAARM Hyderabad	July, 7-10 2020
6	Dr Immanuel Chongboi Haokip	Professional Attachment Training	ICAR-RC for NEH Region, Umiam, Meghalaya	May 7 - September 7, 2020
7	Dr M. Homeshwari Devi	Professional Attachment Training	ICAR-RC for NEH Region, Umiam, Meghalaya	May 7 - September 7, 2020
8	Miss Alka Rani	Webinar on remote sensing in crop monitoring and assessment	IIRS, ISRO, Dehradun	May 19 to June 9, 2020
9	Dr Brij Lal Lakaria	Web based training session on "Methodology for synthesis of district specific IFS models"	ICAR-IIFSR, Modipuram	June 6, 2020
10	Dr Asha Sahu and Dr Sudeshna Bhattacharjya	60th IIRS Outreach Program on "Application of Geoinformatics in Ecological Studies"	Indian Institute of Remote Sensing, Dehradun	July 13-24, 2020

S.No	Name of employee	Title	Organizer	Duration
11	Dr J K Saha	Training Workshop for 'Vigilance Officers of ICAR Institutes'	ICAR-NAARM Hyderabad	August 5-7, 2020
12	Dr Jitendra Kumar	Introduction to Remote Sensing for Tribal Lands	NASA in collaboration with United Tribes Technical College (UTTC), USA	October 6-29, 2020
13	Miss Alka Rani	Polarimetric SAR Remote Sensing for Characterization of Manmade & Natural Features	Indian Institute of Remote Sensing, ISRO, Dehradun	October 26 to November 6, 2020.
14	Dr Immanuel Chongboi Haokip	Analysis of Experimental Data using SAS	ICAR-NAARM, Hyderabad (Online)	November 9-17, 2020

C2 Category: Technical staff : Nil

C3 Category: Administrative staff

S.No.	Name of employee	Title	Organizer	Duration
1	Mr Sanjay Kumar Kori	Enhancing Efficiency and Behavioural Skills of Stenographer grade-III, PA, PS and PPS of ICAR Institutes/HQs	ICAR- NAARM, Hyderabad	February 24-29, 2020

4.2. Professional Attachment Training Organized for Scientist Probationers

S.No.	Name of the Scientist	Name of the College/Institute/University	Duration (month)	Name of the Scientist/ Mentor
1.	Dr Himanshu Mahawar	ICAR-DWR, Jabalpur	Oct-Dec 2020	Dr SR Mohanty

4.3. Research Guidance for Degree Students

S.No.	Name of the Scientist	Name of the College/Institute/University	Degree	Name of the Scientist/ Mentor
1	Ms Mamta Shivran	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior	M. Sc.	Dr SR Mohanty
2	Mr Raghvendra Narvariya	RVSKVV, Gwalior	M.Sc. Soil Science	Dr R Elanchezhian
3	Ms Uma Prajapati	RVSKVV, Gwalior	M.Sc. Soil Science	Dr Pramod Jha
5	Mr Sunil Prajapati	RVSKVV, Gwalior	M. Sc. (Ag.)	Dr J K Thakur
6	Mr Rajesh Choudhary	RVSKVV, Gwalior	M. Sc. (Ag.)	Dr S lenka
7	Mr Pradeep Malviya	RVSKVV, Gwalior	M. Sc. (Ag.)	Dr JK Saha
8	Mr Pramod Sharma	CAU, Jhansi	M. Sc. (Ag.)	Dr AK Bishwas

5. AWARDS, HONOURS AND RECOGNITIONS

5.1 Awards

- Institute has been bestowed with King Bhumibol World Soil Day Award of FAO UN.

- Dr SR Mohanty selected as top 10 scientists from EET CRS Education Expo, New Delhi for 2020.
- Dr SR Mohanty selected as fellow from Global Environment Sustainable Association, New Delhi for 2020.
- Dr A B Singh received Fellow of International Society of Noni Science, Chennaifor the year 2020.
- Dr Asit Mandal received Young Scientist Award by Samgra Vikas Welfare Society (SVWS) during virtual celebration of World Environment Day (June 05, 2020).
- Dr N K Lenka received Eminent Scientist award 2020 from 'The Society for Science of Climate Change and Sustainable Environment', New Delhi.
- Dr Sangeeta Lenka received Eminent Scientist award 2020 from 'The Society for Science of Climate Change and Sustainable Environment', New Delhi.
- Dr Sangeeta Lenka received Science and Engineering Research Board-POWER- fellow in the year 2020.
- Dr Jitendra Kumar conferred Young Scientist Award 15th October, 2020 by Society for Biotic and Environmental Research.
- Dr Jitendra Kumar conferred Best Doctoral Researcher Award 2020 on October 15, 2020 by Society for Biotic and Environmental Research.
- Dr Jitendra Kumar elected fellow of Society of Agriculture and Nutrition during 2020, New Delhi.
- Dr. B P Meena received Young Scientist Award-2020 by Agricultural Technology Development Society (ATDS) Ghaziabad, Uttar Pradesh, India.

5.2 Honours and Recognitions

- Dr Asit Mandal elected as Joint Secretary & Treasurer, Bhopal Chapter of the Indian Society of Soil Science.
- Dr Asit Mandal served as Editorial board member of "Indian journal of Waste Management".
- Dr Asit Mandal selected as Editor for the "Journal of Ecology and Natural Resources" in 2020
- Dr Asit Mandal selected as Editorial board member for the "American Research Journal of Agriculture in 2020.
- Dr Asit Mandal recognized as member of Editorial board member as Academic Editor- PlosOne.
- Dr Asit Mandal served as Associate Editor for the magazine "Popular Kheti" for the year 2020.
- Dr RS Chaudharyacted as rapporteur in National Webinar on "Alternatives to Plastics for Sustainable Soil and Environmental Health" organized by ICAR-IISS, Bhopal on December 30, 2020.
- Dr Asha Sahu received certificate of recognition

of Outstanding Oral Presentation on "Efficient Recycling of Biodegradable City Waste through Rapid Composting Technology" at the "International Webinar on Agriculture & Biotechnology" held during September 16 – 17, 2020.

- Dr AB Singh Acted as examiner for the evaluation of Ph. D thesis at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidylaya Chitrakoot Satna (M. P).
- Dr RH Wanjari acted as member of editorial board in Indian Journal of Agronomy of Indian Society of Agronomy.
- Dr Dhiraj Kumar acted as external advisory member for Thesis Viva–Voce of Mr. Narendra Kumar Bhinda, M.Sc (Ag.) student at RLBCAU, Jhansi on October 10, 2020.
- Dr Dhiraj Kumar acted as external advisory member for Thesis Viva–Voce of Mr. Prakash Chand Choudhary, M.Sc (Ag.) student at RLBCAU, Jhansi on October 13, 2020.
- Dr Dhiraj Kumar acted as Business Manager, Indian Society of Agroforestry, Jhansi (U.P), for the period 2018 to 2020.
- Dr Dhiraj Kumar acted as member Editorial Board of Indian Journal of Agroforestry by the Indian Society of Agroforestry, Jhansi (U.P), w.e.f August, 2019.
- Dr SR Mohanty selected as member from Royal society of Biology, London for 2020.
- Dr R Elanchezhian recognized as Local organizing committee member for the International conference of Pulses 2020 organized at Bhopal during February 10-12, 2020.
- Dr BP Meena acted as external examiner (Principles and Practices of water management-AGRON 504) at, Banda University of Agriculture & Technology, Banda, (U.P.)
- Dr BP Meena acted external examiner (Principles of Organic Farming- AAG 323) at Banda University of Agriculture & Technology, Banda, (U.P.) 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, Dehradun, Uttranchal..
- Dr Brij Lal Lakaria acted as an subject matter expert for interview for the post of Programme Assistant (Soil Science) at KVK Jaora, Ratlam MP on November 26, 2020.
- Dr NK Lenka Organizing Secretary, Felicitation Workshop of Dr. Rattan Lal, World Food prize 2020 Laureate.
- Dr Sanjay Srivastava deputed as external expert for the selection of Soil Testing Assistant on August 24, 2020 for PSS Central Institute of Vocational Education (PSSCIVE), Bhopal.

6. LINKAGES AND COLLABORATION

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., Hindustan Copper Ltd., Malanjkhand, M/s Grasim Industries Limited, Nagda, Ujjain, M.P., UPL Pvt. Ltd, Mumbai, M/s Privi Life Scinece, Mumbaiare collaborating with the Institute on various R&D activities.

List of Co-operating Centres under AICRPs/AINP

AICRPs/AINP	No. of Cooperating Centres		
	ICAR	SAUs/SGUs	Total
AICRP on LTFEU AS GKVK, Bangalore; OUAT, Bhubaneswar; TNAU, Coimbatore; PJTSAU, Hyderabad; JNKVV, Jabalpur; PAU, Ludhiana; CSKHPKV, Palampur; BAU, Ranchi; GBPUAT, Pantnagar; KAU, Pattambi; JAU,Junagarh; MPUAT, Udaipur; VNMAU, Parbhani; Dr PDKV, Akola; IGKVV, Raipur; ICAR-IARI, New Delhi; ICAR-CRIJAF, Barrackpore; ICAR-IASRI, New Delhi	**3**	**15**	**18**
AICRP on MSPE PJTSAU, Hyderabad; RAU, Pusa; AAU, Anand;HAU, Hisar; JNKVV, Jabalpur; Dr PDKV, Akola; OUAT, Bhubaneshwar;PAU, Ludhiana;TNAU, Coimbatore;GBPUAT, Pantnagar;AAU, Jorhat; BCKV, Kalyani; RAU, Ranchi;CSKHPKV, Palampur; CSAUAT, Kanpur; KAU Kerala; UAS Bengaluru; CAU, Manipur; NIANP Bengal-uru;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; PA-JANCOA, 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, Jabal-pur; KAU, Thrissur; MAU, Parbhani; MPUAT, Udaipur; OUAT, Bhubaneswar; RAU, Pusa; TNAU, Coimbatore; YSPUHF, Solan; CRRI, Hazaribagh; ICAR-IARI, New Delhi; DGR, Junagarh; GBPUAT, Pantnagar; UAS, Dharwad	3	14	17

International cooperation

India Japan collaborative project - Department of Science and Technology (DST) India and Japan Society for the Promotion of Science (JSPS) funded project "Methanogenicbioelectrode driven conversion of CO_2 to CH_4 in agrowaste based bioenergy system" was inaugurated on February 26 2020. The meeting was attended by Investigators from India (Dr S R Mohanty, Dr A K Patra and Dr K Bharati) and Japan (Dr SeiyaTsujumura and Dr Masanori Kaneko) along with all the scientists of the institute.

Collaboration with Global Soil Laboratory Network (GLOSOLAN) of FAO, United Nations

ICAR-IISS participated in the survey "Global Assessment on laboratory capacities and needs" of GLOSOLAN, FAO and provided necessary information. Dr Sanjay Srivastava compiled procedure for soil parameters under South East Asia Laboratory Network (SEALNET) and North East and North Africa (NENA) region for harmonization.

7. ONGOING RESEARCH PROJECTS

7.1 Programme I: Soil Health and Input Use Efficiency

(A) Institute Project

1. Long-term evaluation of integrated plant nutrient supply modules for sustainable productivity in Vertisol
   Investigators: BP Meena, AK Biswas, AB Singh, RS Chaudhary, RH Wanjari
2. Evaluation of glauconite as source of potassium for crops
   Investigators: AO Shirale, Gurav Priya Pandurang, Sanjay Srivastava, B.P. Meena and A.K. Biswas
3. Enhancing the productivity of major crops through improving the natural resource base of tribal inhabited areas of central India
   Investigators: Shinogi K.C., Sanjay Srivastava, A.L. Kamble, B.P. Meena, N.K. Sinha, K. Bharati, Gurav Priya Pandurang, A.K. Tripathi, Hiranmoy Das, R.L. Raut (KVK, Balaghat), Rameshwar Ahirwar (KVK, Balaghat), Aparna Jaiswal (COA, Balaghat)
4. Mineralogy of Vertisols in relation K availability in central and western India
   Investigators: Gurav Priya Pandurang, A.O. Shirale, B.P. Meena, B.L. Lakaria, Sanjay Srivastava, P. Chandran (ICAR-NBSS&LUP, Nagpur)
5. Micronutrients distribution in major soil orders of India as influenced by soil properties and land use pattern
   Investigators: S.K. Behera, A.K. Shukla, N.K. Sinha, J.K. Thakur, K. Kartikeyan (ICAR-NBSS&LUP, Nagpur)
6. Enhancement of Soil Health and Livelihood of Tribals in Central India
   Investigators: RH Wanjari, R Elanchezhian, Prabhat Tripathi, RK Singh, KC Shinogi, MV Coumar,Vasudev Meena, AL Kamble, Utkarsh Tiwari, J Somasundaram, AO Shirale, Asit Mandal, Hiranmoy Das, AB Singh, Asha Sahu, SK Behera, AK Vishwakarma, M Mohanty, Seema Bhardwaj, Madhumonti Saha, Sanjay Srivastava, K Bharati, Priya Gurav, BP Meena, AK Tripathi, Abhijit Sarkar, NK Sinha, JK Thakur, I/c KVK Barwani (MP), I/c KVK Rajnandgaon (Chhattisgarh) and I/c KVK Betul (MP)
7. Assessment of nutrient (N & P) use efficiency in wheat genotypes for improved crop productivity
   Investigators:R. Elanchezhian, A.O. Shirale, B.P. Meena, Alka Rani, Sanjay Srivastava, Ajay, S. Ramana, A.K. Biswas, MV Coumar and Renu Pandey (ICAR-IARI, New Delhi)

(B) Externally Funded Projects

8. All India Network Programme on Organic Farming (ICAR, New Delhi)
   Investigators: AB Singh, BP Meena, Brij Lal Lakaria, S Ramana and JK Thakur
9. Ensuring food security, sustainability and soil health through resource conservation based farmer FIRST approach in central India, (ICAR New Delhi)
   Investigators: AK Patra, AK Vishwakarma, RK Singh, AB Singh, BL Lakaria, RH Wanjari, K Bharati, AL Kamble, Asha Sahu, Shinogi KC, Abhay O Shirale, Hiranmoy Das
10. Development of an automated soil nutrient sensing system (NASF, ICAR)
    Investigators: Sanjay Srivastava, A.O. Shirale, P.S. Tiwari (ICAR-CIAE, Bhopal), Vijay Kumar (ICAR-CIAE, Bhopal), Ramesh Kumar Sahani (ICAR-CIAE, Bhopal), Baban Kumar (CSIR-CSIO, Chandigarh), Neelam (CSIR-CSIO, Chandigarh)
11. Assessing the impact of imbalanced use of chemical fertilizer on soil health using a soil function based quantitative approach (DST, New Delhi)
    Investigators: NK Lenka, BP Meena, Sangeeta Lenka, AO Shirale, RH Wanjari, ML Dotaniya, RK Singh
12. Long-term monitoring of soil processing in forests and grasslands (MOEF, GOI)
    Investigators: Pramod Jha, Sumanta Bagchi

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

A.Institute Projects

13. Assessing greenhouse gas emission and soil carbon storage with reversal in tillage practice
    Investigators: Sangeeta Lenka, NK Lenka, S Bhattacharjya
14. Climate change impact on water productivity of major crops in central India
    Investigators: N.K. Sinha, M. Mohanty, J. Somasundaram, Pramod Jha, Alka Rani, Seema

Bhardwaj, Hiranmoy Das, K.M. Hati, R.S. Chaudhary

15. Impacts of conservation agriculture on runoff and soil loss under different cropping system in Vertisols
Investigators: Prabhat Tripathi, R.K. Singh, R.S. Chaudhary, Seema Bhardwaj, J. Somasundaram, M. Mohanty, K.M. Hati

B. External funded projects

16. Assessment of important soil properties of India using mid-infrared spectroscopy (ICAR-ICRAF, Nairobi)
Investigators:K.M. Hati, M. Mohanty, Pramod Jha, R.S. Chaudhary, N.K. Sinha, J.K. Thakur, M. V. Coumar, Pradip Dey, Muneshwar Singh, A.K. Patra, Javed Rizvi
17. CRP-Conservation Agriculture (LCPC: Dr AK Biswas and DLCPC: Dr RS Chaudhary) (ICAR)

a. Development, refinement and validation of conservation agriculture in Vertisols of central India and quantifying impact of CA practices on soil and environment
Investigators: KM Hati (PPI), J Somasundaram, AK Vishwakarma, Sanjay Srivastava, Pramod Jha

b. Demonstration of best-bet conservation agriculture practices on farmers' fields in Vertisols of central India
Investigators: AK Vishwakarma, RH Wanjari, RK Singh, KC Shinogi, AK Tripathi

c. Fine-tuning of conservation agricultural practices for Vertisols of central India
Investigators: J Somasundaram, S Ramana, BP Meena and Abhay Shirale

d. Development of water and nutrient management practices in conservation agriculture for Vertisols of central India
Investigators: RK Singh, Sanjay Srivastava, KV Ramana Rao and NK Sinha

e. Impact of conservation agricultural practices on soil health, carbon sequestration and greenhouse gas emissions in different production systems
Investigators: Pramod Jha, Brij Lal Lakaria, M Mohanty, JK Thakur and K Bharati

18. Cropping systems and soil management effects on soil organic carbon sequestration and greenhouse gas emission in Vertisols of central India under change climate scenarios (NICRA II-Phase, ICAR)
Investigators: M Mohanty, NK Sinha,Pramod Jha, Sangeeta Lenka, J Somasundaram, , AK Vishwakarma, RS Chaudhary, Muneshwar Singhand Seema Bhardwaj
19. Hyper-spectral remote sensing approaches to evaluate soil quality and crop productivity of central India(DST, New Delhi)
Investigators: M Mohanty, NK Sinha, KM Hati, RK Singh, Pradip Dey, RS Chaudhary, AK Patra and BBGaikwad
20. Strategies for enhancing yield of soybean (Glycine Max L) and pigeonpea (Cajanus cajan, L) in India using climate variability information and crop growth simulation models in collaboration with ICAR-IISR, Indore (IITM, Pune)
Investigators: M Mohanty, VS Bhatia, NK Sinha, Prabhat Tripathi, RS Chaudhary, Seema Bhardwaj and AK Patra
21. Sustainable adaptive management of water resources to variable climates of Madhya Pradesh (ICAR-ICARDA, Moracco)
Investigators: M Mohanty, NK Sinha, AK Patra
22. Vulnerability and impact assessment of climate change on soil and crop production in Madhya Pradesh (UNDP-GEF-MoEFCC)
Investigators: Sangeeta Lenka, NK Lenka, M Mohanty, RH Wanjari and AK Patra
23. Assessing the potential impact of climate smart technologies on soil health and nutrient accounting in selected vulnerable districts of MP (EPCO, Bhopal)
Investigators: Sangeeta Lenka, NK Lenka, MV Coumar, M Mohanty, S Bhattacharjya, 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 (NASF, ICAR)
Investigators: Sangeeta Lenka, NK Lenka, Vasudev Meena, Asit Mandal, Biswapati Mandal (BCKV, West Bengal)

7.3 Programme III – Soil Microbial Diversity and Biotechnology

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

B. Externally Funded Projects

26. Enhancing decomposition rate and quality of biowaste through microbial consortia for improving soil health (NASF, ICAR)

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

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

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

29. Exploring soil microbial community and mechanism in soil carbon sequestration under long term land uses in semi-arid sub-humid Central India (SERB, DST, New Delhi)
Investigator: S Bhattacharjya

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

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

7.4 Programme IV: Soil Pollution, Remediation and Environmental Security

A.Institute Project

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

Externally Funded Projects

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

34. Management of Municipal Solid Waste (MSW) contaminated landfill area of Bhanpur, Bhopal (Bhopal Municipal Corporation, Bhopal)
Investigators: Ajay, Tapan Adhiakari, K Bharati, Asit Mandal and JK Saha

35. Management of municpal solid waste contaminated dumping area of Bhanpur, Bhopal(MPCST, Bhopal)
Investigators: Ajay, Tapan Adhikari, K Bharati and Asit Mandal

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

New project approved

37. Soil health assessment and input use efficiency

a. Development of agri-horticultural system for central India under Vertisols, its impact on soil health and improvement in productivity and quality of fruits
Investigators:Narayan Lal, BL Lakaria, AK Vishwakarma, Asha Sahu, Hiranmoy Das, AK Biswas and Pradip Dey

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

a. Deciphering thermophiles from hot springs of Central India for rapid decomposition of crop residues
Investigators: Asha Sahu, Sudeshna Bhattachrjya, Dolamani Amat, Nisha Sahu, K Bharati and Anita Tilwari

b. Exploring endophytic microbial diversity of selected major field crops of India for nutrient supplementation and biocontrol
Investigators: J.K. Thakur, Asit Mandal, Dolamani Amat and MC Manna

39. Impact of climate change on soil processes

a. Impact of climate change on soil physical process in maize based cropping systems in vertisols of central India
Investigators:Jitendra Kumar, NK Sinha, M Mohanty, J. Somasundaram, Alka Rani, KM Hati and RS Chaudhary

b. Soil moisture estimation through remote sensing for agriculture drought monitoring and early warning
Investigators:Alka Rani, NK Sinha, M Mohanty, Jitendra Kumar, Seema Bhardwaj, RS Chaudhary, KM Hati and RK Singh

c. Evaluation of deficit irrigation levels and phosphorus nutrition levels for optimizing water productivity rooting behaviour and yield of wheat in semiarid climate of central India
Investigators : Seema Bhardwaj, Alka Rani, Jitendra Kumar, Prabhat Tripathi, J Somasundaram, RS Chaudhary, M Mohanty

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

a. Assessment/quantification of soil heavy metals using spectroscopy and multi spectral remote data from industrial areas of Kanpur
Investigators:Nisha Sahu, Madhumonti Saha, JK Saha, NK Sinha, Nirmal Kumar (ICAR-NBSSLUP Nagpur), Asik Datta (ICAR-IIPR, Kanpur)

b. Municipal solid waste compost quality assessment for sustainable crop production and environmental protection
Investigators: M. Vassanda Coumar, Tapan Adhikari, Abhijit Sarkar, Nisha Sahu, J. K. Saha, Hiranmoy Das and Ajay

Collaborative Projects in Other Institutes where IISS Scientists are associated in

41. Development and promotion of CA machinery (ICAR-IISS, Bhopal and ICAR-CIAE, Bhopal)
Investigators: Dushyant Singh, NS Chandel, A.K. Vishwakarma

42. System for production of enriched biochar from crop residue (ICAR-IISS, Bhopal and ICAR-CIAE, Bhopal)
Investigators: Sandip Mandal, Chirag Maheswari, A.K. Shukla, S.K. Behera

43. Enhancing input use efficiency and productivity of pulses production system in central India (ICAR-IISS, Bhopal and ICAR-IIPR, Kanpur)
Investigators: Sandeep Kumar, Narendra Kumar, Pramod Jha, R Elanchezhian

8. CONSULTANCIES, CONTRACTUAL SERVICES, PATENTS AND TECHNOLOGY COMMERCIALIZATION

Consultancies /Contractual Services

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

Technology Commercialization/Resource Generation

The technology of Mridaparikshak mini lab commercialized by the institute generated a royalty of Rs. 6625355.00 (Rupees sixty six lakhs twenty five thousand three hundred fifty five only) during 2020. With this the total amount of royalty received by the institute is Rs. 38675337 (Rupees three crore eighty six lakhs seventy five thousand three hundred thirty seven only). This technology was generated by a team of scientists comprising Drs Sanjay Srivastava, Pramod Jha, I Rashmi, Neenu S, AK Biswas, Pradip Dey, Tapan Adhikari, Abhay O Shirale, M Vassanda Coumar and Ashok K Patra.

9. PUBLICATIONS

9.1 Papers in Research Journal

9.1.1 International/ National (NAAS rating more than 6)

Baghel V, Thakur JK, Yadav SS, Manna MC, Mandal A, Shirale AO, Sharma P, Sinha NK, Mohanty M, Singh AB, Patra AK (2020). Phosphorus and Potassium Solubilization from Rock Minerals by Endophytic Burkholderia sp. Strain FDN2-1 in Soil and Shift in Diversity of Bacterial Endophytes of Corn Root Tissue with Crop Growth Stage. *Geomicrobiology Journal* 37(6), pp.550-563. (NAAS Rating: 7.61)

Behera SK, Shukla AK, Dwivedi BS, Cerda A, Lakaria BL (2020). Alleviating soil acidity: optimization of lime and zinc use in maize (Zea mays L.) grown on Alfisols. *Communications in Soil Science and Plant Analysis*, 51(2): 221-235. (NAAS Rating: 6.69)

Behera SK, Shukla AK, Prakash C, Tripathi A, Kumar A, Trivedi V (2020). Establishing management zones of soil sulphur and micronutrients for sustainable crop production. *Land Degradation & Development,* https://doi.org/10.1002/ldr.3698. (NAAS Rating: 10.28)

Behera SK, Shukla AK, Suresh K, Manorama K, Mathur RK, Kumar A, Harinarayana P, Prakash C, Tripathi A (2020). Oil palm cultivation enhances soil pH, electrical conductivity, concentrations of exchangeable calcium, magnesium and available sulphur and soil organic carbon content. *Land Degradation & Development,* 31: 2789-2803.(NAAS Rating: 10.28)

Dev Inder, Ram Asha, Ahlawat SP, Palsaniya DR, Singh R, Dhyani SK, Kumar N, Tewari RK, Singh Mahendra, Sridhar KB, Newaj Ram, Dwivedi RP, Kumar RV, Yadav RS, Chand Lal, Kumar Dhiraj, Prasad J (2020). Bamboo based agroforestry system (Dendrocalamus strictus + sesame-chickpea) for enhancing productivity in semi-arid tropics of central India. *Agroforestry Systems,* 94: 1725-1739. DOI: https://doi.org/10.1007/s10457-020-00492-8. (NAAS Rating: 7.79)

Dhaliwal SS, Sandhu AS, Shukla AK, Sharma V, Kumar B, Singh R (2020).Bio-fortification of oats fodder through zinc enrichment to reduce animal malnutrition. *Journal of Agricultural Science and Technology* 10: 98-108. (NAAS Rating:6.83)

Jain D, Kour R, Bhojiya AA, Meena RH, Singh A, Mohanty SR, Rajpurohit D, Ameta KD (2020). Zinc tolerant plant growth promoting bacteria alleviates phytotoxic effects of zinc on maize through zinc immobilization. *Scientific reports,* 10(1), pp.1-13.(NAAS Rating:10.01)

Jha P, Hati K, Dalal RC, Dang YP, Kopittke PM, Menzies NW (2020). Soil carbon and nitrogen dynamics in a Vertisol following 50 years of no-tillage, crop stubble retention and nitrogen fertilization. *Geoderma*, 358, 113974. (NAAS Rating:10.34)

Kollah B, Ahirwar U, Singh N, Dubey G, Patra AK, Mohanty SR (2020). Chlorpyrifos degradation under the influence of climate factors and fertilizer regimes in a tropical vertisol. *The Journal of Agricultural Science Cambridge*,AGS-2019-00016.(NAAS Rating:7.33)

Kollah B, Bakoriya M, Dubey G, Parmar R, Somasundaram J, Shirale A, Patra A, Mohanty SR (2020). Methane consumption potential of soybean-wheat, maize-wheat and maize-gram cropping systems under conventional and no-tillage agriculture in a tropical vertisol. *The Journal of Agricultural Science,* 158(1-2), 38-46.(NAAS Rating:7.33)

Kollah B, Parmar R, Vishwakarma AK, Dubey G, Patra A, Chaudhari SK (2020). Nitrous oxide production from soybean and maize under the influence of weedicides and zero tillage conservation agriculture. *Journal of Hazardous Materials,* 402, 123572.(NAAS Rating; 13.65)

Kumar Dhiraj, Newaj Ram, Ram A, Prasad Rajendra, Kumar V (2020). Fine roots dynamics and biomass of Phyllanthus emblica based agroforestry system in Bundelkhand region of Central India. *Current Science*, 119(10): 1694-1699. DOI: 10.18520/cs/v119/i10/1694-1699. (NAAS Rating: 6.76)

Kumar R, Bhardwaj AK, Rao BK, Vishwakarma AK, Kakade V, Dinesh D (2020). Soil loss hinders the restoration potential of tree plantations on highly eroded ravine slopes, *Journal of Soils and Sediments*, 21 (2), 1232-1242. (NAAS Rating: 8.67)

Kumawat A, Vishwakarma AK, Wanjari RH, Sharma NK, Yadav D (2020). Impact of levels of residue retention on soil properties under conservation agriculture in Vertisols of central India. *Archives of Agronomy and Soil Science*, 1-15. (NAAS Rating: 7.68)

Lenka NK, Lenka S, Thakur JK, Yashona DS, Shukla AK, Elanchezhian R, Singh KK, Biswas AK, Patra AK (2020). Carbon dioxide and temperature elevation effects on crop evapotranspiration and water use efficiency in soybean as affected by different nitrogen levels. *Agricultural Water Management*, 230, p.105936. (NAAS Rating : 9.54)

Lenka S, SK Malviya, NK Lenka, S Sahoo, S Bhattacharjya, RC Jain JK Saha, Patra AK (2020). Manure addition influences the effect of tillage on soil aggregation and aggregate associated carbon in a Vertisol of Central India. *Jouranal of Environmental Biology*,41 : 1585-1593.(NAAS Rating : 6.56)

Mahanti NK, Chakraborty SK, Kotwaliwale N, Vishwakarma AK (2020). Chemometric strategies for nondestructive and rapid assessment of nitrate content in harvested spinach using Vis-NIR spectroscopy. *Journal of Food Science*, 85 (10), 3653-3662. (NAAS Rating:8.08)

Mandal Asit, Sarkar Binoy, Owens Gary, Thakur J K, Manna MC, Niazi Nabeel Khan, Somasundaram J, Patra AK (2020). Impact of genetically modified crops on rhizosphere microorganisms and processes. *Applied-Soil Ecology*, 148, p.103492. (NAAS Rating:9.45)

Manna MC, Rahman MM, Naidu R, Fazzle Bari, A S M, Singh AB, Thakur JK, Ghosh A, Patra AK, Chaudhai SK, Rao A Subba (2020). Organic Farming: A Prospect for Food, Environment and Livelihood Security in Indian agriculture. *Advances in Agronomy*, Volume 170 ISBN: 9780128245910. (NAAS Rating: 9.60)

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B. Technical/Popular Articles/Review Articles

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भारत प्रकाश मीणा, ए के बिस्वास, ए ओ शिराले, प्रिया पी गुरव, वासुदेव मीणा, एच दास, अंकुश कांबले, बृज लाल लकारिया, प्रमोद झा, ए के पात्र (2020). टिकाऊ फसल उत्पादन और मृदा स्वास्थ्य के लिए समन्वित पोषक तत्व प्रबंधन, मृदा स्वास्थ्य आलोक, जुलाई 2020।

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सी पी सावंत, के पी सिंह, आर एस सिंह, बृज लाल लकारिया, अनुराग पटेल, अजिता गुप्ता, अभिजीत खडतकर, मनोज कुमार (2020). संरक्षण कृषि में मक्का बुवाई यंत्रों का मध्य भारत की काली मृदा में तुलनात्मक अध्ययन। भारतीय कृषि अनुसंधान पत्रिका, खण्ड 35, अंक (1 व 2): 39.44 ।

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D. Books, Reports, Souvenir and Manuals

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10. COMMITTEES/CELLS/ SECTIONS/UNITS

Quinquenial Review Team		
1	Dr VS Tomar	Chairman
2	Dr Biswapati Mandal	Member
3	Dr AL Pharande	Member
4	Dr HK Senapati	Member
5	Dr Masood Ali	Member
6	Dr M Chinnadurai	Member
7	Dr JK Saha	Member Secretary
Research Advisory Committee		
1	Dr NN Goswami	Chairman
2	Dr DK Benbi	Member
3	Dr HK Senapati	Member
4	Dr JC Tarafdar	Member
5	Dr DK Das	Member
6	Dr KS Subramaniam	Member
7	Dr SK Chaudhari, DDG (NRM), ICAR	Member
8	Dr AK Patra, Director, ICAR-IISS, Bhopal	Member
9	Dr AK Biswas, I/c Head, Division of SC&F	Member Secretary
Institute Management Committee		
1	Dr Ashok K. Patra	Chairman
2	Director of Agriculture, MP Govt., Bhopal	Member
3	Director of Agriculture, Chhattisgarh Govt. Raipur	Member
4	Director (Research) JNKVV, Jabalpur	Member
5	Dr RN Sahoo, Pr. Scientist,Division of Agricultural Physics, ICAR-IARI, New Delhi-12	Member
6	Dr MJ Kaledhonkar. PC, AICRP (SWS), ICAR- CSSRI, Karnal	Member
7	Dr N Ravisankar, Pr Scientist & National PI	Member
8	Dr Sanjay Ray, Head, Jorhat Regional Station of ICAR-NBSS&LUP, Nagpur	Member
9	F&AO, ICAR-IISR, Indore	Member
10	Mr Bhupendra Singh Thakur, Mungeli, Chhattisgarh	Member
11	Mr Om Prakash Yadav, Indore	Member
12	Mr SK Gupta	Member Secretary
Institute Building Committee		
1	Dr Ashok K Patra, Director	Chairman
2	Dr MC Manna, HOD (SB)	Member
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 (MSPE)	Member
9	SAO	Member
PME Committee		
1	Dr Ashok K Patra, Director	Chairman
2	Dr RS Chaudhary, I/c HOD (SP)	Member
3	Dr JK Saha, I/c HOD (ESS)	Member
4	Dr MC Manna, HOD (SB)	Member
5	Dr AK Biswas, I/c HOD (SC&F)	Member
6	Dr R Elanchezhian, Pr Scientist & I/c PME	Member Secretary
Institute Purchase Committee		
1	Dr Pradip Dey, I/c PC (STCR), Dr KM Hati, Pr. Scientist (Alternate)	Chairman
2	Dr BL Lakaria, Pr. Scientist	Member
3	Dr AK Vishwakarma, Pr. Scientist	Member
4	Dr Monoranjan Mohanty, Pr. Scientist	Member
5	Dr M Vassanda Coumar, Sr Scientist	Member
6	Finance & Accounts Officer (FAO) AF&AO (alternate in the absence of FAO)	Member
7	Senior Administrative Officer (SAO) AAO (alternate in the absence of SAO)	Member Secretary
Institute Technology Management Committee		
1	Dr Ashok K Patra, Director	Chairman
2	Dr Niranjan Mishra, Pr. Scientist & I/c ITMU, ICAR-NIHSAD	Outside Expert
3	Dr MC Manna, HOD (SB)	Technical Expert
4	Dr AK Biswas, I/c I/c HOD (SC&F)	Member
5	Dr Pradip Dey, I/c PC (STCR)	Technical Expert
6	Dr AB Singh, Pr. Scientist	Member
7	Dr R Elanchezhian, I/c PME Cell	Member
8	Dr Sanjay Srivastava, Pr. Scientist & I/c ITMU	Member Secretary
Institute Technology Management Unit		
1	Dr Sanjay Srivastava, Pr. Scientist	In-charge
2	Dr Monoranjan Mohanty, Pr. Scientist	Member
3	Dr JK Thakur, Scientist	Member
4	Dr M Vassanda Coumar, Sr. Scientist	Member
5	Dr Shinogi KC, Scientist	Member
Technology Assessment & Transfer Unit		
1	Dr AB Singh, I/c HoD (SB)	In-charge
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 Shinogi KC, Scientist	Member
Prioritisation, Monitoring & Evaluation Cell (PME Cell)		
1	Dr R Elanchezhian, Pr. Scientist	Incharge
2	Dr KM Hati, Pr. Scientist	Member
3	Dr AK Vishwakarma, Pr. Scientist	Member
4	Dr Monoranjan Mohanty, Pr.Scientist	Member
5	Dr M Vassanda Coumar, Sr. Scientist	Member
6	Dr Asit Mandal, Sr.Scientist	Member
7	Mr Sanjay Kumar Kori, Steno Gr.-III	Member
Institute Video Production Committee		
1	Dr Sanjay Srivastava, Pr. Scientist & I/c ITMU	Chairman
2	Dr R. Elanchezhian, Pr. Scientist & I/c PME	Member
3	Dr Monoranjan Mohanty, Pr. Scientist & I/c FAO	Member
4	Dr Shinogi KC, Scientist	Member
5	Dr J Somasundaram, Pr. Scientist & I/c AKMU	Member Secretary
Institute Works Committee		
1	Dr AK Shukla, I/c PC (MSPE)	Chairman
2	Dr NK Lenka, Pr. Scientist	Member
3	Dr J Somasundaram, Pr. Scientist	Member
4	Dr SP Singh TO, ICAR-CIAE, Bhopal	Member
5	SAO or AAO	Member
6	F&AO or AF&AO	Member
Farm & Water Management Committee		
1	Dr AK Vishwakarma, Pr. Scientist	Chairman
2	Dr RH Wanjari, Pr. Scientist	Member
3	Dr RK Singh, Pr. Scientist	Member
4	Mr OP Shukla, T-4	Member
5	Mr CT Wankhede, Electrician	Member
6	Mr DR Darwai, I/c Farm Superintendent	Member Secretary
Farm Advisory Committee		
1	Dr MC Manna, HOD (SB)	Chairman
2	Dr RS Chaudhary, I/c HOD (SP)	Member
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
Horticulture Maintenance Committee		
1	Dr MV Coumar, Sr. Scientist	Chairman
2	Dr Hiranmoy Das, Sr. Scientist	Member
3	Dr Abhijit Sarkar, Scientist	Member
4	Mr RK Mandloi, CTO	Member
4	Mr DR Darwai, I/c Farm Superintendent	Member

Inter-Institutional Transfer Committee		
1	Dr JK Saha, I/c HoD (ESS)	Chairman
2	Dr R Elanchezhian, Pr. Scientist & I/c PME	Member
3	Dr KM Hati, Pr. Scientist & Nodal Officer (HRD)	Member
4	Mrs Seema Sahu, ACTO	Member
5	SAO	Member
Mridaparikshak Technology Management Committee		
1	Dr Pradip Dey, I/c PC (STCR)	Chairman
2	Dr AK Biswas, I/c HoD (SC&F)	Co-Chairman
3	Dr Tapan Adhikari, Pr. Scientist	Member
4	Dr Monoranjan Mohanty, Pr. Scientist	Member
5	Dr Sanjay Srivastava, Pr. Scientist & PI (Mridaparikshak)	Member Secretary
Consultancy Processing Cell		
1	Dr Pradip Dey, I/c PC (STCR)	Chairman
2	Dr Sanjay Srivastava, Pr. Scientist	Member
3	Dr R Elanchezhian, Pr. Scientist	Member
4	Dr SR Mohanty, Pr. Scientist	Member
5	Dr Sangeeta Lenka, Sr. Scientist	Member
6	SAO	Member
7	F&AO	Member
Civil and Electrical Maintenance Committee		
1	Dr RK Singh, Pr. Scientist	Chairman
2	Dr RH Wanjari, Pr. Scientist	Member
3	Mr RK Mandloi, CTO	Member
4	Mr CT Wankhede, TO	Member
5	Mr Sukhram Sen, Technical Officer	Member
6	Mr Venny Joy, PA	Member
Library Committee		
1	Director	Chairman
2	All PCs	Member
3	All HoDs	Member
4	I/c PME Cell	Member
5	F&AO	Member
6	SAO	Member
7	Librarian	Member
8	I/c Library	Member Secretary
Library Function Committee		
1	Dr AK Biswas, I/c HOD (SC&F)	Chairman
2	Dr Kollah Bharati, Pr. Scientist	Member
3	Dr SK Behera, Pr. Scientist & Library Incharge	Member

4	Dr Shinogi KC, Scientist	Member
5	Mrs Madhumonti Saha, Scientist	Member
6	Mrs Nirmala Mahajan, ACTO & Librarian	Member
7	SAO	Member
8	F&AO	Member
Campus Security Committee		
1	Dr BP Meena, Scientist & Security Incharge	Chairman
2	Dr AO Shirale, Scientist	Member
3	SAO	Member
4	F&AO	Member
5	Mr Sukhram Sen, STA	Member
6	Mr Anurag, Security Supervisor	Member Secretary
Academic Cell		
1	Dr KM Hati, Pr. Scientist	Chairman
2	Dr R Elanchezhian, Pr. Scientist	Member
3	Dr Kollah Bharati, Pr. Scientist	Member
4	Dr M Vassanda Coumar, Sr. Scientist	Member
Contractual Research Project Monitoring Committee		
1	Director, ICAR-IISS, Bhopal	Chairman
2	CPC Chairman	Member
3	I/c PME Cell	Member
4	Project Leader of the Contractual Research Project	Member
5	Co-PI/Associate	Member
Women Cell		
1	Dr Kollah Bharati, Pr. Scientist	Chairperson
2	Dr Asha Sahu, Scientist	Member
3	Dr Sudeshna Bhattacharjya, Scientist	Member
4	Mrs Nirmala Mahajan, ACTO	Member
5	Mrs Geeta Yadav, PS	Member
6	Mrs Raksha Dixit, LDC	Member
7	Mrs Kavita Bai, SSS	Member
Committee for Prevention of Sexual Harassment of Women Employees		
1	Dr Sangeeta Lenka, Sr. Scientist	Chairperson
2	Dr Shalini Chakraborty, Scientist	
3	Mrs Seema Bhardwaj, Scientist	Member
4	Dr Shinogi KC, Scientist	Member
5	Mrs Yojana Meshram, PA	Member
6	Mrs Babita Tiwari, Assistant	Member
7	SAO	Member Secretary

Hindi Committee		
1	Dr Ashok K Patra, Director	Chairman
2	Dr AK Tripathi, Pr. Scientist	Member
3	Dr S Ramana, Pr. Scientist	Member
4	Dr Asha Sahu, Scientist	Member
5	SAO	Member
6	Mr Rajesh Tiwari, STO	Member
7	Mrs Babita Tiwari, Assistant	Member Secretary
Renewable Bio/Solar Energy Committee		
1	Dr AK Biswas, I/c HOD (SC&F)	Chairman
2	Dr Prabhat Tripathi, Pr. Scientist	Member
3	Dr AK Vishwakarma, Pr. Scientist	Member
4	SAO	Member
5	Dr PC Jena, Scientist, ICAR-CIAE, Bhopal	Member (External Expert)
6	Mr CT Wankhede, TO	Member
Condemnation of Permanent Articles Committee		
1	Dr Brij Lal Lakaria, Pr. Scientist	Chairman
2	Dr Prabhat Tripathi, Pr. Scientist	Member
3	Dr Sangeeta Lenka, Sr. Scientist	Member
4	AAO	Member
5	AF&AO	Member
Foreign Deputation Committee		
1	Dr MC Manna, HOD (SB)	Chairman
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, I/c HoD (SB)	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 Hira Lal Gupta, Assistant	Member
Monitoring/Utilization of Plant/Machinery/Equipments/Instruments		
1	Dr AB Singh, I/c HoD (SB)	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, Sr. Scientist (Alternate)	Member
4	Mr D.R. 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, CTO	Member
4	Mr Pramod Chauhan, STO	Member
Agricultural Knowledge Management Unit (AKMU)		
1	Dr J Somasundaram, Pr. Scientist	Incharge
2	Dr NK Sinha, Scientist (Alternate)	Member
3	AAO	Member
Vehicle Operation Committee		
1	Dr AO Shirale, Scientist	Incharge
2	Dr. Hiranmoy Das, Sr. 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, Steno Gr.-III	Office Staff
Screen House		
1	Dr S Ramana, Pr. Scientist	Incharge

2	Dr Dolamani Amat, Scientist	Alternate incharge
HRD (Training)		
1	Dr KM Hati, Pr. Scientist	Nodal Officer
2	Dr Monoranjan Mohanty, Pr. Scientist	Co-Nodal Officer
3	Mr Sanjay Kumar Kori, Steno Gr.-III	Member
Mera Gaon Mera Gaurav		
1	Dr AB Singh, I/c HoD (SB)	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, Sr. Scientist	Member
4	Dr Vasudev Meena, Scientist	Member
5	Dr RH Wanjari, Pr. Scientist	Member Secretary & Nodal Officer
6	AAO	Member
7	AF&AO	Member
8	Mr Sanjay Katinga, LDC	Member
Schedule Castes Sub Plan (SCSP)		
1	Dr AB Singh, I/c HoD (SB), (Nodal Officer, MGMG)	Chairman
2	Dr Prabhat Tripathi, Pr. Scientist (Co-Nodal Officer, MGMG)	Member
3	Dr AK Vishwakarma, Pr. Scientist,	Member
4	Dr Monoranjan Mohanty, Pr. Scientist	Member
5	Dr N K Sinha, Scientist	Member
6	Dr Vasudev Meena, Scientist	Member
7	Dr BP Meena, Scientist	Member Secretary
COVID-19 Management Committee		
1	Dr NK Lenka, Pr Scientist	Nodal Officer
2	Dr RK Singh, Pr. Scientist & I/c Maintenance and Civil Engineering	Co-Nodal Officer
3	Dr AO Shirale, Scientist & I/c Vehicle	Member
4	Sh SK Gupta, SAO	Member
5	Sh Rajesh Dubey, AF&AO	Member
6	Sh Anurag, Security Supervisor	Member
7	Sh Khilan Singh Raghuvanshi, T-5 & IJSC Representative	Member
8	Dr Bharat Prakash Meena, Scientist & I/c Security & I/c Hostel	Member Secretary

11. IMPORTANT MEETINGS/ACTIVITIES

Republic Day

The 71st Republic Day was celebrated on January 26, 2020 in the Institute premises with great gaiety and fervor.

Foundation Day

The ICAR-Indian Institute of Soil Science (ICAR-IISS) celebrated its 33rd Foundation Day on April 16, 2020. Hon'ble Dr SK Chaudhari, DDG (NRM) graced the occasion as the Chief Guest. He emphasized on different ecosystem functions of soil and underlined the role of soil in the survival of mankind, animal and plant kingdom.

International Yoga Day

ICAR-Indian Institute of Soil Science celebrated 6th International Yoga Day on June 21, 2020. The staff members and their families performed yoga.

Institute Research Council

Institute Research Council (IRC) meeting was held during July 29-August 1 and 13th,14th, 18th, 27th August and September 4th, 2020. Dr. A.K. Patra, Director chaired the session and total of 36 ongoing projects including external funded and 12 new projects were presented and reviewed.

Independence Day

The 74th Independence Day' was celebrated on August 15, 2020 in the Institute premises with great gaiety and fervor.

Hindi Pakhwada

Hindi Pakhwada was celebrated in the Institute during September 14-28, 2020. Several competitions such as Debate, Quiz, Hindi vocabulary (Sabda Gyan), Typing were conducted. The Director, ICAR-IISS distributed prizes to the winners of different competitions.

Swachch Bharat Mission

First Swachhta Pakhwada was celebrated during September 26 - October 2, 2020. Different activities were conducted under Swachh Bharat Mission (SBM) and celebrated 150th Birth Anniversary of Mahatma Gandhi. Activities such asbanner display, tree plantation,Swachhta Walkathons, swachhta awards among residents and labs. Special lecture was delivered by Dr Ajay, Pr. Scientist on the Gandhian Philosophy on Agriculture, Swachhta and Gram Swaraj. Swachhta winners were felicitated through video conferencing. 2nd Swachhta Pakhwada, held from December 16-31, 2020. Swachhta Pledge was taken on December 16, 2020 by the staff members. A national webinar on “Alternative to Plastics for Sustainable Soil and Environmental Health” was held on December 30, 2020.

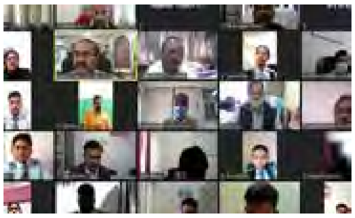
Vigilance Awareness Week

Vigilance Awareness Week celebrated during October 27 to November 2, 2020 and all staff attended lecture delivered by Vigilance Officer on October 28, 2020. The closing ceremony conducted with a lecture of Mr SK Mitra, Former Director (P), ICAR, New Delhi.

Soil Health Awareness Week

Soil health awareness week' celebrated 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 December 1-7, 2020 including Farmer-Scientist Interaction Meet & Field Day at Karond Khurd, Bherupura, Parwalia Sadak and Khamkheda, Bhopal.

Agricultural Education Day organized on December 3, 2020 with a theme "Awareness on soil health: Keep soil alive, protect soil biodiversity"for school students of Govt. Sardar Patel Higher Secondary School, Bhopal. Expert interactive session on soil Health for sustaining Soil and Crop Productivity was also organized for the college students of Bhopal School of Social Science, Bhopal.



World Soil Day celebrated on December 5, 2020 with the theme “Keep Soil Alive, Protect Soil Biodiversity”.

March past and Farmers-Scientists Interface Meeting was organized on Use of Soil Health Cards.

Special activities/efforts taken during COVID-19 pandemic

ICAR-IISS, Bhopal staff distributed eatables and drinking water to the migrant workers in coordination with Bhopal Municipal Corporation. Scientists and technical staff distributed ration, mask and gloves during COVID-19 pandemic.

12. PARTICIPATION OF SCIENTISTS IN CONFERENCES/ SYMPOSIA/SEMINARS/WORKSHOPS/MEETINGS

Name	Programme	Venue	Period
Dr AK Patra	Integrated Farming System towards nutritional security & sustainable agriculture (As member of National Advisory Committee and guest of honour in the Krishi Samridhi Mela)	Bhaanyaganga KVK, RKMA, Sargachi	January 10-13, 2020
Dr AK Patra	Annual review meeting of CGIAR centre	NASC, New Delhi	January 14-15, 2020
Dr NK Lenka	Review meeting of DST-SERB	CSIR-National Institute of Oceanograph, Goa	January 19, 2020
Dr AK Patra	Jury member for Mahindra Samriddhi India Agri Award	New Delhi	January 20-22, 2020
Dr Pradip Dey	CIMMYT meeting on fertilizer recommendations	Patna, Bihar	January 20-21, 2020
Dr Pradip Dey	Farmers Conference	JNKVV, Jabalpur	January 28-29, 2020
Dr AK Patra	Review meeting of Foreign Aided Project	ICAR, New Delhi	January 29-30, 2020
Dr AK Patra	Meeting on waste resource management	Dr. RPCAU, Pusa, Bihar and KVK, Sujani Deoghar	February 8-10, 2020
Dr Narayan Lal	4th International Conference on Multidisciplinary Research and Development	Bhopal	February 9, 2020
Drs R Elanchezhian, BP Meena, AO Shirale	International Conference – Pulses the climate smart crops: Challenges and Opportunities	Bhopal	February 10-12, 2020
Drs Pradip Dey, Sanjay Srivastava	Meeting on commercialization of ICAR-IISS technology	ICAR, New Delhi	February 13, 2020
Dr JK Saha	International Seminar on 'Contaminated Sites' and Concurrent Conference on Geoenvironment & Sustainability (Geoenvironment-2020)	IIT, New Delhi	February 17-21, 2020
Miss Alka Rani	National Conference on Geospatial Technologies in Agriculture	ICAR-NAARM, Hyderabad	February 20-21, 2020
Dr R Elanchezhian	ISPP North Zonal Seminar – Crop Productivity and Stress Management	CSAU&T, Kanpur	February 22, 2020
Dr Sanjay Srivastava	Inter Media Publicity Coordination Committee (IMPCC) meeting	PIB, Bhopal	February 24, 2020
Dr Pradip Dey	11th National KVK Conference	NASC Complex, New Delhi	February 29, 2020
Drs MV Coumar, NK Sinha, BP Meena, Mr RK Mandloi	PUSA Krishi Vigyan Mela	ICAR- IARI, New Delhi	March 1-3, 2020
Dr Pradip Dey	National Seminar on Agriculture Sustainability	Krishi Bhawan, New Delhi	March 6, 2020
Drs Asit Mandal, JK Thakur, Narayan Lal	National Conference on scientific & environmental innovation and implementation of sustainable development goals	MPCST, Bhopal	March 7-8, 2020
Drs AK Patra, Muneshwar Singh, Pradip Dey, AK Shukla, SR Mohanty	ICAR Directors Conference	ICAR, New Delhi	March 19, 2020

Name	Programme	Venue	Period
Dr AK Patra	Directors Conference	ICAR, New Delhi	April 10, 2020
All Scientists	33rd Foundation Day of ICAR-IISS, Bhopal	ICAR-IISS, Bhopal	April 16, 2020
Drs AK Shukla, Muneshwar Singh, Pradep Dey, AK Biswas, SR Mohanty	EFC/SFC Review Meeting of IISS and AICRP's and CRP on CA organised by NRM Division of ICAR	Member	May 6-7, 2020
Dr A K Biswas	International Training programme on 'Conservation Agriculture Based Crop Management Technologies in Climate Smart Agriculture	CAAST-CSAWM Mahatma Phule Vidhayapeeth, Rahuri	May 18-22, 2020
Dr Narayan Lal	Webinar on Introduction of New J-Gate @ CeRA Consortia Platform	IGKV, Raipur	May 20, 2020
Dr R Elanchezhian	Webinar on Analytical Applications (Good Water Practices for LC-MS / ICP-MS / HPLC)	Milliq Web connect of Merck life sciences Ltd, Ahmedabad	May 21, 2020
All Scientists	Webinar on Soil Biodiversity and Human Health on the occasion of International Day for Biological Diversity	ICAR-IISS, Bhopal	May 22, 2020
Dr Narayan Lal	Webinar on quantitative methods for social sciences	ICAR-NIAP, New Delhi	June 1-23, 2020
Drs AK Biswas, NK Lenka, BP Meena	Webinar on COVID-19: Impacts and New Normal in Agriculture	NAAS, New Delhi	June 5, 2020
Dr Asha Sahu	Virtual Conference on “Sustainable Solid Waste Management during COVID-19”	National Solid Waste Association of India	June 5, 2020
All Scientists	Webinar on “Soil Pollution – Threat to Soil Biodiversity”	ICAR IISS Bhopal	June 5, 2020
Dr Asha Sahu	Interaction Meeting on “Significance of Ecobiome Soil Microbial Analysis and its Impact on Soil Health and Productivity”	ICAR-IISS, Bhopal	June 6, 2020
Dr Pradip Dey	Webinar on Impact and Implications of COVID- 19 on Agrochemicals Industry & Draft Order for Banning of 27 Molecules	FICCI, New Delhi	June 11, 2020
All scientists	National Webinar on Biochar Potential Availability, Usefulness and Limitation for Use in Indian Agriculture	ICAR-IISS, Bhopal	June 19, 2020
Dr Asit Mandal	HPTLC-Technique and Herbal Applications	Anchrom Enterprise Pvt Ltd., Mumbai and MPCST, Bhopal	June 20, 2020
Drs NK Lenka, NK Sinha, Hiranmoy Das	Implementation of e-office in ICAR	ICAR, New Delhi	June 24, 2020
Dr AK Biswas	Online project monitoring committee meeting	DST, New Delhi	June 26, 2020
Drs Pradip Dey, AK Biswas, Sanjay Srivastava, Pramod Jha, AO Shirale	Fourth meeting of the Asian Soil Laboratory Network (SEALNET)	FAO, Rome, Italy	June 30 to July 2, 2020
Dr Pradip Dey	National Webinar on "Impact of Population Pressure on Natural Resources and Environment"	Academy of Natural Resources Conservation and Management (ANRCM), Lucknow	July 11, 2020
Drs Pradip Dey and AK Biswas	Virtual Meeting on SOC under the chairmanship of DDG (NRM)	ICAR, New Delhi	July 15, 2020

Name	Programme	Venue	Period
All scientits	Felicitation Programme of Dr. Ratan Lal, World Food Prize Winner'	ICAR-IISS, Bhopal chapters of ISSS and NAAS	July 21, 2020
Dr A K Biswas	Webinar on 'Presentation of Foreign and Pravasi Fellows'	NAAS, New Delhi	July 21, 2020
Drs JK Saha, Sanjay Srivastava, R Elanchezhian	Video meeting 'NABL Accreditation of ICAR Laboratories'	Intellectual Property & Training Management Unit, ICAR, New Delhi	July 22, 2020
Drs R S Chaudhary, Brij Lal Lakaria, AK Vishwakrama, Prmod Jha, J Somasundara, MV Coumar, Sangeeta Lenka, Asit Mandal, BP Meena, JK Thakur, Nishant K Sinha, Jitendra Kumar, Abhiiit Sarkar, Miss Alka Rani	International Webinar on Achieving Land Degradation Neutrality (LDN)	IASWC and ICAR and IISWC and ICFRE, Dehradun	22-24 July, 2020
Drs Pradip Dey, Sanjay Srivastava, Asit Mandal, JK Thakur, Asha Sahu	Webinar on "Patent Prosecution Challenges and Strategies in India"	Frontiers of Legal and Turnip Innovations, Mumbai	July 25, 2020
Dr Sanjay Srivastava	Meeting on IMPCC (Inter Media Publicity Coordination Committee)	PIB, Bhopal	July 29, 2020
Dr Asit Mandal	Workshop on "Cloud Computing Essentials"	Turnip Innovations, Mumbai	July 30 - August 1, 2020
Dr Asha Sahu	Webinar on "Host-microbe interaction: present and future perspective"	Presidency University, Kolkata	August 6, 2020
All Scientists	Virtual Meeting of AICRP LTFE on "Long-Term Fertilizer Experiments: Achievements and Future Strategies''	ICAR-IISS, Bhopal	August 11-12, 2020
Drs AK Patra, AK Shukla, AK Biswas	27th Annual General Body Meeting of NAAS'	NAAS, New Delhi	August 13, 2020
Dr A K Biswas	National Webinar on 'Higher Education and Research in Natural Resource Management for Environmental Sustainability'	CAAST-CSAWM Mahatma Phule Vidhyapeeth, Rahuri	August 14, 2020
Dr JK Saha	Publishing 101: Earth Sciences, Geography & Environmental Sciences	Springer Publisher	August 20, 2020
Dr Asha Sahu	National Webinar on "Recent Advances in Soil Microbiological Research with a Special Thrust to Biofertilizer Technology"	Bihar Agricultural University, Sabour	August 25, 2020
Dr Pradip Dey	National Webinar on 'Abiotic Stress in Agriculture: Geospatial Characterization and Management Options'	ICAR-NIASM, Baramati, Pune	August 27, 2020
Dr Sanjay Srivastava	Meeting on Inter Media Publicity Coordination Committee	PIB, Bhopal.	August 27, 2020
All Scientists	Inauguration of academic and administrative building of Rani Lakshmi Bai Central Agriculture University, Jhansi, inaugurated by Hon'ble PM of India	RLBCAU, Jhansi	August 29, 2020.
Dr Pradip Dey	Online Brainstorming Session "Overcoming India's Water Scarcity through Micro-Irrigation: Opportunities and Challenges"	International Development Centre Foundation, New Delhi	September 1, 2020

Name	Programme	Venue	Period
Dr Pradip Dey	35th FAO Regional Conference for Asia and the Pacific - Drafting Committee	FAO, Rome (Online)	September 1, 2020
Drs AK Patra, AK Biswas, BL Lakaria, Pramod Jha	'Promoting Biochar in India with GIZ India and NRAA	GIZ and NRAA (Online)	September 1, 2020
Dr Pradip Dey	Webinar on Trends in Biomedicine & Life Sciences Publishing and Nuances and Tools of Scientific Publishing	Springer Nature in collaboration with Delcon, a DBT e-library consortium	September 3, 2020
Drs Sanjay Srivastava, JK Thakur	Google patent workshop	Turnip Innovations, Mumbai	September 5, 2020
Dr R Elanchezhian	National Webinar on Future perspectives in Agricultural Education	NAHEP, ICAR-IARI, New Delhi	September 5, 2020
Dr Pradip Dey	Network Program on Precision Agriculture	ICAR, New Delhi	September 6-7, 2020
Dr A B Singh	Organic Farming and Natural Farming in India	Centre for Science and Environment, India	September 8, 2020
Drs Pradip Dey, RS Chaudhary, KM Hati,AB Singh, M. Mohanty, J Somasundaram, Dhiraj Kumar, Nishant K Sinha, Jitendra Kumar, Miss Alka Rani	International webinar on Drone Remote Sensing in Agriculture	ICAR-IARI, New Delhi	September 9, 2020
Dr Pradip Dey	7th European soil partnership plenary assembly,	FOEN, Switzerland (Online)	September 10, 2020
All scientists	7th Dr BP Ghildyal Memorial Lecture on 'Transforming Indian Agriculture in New Normal'	Indian Society of Agrophysics & Division of Agricultural Physics, ICAR-IARI, New Delhi	September 10, 2020
Dr RH Wanjari	Innovative Approaches towards Managing Soil Health for Climate Smart Agriculture	Parbhani Chapter ISSS, VNMAU Parbhani,Maharashtra	September 12, 2020
Dr Asha Sahu	International webinar on Agriculture & Biotechnology"	Online	September 16-17, 2020
Drs AK Patra, Pradip Dey, R S Chaudhary, KM Hati, Pramod Jha, MV Coumar, Nishant K Sinha, M Mohanty and JK Thakur, Dhiraj Kumar	First Plenary Meeting on Spectroscopy of the Global Soil Laboratory Network (GLOSOLAN)	FAO (Online)	September 23-25, 2020
Dr RH Wanjari	Innovative Approaches towards Managing Soil Health for Climate Smart Agriculture	ISSS Parbhani Chapter, VNMAU Parbhani (Maharashtra)	September 27, 2020
All Scientists	International Webinar on "Soil Spectroscopy: An emerging technique for rapid soil health assessment"	ICAR-IISS, Bhopal and World Agroforestry, Nairobi	October 1, 2020
Dr Pradip Dey	Meeting of the European and Eurasian Soil Laboratory Network (EUROSOLAN)	GLOSOLAN (Online)	October 2, 2020
Dr Pradip Dey	Disaster Management and Mitigation" (Phase-3)	DNGPIT, Tamil Nadu	October 5-10, 2020

Name	Programme	Venue	Period
Dr Pradip Dey	RAISE 2020 virtual global summit on Artificial Intelligence	New Delhi	October 5- 9, 2020
Drs AK Patra, AK Biswas, BL Lakaria, Pramod Jha	Webinar on "Biochar Forum: Science, Policy and Practice Interface"	GIZ and NRAA (Online)	October 5-6, 2020
Dr Pradip Dey	Virtual meeting on Food Security Roundtable: Strengthening Food Security in 2020 & Beyond	World Bank (Online)	October 9, 2020
Dr A K Biswas	International Webinar (VAIBHAV) on ‘Resource Conservation Technologies’	ICAR, New Delhi	October 9, 2020
Drs AK Patra, R Elanchezhian, NK Lenka	Interactive webinar on "Soil, water & food security"	SAGE University, Bhopal	October 16, 2020
Dr Pradip Dey	Zoom to grassroots for food security to build back better”	TNAU, Coimbatore	October 16, 2020
Drs AK Patra, RS Chaudhary, Pradip Dey	75th foundation day of FAO	FAO (Online)	October 16, 2020
Drs AK Patra, Pradip Dey, RS Chaudhary, K M Hat, M Mohanty, Pramod Jha, M V Coumar, NK Sinha, JK Takur, Dhiraj Kumar	First GLOSOLAN plenary meeting on soil spectroscopy	GLOSOLAN (Online)	October 19, 2020
Dr Pradip Dey	Virtual meeting on From Learning Poverty to Learning of the Future: Charting a Course Beyond the Pandemic	World Bank (Online)	October 20, 2020.
Dr J K Saha	Webinar on Power to the Norms	Centre for Science and Environment, New Delhi	October 21, 2020
Dr Pradip Dey	FDP on ‘Engineering Pedagogy in Post COVID-19 Paradigm’	Sangli, Maharashtra	October 19-20 , 2020
Drs Hiranmoy Das, Vasudev Meena	International webinar on Harnessing the potential of tropical tuber crops under changing climate (HPTTC 2020)	ICAR-CTCRI, Thiruvananthapuram	October 27, 2020
All Scientists	National Webinar on “Quality improvement and proficiency testing of soil laboratories in India towards Improving the Quality of Analytical Data and Harmonization of Soil Test Methods	ICAR-IISS, Bhopal	October 31, 2020
Dr RH Wanjari	Innovative Approaches towards Managing Soil Health for Climate Smart Agriculture	ISSS Parbhani Chapter, VNMAU Parbhani, Maharashtra	October 31, 2020
Dr Pradip Dey	Foundation Day Lecture of the Indian Academy of Horticultural Sciences (IAHS) (formerly the Horticultural Society of India), Lecture by Dr T. Mohapatra, Secretary, DARE & DG, ICAR	ICAR, New Delhi	November 6, 2020
Dr Sanjay Srivastava	GLOSOLAN Pre meeting	FAO (Online)	November 9, 2020
Dr Hiranmoy Das	International conference on recent trends in analysis and optimization (ICRTAO-2020)	NITTTR, Bhopal	November 9-11, 2020
Dr Pradip Dey	Inception Meeting: Land Use Planning Course Development	World Bank; ICAR-NAHEP; MPKV, Rahuri	November 10, 2020

Name	Programme	Venue	Period
Drs Pradip Dey, AK Biswas, Sanjay Srivastava, Pramod Jha, Hiranmoy Das, AO Shirale	4th meeting of the Global Soil Laboratory Network	GLOSOLAN (Online)	November 11-13, 2020
Dr Pradip Dey	Webinar on Value of IPR in Academic Researches	BVICAM, New Delhi	November 21, 2020
Dr Sanjay Srivastava	Virtual Workshop and Review Meeting of ZTMCs/ ITMUs/ ABIs	ICAR, New Delhi	November 23, 2020
Drs A B Singh, BP Meena	XV Annual Group Meeting of All India Network Programme on Organic Farming	ICAR-IIFSR, Modipuram	November 25-26, 2020
All Scientists	Meeting on Agricultural Education Day: Keep Soil Alive Protect Soil Biodiversity,	ICAR-IISS, Bhopal.	December 3, 2020
All Scientists	Award ceremony on World Soil Day 2020 "Keep soil alive, Protect soil biodiversity"	FAO (Online), United Nations	December 4, 2020
Dr Pradip Dey	CFCS Webinar, Strategies and Responses of the Caribbean to Food Security during the COVID-19 Pandemic	Puerto Rico (Online)	December 4, 2020
Dr Pradip Dey	National e-Posters Olympaid during World Soil Day Celebration-2020 on "SOILS, BIOMES AND RESILIENCE TO CLIMATE CHANGE"	Soil Conservation Society of India	December 4-5, 2020
All Scientists	World Soil Day	ICAR-IISS, Bhopal	December 5, 2020
Dr R Elanchezhian	International Plant Physiology Virtual Conference –Prospects of Plant Physiology for Climate proofing Agriculture	SKUAST Jammu and ISPP, New Delhi	December 6-7, 2020
Dr Sangeeta Lenka	Workshop on Gender Sensitization	ISTM, New Delhi	December 15, 2020
All Scientists	PM Kisan Samman Nidhi	ICAR, New Delhi	December 25, 2020
All Scientists	National webinar on "Alternatives to Plastics for Sustainable Soil and Environmental Health"	ICAR-IISS, Bhopal	December 30, 2020

13. WORKSHOPS, SEMINARS AND TRAININGS ORGANIZED

Trainings

Programme	Course Directors/Coordinators	Duration	Sponsored by
A Farmer Field School (FFS) on Use of organic inputs based on soil health card recommendations	Drs Shinogi KC, BP Meena, NK Sinha	January 22-24, 2020	ICAR-IISS, Bhopal
Training-cum-farmer-Scientist interactive meet under skill development programme of SCSP	Drs BP Meena, AK Biswas, B L Lakaria, Asha Sahu, Miss Alka Rani	February 4, 2020	ICAR-IISS, Bhopal
Soil Testing & Nutritional Recommendation for Kharif and Rabi Crops	Drs Pramod Jha, AK Vishwakarma and AK Tripathi	February 17-21, 2020	Department of Agriculture and Farmers Welfare M.P.
Tribal Women Farmers' Skill Development on Soil Health Management under STC	Drs RH Wanjari, Brij Lal Lakaria, Sudeshna Bhattacharjya and AB Singh	March 4-11, 2020	ICAR-IISS, Bhopal
Organic farming and Soil Health Management	Dr AB Singh	March 12, 2020	ICAR-IISS, Bhopal
Soil Health Assessment and Development of Soil Health Card	Drs R Elanchezhian, Priya Gurav, MV Coumar	March 12-16, 2020	Department of Agriculture and Farmers Welfare M.P.
Crop Simulation Modelling and impacts of Climate Change on Agricultural Production: A Training program on multi-model simulations Systems under NICRA	Drs M Mohanty, NK Sinha, J Somasundaram	March 16-21, 2020	ICAR-IISS, Bhopal
Organic farming and Soil Health Management	Dr AB Singh	March 17, 2020	ICAR-IISS, Bhopal
Farmers-Scientists interface meeting under the SCSP	Drs BP Meena, AK Biswas, B L Lakaria, Asha Sahu, Miss Alka Rani	September 22, 2020	ICAR-IISS, Bhopal
Resource Conservation Technology in Agriculture	Drs AK Biswas, AK Vishwakarma	October 13-16, 2020	ICAR IISS and SIAET, Bhopal
Soil Testing and Nutritional Recommendations for Agricultural Crops	Drs AK Biswas, Brij Lal Lakaria, Deepika Dixit (SIAET)	October 20-24, 2020	ICAR IISS and SIAET, Bhopal
Soil Health Management	Drs Pradip Dey, Dr Sanjay Srivastava, Dr RH Wanjari and Shri M.P. Tiwari	November 17-20, 2020	ICAR-IISS, Bhopal and SIAET, Bhopal
Training and farmer-Scientist interaction meet on climate smart agriculture under NICRA project	Dr AB Singh	December 6, 2020	ICAR-IISS, Bhopal
Integrated Nutrient Management	Drs Pradip Dey, RH Wanjari and M Vassanda Coumar	December 21-23, 2020	ICAR-IISS, Bhopal and SIAET, Bhopal

Workshop/Webinar/Conference/Meeting/Day/Mela

Title	Organizers/Coordinators	Duration	Sponsored by
Kisan Mela	Dr AB Singh	February 20, 2020	ICAR- IISS, Bhopal and Deputy Director Farmer Welfare and Agriculture Development Bhopal

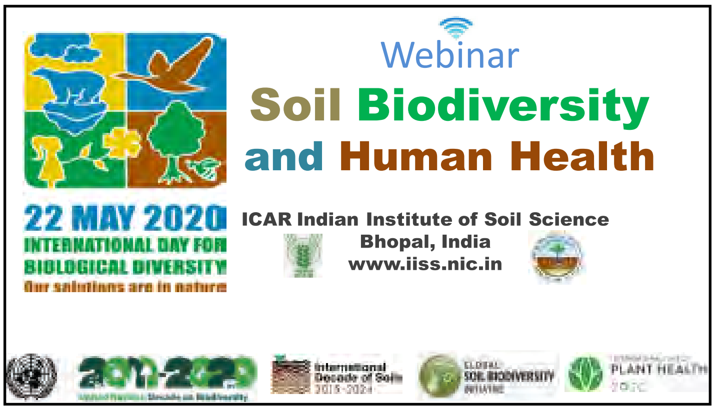
Title	Organizers/Coordinators	Duration	Sponsored by
Review meeting of the ICAR-IISS-ICRAF collaborative project on Assessment of important soil properties of India using Mid-Infrared Spectroscopy	Dr KM Hati	May 1, 2020	ICAR-IISS, Bhopal
International Day for Biological Diversity	Dr SR Mohanty	May 22, 2020	ICAR-IISS, Bhopal
Soil Pollution – Threat to Soil Biodiversity' on the occasion of World Environment Day	Dr JK Saha	June 5 , 2020	ICAR-IISS, Bhopal
National Webinar on 'Biochar: Potential Availability, Usefulness and Limitation for Use in Indian Agriculture'	Drs T Mohapatra, SK Chaudhari, AK Patra, A K Biswas, BL Lakaria, Pramod Jha	June 19, 2020	ICAR-IISS, Bhopal
Long-Term Fertilizer Experiments: Achievements and Future Strategies	Drs Muneshwar Singh, RH Wanjari	August 11-13, 2020	ICAR-IISS, Bhopal
Information System on Long-Term Fertilizer Experiments	Drs AK Patra, RH Wanjari, Dhiraj Kumar, BN Mandal	September 4, 2020	ICAR-IISS, Bhopal
International Webinar on "Soil Spectroscopy: An emerging technique for rapid soil health assessment"	Drs. AK, Patra, RS Chaudhary, MC Manna, AK Biswas, JK Saha, AK Shukla, Pradip Dey, SR Mohanty, Sanjay Srivastava, R Elanchezhian, J Somasundaram, Prabhat Tripathi, RK Singh, Pramod Jha, JK Thakur, MV Coumar, NK Sinha, Dhiraj Kumar, M Mohanty, KM Hati, Ms. Seema Bhardwaj, Miss. Alka Rani	October 1, 2020	ICAR-IISS, Bhopal
National Webinar on "Quality Improvement and Proficiency Testing of Soil Laboratories in India - towards improving the quality of analytical data and harmonization of soil test methods"	Drs Sanjay Srivastava, AK Biswas, Pramod Jha	October 31, 2020	ICAR-IISS, Bhopal
Mahila Kisan Divas	Drs Sangeeta Lenka, K Bharati, Asha Sahu	October 15, 2020	ICAR-IISS, Bhopal
Conference on Developing Human Resources for Recalibrating STCR	Drs AK Patra, Pradip Dey	November 10, 2020	AICRP on STCR, ICAR-IISS, Bhopal
Soil Health Management	Drs Pradip Dey, Sanjay Srivastava, RH Wanjari, Shri MP Tiwari	November 17-20, 2020	ICAR-IISS Bhopal & SIAET Bhopal
Training and farmer-Scientist interaction programme under Soil Health Awareness Week 1-7 December, 2020 and Improving Soil Health Campaign Month	Dr AB Singh, R Elanchezhian, AK Vishwakarma, M. Mohanty	December 1-7, 2020	ICAR-IISS, Bhopal
Agricultural Education day	Dr AB Singh, R Elanchezhian, AK Vishwakarma, M. Mohanty	December 3, 2020	ICAR-IISS, Bhopal
World Soil Day	Dr AB Singh, R Elanchezhian, AK Vishwakarma, M. Mohanty	December 5, 2020	ICAR-IISS, Bhopal
A Field Day cum Farmers' Scientist interaction	Drs AB Singh, M Mohanty, Nishant Sinha, Jitendra Kumar, Dhiraj Kumar, Dolamani Amat	December, 22, 2020	ICAR-IISS, Bhopal
A Kisan Diwas	Drs A B Singh, M Mohanty, Nishant Sinha, Jitendra Kumar, Asit Mandal, Dolamani Amat, Dhiraj Kumar	December 23, 2020	ICAR-IISS, Bhopal
Programme for farmers during release of PM Kisan Samman Nidhi	Dr AB Singh	December 25, 2020	ICAR-IISS, Bhopal

Tribal Women Farmers' Skill Development on Soil Health Management

A training programme on 'Tribal Women Farmers' Skill Development on Soil Health Management" was organised to impart skill development of tribal women at ICAR-IISS, Bhopal during March 4-11, 2020. This training was organised for women tribals of Malda (West Bengal) in collaboration with ICAR-CISH, Regional Research Station, Malda (West Bengal). The training addressed various issues of soil health management such as importance of soil sampling, soil testing and analysis in the laboratory and introduction to 'Mridaparikshak', importance of micronutrients, vermicomposting, organic farming, integrated nutrient management, methods of composting, fertilizers application, cultivation of vegetables in polyhouse, exposer to farm implements & farm machinery, conservation agriculture, best management practices etc.

International Day for Biological Diversity

International Day for Biological Diversity was celebrated on May 22, 2020 and a webinar on "Soil Biodiversity and Human Health" was organized. Dr SK Chaudhari, DDG (NRM), Dr AK Saxena, Director of ICAR-NBAIM, Dr DLN Rao, former Emeritus Scientist of the institutegraced the occasion. and scientists of the institute participated in the program.

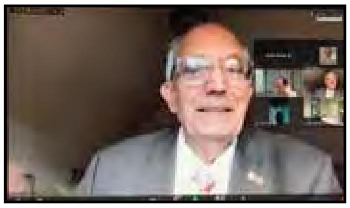
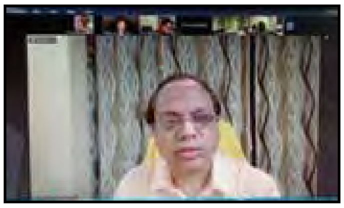


Webinar on 'Biochar: Potential Availability, Usefulness and Limitation in the Context of Indian Agriculture'

A webinar on 'Biochar: Potential Availability, Usefulness and Limitation in the Context of Indian Agriculture'was organized on June 19, 2020. Dr Dinesh Mohan, Prof. JNU, Dr Balwant Singh, Professor from University of Sydney, Australia and Dr SK Chaudhari, DDG NRM presented their views on role of biochar in agricutlture. Hon'ble Trilochan Mohapatra, Secreatary DARE and Director General, ICAR in his concluding remark emphasized that there is a need of long term studies on biochar for understanding its properties, efficacy and usefulness in agriculture.

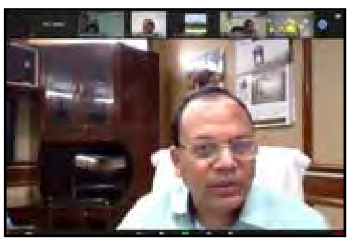
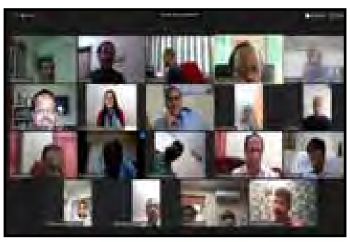
Felicitation of Dr. Rattan Lal, World Food Prize 2020 Laureate

A virtual felicitation function was organized jointly with Bhopal Chapter of NAAS and ISSS on July 21, 2020 in the honour of Indian-American Soil Scientist, Dr. Rattan Lal, the winner of the World Food Prize 2020. Dr SK Chaudhari, DDG (NRM), ICAR, Dr SK Rao, VC, RVSKVV, Gwalior; Dr Ashok Dhawan, VC, VNMKV, Parbhani, Maharashtra; Former VCs Dr VS Tomar and Dr Anil Kumar Singh; Directors and past Directors of several ICAR Institutes, Fellows and Associates from NAAS-Bhopal Chapter and scientists participated in the programme.


Virtual Meeting on "Long-Term Fertilizer Experiments: Achievements and Future Strategies"

A virtual meeting of All India Coordinated Research Project on Long-Term Fertilizer Experiments (AICRP- LTFE) on "Long-Term Fertilizer Experiments: Achievements and Future Strategies" was organised at ICAR-Indian Institute of Soil Science, Bhopal during 11-12th August 2020. Dr SK Chaudhari DDG (NRM), Dr Himanshu Pathak, Director, ICAR-NIASM, Baramati Dr B Venkateswarlu (Ex-VC, VNMAU Parbhani) and Dr Tapas Bhattacharyya (Ex VC, DBSKKV Dapoli) participated as Experts. During the two-days of virtual meeting, with four Technical Sessions, various key issues such as integrated nutrient management, soil health, nutrient dynamics, soil functional diversity, carbon sequestration, impact of climate on soil quality, digitization of LTFE database, organic farming, crop residue addition /conservation agriculture, technology transfer to the farmers in tribal areas, etc. were deliberated. About 80 Scientists from 18 centres of LTFE from different states and UTs have actively participated in the meeting.

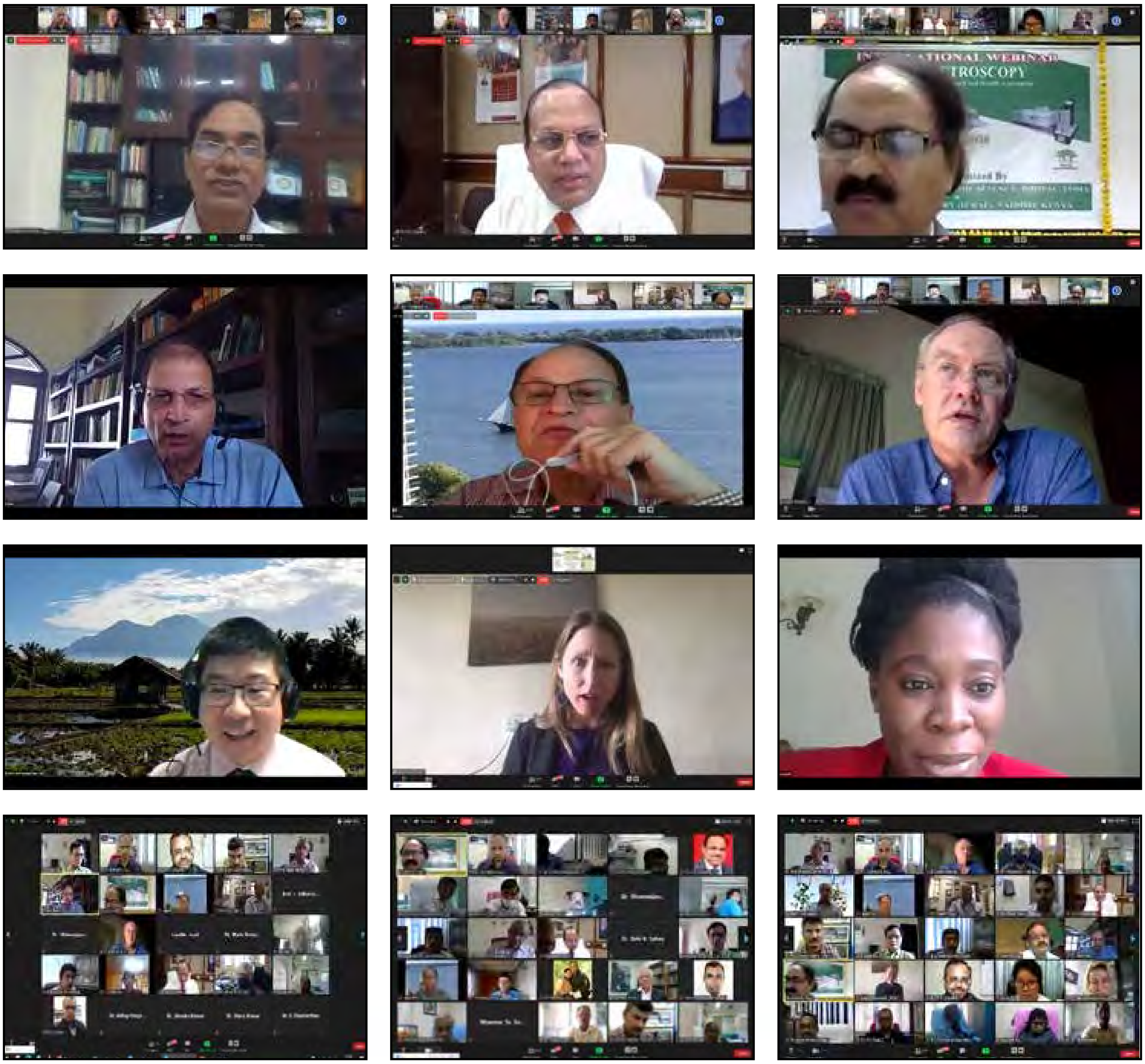

Interactive Session at SAGE University, Bhopal on World Food Day

The institute in collaboration with the NAAS, Bhopal Chapter organized a one day interactive session on the theme :"Soil, Water, and Food : Issues and Challenges in the Present Era" at the Sage School of Agriculture, SAGE University, Bhopal on October 16, 2020. The interactive session was graced by Dr Ashok K Patra, Director, IISS, Bhopal Dr VK Jain, VC of the SAGE University; Ms. Shivani Agrawal, Executive Director, SAGE University. The interactive session was attended by the students and faculty members of the SAGE University. Dr Ashok K Patra delivered the talk on "Soil & Crop health management - Issues and strategies".

International Webinar on "Soil Spectroscopy: An Emerging Technique for Rapid Soil Health Assessment"

The institute in collaboration with World Agroforestry (ICRAF), Nairobi, Kenya organized an International Webinar on Soil Spectroscopy on October 1, 2020. Around 850 participants representing 28 countries from scientific, educational and private & public research institutions attended the webinar. Besides, Inter-Governmental Technical Panel members on Soils, FAO, Global Soil Laboratory Network, South East Asia Laboratory Network, Asian Soil Partnerships, Focal Points of Global Soil Partnerships, and representatives from SAARC Agriculture Centre also participated.

Dr Trilochan Mohapatra, Hon'ble Secretary, DARE and DG, ICAR, New Delhi, Dr Tony Simons, DG, World Agroforestry (ICRAF), Nairobi, Kenya, Dr SK Chaudhari, DDG (NRM), ICAR, New Delhi, Dr Ravi Prabhu, DDG (Research), ICRAF, Nairobi, Dr Ashok K Patra, Director, ICAR-IISS and Dr Javed Rizvi, Director, South Asia Program, ICRAF, New Delhi graced the occasion. In addition, seven eminent speakers shared their research experiences from Australia, Africa, U.K. and India during the Webinar.



International Webinar on Soil Spectroscopy

National Webinar on ''Quality Improvement and Proficiency Testing of Soil Laboratories in India''

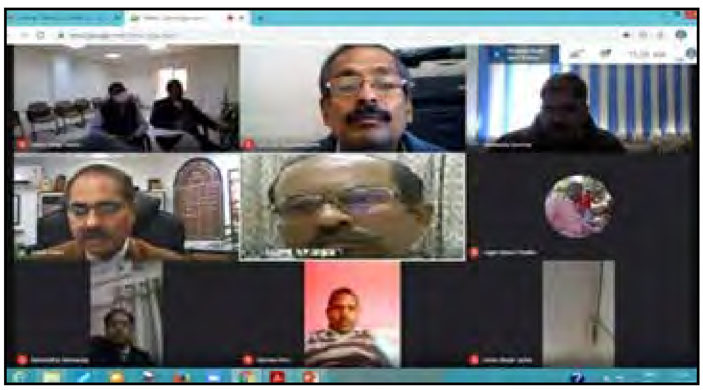
A national webinar on 'Quality Improvement and Proficiency Testing of Soil Laboratories in India' was organized on October 31, 2020 with a theme 'Towards Improving the Quality of Analytical Data and Harmonization of Soil Test Methods'.Dr SK Chaudhari, Deputy Director General (NRM), ICAR graced the occasionand emphasized the need of maintaining the quality standards in soil testing with uniform protocols. Around 300 participants representing Agricultural Universities, ICAR institutes, KVK, State Department of Agriculture attended the webinar.

Virtual Conference on "Developing Human Resources for Recalibrating STCR" organized at ICAR-IISS, Bhopal

On the occasion of World Science Day for Peace and Development (#Science Day, #UNESCO), ICAR-AICRP on Soil Test Crop Response (STCR) organized a Virtual Conference on "Developing Human Resources for Recalibrating STCR" on November 10, 2020. The conference was graced by Dr. M. Velayutham, former Director of ICAR-NBSS&LUP, Dr A Subba Rao, former Director of ICAR-IISS, Dr KCK Reddy, former Project Coordinator (STCR) Dr M Muralidharadu, former Project Coordinator (STCR). STCR-Industry Interface session was organized in which Dr Amit Rastogi, Executive Vice President-Technology, Coromandel International Limited, Hyderabad shared the experiences of the Company on use of STCR prescription equations for development of customized fertiliser formulations. Dr Shantanu Kar, Deputy Manager of Coromandel International Limited also participated in the programme. A Farmers' Interface was also organized wherein the farmers expressed their opinions and experiences regarding the handholding of STCR especially under Schedule Tribe Component (STC) and Scheduled Castes Sub Plan (SCSP).

Training Conducted

Online Training on 'Soil Health Management' (November 17-20, 2020)



Online Training on 'Integrated Nutrient Management' (December 21-23, 2020)

Soil health assessment and preparation of soil health card during March 2-6, 2020

Women Cell organised "Mahila Kisan Diwas" on October 15, 2020

Organized different activities and programs on "Constitution of India" from 26 November, 2019 to 26 November, 2020

Improving soil health campaign, Kisan Diwas and Swachhata Abhiyan at Tarasewania village, Bhopal

Soil Health Awareness campaign month

Visit to farmers field at Village Karod Khurd

Soil Health awarness program at Raipur

Farmer-Scientist Interaction Meet and Field Day at Village Karod Khurd

(a)

(b)

Farmer-Scientist interaction meet (a) Kalakheda, (b) Ratapura under the NICRA Project

(c)

Farmer-Scientist interaction meet at (c) Mugaliahat village under the NICRA project

Training Crop Simulation Modelling and impacts of Climate Change on Agricultural Production:
A Training program on multi-model simulations ystems under NICRA

Farmer Scientist interaction meet at Kanera

The Institute organized a national Webinar on "Alternatives to Plastics for Sustainable Soil and Environmental Health" on December 30, 2020. Dr SK Chaudhari, DDG (NRM), Dr CL Acharya, Former Director, ICAR-IISS and Directors of various NRM institutes graced the occasion. About 150 participants joined in the webinar comprising of eminent speakers and scientists, faculties, students, research fellows.

14. DISTINGUISHED VISITORS

Dr Seiya Tsujumura and Dr Masanori Kaneko, University of Tsukuba, Japan visited the institute on February 26, 2020

15. INFRASTRUCTURE DEVELOPMENT

Instrument/Equipment Purchased

During the year 2020, FTIR Spectrometer, BOD Incubator, pH Meter with Redox Electrode, Gas Cylinder of AAS, CHN Analyser, Deep Freezer, Plant Canopy Analyser, Real Time PCR Machine (2 Nos.), Hatching Machine, Gas Chromatograph, Split Slit Drill, Happy Seeder, Water Tanker, Glassware Dryer Oven, SKU.HI1310 for pH Electrode for pH Meter, Air Conditioner (4 Nos.), Desktop Computer, Automatic N Distillation, Hot Air Oven, Water Cooler, Fabrication/Accel Comp Composting Machine & Heavy Duty Accel- Comp Shredder, Gel Documentation System, Refrigerator, Free Air CO_2 Enrichment System, Multi-Parameter, Ultra-Pure Water Purification System, Laboratory Refrigerator, Hot Plate, GPS, PCR Thermal Cyclers, Weighing Balance, Wet Sieving Apparatus, pH Meter, ICP-OES Instrument, Digital multi- functional printer/Photocopier Machine, Mulcher Cum Zero Till Sowing Machine and Automatic N Distillation were purchased.

Library

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

Documents	Addition during 2020	Total
Books	2	2593
Bound Journals	116	3180
Annual Reports	20	2630
Foreign and Indian Journals	Nil	Nil

Farm Activities

Agriculture farm section of the institute is working as service section to assist the various research activities round the year in the form of:-

i) Arrangement of inputs such as seed, fertilizers and pesticides and shaping of experimental fields

ii) Preparation of experimental sites as per treatment requirement.

iii) Round the year management of irrigation water as and when required to experimental crops through rain water harvesting or bore wells

iv) Arrangement of crop harvesting and threshing of experimental crops.

v) Agril farm section also extended its services to various projects running nearby villages

A total revenue of Rs. 13,39,275/- was generated by farm section during January- December 2020.

Model Compost Unit at ICAR-IISS, Bhopal was inaugurated by Dr. AK Patra, Director, ICAR-IISS on September 24, 2020.

16. SCIENTIFIC, TECHNICAL, ADMINISTRATIVE, SUPPORTING PERSONNEL

Details of manpower

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
DIRECTOR'S CELL				
Dr Ashok 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
Mr Sunny Kumar	Steno. Gr.-III	Office Staff	21.12.2011	21.12.2011
Mr Sukh Ram Sen	T-4	Sr. Tech. Asstt. (Driver)	25.01.1991	25.01.1991
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
Mrs Seema Bhardwaj	Scientist	Soil Science/Pedology	07.01.2008	07.07.2018
Dr NK Sinha	Scientist	Agriculture Physics	20.04.2010	27.08.2010
Dr Jitendra Kumar	Scientist	Soil Science/Soil Physics	15.09.2011	02.01.2020
Ms Alka Rani	Scientist	Soil Science	04.01.2019	12.04.2019
Mr 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 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 Science	01.01.2015	10.04.2015

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
Dr Gurav Priya Pandurang	Scientist	Soil Science & Agricultural Chemistry	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	Sr. 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/Microbiology	03.05.2010	03.05.2010
Dr S Bhattacharjya	Scientist	Soil Science	01.01.2015	10.04.2015
Dr Dolamani Amat	Scientist	Agricultural 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 Kirti 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	Sr. Scientist	Soil Chemistry/Fertility	04.11.2009	15.03.2010
Dr Vasudev Meena	Sr. Scientist	Agronomy	15.09.2011	23.12.2011
Dr Abhijit Sarkar	Scientist	Soil Science	05.07.2016	29.06.2018
Mrs Madhumonti Saha	Scientist	Soil Science	05.07.2017	29.06.2018
Dr Nisha Sahu	Scientist	Soil Science	23.01.2012	30.11.2019
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

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
Dr Dhiraj Kumar	Scientist	Soil Science & Agricultural Chemistry	01.01.2015	13.08.2020
Mrs Geeta Yadav	Private Secretary	Office Staff	26.12.1995	26.12.1995
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	Pr. Scientist	Soil Science & Agricultural Chemistry	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
Dr Hiranmoy Das	Scientist	Agricultural Statistics	15.09.2011	23.12.2011
Dr Immanuel Chongboi Haokip	Scientist	Soil Science	07.01.2020	04.04.2020
Mrs Yojana Meshram	Personal Assistant	Office Staff	12.05.1997	12.05.1997
Mrs Kavita Bai	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
Dr M Homeshwari Devi	Scientist	Soil Science	07.01.2020	04.04.2020
PME CELL				
Dr R Elanchezhian	Pr. Scientist	Officer In-charge	09.11.1998	17.02.2012
Mr Sanjay Kumar Kori	Steno. Grade-III	Office Staff	03.01.2012	03.01.2012
Mr Sanjay Kumar Parihar	T-3	Technical Assistant	29.06.2019	29.06.2019
ITMU				
Dr Sanjay Srivastava	Pr. Scientist	Officer In-Charge	22.03.1996	02.09.1996
Mr Sanjay Kumar Parihar	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

Name	Designation	Discipline/ category	Date of Joining ICAR	Date of Joining IISS
REFERRAL LAB				
Dr Pradip Dey	Pr. Scientist & I/c PC (STCR)	Officer In-Charge	03.06.1993	01.02.2012
FARM SECTION				
Dr AK Vishwakarma	Pr. Scientist	Officer In-Charge	16.04.2003	01.08.2013
Mr OP Shukla	T-5	Technical Officer (Tractor Mech.)	22.04.1989	22.04.1989
Mr CT Wankhede	T-5	Technical Officer (Electrician)	03.08.1992	03.08.1992
Mr DR Darwai	T-6	Sr. 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 Science	01.01.2015	10.04.2015
ADMINISTRATION SECTION				
Mr SK Gupta	SAO	Administration	14.11.1986	01.04.2017
Mr Rajesh Dubey	AF&AO	Audit & account	21.12.1988	26.11.1998
Mr AS Rajput	AAO	Administration	14.03.1990	14.03.1990
Mrs Babita Tiwari	Assistant	Central store	30.05.1996	30.05.1996
Mr Bansi Lal Sarsodia	Assistant	Purchase section	10.09.1997	10.09.1997
Mr Hira Lal Gupta	Assistant	Bill section	23.12.1988	23.12.1988
Mr OP Yadav	UDC	Audit & Account	19.12.1988	19.12.1988
Mr Jineshwar Prasad	UDC	Bill Section	13.12.1988	13.12.1988
Mr Sanjay Katinga	LDC	Cash Section	20.06.1989	20.06.1989
Mrs Raksha Dixit	LDC	Establishment Section	24.05.2013	24.05.2013
Mr Anurag	Security Supervisor	Security section	29.09.1997	29.09.1997
Mr 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

Promotion

1. Dr Sanjib Kumar Behera promoted from Senior Scientist to Principal Scientist w.e.f. May 02, 2018.
2. Dr Hiranmoy Das promoted from Scientist Revised Research Level (RRL-10)to Scientist RRL-11 w.e.f. September 15, 2016.
3. Dr M Vassanda Coumar promoted from Scientist to Sr.Scientist w.e.f. November 4, 2018.
4. Dr Sudeshana Bhattacharjya promoted from Scientist (RRL-10) to Scientist (RRL-11) w.e.f. January 1, 2019.
5. Dr Asit Mandal promoted from Scientist to Sr.Scientist w.e.f. June 23, 2018.
6. Dr Vasudev Meena promoted from Scientist (RRL-10) to Scientist (RRL-11) w.e.fSeptember 15, 2016.
7. Dr AO Shirale promoted from Scientist (RRL-10) to Scientist (RRL-11) w.e.f. January 1, 2019.
8. Mr R K Mandloi and Mr Deepak Kaul promoted from

ACTO to CTO w.e.f. January 1, 2018.

9. Mr Jineshwar Prasad got MACP w.e.f. December 13, 2018.
10. Mr Laxmi Narayan Chuksey got MACP w.e.f. December 17, 2019.
11. Mr Sanjay Katenga got MACP w.e.f. June 20, 2019.
12. Mr Harish Kumar got MACP w.e.f. March 14, 2020.
13. Mr Darash Ram got MACP w.e.f. March 15, 2020.
14. Mr Ram Bharose got MACP w.e.f. March 20, 2020.

Transfer

1. Dr MC Manna transferred on deputation to RPCAU, Samastipur on October 29, 2020.
2. Mrs Kirti Chaturvedi transferred to ICAR-IGFRI, Jhansi on April 24, 2020.

Joining

1. Dr Jitendra Kumar, Scientist joined at ICAR-IISS, Bhopal on January 02, 2020.

2. Dr Immanuel Chongboi Haokip Scientist joined at ICAR-IISS, Bhopal on April 04. 2020.

3. Dr. M. Homweshwari Devi Scientist joined at ICAR-IISS, Bhopal on April 04. 2020.

4. Dr Dhiraj Kumar, Scientist joined at ICAR-IISS, Bhopal on August 13, 2020.

Superannuation

1. Dr Muneshwar Singh PC (LTFE) superannuated on August 31, 2020.








गांधी जयंती की शुभकामनाएं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