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Annual Report 2023

Climate Change

Simulation Modelling

Environmental Pollution

Waste Management

SUSTAINABLE DEVELOPMENT GOALS

Division of Environmental Sciences

ICAR-Indian Agricultural Research Institute

New Delhi 12

Annual Report
2023

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Preface

It is with great pride and satisfaction that I present the annual report 2023 of the Division of Environmental Sciences. This year marks a significant milestone as we celebrate the 31st anniversary of our establishment in 1993. Over the past three decades, our division has made exemplary contributions to the field of environmental sciences, addressing some of the most pressing issues of our time.

The Division of Environmental Sciences was established in 1993 with a mission to advance the understanding of environmental processes and develop sustainable solutions to environmental challenges especially in agroecosystems. Since its inception, the Division has grown significantly, evolving into a hub of research and innovation. Our vision has always been to lead the way in environmental research, focusing on climate change, sustainable development, simulation modelling, environmental pollution, create wealth from waste and the preservation of ecosystem services.

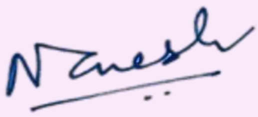
Our division has been at the forefront of climate change research, with a focus on understanding the impacts of climate change and developing effective adaptation and mitigation strategies. We have conducted extensive research on the drivers of climate change, including greenhouse gas emissions and land-use changes. Our team has been actively involved in the development of policies and strategies aimed at reducing greenhouse gas emissions and impacts on agriculture through green adaptation technologies to promote sustainable development. In response to the growing challenges posed by climate change to agriculture, our division has pioneered research in climate-resilient agriculture. We have developed and tested various adaptation strategies to help farmers cope with the changing climate. This includes the improved nutrient and water management practices and the promotion of improved agronomic and agroforestry systems. Our work in this area especially under NICRA Project has been instrumental in enhancing the resilience of agricultural systems to climate variability.

The division has made significant advancements in the development of simulation models for crops. These models are used to forecast crop yields, assess the impact of climate change on agricultural productivity, and develop strategies for optimizing resource use. Our models have been widely adopted by policymakers and practitioners, providing valuable insights for planning and decision-making in the agricultural sector. A key area of our research has been the quantification of greenhouse gas emissions and the development of emission inventories. Our team has conducted comprehensive assessments of emissions from various sectors, including agriculture, energy, and waste management.

The climate change impacts, adaptation and vulnerability assessments on 11 crops and GHG inventory from agricultural soils, nitrogen fertilizer and crop residue burning have been reported by India as the BUR, Third National Communication to United Nations Framework convention on Climate Change (UNFCCC).

The division has also focused on addressing the challenges of waste management, remediation of pollutants and environmental pollution. We have conducted research on the sources, impacts, and management of various pollutants, including plastic waste, heavy metals, and air pollutants. We are also quantifying and valuing ecosystem services, including carbon sequestration and biodiversity conservation. This research has highlighted the importance of protecting and restoring ecosystems as a means of achieving net-zero emissions and sustainable development. As we look to the future, our division is committed to continuing our work towards achieving net-zero emissions from agriculture and promoting sustainable agriculture. We are exploring new research avenues, including the development of nature-based solutions, the integration of renewable energy in agricultural systems, and the promotion of sustainable consumption and production patterns. Our aim is to contribute to a more sustainable and resilient future for all.

Finally, the Division of Environmental Sciences has made remarkable progress in addressing some of the most critical environmental challenges of our time. Our achievements are a testament to the hard work and dedication of our scientists, staff, and partners. As we move forward, we remain committed to advancing our research, fostering innovation, and contributing to a more sustainable and equitable world. I would like to thank Dr. T.R. Sharma, Director, IARI, Dr. Viswanathan Chinnusamy, Joint Director (Research), Dr. Anupama Singh Jt. Director (Education) and Dr. R.N. Padaria, Jt. Director (Extension) for their constant support and guidance. I also thank Dr. Himanshu Pathak, Secretary (DARE) & Director General (ICAR) for constant support and encouragement for the inclusive growth of the Division. I acknowledge the funding agencies such as ICAR, DBT, DST, NASF (ICAR), NAHEP (ICAR), BARC and other national Instituitions as well as the Ministries viz., MoA&FW, MoEF&CC, MoSteel, MoS&T & SANH, FAO. Further I thank the support from the International agencies, such as AgMIP, FAO, SANH, IRRI for externally funded projects and studies for the financial year 2023 that immensely helped in meeting our research, teaching, and service goals. I express my sincere admiration to the Annual Report editorial team for bringing out the annual report. I look forward to more productive years ahead.



(Soora Naresh Kumar)

Head, Division of Environmental Sciences

Contents

Division of Environmental Sciences: An Introduction

The Division of Environmental Sciences is a dynamic, interdisciplinary department at the forefront of tackling current and future environmental challenges. Our research extends to crucial areas such as climate change, simulation modeling, greenhouse gases emission quantification, waste management, environmental pollution and ecosystem services where innovative strategies are developed to mitigate the environmental impact. The Division of Environmental Science is actively engaged in cutting-edge research on a wide range of critical environmental issues. The research focuses on climate change, with particular emphasis on simulation modeling to predict future climate scenarios and their potential impacts. Additionally, the division is involved in quantifying greenhouse gas emissions to understand their sources better and mitigate their effects. Waste management practices are being studied to develop more efficient and sustainable solutions. The division also addresses various aspects of environmental pollution, including air, water, and soil contamination, and their impacts on human health and the environment. Furthermore, the division explores ecosystem services, assessing the benefits provided by natural ecosystems and how they can be preserved and enhanced to support biodiversity and human well-being.

Moreover, we delve into the realm of ecosystem services, studying the benefits that ecosystems provide to society and farmers and devising strategies for their sustainable management and conservation. Finally, our division is actively engaged in studying the behavior and remediation of heavy metals in the environment (water, soil and plants), recognizing their significant impact on ecosystems and human health. Through innovative research and national and international collaboration, the Division of Environmental Sciences is committed to advancing knowledge and implementing practical solutions to safeguard our planet for future generations. Division of Environmental Sciences was established in 1993, has a mission for development of sustainable agriculture, climate change adaptation and mitigation strategies, management of environmental pollution, extension and teaching for the benefit of society and farming community.

The vision of this multi-disciplinary division is ‘Enhancing resilience of Indian agriculture to environmental change’. A group of 16 scientists belonging to 7 different disciplines are working in this division with a mission of development and dissemination of efficient and economically viable technologies for climate-resilience, sustainable agriculture and environment protection.

Mandates of the Division

- To conduct basic and strategic research for environment resilient sustainable agriculture with a special emphasis on rainfed and small-scale farmers.
- To impart post-graduate education and training on agriculture-environment inter-relationships.
- To provide advisory and consultancy services on environment assessment and climate change in agriculture.

Thrust research areas

- Climate change, GHGs quantification, Inventory development, Emission factor refinement, adaptation and mitigation strategies
- Climate resilient agriculture
- Development of simulation models for crops, forecasting and vulnerability assessment
- Environmental Pollution (soil, air, and water pollution)
- Waste management, utilization and value addition
- Assessment of microplastics in soil and development of bioplastics
- Quantification of polyaromatic hydrocarbons (PAHs) in air and soil and their toxicity assessment
- Biogas production, enrichment and utilization
- Heavy metals contamination in soil, water, air and plants and their toxicity assessment
- Quantification of ecosystem services and their valuation
- Nutri-physiology and radio-ecological studies
- Development of nano and climate smart fertilizers
- Division also engaged in teaching, extension, capacity building and policy formulation

EXECUTIVE SUMMARY

The Division of Environmental Science has made significant strides over the past year in advancing our understanding and management of environmental challenges through innovative research. Our work spans a broad spectrum of environmental issues, from climate change and greenhouse gas (GHG) emissions, environmental pollution, to soil and waste management. This executive summary provides an overview of our key research activities and their implications for environmental sustainability. We developed detailed Climate Model Intercomparison Project Phase 5 (CMIP5) scenarios linked crop simulation model (infoCrop v2.1) based projections on climate change impacts on major agricultural crops in India. This work involved simulating various climate scenarios to understand potential changes in temperature, precipitation, and extreme weather events and their impacts on crop productivity. The studies also indicated the adaptation gains, pivotal for developing adaptive strategies for agricultural planning and resource management.

Our research into GHG emissions from crop fields has provided crucial insights into greenhouse gas dynamics in agricultural settings. By simulating their fluxes, we have identified key factors influencing emissions and potential mitigation strategies, contributing to more sustainable rice cultivation practices. We also developed the new emission coefficients for CH_4 and N_2O from different agricultural practices. This work helps refine GHG inventories and improves the accuracy of emissions reporting, supporting more effective climate change mitigation strategies in the agricultural sector. Our GHG inventories now include detailed data on emissions from rice residue burning in Punjab and Haryana. This research highlights the significant impact of such practices on regional air quality and global warming, underlining the need for alternative residue management strategies.

We quantified reactive nitrogen emissions from crop and livestock production systems, revealing critical insights into nitrogen cycling and its environmental impacts. These findings are essential for developing strategies to minimize nitrogen pollution and enhance nutrient use efficiency. Our research on the effects of elevated temperature and atmospheric CO_2 concentrations on crop growth has uncovered significant impacts on yield, quality, and plant physiology. Understanding these effects helps in designing resilient crop varieties and agricultural practices suited to future climate conditions.

We investigated how various air pollutants affect crop health and productivity. This research is crucial for developing strategies to mitigate the adverse effects of air pollution on agriculture, ensuring food security and crop sustainability. Presently, focus on emerging pollutants, such as studies on PAHs, revealed their detrimental effects on soil health and crop growth. This research informs strategies for managing contaminated soils and protecting agricultural systems from these harmful compounds.

We are also deeply looking in to the comprehensive analyses of soil carbon pools, budgeting, quality and stability. These studies are vital for understanding carbon sequestration potential and developing strategies to enhance soil carbon storage as part of climate change mitigation efforts. Our research focused on various mitigation strategies, including the application of coated, nano, and modified fertilizers. These approaches aim to reduce GHG emissions, improve nutrient use efficiency, and enhance crop resilience. We explored methods for addressing heavy metals contamination in soils, including phytosiderophore-based mobilization and bioremediation techniques. These studies are critical for restoring contaminated lands and protecting environmental and human health. We synthesized cellulose-based bioplastics using nanoparticles derived from corn cobs. This research supports the development of sustainable materials and reduces reliance on petrochemical-based plastics. The Division of Environmental Science has made substantial progress in addressing critical environmental issues through its diverse research portfolio. Our work enhances scientific understanding and contributes to practical solutions for environmental management and sustainability. As we move forward, we remain committed to advancing research that supports a healthier and more sustainable environment.

1. Scientific activities

Creation of CMIP6 climate change scenarios over India for agricultural seasons

The surface (2m) daily data on temperature (min, max), precipitation, solar radiation, windspeed, etc are downloaded from the Earth System Grid Federation (ESGF) source for the CMIP6 23 Global Climate Models (GCMs). The data has a spatial resolution ranging from 1ox1o to 5ox5o. All these data are being processed to re-gird the data to IMD observed data spatial scale for further identification of bias and correction so as to eventually develop the ensemble data. This will be used for impact and adaptation assessments.

Identification of vulnerable districts/ ACZs for adaptation prioritization-wheat 2030-RCP 4.5

The impact of climate change on wheat .2

productivity in RCP 4.5 is analyzed agro-climatic zone-wise. The crop models (InfoCrop, DSSAT and APSIM) based analysis indicated that in RCP 4.5 2030 scenario (2010-2039), impacts are projected to be more in Regional Climate Model Scenarios as compared to that of Global Climate Model Scenarios. The agro-climatic zones in the eastern, north eastern, central and south central are more vulnerable to climate change as far as wheat productivity with current management is concerned.

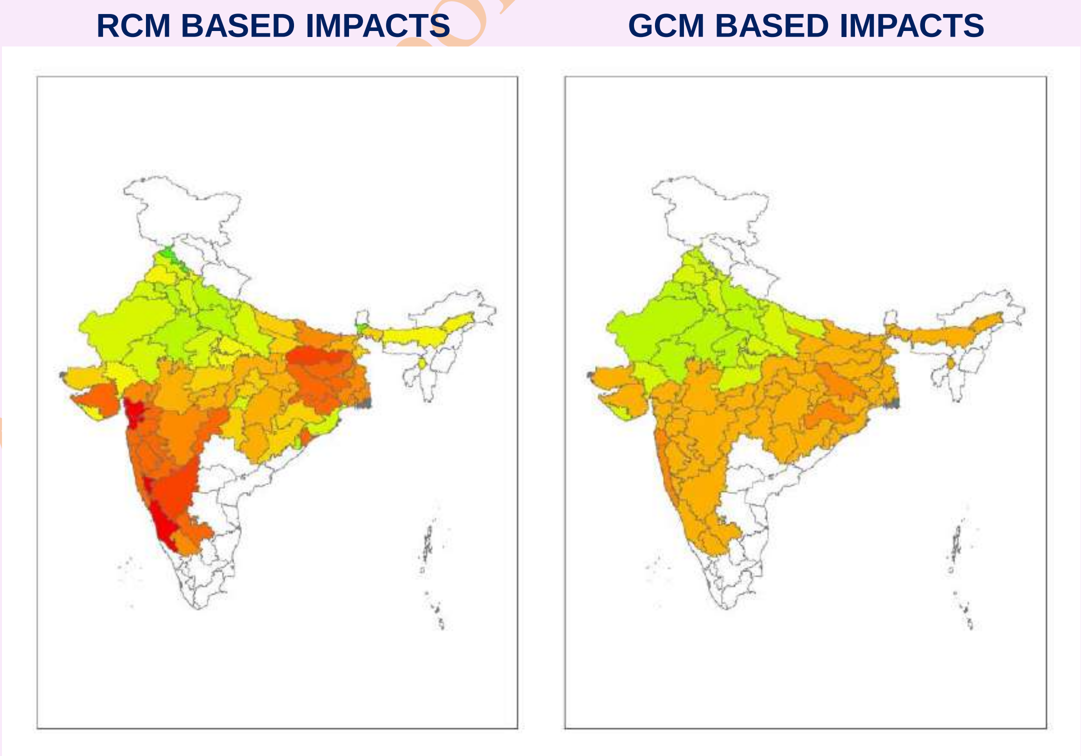


Fig. 1. Impact of climate change on wheat productivity in different agro-climatic zones

The analysis indicated that number of districts in Punjab projected to be vulnerable with current managements are 3 under RCM climate scenarios of RCP 4.5 in 2020s and 2030s as compared to just one district under GCM similar climate scenarios. Similarly, in Haryana, the number of vulnerable districts is 6 and 3 under RCM and GCM RCP 4.5 climate scenarios in 2020s and 2030s. Similar analysis indicated 35 and 32 districts of Madhya Pradesh vulnerable under RCM and GCM RCP 4.5 climate scenarios in 2020s and 2030s. In Uttar Pradesh, such number of districts are 33 and 28, respectively. The number of vulnerable districts with current management are projected to significantly go up in RCP 4.5 climate scenarios of 2050 and 2080.

Simulation of methane emission from direct seeds rice fields to assess the maladaptation effects under different conditions in India

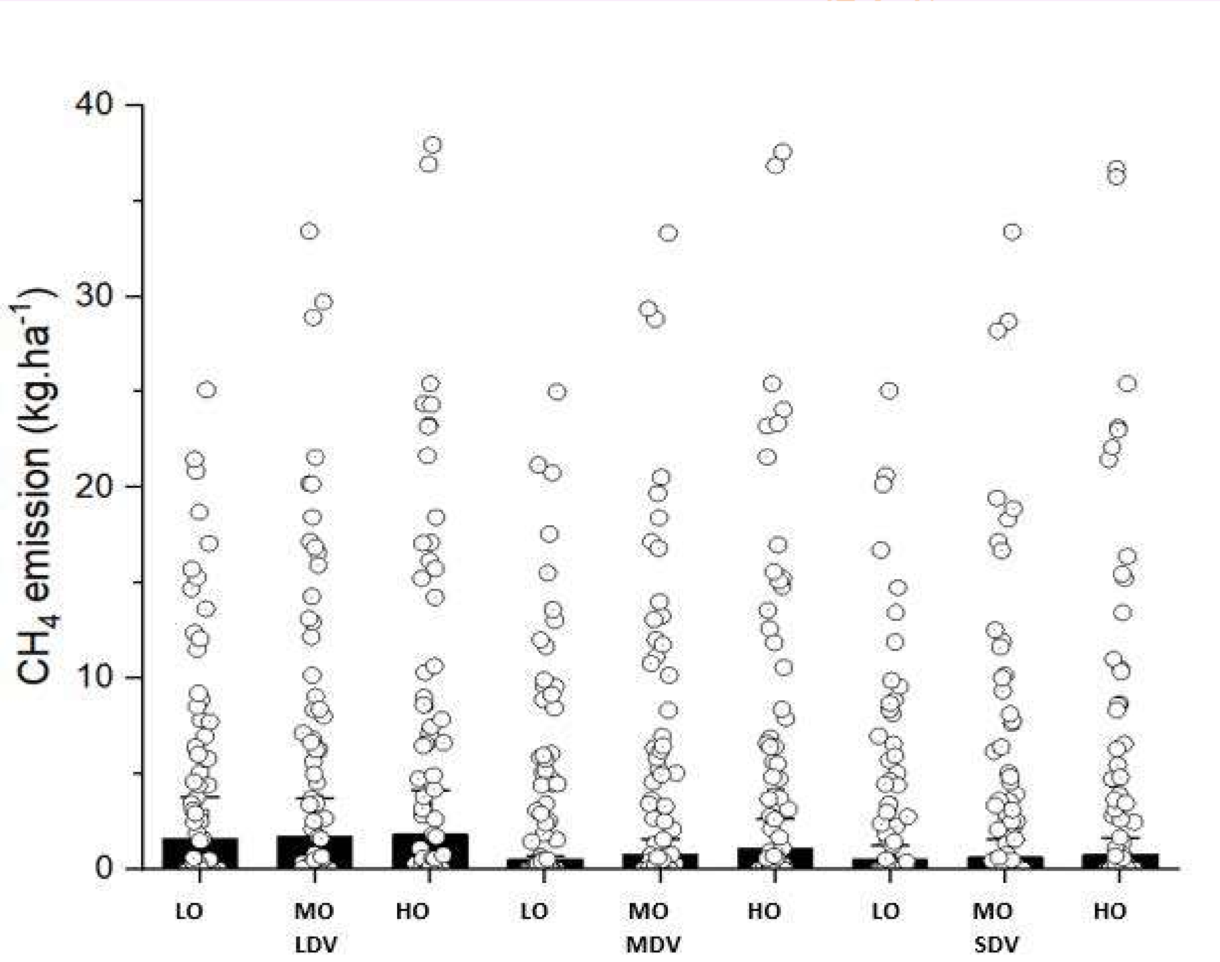


Fig. 2. Simulated methane emission from direct seed rice under different management conditions of low (LO), medium (MO) and high (HO) organic content application with long (LDV), medium (MDV) and short-duration varieties (SDV) of rice.

A simulation analysis using the calibrated and validated InfoCrop rice model (v2.1) was done for the methane emission from direct seed rice fields under different management and agro-climatic conditions in India. The simulation was performed for 30-year period in 146 locations in India. The results indicated that in general methane emission from DSR fields ranged from 1.5 to 4.7 kg/ha. The longer duration varieties grown with high organic matter (10 Mg/ha) application and anaerobic conditions have more emissions than when grown in low organic matter (up to 1 Mg/ha) application/residue conditions. In addition, the results indicated that methane emissions were low from DSR field with short or medium duration rice varieties grown with low organic matter.

Emission coefficient of nitrous oxide from agricultural soils: greenhouse gas inventory refinement

For the refinement of greenhouse gas emission inventory from agricultural soils, the emissions of nitrous oxide were quantified for estimation of emission coefficients under neem coated urea application growing wheat, potato and onion, cowpea and sugarcane crops. For quantification of nitrous oxide emissions, wheat variety HD 3226 was grown under no nitrogen (control), 120 kg N/ha and 150 kg neem coated urea (NCU). Sugarcane Co 0238 was grown under 150 and 200 kg N/ha of NCU. The fluxes of N_2O were quantified using close chamber technique for the crop duration of 127 and 346 days for wheat and sugarcane, respectively. In wheat the emission of N_2O ranged from 0.29 kg N_2O-N/ha in control to 1.022 kg N_2O-N/ha in 150 kg NCU-N/ha treatment. In sugarcane the N_2O emission ranged from 0.75 kg N_2O^- N/ha in control to 2.58 kg N_2O-N/ha in 200 Kg NCU-N/ha treatment. The % of applied N lost as N_2O ranged from 0.68% to 0.71% under the different NCU treatments in sugarcane, whereas in wheat the N_2O EF was ranging 0.52 to 0.55% and was significantly lower than the IPCC default emission factor of 1%. The sugarcane yield ranged from 10.2 to 11.3 kg/m^2 under the different NCU treatments, whereas in wheat the yield ranged from 4.8 to 5.3 kg/m^2. The cowpea variety Pusa Sukomal was grown with the application of 25g N/m^2. The emission of N_2O during the crop growth period was observed to be 74.7 g N_2O/m^2 resulting in an emission factor of 0.51% of N_2O-N. Potato variety Neelkanth was grown with the application of 150 kg N/ha of neem coated urea (NCU) and no nitrogen control. The N_2O EF ranged from 0.52 %, whereas in onion the N_2O EF was 0.493% with 120 kg NCU-N/ha and was 0.499% with an additional dose of foliar spray of N using

19-19-19 NPK fertilizer at 60 days after transplanting.

Table 1: Emission factors of nitrous oxide from soils under different crops

Crop	Fertilizer (kg N ha^{-1})	EF of N_2O-N (%)
Cowpea	NCU (21)	0.511
Sugarcane	NCU (150)	0.689
	NCU (200)	0.705
Wheat	NCU (120)	0.524
	NCU (150)	0.555
Potato	NCU (150)	0.522
Onion	NCU (120)	0.493
	NCU+ FS (19-19-19)	0.499

Fig 3. Sampling of GHG emission using close chamber technique in different crops

Scaling factors of methane and nitrous oxide emission from Rice cultivation for alternate wetting and drying practice

Emissions of methane and nitrous oxide from rice cultivation is a key source category in Indian Greenhouse gas emission inventory from all sectors. For estimating methane emissions from rice cultivation, as per the revised IPCC 2006 GHG inventory preparation guidelines, Daily methane emission factors and country specific scaling factors for different irrigation practices as compared to conventional practice needs to be developed. An experiment was carried out in Kharif season growing rice in loam textured soil, with soil organic carbon OF 0.48%. Crop variety Pusa 1847 was grown under continuous flooding (CF) and alternate drying and wetting (AWD) practice under different synthetic and organic fertilizer treatments (Table 2). The crop was irrigated for 85-90 days and the fields were dried for 15-20 days before harvest. The emission of methane and nitrous oxide were measured by close chamber technique. The daily methane emission under conventional practice with synthetic N application ranged from 0.45 to 0.46 kg CH_4/ha/day from CF rice field. The scaling factor of methane emission for AWD practice was estimated to be 0.47$\pm$0.03. The nitrous oxide emission ranged from 0.295 to 0.310% of applied N under CF and the scaling factor for AWD was 1.82 $\pm$ 0.061.

Table 2: Emission factor of methane and nitrous oxide from rice cultivation

Emission Factor	**Methane emission (kg/ha/day)**		**Nitrous oxide (% N applied)**	
N Fertilizer	**Continuous flooding**	**Alternate wetting & drying**	**Continuous flooding**	**Alternate wetting & drying**
Synthetic N (NCU@120 kg)	0.446	18.2	0.310	0.583
Synthetic N (DAP@120 kg)	0.462	17.3	0.295	0.548
Organic N (Compost 100%)	0.901	35.7	0.218	0.391
Organic N (FYM 100%)	0.919	34.5	0.191	0.352
Integrated N (50% compost+ 50% urea)	0.727	26.7	0.264	0.494
Integrated N (25% compost+ 75% urea)	0.592	22.8	0.299	0.538
Integrated N (50% urea+ 50% FYM)	0.734	30.6	0.253	0.430
Integrated N (25% FYM+ 75% urea)	0.573	25.4	0.276	0.484
LSD (p=0.05)	0.080	0.034	0.023	0.038

Estimates of methane and nitrous oxide emissions form agricultural soils

The inventory of methane and nitrous oxide emission from agricultural soils was prepared using the IPCC inventory preparation guidelines for the base year 2021-22. The methane emissions from rice cultivation amounted to 3.57 Gg from 46.28 Mha of cultivated area under different rice ecosystems. The contribution of different water regimes to methane emission is shown in (Fig 4a). The total direct emissions of nitrous oxide were 231.9 Gg, out of which 168 Gg were from consumption of 19.43 MT of synthetic N fertilizer. The indirect N_2O emissions for 2021-22 were estimated to be 58.36 Gg from all sources of N input to agricultural soils. The contribution of different N input sources to N_2O emissions is shown in (Fig. 4a & b).

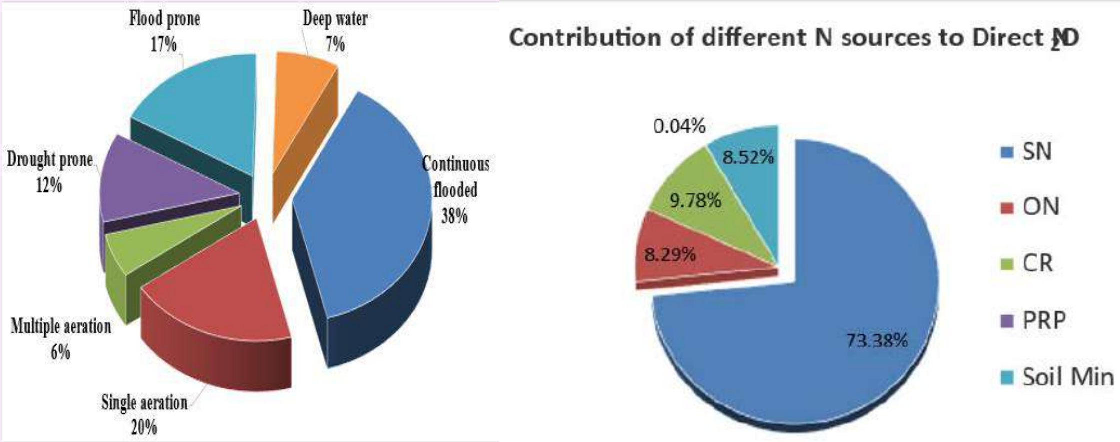


Fig. 4. (a) Methane emission from different rice grown under different water regimes, (b) Contribution of different N inputs to Nitrous oxide emissions

Development of N_2O emission factor from vegetable cultivation

Field experiment was conducted growing potato, and onion under different doses of N (0), 150, 220 & 280 kg/ha in potato and 0, 150 and 200 kg/ha in onion) to quantify the emission of N_2O. The loss of applied N varied from 0.45 to 0.69% and o.56 -0.68% in potato and onion respectively, under different N doses. No significant difference was observed in N_2O emission from ridge (49.5%) and furrow (50.5%) in potato.

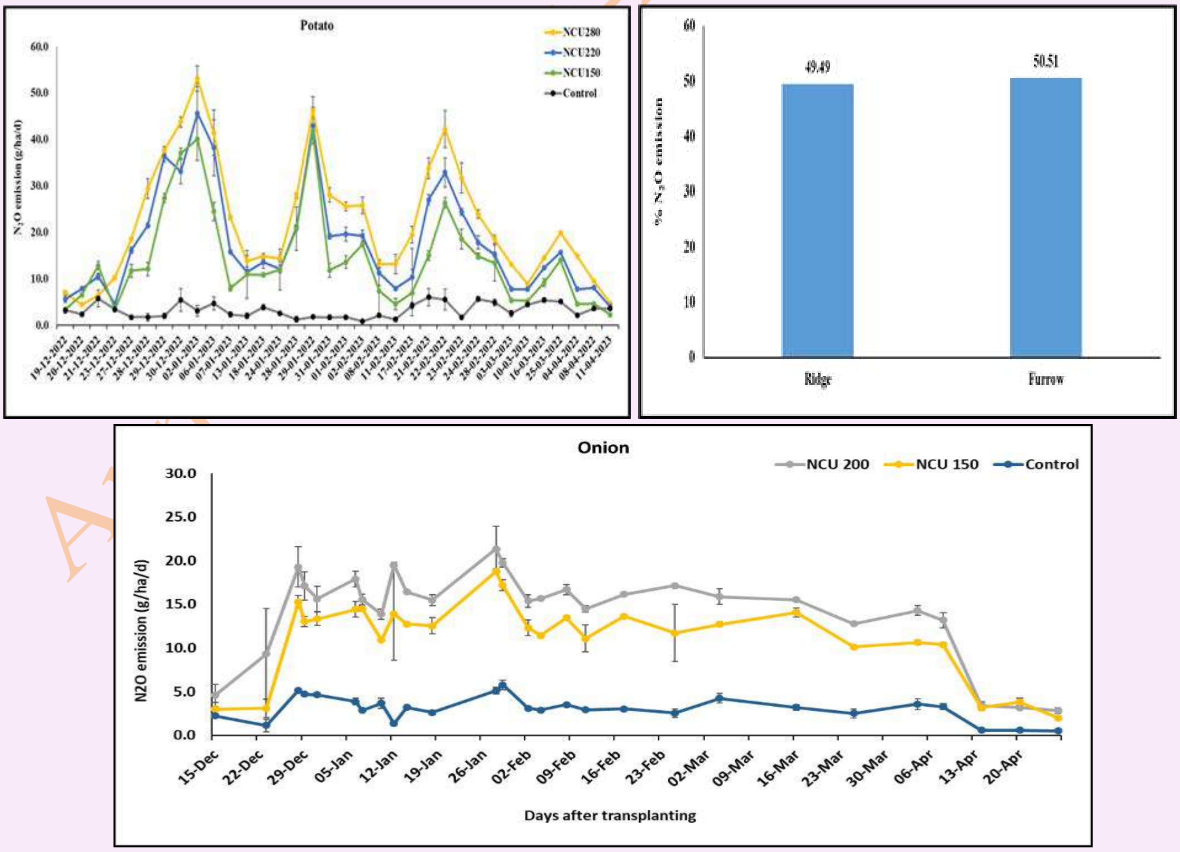


Fig. 5. N_2O emission factor from vegetable cultivation

Development of emission factor (EF) of nitrous oxide and greenhouse gas intensity (GHGI) from cauliflower cultivation systems

The field experiment was conducted to quantify the nitrous oxide (N_2O) emission and calculated the N_2O emission factor under different cultivation practices, i.e. flat bed and ridge & furrow system. The monitoring of nitrous oxide emission in cauliflower under different cultivation practices was carried out in ICAR-IARI, New Delhi field. The nitrous oxide fluxes were quantified under flat bed and ridge-furrow system of cauliflower cultivation. The emission was monitored under standard fertilizer and irrigation practices. The emission factor (EF) of N_2O-N from flatbed cultivation (0.72%) was higher than the emission factor (EF) of N_2O-N under ridge and furrow cultivation (0.67%). The emission factor (EF) of N_2O-N from ridge (0.56%) lower than furrow (0.77%). The greenhouse gas intensity (GHGI) was also higher in flatbed system (0.019 kg CO_2 eq/kg curd yield) as compared to ridge & furrow system (0.012 kg CO_2 eq/kg curd yield).

Emission of GHG from rice residue burning in Punjab and Haryana

The amount of rice straw burned and the emission of GHG and air pollutants due to burning of rice residues in districts Punjab and Haryana was quantified based on real time monitoring of rice area burned in two states. In the year 2023, ~78 % of rice stubble was burned in districts of Punjab compared to ~ 70 % in 2022. This year in state of Haryana extremely high amount of rice straw burned (~66%) compared to last several years (~25% in 2022). The rice stubble burning in districts of Punjab and Haryana (~27 million tons) resulted in emission 37.6 million tons of GHG (CO_2 eq), 65.10 Gg of PM 2.5. 48.82 Gg of PM10 and 2.69 million tons of gaseous air pollutants (Fig 6). The trend in rice straw burned and related emissions were also analyzed for last 7 years in the two states. Analysis of data revealed that although the area under rice cultivation is almost same in the two states, the % rice area burned has shown increasing trend from 2019 in Punjab and 2021 in Haryana. In the state of Haryana an increase of 127% in amount of straw burned was whereas the observed increase in Punjab was 17.7% due to increased incidents of burning in different districts of Punjab and Haryana in 2023 compared to 2022.

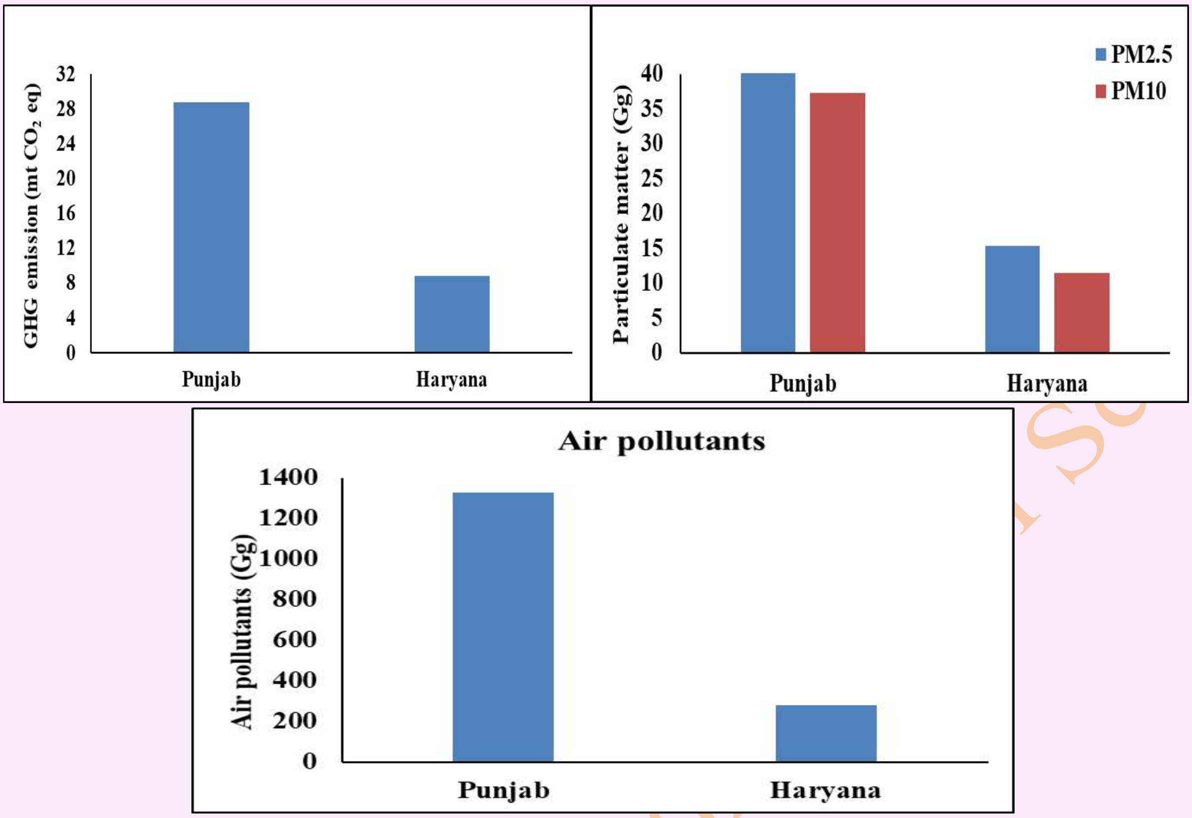


Fig. 6. GHG emission from rice residue burning

Emission of reactive nitrogen from crop and livestock production in India and their mitigation strategies

Agricultural activities like crop and livestock production are the major source of reactive nitrogen (Nr) emission accounting for 80-90% of NH_3, 10% NO and 60-70% of N_2O to the global anthropogenic emission of these gases (Ciais 2013, IPCC 2013). Although nitrogen is a major nutrient required for growth and productivity of crop and livestock, approximately 50% of N applied to cropland does not enter the food chain and are emitted in different forms to the atmosphere. The emission of Nr from different sources may have profound effect on air and water quality. The Nr gases have wide range of adverse environmental impacts such as photochemical pollution, reduced visibility due to haze formation, acid rain, eutrophication of water bodies, stratospheric ozone layer depletion, and global warming. The present study estimated the emission of the two Nr gases (NH_3, NOx) from Indian agriculture for base year 2015 using IPCC 2006/EMEP guidelines and India specific management practices and emission factors. The emission of NH_3, and NOx were estimated from agricultural soil as 2864 Gg/yr, and 191.86 Gg/yr and crop residue burning

105.8 Gg/yr, and 256.4 Gg/yr respectively. The estimates for India were compared with global emissions of Nr species. The estimates were also compared with EDGAR estimates for India. Among different states of India, U.P. had highest emission of Nr. The per unit area emission was highest in Pondicherry. Mitigating nitrogen pollution from croplands is a big challenge. Globally, India ranked third in consumption of fertilizers. The emission of Nr from cropland are bound to increase as there is need to increase the food production to feed the population. However, careful N management in the cropland such as application of N at right time, right place may help in reducing the N application rates. Also, partial substitution of synthetic N by organic N such as manures/compost and use of dual inhibitors coated fertilizers (urease and nitrification inhibitors) can reduce Nr emissions.

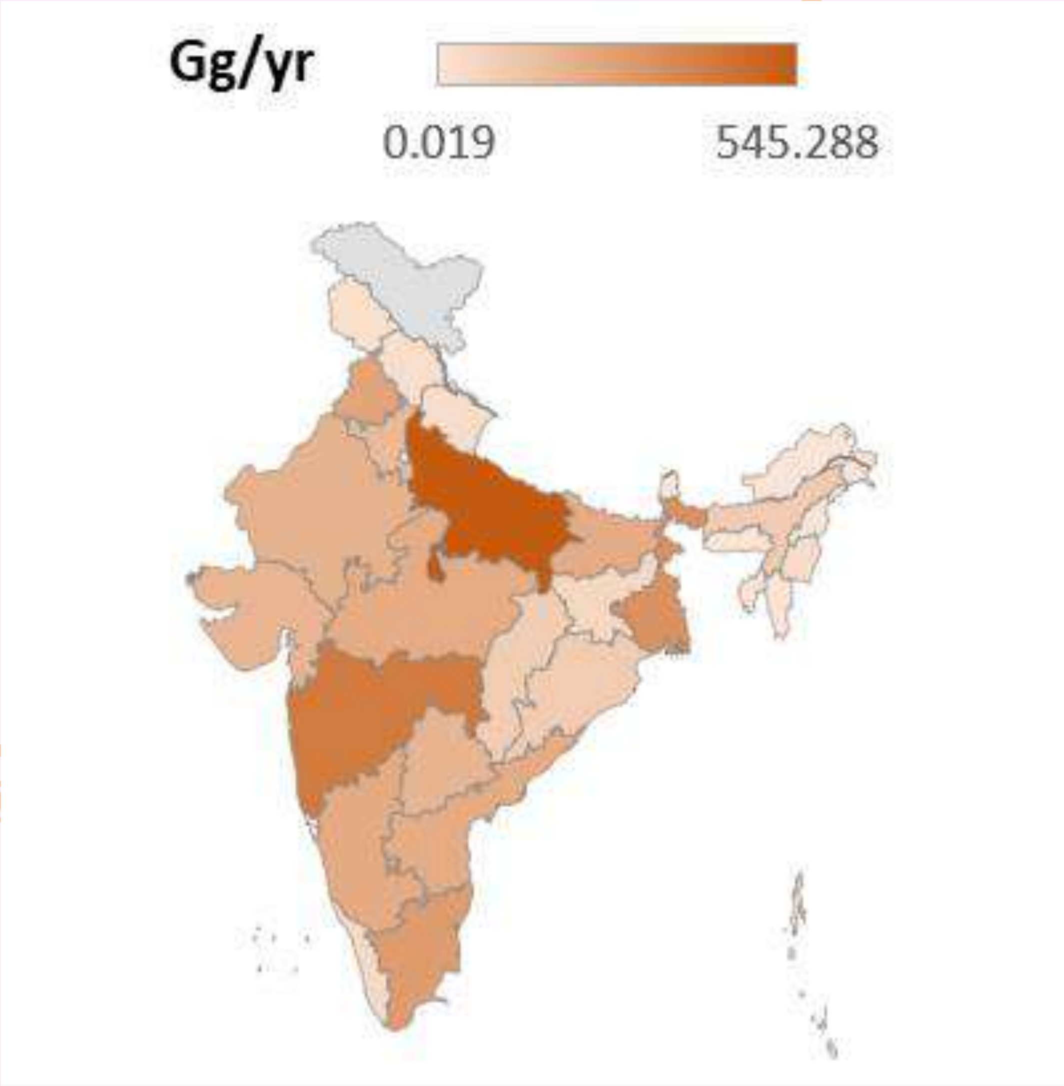


Fig. 7. Emission of reactive nitrogen from Agriculture

Reactive N losses under elevated CO_2 and temperature interaction in wheat with foliar application of liquid nano urea

An experiment was conducted in T-FACE rings for the second-year growing wheat with Neem coated urea (NCU) and two combinations of NCU and Liquid nano urea (LNU1 and LNU 2) for quantifying reactive N losses under elevated CO_2 (EC, 565ppm), elevated temperature (ET, 1.75℃), and their interaction (ECT). NCU was applied in three equal splits at 21, 42 and 62 DAS. In LNU1, two splits of N were top dressed with NCU at 21 and 42 DAS, and one foliar spray of LNU (4%) was applied at 62 DAS, whereas in LNU2, two foliar sprays of LNU were carried out at 62 and 72 DAS. The fluxes of nitrous oxide (N_2O) and ammonia (NH_3) were significantly ($p = 0.05$) higher under ECT in the NCU treatment. NH_3 emissions could not be detected after the foliar application of LNU, however N_2O emissions were observed. Lower cumulative emission of N_2O and NH_3 was recorded under LNU as compared to NCU under all the climate treatments. The grain yield of wheat was significantly lower ($p<0.01$) with the application of Liquid nano urea as compared to NCU alone. The grain yield improved by 5% in LNU2 over LNU1 treatment.

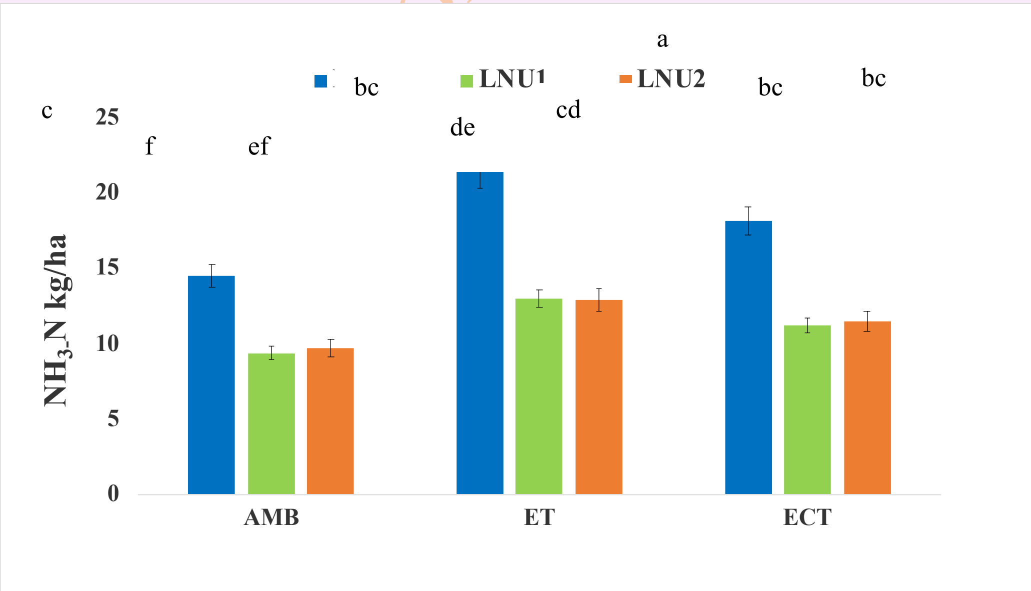


Fig 8. Ammonia volatilization in wheat grown under elevated CO_2 and temperature interaction with liquid nano urea application

Effect of elevated CO_2 and O_3 exposure on soil microbial functional diversity in wheat crop

Rising levels of CO_2 in the atmosphere can enhance plant growth and productivity, via increasing the photosynthetic rate, root and shoot biomass, and also modifying carbon allocation to the soil. Conversely, EO levels are documented to affect the ecosystem processes adversely by reducing the photosynthesis rates and augmenting the oxidative stress, which results in reduced growth, yield, biomass and grain quality. Soil health and fertility can also be significantly impacted by EC and EO. Microbial community-level physiological profile (CLPP) showed distinct metabolic variations among treatments. Functional diversity indices revealed increased diversity under EC and ECO but decreased diversity under EO. In the first year, EC increased Shannon diversity index (H') by 8.5% compared to control, while EO decreased it by 6.5%. In the second year, EC increased H' by 6%, EO decreased it by 5.07%, and ECO exhibited intermediate values.

Amelioration of Ozone effect on mustard with microbial interventions

A free air concentration enrichment experiment under elevated (e) ozone (eO3, 60± 10 ppb), carbon dioxide (eCO_2, 550 ± 50 ppm), a mixture of $eO_3 \times eCO_2$, and ambient air concentration on mustard crop (PDZM 31) was conducted for investigating the impact of inoculation of PGPRs on the amelioration of elevated level of ozone and its combination (O_3 and CO_2) that may occur under future climates. The microbial consortium (*B. subtilis*, B. *licheniformis* and *Ps. Fluorescence).* inoculation of mustard crop ameliorated not only the negative effects of ozone on yield but also increased its yield under elevated CO_2. In the mustard oil Oleic acid (C18:1) was the predominant fatty acids (FA), while linoleic acid (C18:2) and linolenic acid (C18:3) were the second and the third most abundant FAs. Furthermore, palmitic (C16:0), and eicosanoid acids (C20:1) were also present. The fraction of the two polyunsaturated FAs, C18:2 and C18:3 of the total seed oil was reduced in elevated ozone treatment relative to ambient.

Response of *aestivum* and *durum* wheat to elevated CO_2 and temperature interaction

A study was undertaken at experimental field of Division of Environmental Sciences, ICAR-Indian Agriculture Research Institute (IARI), New Delhi to study the interactive effect of elevated CO_2 and temperature on *aestivum* and *durum* wheat. Both *aestivum* and *durum* varieties were grown inside the open top chambers

(OTC) under two levels of CO_2 concentration (ambient and elevated 550 ± 25 ppm and two temperature levels i.e. ambient and elevated (+2.5ºC). Wheat varieties matured early in high temperature treatment. Growth and yield decreased in elevated temperature treatment. Yield reduction due to temperature rise was less in *durum* varieties as compared to *aestivum* varieties under elevated temperature condition (Fig 9). In elevated CO_2 plus temperature treatment, yield reduction was 5.5% in *aestivum* wheat and 4.2% in *durum* wheat as compared to ambient treatment. C/N ratio of wheat grains also increased in elevated CO_2 plus high temperature treatment.

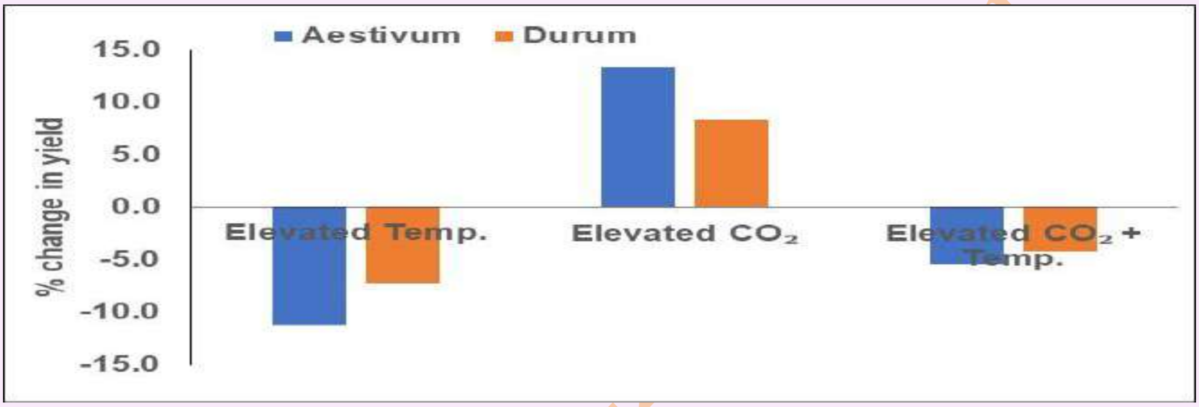


Fig. 9. Percent change in yield of *aestivum* and *durum* wheat varieties under elevated CO_2 and temperature condition

Quantification of CO_2 and CH_4 emission flux and carbon budgeting from rice-wheat cropping system

The eddy covariance flux tower provides quantitative and qualitative data with continuous basis data with high accuracy and less uncertainty. Data on CO_2 and CH_4 emission flux and micrometeorological parameters were collected from the eddy covariance flux tower (10 Hz frequency data) in the rice-wheat cropping system. Data gap-filling was manually carried out, and anomalies were removed from the collected data. Data are under quantification for CO_2 and CH_4 emissions from the rice-wheat cropping system. Further, these data can also be utilized to calculate the net ecosystem exchange of carbon and the carbon budget of the rice-wheat system. The NEE rate during the total crop period (125 days) in wheat was -3.14 g C/m^2/day and cumulative NEE during the total crop period (125 days) was -434 g C/m^2. This data will be used for the quantification of total Carbon budget in rice-wheat system (Fig. 10).

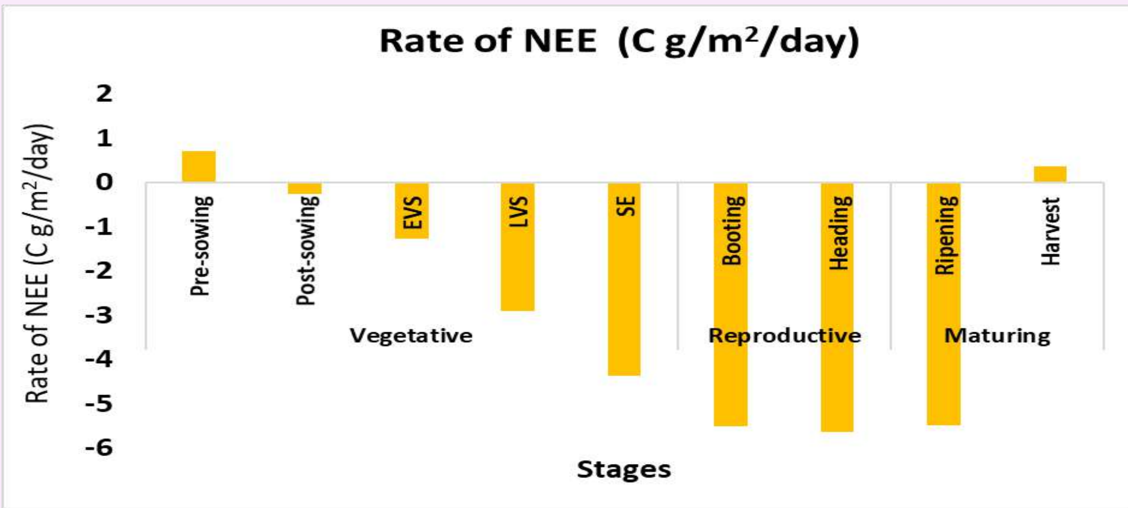


Fig. 10. Rate of NEE in wheat crop

Elevated CO_2 alters aggregate-carbon and microbial community but does not affect total soil organic C in the semi-arid tropics

Elevated CO_2 increases biomass productivity, however, the retention of added C under such condition is less known in the arable soils of the Tropics. Hence, an experiment was conducted in free-air atmospheric carbon-dioxide enrichment (FACE) rings to assess the impacts of eight years of elevated CO_2 levels (550 ppm) on soil aggregation, soil organic carbon (SOC), microbial community and greenhouse gas (GHG) emission in a sandy loam soil. Aboveground biomass productivity of all crops increased significantly under elevated CO_2 as compared to the ambient CO_2, however, soils under elevated and ambient CO_2 had similar total SOC in all layers, up to 0-90 cm profile. Soils under elevated CO_2 had ~54% higher large macroaggregates, but had ~14% fewer microaggregates than ambient CO_2 in the 0-5 cm layer. β-glucosidase activity within microaggregates in the topsoil under elevated CO_2 was 25% higher than ambient CO_2. Moreover, soil macro- and microaggregates under elevated CO_2 had ~31 and 35% higher phenol oxidase activities, respectively, than those under ambient CO_2 in the topsoil. Soils exposed to elevated CO_2 had higher relative abundances of fungi than ambient CO_2. A 23.4% higher qCO_2 and higher global warming potential was observed in elevated CO_2 exposed soil as compared to ambient. These results reveal that under elevated CO_2, carbon sequestration is hindered by higher fungal activity and higher activities of soil C degrading enzymes.

Mitigating methane using biochar microbial interventions in rice-rice system

Experiments were repeated for the second year for mitigation of methane in irrigated flooded rice in the fields of Adhuturai, Tamilnadu in rice-rice system. Basal application of biochar @ 2 t/ha and Liquid formulation of a consortium of methane utilizing bacteria (MUB) was applied through seedling root dip technology and as spray formulation at maximum tillering stage in the rice variety of BPT- 5204 (medium duration) to quantify the methane mitigation potential in rice soil in Sambha rice season. The presence of biochar reduced methane by 4.6 to 6.1 % and MUB reduced it by 15.3% as compared to NCU alone (Fig 11). Application of MUB along with biochar reduced the methane emission by 17.3%. The N_2O emission reduced by 12.3 to 14.2% in the Biochar treatments. The methane utilizing bacteria was found to be having plant growth promoting traits as highest number of tillers was observed in 100% N+MUB treatment. Biochar alone treatment had no significant impact on the rice yield. The use of Biochar with MUB reduced the GHG intensity and significantly increased the soil organic carbon content of the rice soil.

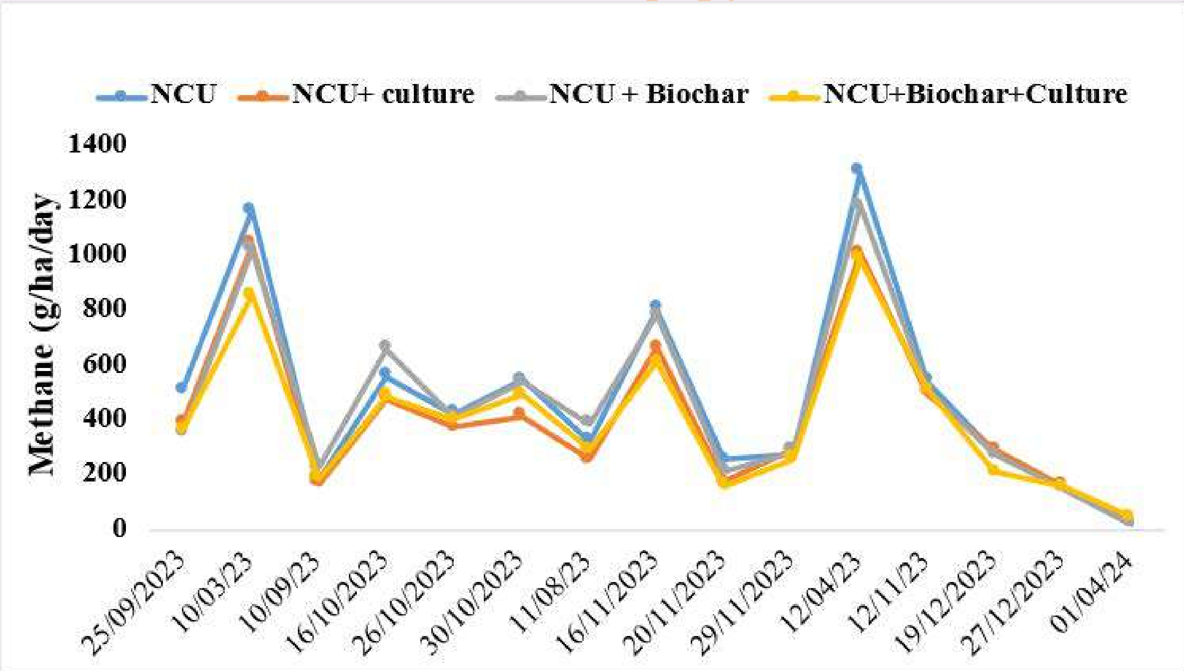


Fig 11. Emission of methane with Biochar and MUB application in flooded rice

Table 3: Methane and nitrous oxide emission (g/m^2) in different rice variety on application of methane utilizing bacteria

Variety	Treatment	Methane (g/m^2)	Nitrous oxide (mg/m^2)	Grain yield (g/m^2)
BPT-5204	NCU	91.7a	127.3a	486b
	NCU + MUB	77.6b	126.1a	522a
	NCU+Biochar	87.6a	111.6b	504b
	NCU+Biochar+MUB	75.5b	109.1b	529a

Means followed by the same letter in a column did not differ significantly ($P \leq 0.05$) by DMRT

Plant based coated fertilizer for N_2O mitigation from Vegetable crops

Three plant based coated fertilizers namely resin coated urea (PCU), tagetus extract coated urea (CU1) and biochar coated urea (CU3) were prepared and tested under lab conditions for their N release pattern. These fertilizers were then tested under field conditions growing onion (Var. AFLR) and were compared with urea and neem coated urea. The N was applied @ 150 kg N/ha in three equal splits. The N_2O emission varied between 0.44 and 2.28 kg/ha among the different N sources. The loss of applied N ranged from 0.53-0.78% of the applied N. The mitigation potential of different coated fertilizers ranged from 10-25.8% > The bulb yield was at par with urea in all the treatments except CU3 treatment where it was significantly higher than urea but similar to NCU.

Table 4. N_2O mitigation from plant based coated fertilizer in vegetables

Treatment	N_2O emission (kg/ha)	EF (% loss of applied N)	Mitigation potential (%)	Yield (kg/m^2)
Control (No-N)	0.436			1.62
Urea	2.279	0.782		2.85
NCU	2.044	0.682	10.33	2.99
PCU	1.826	0.590	19.90	2.95
CU-1	1.967	0.650	13.69	2.88
CU-3	1.690	0.532	25.83	3.05
LSD	+-115.77			+-0.19

Fig. 12. Plant based coated fertilizer

Effect of elevated concentration of gaseous air pollutants on growth and nutritional quality of tomato

Experiments were conducted in plastic enclosures to assess S-assimilation from SO2 enriched growing conditions at Ambient (7-25 µg/m3, C), Ambient + 10 µg/m3 (LSE), Ambient + 40 µg/m^3 (HSE) across crops while the4 effect of NO_2 enrichment at Ambient (25-35 µg/m^3,C), Ambient + 10-15 µg/m3 (LNE), Ambient + 40-50 µg/m3 (HNE), daily for 1 hours continuously for 7 day duration on growth and nitrogen nutrition at 30 days of crop growth. Effect of variable concentrations of gaseous pollutants were monitored over 21 days after the exposure in tomato in terms of the plant growth, physiological and nutritional attributes and fruit quality and that the effect appears to be temporary in nature and revival of growth was evident during the post-exposure period

To evaluate the impact of various amendments on remediation of metal contaminated soils

Phosphate enriched chitosan beads have been developed and evaluated to immobilize the Cd in a Cd contaminated soil to reduce the leachability of the Cd to ground water and translocation to plants. Chitosan-phosphate (CH-P) products were synthesized using single super phosphate (SSP), mono-calcium phosphate (MCP), di-ammonium phosphate (DAP) and di-potassium hydrogen phosphate (DPP), respectively, and their physicochemical properties characterized. Total P contents of CH-SSP, CH-MCP, CH-DAP and CH-DPP were 56750±840, 75000±1140, 3500±20 and 8500±120 mg kg-1, respectively. Water soluble and citrate soluble P contents of CH-SSP, CH-MCP, CH-DAP and CH-DPP were 5.8 and 58.8 %, 11.9 and 49.6 %, 84.3 and 99.6 %, and 91.5 and 98.8 % of total P, respectively. Indian mustard (*Brassica juncea*) was grown as test crop. Results show that DMY is significantly increased in different phosphatic material treatments as compared to control (no P) treatments and highest DMY was recorded in CH-SSP treatment. Uptake of Cd by mustard shoot was significantly reduced in different phosphates treatments in comparison to control and reverse was found to true in case of P uptake by mustard shoot. Lowest Cd uptake and highest P uptake by mustard shoot was observed in SSP treatment. Results from pore water and bioavailable P and Cd indicates that their significant increase in bioavailability of P and simultaneously significant reduction in Cd bioavailability by different phosphate enriched chitosan materials thereby increased immobilization of Pb in contaminated soil. Further results from this study show that phosphate enriched chitosan material could be used as an ecofriendly nontoxic material for cadmium immobilization in contaminated soils.

To study phosphorus stratification under different agriculture practices

Impact of tillage, residue, and nitrogen management on crop growth and soil health under maize-wheat cropping system studied under field condition. The experiment was conducted in split-split plot design with two level of tillage as main plot of conventional tillage (CT) and no tillage (NT), two level of residue as sub plot of residue (R+) and without residue (R0) and three level of nitrogen as sub-sub plot of 50%, 100% and 150% recommended dose of nitrogen (RDN) for both maize and wheat crop. It was observed that the soil organic carbon (SOC), enzymes activity (dehydrogenase, acid phosphatase and alkaline phosphatase), microbial biomass carbon (MBC), microbial biomass phosphorus (MBP) and glomalin content was significantly higher under no tillage and residue treatment at 0-5 and 5-15 cm soil depth. Enzymes activity and MBC was found significant higher by application of 100 and 150% RDN respectively at 0-5 and 5-15 cm soil depth.

Evaluation of the drinking water quality and potential health risks of nitrate and fluoride in Southwest Delhi, India

A study was conducted to evaluate the water quality index (WQI) and also performed potential human health risk assessment i.e. Hazards quotient (HQ), total hazard index (THI) of nitrate and fluoride through ingestion of groundwater in pre-monsoon and post-monsoon seasons. The WQI classification showed that 56%, and 34% of groundwater resources were unfit for consumption in premonsoon and post-monsoon seasons. The HQ and THI of the noncarcinogenic hazards were computed using the potential health risk assessment of nitrate and fluoride contaminated groundwater. The findings showed that in adults, 26% and 36% of the water samples had high risk quotients for HQ-NO_3^- and HQ-F^-, respectively, while in children, 40% and 54% of the samples had risk quotients for HQNO_3^- and HQ-F^- above the permissible level. This suggests that F^-contributes more to the non-carcinogenic risk than NO_3^- in premonsoon. However, NO_3^- adds more to the non-carcinogenic risk than F^- in post-monsoon, as shown by the HQ-NO_3^- and HQ-F^- in 42% and 2% of samples for adults, and in 58% and 14% of samples for children, respectively. Children in the study area were more vulnerable to the non-carcinogenic effects of NO_3^- and F^- according to the findings. Total hazards index (THI) for adults and children in for NO_3^- and F^- were ranged from 0.34 to 8.61 (Avg. 1.68) and 0 to 8.20 (Avg. 1.75) in pre-monsoon season. Similarly, NO3$^-$ and F^- were ranged from 0.37 to 2.85 (Avg. 1.86) and 0 to 2.86 (Avg. 0.85) in post-monsoon season, respectively. The results of this study can improve effective environmental management measures for enhancing the groundwater quality and public health of the study area.

Effect of Particulate Matter Associated Polycyclic-Aromatic Hydrocarbons and Heavy Metals on Growth and Nutraceutical Properties of Tomato (*Solanum Lycopersicum*)

Atmospheric concentrations of PM10 and associated polycyclic aromatic hydrocarbons (PAHs) heavy metals (HMs) were quantified to study the air pollution load of two distinct location of Delhi viz. (1) Agricultural farms of Indian Agricultural Research Institute (IARI) and (2) Yamuna flood plains (YFP). Tomato crop was grown for studying their response to air pollutant at both sites. The air sampling has been done for two consecutive years in winter season, comprising the months from November to April in 2021-22 and 2022-23 respectively. The glass fiber filter paper was used for the particulate matter deposition in high volume sampler. The monthly average concentration of PM10 varies from 112 $\mu g/m^3$ to 187 $\mu g/m^3$ at IARI and 205 $\mu g/m^3$ to 364 $\mu g/m^3$ at YFP. The highest concentration of PM10 was recorded in the month of January. The concentration of PM10 and associated PAHs and HMs were significantly higher at the YFP area. Out of 16 PAH notified by USEPA 10 were found in our study in which benzo[ghi] perylene has the highest in percentage wise contribution in total PAHs. The total HMs concentration load was 18% and 27% more in the YFP in comparison to the IARI farms in the year 2021-22 and 2022-23 respectively. The higher concentration of PAHs and HMs recorded at YFP because of its location which is cross section of roads having very heavy traffic throughout 24 hrs. and a thermal power plant nearby. The heavy metals concentration trend at each location was in the order of Zn > Fe > Pb > Ni > Cd.

The concentration of Pb, Ni, and Cd was significantly less at IARI in comparison to YFP. For the assessment of impact of PM10 and their associated PAHs and HMs on tomato, leaf sample of plant analyzed at 30 days of interval at three stages of plant at 30 DAT (days after transplanting), 60 DAT, 90 DAT. The significant decline in photosynthetic rate (11%, 16%), Stomatal conductance (18%, 20%), and transpiration rate (33%, 37%) in tomato plant recorded at 60 DAT at YFP site compare to IARI in 2021-22 and 2022-23 respectively. The oxidative stress (O^{-}_{2}, H_2O_2, lipid peroxidation) and Production of enzymatic antioxidant (SOD, CAT, Peroxidase) and non-enzymatic (ascorbic acid) antioxidant to counter oxidative stress were being significantly higher at 60 DAT at YFP site compare to IARI. The mineral profile (N, P, K, Ca, Mg, Fe, Zn) of tomato leaf was significantly lower at YFP site. The dietary value (Total antioxidant, vitamin C, lycopene) and mineral profile (P, K, Ca, Mg, Fe, Zn) of tomato inferior at YFP site.

Study on phytosiderophore based heavy metal mobilization and interaction with other micronutrients

Wheat crop was grown under cadmium (Cd) and lead (Pb) contaminated soil where diurnal release pattern of phytosiderophore (PS) was monitored. PS was released maximum during morning hours and it was significantly reduced with the presence of Cd and Pb in the soil. The reduced PS release led to a decrease in iron (Fe) and zinc (Zn) content of the wheat plant which may further change the release pattern of PS by wheat root as evidenced through an independent hydroponic study, where an increase in the PS release was recorded in the presence of Cd and Pb at the seedling stage. However, an increase in PS release does not lead to increased accumulation of Cd and Pb by the wheat seedling suggesting an immobilization of heavy metals-PS (HM-PS) complex in the rhizosphere. The relationship between PS release and Cd/Pb uptake by root, stem, leaf and grain tissues were determined in addition to the root to shoot translocation pattern of Cd and Pb. Shoot content of Fe and Zn was reduced significantly in the presence of Cd and Pb while the effect was opposite when nutrient content of grain was analysed. The Fe and Zn content of grain was found to be significantly higher in crops grown on Cd+ and Pb+ in comparison to control and similar trend was observed for the manganese (Mn) and copper (Cu) also. The Cd and Pb treatment significantly reduced the area and biomass of both root and leaves. Further, the interactive effect of Cd/Pb availability in the soil on micronutrient (Fe, Zn, Cu and Mn) uptake by wheat suggest a dynamic distribution of micronutrients to different plant parts warranting a detailed investigation to assess the role of HM-PS complex on different uptake mechanism and translocation of these nutrients within plant system.

Strategies for oil removal from polluted water and soil

Biosurfactant was recovered after culturing different microbes in nutrient broth solution. Oil dispersion was achieved and oil spill on water can be obtained in polluted water and it is used to desorb the strongly adsorbed pollutant from soil (Fig. 13).

Fig. 13. Oil dispersion using biosurfactant

To evaluate the effect of engineered nano-particles on plant growth and soil health

During the year, the effects of zinc oxide nanoparticles (ZnO NPs) on rice (*Oryza sativa* L. cv. PB1509) plant growth were assessed in soil microcosm (5, 10, 25 50 mg/kg) experiments. In both hydroponics and soil experiments, Zinc (Zn) accumulation in plant parts (roots, shoots and grains) was found to increase with increasing doses of ZnO NPs. Grains accumulated 29 mg/kg Zn at 50 mg/kg ZnO

NPs. Antioxidant enzyme activities (SOD, CAT, APX and GPX) were mostly increased or unaffected by all ZnO NPs doses. In soil experiments, acid and alkaline phosphatase activities were increased at 5 mg kg^{-1} followed by a declining trend. However, a significant decrease occurred only at 50 mg kg^{-1}. Urease activity in soil was significantly increased at all doses of ZnO NPs, while the activity of dehydrogenase did not show any significant change up to 25 mg/kg. The DTPA extractable Zn concentration in the soil was significantly elevated with increasing exposure concentrations of ZnO NPs. This study suggests a dose of up to 10 mg kg^{-1} would be an appropriate dose for augmenting the growth of rice plants and Zn accumulation, and this can be practically utilized for rice plants growing in submerged conditions.

Developed Modified Ion Exchange Resin Method for Extraction of Micronutrient Cations from Soils

Different chemical extractants and ion exchange resins are used to assess the bioavailability of soil nutrients for crop plants. The major problems associated with the use of IER in soil testing are their reusability and the difficulties encountered in their separation from the soil being extracted. We addressed these difficulties by encapsulating a weakly acidic cation exchange resin and weakly basic anion exchange resin in separate dialysis membrane pouches and suspending them together in a cellulose extraction thimble during extraction. The suitability of this method has been evaluated for diverse types of soils widely varying in physicochemical properties. The standardization of protocol revealed that the ideal conditions for extraction of micronutrients were: 20:40 soil water ratio and 4 h extraction at 25°C in a shaker incubator at 120 rpm. This simple modified ion exchange resin method can be used multiple times for routine soil tests in laboratories for extraction of cationic micronutrients. The soil extracts can be analyzed for cationic micronutrients.

Upscaling of modified urea-based fertilizer

To reduce the burden on government for import of nitrogenous fertilizer, two different kinds of products were tested and their up-scaling process were refined to produce i). Bead based and ii). powder based modified urea. During up-scaling process, nitrogen content-based fertilizer was up scaled. Process was optimized for production upto 400 g/batch, 10-13 N (Bead based) and 800 g/batch, 40-46%N (Powder based), respectively (Fig 14).

Fig. 14. Modified urea bead and powder based slow-release fertilizer

Empirical observation of natural farming inputs on nitrogen uptake, soil health and crop yield of rice-wheat cropping

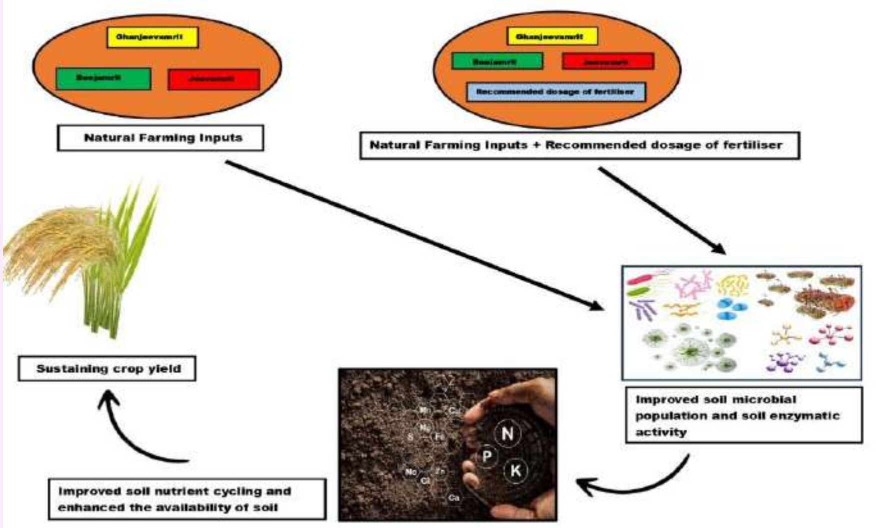


Fig. 15. Pictorial representation of application of natural farming inputs (ghanjeevamrit, jeevamrit, beejamrit) and natural farming inputs integrated with recommended dosage of fertilizers showing significant improvement in soil biological quality, soil microbial community, soil nutrient availability and sustaining crop yield.

Natural Farming represents an agro-ecological methodology for farming that emphasizes regenerative practices to promote holistic ecological balance and reduce the dependence on external inputs and financial resources. Substantial concern has recently arisen over the need to encourage agroecosystems that are more sustainable to improve the deteriorating soil health as well as reversing the yield plateau of crop. So, the current on farm field experiment was executed comprising of 8 treatments with different combination of natural farming inputs (Ghanjeevamrit, Jeevamrit, Beejamrit), organic fertilizer (such as FYM), integrated nutrient management (NPK, FYM, Azotobacter and Azolla) and in-organic (NPK) to examine and compare the consequence of natural farming inputs, organic fertilizer and in- organic dosage of fertilizer on soil nitrogen uptake, soil physicochemical properties, soil biological properties, soil microbial population and crop yields in a rice-wheat cropping system over two crop seasons 2021-23 [rice (Pusa-1509) and wheat (HD-3086)].

The study results demonstrated that there was significant ($p<0.05$) increase in the soil's nitrogen availability and nitrogen uptake with the use of natural farming inputs as compared to control treatment, whereas natural farming treatments (TNF1, TNF2, TNF3, TMNF) were inferior to integrated nutrient management (T_{INM}). They recommended doses of fertilizer (T_{RDF}) treatment in case of nitrogen uptake by both rice and wheat crops. The soil enzymatic activity (Dehydrogenase, β-glucosidase, and urease), soil microbial biomass carbon and nitrogen, and soil microbial population (Bacteria, fungi, and actinomycetes) were significantly ($p<0.05$) higher in treatment receiving natural farming inputs compare to inorganic fertilizer and organic fertilizer. A positive and significant correlation was observed between potential mineralization nitrogen and soil enzymatic activity (Dehydrogenase, β-glucosidase and urease), soil microbial biomass carbon, nitrogen, and soil microbial population (Bacteria, fungi and actinomycetes. The crop yield at the end of experiment recorded to be highest in treatment T_{INM} (75 % RDF (In-organic) + 25% RDF (FYM) + BGA) i.e., (Rice- 4.76 t/ha and Wheat- 5.82 t/ha) compared to T_{RDF} and T_{NF}. A crop yield reduction of 14.2% was observed in treatment receiving natural farming inputs compare to T_{INM}. A significant increase in crop yield was observed in T_{MNF} (Jeevamrit (25%) + Ghanjeevamrit (25%) + 50% RDF through FYM + Beejamrit) compare to Tc (Control) and T_{FYM} (Farmyard manure). Therefore, our study suggests that adoption of natural farming inputs over time can facilitate the enhancement of soil biological health.

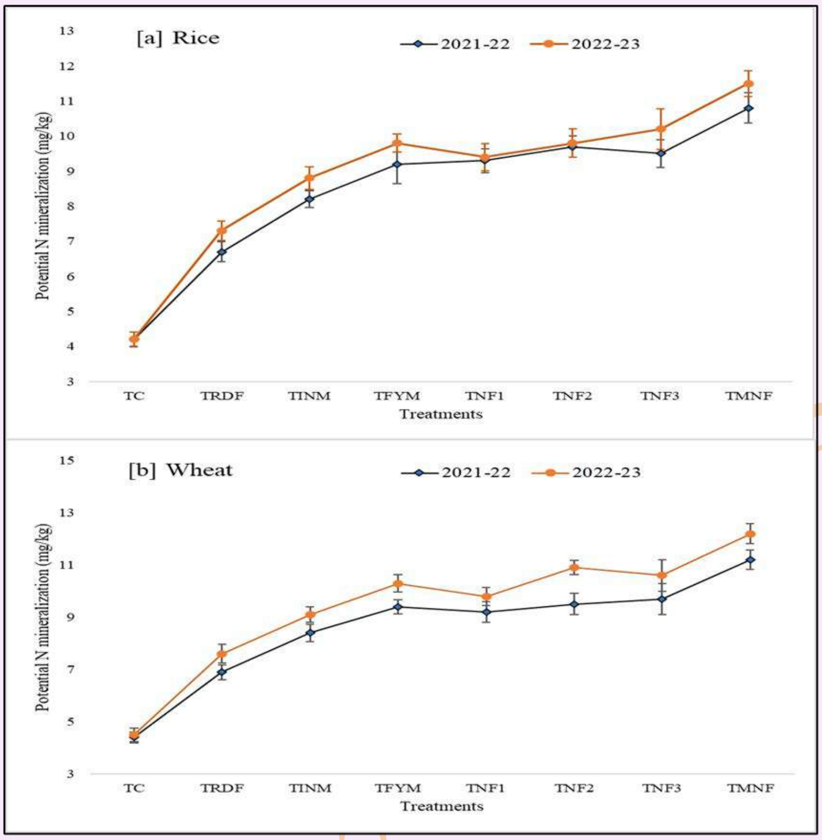


Fig. 16. Effect of different nutrient management practices on potential nitrogen mineralization during rice and wheat cropping season 2021-22 and 2022-23. [T_{C}: Control, T_{RDF}: Recommended dosage of fertilizer, T_{INM}: Integrated nutrient management, T_{FYM}: Farm yard manure, T_{NF-1}: Natural Farming-1, T_{NF-2}: Natural Farming-2, T_{NF-3}: Natural Farming-3, T_{MNF}: Modified Natural Farming]

Effect of different agri-management practices on soil carbon pools

Soil organic carbon (SOC) is a critical component of terrestrial ecosystems, influencing soil health, fertility, and carbon sequestration potential. The NEH region of India, Tripura characterized by its diverse agro-ecological zones and land use systems (LUS), presents a unique opportunity to investigate the various land use regimes' effects on SOC pools. The present study aims to assess and compare the effects of various land use systems, including bamboo, tea, mango, lemon, rice-rice, wheat-millet and okra-onion and also selected the uncultivated field, on SOC dynamics in this region. Walkley and Black carbon (WBC) significantly vary among the selected LUS, ranging from 7.14 to 12.4 g/kg, with the maximum values in tea LUS. In 0-30cm depth, very labile C (C_{VL}) pools are very variable among the selected LUS (2.04 – 5.35 g/kg), which is the highest in tea and mango compared to the uncultivated system. The C pools in selected LUS indicated the deviation depth and land use pattern.

Green synthesis of ZnO nanoparticles from maize husk extract (MHE) and banana peel Extract (BPE) for arsenic water pollution treatment

Metal oxides such as Zinc Oxide (ZnO) nanoparticles, have been the subject of extensive investigation due to their wide applications in various sectors. The traditional methods of nanoparticle synthesis are laced with many disadvantages hence green synthesis approach emerged as an alternative, as it is a clean, non-toxic and environmentally friendly method. Agricultural by-products such as maize husk extract (MHE) and banana peel Extract (BPE) was used for synthesis of nanoparticles. Biogenic mediated ZnO nanoparticles synthesis from BPE and MHE displayed a notable negative zeta (ζ) potential value of -49.8 mV and -47.8 respectively. The FT-IR spectrum of ZnO nanoparticles derived from BPE and MHE, revealed prominent peaks, within the range of 434.89/cm to 407.13/cm and 489.03 to 403.18/cm respectively. As the adsorbent dosage of BPE nanoparticles elevated from 10 mg to 30 mg, the pH level from 3 to 6, and the contact time from 30 minutes to 60 minutes, the arsenic removal percentage exhibited a significant rise from 50.8% to its peak at 94.7%.

Effect of Linz-Donawitz (LD) slag particle size and application rate on heavy metal uptake and partitioning in crop plants

A significant positive effect of LD-slag application on plant (shoot-root) mass was observed across the experimental crops viz., spinach, carrot and wheat, when compared with respective no slag control treatment. Shoot and root mass, in general, were positively more so at 50-100µ PS than at 50µ with a dose dependent effect from 0.25 to 1 t/ha rate of SS application when compared with no-slag control. Slag application irrespective of PS and rate of application improved/did not limit photosynthetic rate significantly over no-slag control in carrot, spinach and wheat. SS application increased shoot lead, Cd and Cr content of spinach alone when compared with respective no slag control treatments, and that the affect was independent of the PS. Tissue concentration of heavy metals was however, quite low and well below the permissible limit.

Effect of bioaugmented Linz-Donawitz slag and biochar on physiological and yield attributes of wheat (*Triticum aestivum*)

Industrial wastes and agricultural by-products are increasingly used in crop production as supplements along with fertilizers. Our study reported an increase in total leaf area (18.2–21.3%), chlorophyll content (26.5–31.0%), net photosynthetic rate (93.2%), stomatal conductance (61.3%), transpiration rate (24.7%) in bioaugmented treatments with LD slag and biochar over 100% RDF. A yield increase of 25.6 and 27.1% were found in bioaugmented treatments with a combination of LD slag: 2 t/ha and biochar: 1 t/ha over 100%RDF during 1st and 2nd year, respectively. No. of spikes, grains per spike and dry biomass weight were positively influenced by bioaugmentation. The bioaugmented treatments with a combination of LD slag and biochar gave significantly higher grain yield, followed by bioaugmented LD slag compared to bioaugmented biochar alone in the respective application rate of treatments. This study is further undergoing for more understanding the effect of bioaugmented Linz-Donawitz slag.

Growth and yield responses of bioaugmented Linz-Donawitz slag and biochar application in rice (*Oryza sativa* L.)

The experiment was conducted to determine the effects of LD slag (LD), biochar (BC), and cow-dung (CD) in bioaugmented and unamended combinations at different application rates on crop growth and yield attributes in Rice variety Pusa 44. The experimental findings indicated an increase in no. of effective tillers (22.8%), grain yield per hill (29.7%), and dry biomass weight (23.8%), were positively influenced by bioaugmentation with LD and BC over 100% RDF. A grain yield increase of 23.7% in bioaugmented LD: 2 t/ha + BC: 1t ha^{-1} over 100% RDF. The increase in grain yield followed the order: bioaugmented LD+BC >bioaugmented LD slag> bioaugmented BC at the respective application rate. Unamended LD and BC recorded lower yield over bioaugmented LD and BC treatment. These results highlighted the synergetic effect of bioaugmentation of LD + BC with 100%RDF over the standalone application LD slag for achieving a high yield and stable rice production.

Extraction and development of cellulose-based bioplastics synthesized using nano-particles from corn cobs

Corn cobs were collected from the field, ground into fine particles, and sieved through 30 mesh sieves. The corn cobs were treated with 5% NaOH solution for 3 hours at 80 degrees C temperature and stirred continuously at a ratio of 1:10. Then, acquired cellulose was washed with distilled water so that the effluent became neutral. The obtained pre-husk was bleached with 5% $NaClO_2$ solution for 3 hours at 80°C temperatures at an acidic pH. The residual lignin present in the effluent was washed away by repeated washing with distilled water. The effluent was filtered and washed with deionized water. The obtained cellulose was dried for 24 hours in an oven and stored in a dry place.

The bioplastic sheets were prepared using cellulose obtained from corn cob and TiO_2 through xanthation, followed by the addition of natural plasticizers. The morphology of bioplastic films was studied under a Scanning Electron Microscope to understand their mechanical and barrier properties. The rough surface is due to the presence of cellulose particles rather than the matrix. This work will be continued for further testing and confirmation.

Effect of steel slag-based fertilizer products on cereal and vegetable crops

Effect of variably amended steel slag products on wheat and brinjal crops with two rates of application i.e. @ 1t/ha and @ 2t/ha for wheat and @ 3t/ha for brinjal was analyzed on shoot biomass and grain/fruit yield under pot culture. These products were tested with 80% recommended NPK, and the plants grown under only NPK at 80% and 100% RDF were treated as control.

Wheat: Effect of slag alone treatment (without NPK) was also examined, and it produced the lowest plant biomass (3.85-4.17g/plant) as well as grain yield (1.33-1.59 g/plant). Three products (SP 3, 5 and SP 9) at both application rates produced shoot biomass higher than or at par with 100% RDF application, while the products SP2 at lower rate of application and SP4 and SP6 at higher application rate produced biomass higher than 100% RDF. Among various products, highest grain yield was produced by SP6 (2.71 & 2.86 g/plant) and SP5 (2.56 & 2.68 g/plant), which was higher than the grain yield obtained by 100% RDF application (2.64 g/plant).

Brinjal: Results revealed that the application of amended products improved field performance of crop in terms of yield and quality of brinjal. As compared to the 80% RDF control, products such as SP3, SP4, and SP5 @3t/ha showed increased fruit mass in both the cv. Pusa vaibhav and Pusa oishiki. Moreover, fruit yield was improved by all the products except SP1 as compared to 100% RDF application in both the cultivars and highest yield was produced by SP4, SP5 and SP6 application. Effect of steel slag based amended products at different rates of application was also analyzed for heavy metal accumulation in grain/produce of wheat and brinjal. These products were tested with 80% recommended NPK, and the crops grown under only NPK at 80% RDF were treated as control. Effect of slag alone treatment (without NPK) was also examined, and it showed highest accumulation of heavy metals in shoot compared to amended products and control. The heavy metal accumulation in shoot and also in produce was within the permissible limit prescribed by WHO and FCO. A long-term study is however, required to assess the accumulation of these metals with sustained application of steel slag-based value-added products.

Use of microbial extracts as bio-pesticide

Compounds were isolated from *Pseudomonas* sp. and found effective against white flies. LC_{50} value was observed as 781.50 ppm at 96 h. (Table 5) (SDG 3, 9).

Table 5: White fly mortality against microbial extract at different time

Duration of exposures	N (no. of insects used per treatment)	df	Slope	LC_{50} (ppm)	Fiducial limit
72 hrs	45	4	0.677	2396.27	780.399 to 9478.412
96 hrs	45	4	0.615	781.49	172.681 to 1862.143

2. Intellectual property:

Copyrights granted

- **Model InfoCrop V2.1**

  Lead developer: Dr. S. Naresh Kumar

  Co-developer: Dr. P.K. Aggarwal, Shweta Panjwani, Dr. Subhash Chnader, DR. H. Pathak, D.N. Swaroopa Rani
- VignaradSim v1. (Mung bean model)-Naresh Kumar et al., 2023
- CauliSim v1. (Cauliflower model)- Naresh Kumar et al., 2023
- Spinach model v.1- Naresh Kumar et al., 2023
- Fertigation automation software for hydroponics - Kishore avane *et al*

Patent application filed

1. Dr. Usha K and Dr. Bhupinder Singh (2023). Laser-induced graphene production from single-use plastic. Patent filed vide application no. 202311030667 dated: 3rd June, 2023.

3. Linkages and Collaboration

Institutes/Industry/University, and details of collaboration (whether it is in project, if so, name of the project, PI etc).

- Agriculture Model Intercomparison and Improvement Project (AgMIP- Global Steering Council Member, led by Columbia University and NASA.
- DST Technology development Programme, Expert Member
- DST Device development Programme, Expert Member
- DST SHRI Programme, Expert Member
- DST INSPIRE Programme, Expert Member
- DAC committee on crop yield forecast (member)
- MoEF&Cc member on Persitant Organic Pollutants
- Beurue of Indian Standards, Expert member.
- MoEFCC Panel on Persitant Organic Pollutants, Expert member.
- MoA&FW committee for crop yield forecast, Expert member.
- Ministry of Steel and Steel Industry: Project (Code 24-774): Development of steel slag-based cost-effective eco-friendly fertilizers for sustainable agriculture and inclusive growth. Tata Steel Limited; JSW Steel Limited; SAIL
- Tata Steel Limited Contract research Project (Code 79-121): Assessment and Utilization of Yellow Gypsum in Agriculture Under Variable Environment
- VNIT, Nagpur under the project Use of Biomass ashes to enhance the nutrient supply to the plant and effect on soil health
- IIT, Delhi
- G.B. Pant University of Agriculture & Technology, Pantnagar
- Bhabha Atomic Research Centre, Mumbai
- Collaboration with the NESA (National Environmental Science Academy) New Delhi and working as General Secretary of NESA for organizing environmental awareness and workshop and conferences

4. Education

a) Summary of UG, PG education

Details of courses offered in MSc and PhD during Semester I and Semester II

Course name	Course code		Credits
Semester I			
Introduction to Environmental Sciences	ES 501	MSc	2 + 1
Environmental Chemistry	ES 502	MSc	2 + 1
Climate Change and Climate Smart Agriculture	ES 503	MSc	2 + 1
Instrumental Methods for Environmental Monitoring	ES 504	MSc	2 + 1
Environmental Pollution	ES 506	MSc	2 + 1
Analysis of Agroecosystem	ES 601	PhD	2 + 1
Environmental Impact Assessment	ES 602	PhD	2 + 1
Waste Management	ES 603	PhD	2 + 1
Crop Geography and Ecology	ES 604	PhD	2 + 1
Agrostology and Agroforestry	ES510	MSc	2 + 1
Master's Seminar	ES 591	MSc	1 + 0
Doctoral Seminar I	ES 691	PhD	1 + 0
Doctoral Seminar II	ES692	PhD	1 + 0
Semester II			
Environmental Engineering	ES 505	MSc	2 + 1
Environmental Microbiology and Ecology	ES 507	MSc	2 + 1
Biofuels and Environmental Protection	ES 508	MSc	2 + 1
Environmental Toxicology	ES 509	MSc	2 + 1
Environmental Geosciences	ES 511	MSc	2 + 0
Biodiversity	ES 605	PhD	2 + 1
Plant Growth Modeling & Simulation of Ecological Processes	ES 606	PhD	2 + 1
Introduction to Environment Law and Policy	ES 607	PhD	2 + 1
Masters Seminar	ES 591	MSc	1 + 0
Doctoral Seminar I	ES 691	PhD	1 + 0
Doctoral Seminar II	ES 692	PhD	1 + 0

b) No. of students admitted: MSc- 15

PhD- 17

c) Fellowships secured by the students (other than IARI Fellowship)

S. No.	Name of the student	Name of the Fellowship	Awarding Agency
1	Partha Pratim Maity	UGC NET (OBC)	UGC
2	Ankita Paul	UGC NET	UGC
3	Shravani Sanyal	UGC NET JRF	UGC
4	Vinita	UGC NET JRF	UGC
5	Raviteja Machanuru	ICAR – SRF	UGC
6	Ram Krishna Dubey	UGC-NET JRF	UGC
7	Babetlang Kharshiing	NFST	UGC
8	Mathiyarasi K.	UGC-NF-OBC	UGC
9	Anusha B S	UGC-NET-NFSC	UGC
10	Apoorva M. S.	UGC-NF-OBC	UGC
11	Divya Pooja	UGC-SRF	UGC
12	Rishabh Shrivastava	UGC NET JRF	UGC
13	Lukeshwari Shyam	UGC NET JRF	UGC

d) Students awarded with degrees during 2023

S. No.	M.Sc./ Ph.D.	Name of the student	Name of the Chairman	Title of the Thesis
1.	Ph.D	Mr. Alimamy Alie Kamara,11146	Dr. S. Naresh Kumar	Quantification and simulation of maize-wheat-green gram cropping system response to FYM, nitrogen, phosphorus and climate change
2.	Ph.D	Mr. Dinesh G.K,11027	Dr. Dinesh Kumar Sharma	Quantification of Ecosystem Services in Conservation Agriculture under Maize-Wheat Mung Bean Cropping System
3.	Ph.D	Mr. Ram Kumar, Roll No. 10610,	Dr. Arti Bhatia	Effect of Ozone and Carbon Dioxide Interaction on Growth, Yield and Greenhouse Gas Emission in Rice: Field and Simulation Studies.
4.	Ph.D	Ms. Amita Raj, Roll No. 10443	Dr. Arti Bhatia	Integrated assessment of greenhouse gas emission in rice-wheat cropping system
5.	Ph.D	Ms. Divya Pooja B Roll No. 11490	Dr. Shiv Prasad	Effect of bio-augmented Linz-Donawitz slag on soil physico-chemical properties, crop yield and grain quality in rice-wheat cropping system
6.	Ph.D	Mr. Chandra Prakash	Dr. Shakeel A. Khan	Effects of particulate matter associated polycyclic aromatic hydrocarbons and heavy metals on growth and nutraceutical properties of tomato (*Solanum lycopersicum* L.).
7.	M.Sc	Mr.Ankit K. Ver ma, 60070	Dr. Namita Das Saha	Soil carbon, nitrogen pools and GHGs emission under different land use systems of Hazaribagh, Jharkhand
8.	M.Sc	Mr. Sadashiva G N, 70004	Dr. Ajay K Singh	Water Deficit Response of Soybean Plants Differing in

				Ethylene Sensitivity
9.	M.Sc	Mr. Siddesh, 70003	Dr. Himanshu Pathak	Carbon Sequestration in Mango, Coconut, and Pomegranate Orchards in a Semi-Arid Region.
10.	M.Sc	Mr. Surendhar, P, 60069	Dr. Dipak K. Gupta	Quantification of Greenhouse and Ammonia Gas Emissions from Different Cattle Manure Management Systems
11.	M.Sc	Anushka Anil, 21457	Dr. Dinesh Kumar Sharma	Impact of elevated ozone, carbon dioxide and their interaction on growth, yield, and reproductive behaviour in Indian Mustard
12.	M.Sc	Ms. Apoorva M S, 21456	Dr. Arti Bhatia	Interactive effect of elevated CO2, temperature and N fertilizer on gaseous N fluxes and nitrogen use efficiency in wheat
13.	M.Sc	Mr. Azhar M., 21455	Dr. Anita Chaudhary	Evaluation of Antifungal Potential of Lacto-fermented Agricultural Byproducts
14.	M.Sc	Mr. Rishabh Sriv astava, 21460	Dr. Navindu Gupta	Effect of bioslurry on soil properties, yield and nutritional quality of pea (*Pisum sativum* l.)
15.	M.Sc	Yadaraboyana S. K., 21458	Dr. Niveta Jain	Greenhouse gas emission under different rice residue management practices using Pusa Decomposer in succeeding wheat crop
16.	M.Sc	Mr. Avinash C	Dr. Shiv Prasad	Effect of organically amended Linz-Donawitz slag on wheat (*Triticum Aestivum* L.) crop growth, yield and grain quality

Research Scholars registered in different universities for Ph.D.

S. No.	Name of the research scholar	Name of the Principal Investigator/ co-guide	Title of the thesis	University at which registered
1.	Bhawna Joshi (Technical Officer –T3)	Anita Chaudhary (Co-Guide)	Assessment of structural and functional divergence of soil microbial community under elevated CO_2 and O_3 in wheat crop	Amity University, Noida
2.	Ritu Nagdev (Scientist, NBSSLUP, RC Delhi)	Shakeel A. Khan (Co-Guide)	Biogas slurry valorization through organo-mineral amendments for sustainable crop production	Amity University, Noida

(f) Awards and recognitions received by the students

Sl. No.	Name of the Student	Name of the award	Year	Agency/ Institute
1.	Sibnanda Darjee	Best Oral Presentation Award	2023	Organized by NewAge Mobilization Society, New Delhi
2.	Sibnanda Darjee	3rd Position, Participated in Painting	2023	Organized by occasion of the ‘’ Foundation Day of ICAR-IARI
3.	Sethupati N	1st Position in the oral/poster presentation	2023	Organized by the Department of Chemistry, Miranda House, Ministry of environment, Forest & Climate Change, Gov of India

4.	Gayatri J	1st Position in the oral/poster presentation	2023	Organized by the Department of Chemistry, Miranda House, Ministry of environment, Forest & Climate Change, GoI
5.	Vinita Mulodia	Young Scientist Award	2022	Organized at NAU, Navsari. 22-23 September, 2022
6.	Vinita Mulodia	Selected as Assistant Manager (Grade –A) Officer	2023	NABARD, Govt. of India
7.	Naveen Malik	selected as Assistant Officer	2023	NTPC, Govt. of India
8.	Chandra Prakash	join as Senior Scientific Assistant in CPCB, New Delhi	2023	CPCB, Delhi, Ministry of Environment, Forest and Climate Change, GOI, New Delhi
9.	Priyanka Meena	Selected as Scientist through ARS	2022-23	ASRB, New Delhi
10.	Raviteja M.	Selected as Scientist through ARS	2022-23	ASRB, New Delhi
11.	Chandra Prakash	Senior Scientific Officer	2022-23	CPCB, New Delhi
12.	Mayank Tiwari	Environment Officer	2022-23	NABARD

(g) Events organized by study circle of the Division:

Teacher's day celebration on 5th September

Farewell Programme for the degree holder

Orientation Programme for new students

New Year 2023 celebration

5. Internship & mentorship by the scientist

- Ms Jo Cook, from York University, UK for one month (Oct, 2023) to get training on simulation modelling
- Ms Elizabeth Carper, from York University, UK for one month (Oct, 2023) to get training on simulation modelling
- Mentorship for 3-month Professional Attachment training of Mr. Ravi Teja Machanuru, Scientist, IARI, Assam [reference no IARI Assam/23-24/IPAT Training dated 14.08.2023]
- DST Post Doctorate Fellow (TARE) Dr. Anwesha Khanra (DST No: TAR/2022/000232) project entitled "A Sustainable Approach of Microalgae Mediated Wastewater Treatment Through One Pot Multiphasic Fed Batch Strategy and Biopolymer Production Towards Metal Corrosion Inhibition"

6. Awards and recognitions received by the scientists

a) ICAR/National Awards

S. No.	Name of the Scientist	Name of the Award	Awarding agency	Nature of award (Medal/ Certificate/ amount of Cash price)	Achievement for which the award was given (Life-time achievement/ any specific discover / technology etc for which the award was given)
1.	**Dr. S. Naresh Kumar**	Appreciation certificate	World Meteorological Organization Geneva	certificate	For contribution as Expert member in SERCOM group.
		Member	Steering Council (2018-2022; 2023-2025), Agricultural Model Intercomparison and Improvement Programme (AgMIP), NASA, GISS, Columbia University, USA		
		Member	WMO Task Team on Climate and Agricultural Modelling for Sustainable Agriculture, WMO, Geneva (2018-2020);		

		Member	Panel on Standards for Environmental Services, Bureau of Indian Standards, GoI (2020 inwards)		
		Lead author	IVA -Agriculture for India's Third National Communication to UNFCCC		
		Expert member	Urban waste to wealth, Ministry of Urban Affairs, GoI		
		Expert member	Persistent Organic Pollutants, MoEF&CC		
		Expert	The Zero Carbon Challenge programme for evaluating the innovative ideas-based projects, IIT-Madras, Chennai		
2.	**Dr. Bhupinder Singh**	Member	IBSC, Tata Steel Limited Jamshedpur		
3.	**Dr. Niveta Jain**	Expert Review Team member of, Germany	UNFCCC		Technical assessment of National Communication and Biennial Report of Annex 1 countries (Developed Countries)
		Member of Editorial board	IPCC		Emission Factor Database,

					Agriculture sector,
		Expert Member,	MoEFCC		For greenhouse gas inventory (Agriculture sector), for National Communication & biennial updates to UNFCCC and IPCC Reports
		Resource Person	ARS, Jodhpur		In Training Program at Agricultural Research Station Jodhpur
		Resource Person	ICAR Research Complex for Eastern Region		For ICAR Research Complex for Eastern Region for training on methodology for GHG accounting
		Resource Person	Amity University		For Amity University, Noida for Faculty Development Program
4.	**Dr. Ranjan Bhattacharyya**	Expert Member of the Intergovernmental Technical Panel on Soils (ITPS)	FAO	Certificate	Outstanding contributions in Soil Science
5.	**Dr. Shakeel A. Khan**	Outstanding Faculty of the year Award" 2023	EET CRS Research Wing for Excellence in Professional Education & Industry, Educationexpo.tv	Certificate	Outstanding Faculty of the year Award"
		NABL Assessor as per ISO/IEC 17025: 2017 (Air, Water, Soil, Environment and	NABL		Auditing of the seven (7) Air, Water, Soil, Environment and Pollution

		Pollution)			labs at Raipur, Pune, Kolkata, Mumbai, Rajkot, Patiala and Surat as per ISO/IEC 17025: 2017 under Quality Council of India (QCI)
6.	**Dr. Ashish Khandelwal**	SPS India Best PhD Thesis award 2022	Society of Pesticide Science India	Certificate and Rs. 5000 cash prize	Best Ph.D. thesis in the field of agrochemicals/ Agricultural Chemicals
7.	**Dr. Sandeep Kumar**	Environmentalist of the Year Award 2023	NESA and CSIR-NBRI	Certificate	For the significant contribution in the field of Environmental Sciences
8.	**Dr. Sunita Yadav**	Certificate of Appreciation for Pusa Samachar	IARI, New Delhi	Certificate	Transfer of technology and information
		NESA Scientist of the year Award 2023	NESA	Certificate	For the significant contribution in the field of Soil Science and Agricultural chemistry

b) Fellowship/Associateship of National academies

S. No.	Name of the Scientist	Fellowship/ Associateship	Name of the Academy
1.	Dr. Shakeel A. Khan	• Fellow	NESA, New Delhi
		• Expert advisor and Adjunct Professor	Centre for Environment and Sustainable Development (CESD) Jamia Hamdard University, New Delhi-110062
2.	Ranjan Bhattacharyya	• Fellowship	Royal Society of Biology, UK
		• Fellowship	Society for Science of Climate Change and Sustainable Environment

7. Budget Estimates

a) Head-wise budget received and expenditure under EFC

Division	Sanctioned Budget		Expenditure (INR in lakhs)	
Environmental Science	Lab equipment	7.0	Minor Head	6.97
	Office equipment	2.5	Office equipment	2.42
Total		**9.5**		**9.39**

b) Budget received from external grant

S. No.	Name of the project	Name of the PI	Name of the Co-PIs	Duration (From- to -)	Sanctioned budget	Budget Received	Institutional charge for 2022-23
1.	National innovation in climate Resilient Agriculture " (NICRA) (12-115)	Dr. S. Naresh Kumar	Dr. Arti Bhatia	2021- 2026	12.20 Cr	267.50	
2.	"National Mission for sustainable Himalayan ecosystem" (NMSHE) (24-783)	Dr. S. Naresh Kumar		2021-2026	218	33,66,802	1,00000
3.	"AICRP on Renewable source of Energy" (12-103)	Dr. Shiv Prasad		2021-24	2.75	0.95000	
4.	Assessment and Utilization of Yellow Gypsum in Agriculture Under Variable Environment Code 79-121	D.r Bhupinder Singh	Dr. Manoj Shrivastava	2019-2024	2.47 Cr	0.12 Cr	847782
5.	Code 24-774: Development of steel slag-based cost-effective eco-friendly fertilizers for sustainable agriculture and inclusive growth	Dr. Bhupinder Singh	Dr. Shiv Prasad	2021-2024	8.66 Cr	3.4 Cr	441000
6.	Utilisation of Bioslurry (dry and liquid) in various cropping systems in identified regions in coordination with ICAR-KVK, State Agricultural	Dr Manoj Shrivastava	Dr. S.A. Khan	3.1.2023 to 31.8.2023	63.5 Lakhs	50 Lakhs	7, 20, 000

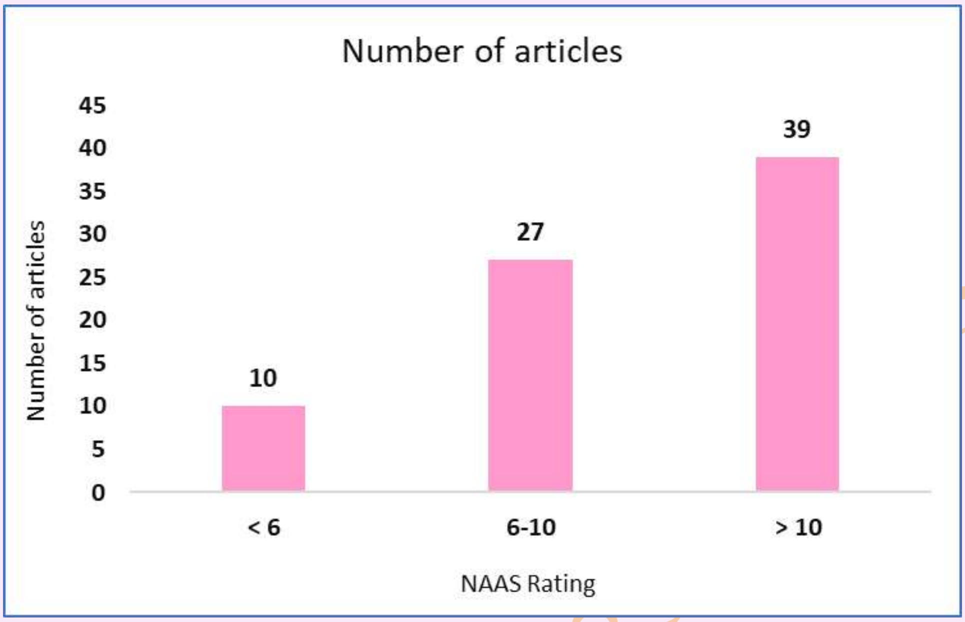
	Universities, MNRE and MoPNG installed biogas plants						
7.	Use of Biomass ashes to enhance the nutrient supply to the plant and effect on soil health	Dr Manoj Shrivastava	Dr. Ashish Khandelwal	2020-2023	4.8 lakhs	4.8 lakhs	72000
8.	"Global Challenges Research Fund (GCRF) South Asian Nitrogen Hub" (24-754)	Dr. Arti Bhatia	Dr. Niveta Jain	2020-24	583.3	115.20138	539800
9.	The South Asia Agriculture Adaptation Atlas: Interconnections between climate risks, practices, technologies and policies (ACASA)	Dr. Arti Bhatia	Dr. S. Naresh Kumar	2023-26	80.733	27.20	27000
10.	Quantifying CO_2 equivalent emission in rice, wheat and maize under improved agricultural management practices using simulation tools	Dr. Arti Bhatia	Dr. Bidisha Chakrabarti	2022-25	22.74	5.68	-
11.	Smartchem Technologies Ltd. (Mahadhan Solutek)	Dr. Niveta Jain	Dr. Arti Bhatia	2022-24	46.53	25.00	

c) Revenue generated:

- Gamma irradiation of pollen and woody plants: Rs 0.604 Lakh

8. PUBLICATIONS

- During 2023, total number of publications: 92



a) Research and review Publications (in peer reviewed NAAS rated journals only)

S. No.	Bibliography of Publication (in IJAS format)	NAAS Rating (2023)	Impact Factor (Thomson Reuters)
1.	Kiruthiga B, Singh M, Khanna M, Singh S, Parihar CM, Bandyopadhyay K K, KUMAR S N, Rajput J and Kishor N. 2023. Crop yield, water use efficiency and economic assessment of purple broccoli (Brassica oleracea) across varied water and nitrogen management practices. *Indian Journal of Agricultural Sciences* **93** (11): 1202–1207.	6.4	0.4
2.	Roy P, Bhattacharyya R, Singh R J, Sharma N K, Kumar G, Madhu M, Biswas D R, Ghosh A, Das S, Joseph A M and Das T K. 2023. Impact of agro-geotextiles on soil aggregation and organic carbon sequestration under a conservation-tilled maize-based cropping system in the Indian Himalayas. *Frontiers in Environmental Science* **16**; 11:1309106.	10.6	4.6
3.	Jawaharjothi G, Sharma D K, Kovilpillai B, Bhatia A, Kumar S, Prasad M, Suroshe S S, Kumar RR, Dunna V and Kumar SN. 2023. Impacts of elevated ozone and	6.4	0.4

	CO_2 on growth and yield of double zero mustard (Brassica juncea). *The Indian Journal of Agricultural Sciences* 15;**93** (7):743-9.		
4.	Gavhane K P, Hasan M, Singh D K, Kumar S N, Sahoo R N and Alam W. 2023. Determination of optimal daily light integral (DLI) for indoor cultivation of iceberg lettuce in an indigenous vertical hydroponic system. *Scientific Reports* 5**;13**(1):10923.	10.6	4.6
5.	Bisht M, Shrivastava M, N Kumar S and Singh R. 2023. Evaluation of the drinking water quality and potential health risks of nitrate and fluoride in Southwest Delhi, India. *International Journal of Environmental Analytical Chemistry*. **30**:1-23.	8.6	2.6
6.	Adak S, Bandyopadhyay K, Sahoo R N, Krishnan P, Sehgal V K, Kumar S N, Datta S P, Sarangi A, Bana R S, Mandal N and Bhattacharya P. 2023. Interactive effect of tillage, residue, nitrogen, and irrigation management on yield, radiation productivity and water productivity of winter wheat in semi-arid climate. *Journal of Agrometeorology*. Aug 31;**25**(3):383-91.	6.0	
7.	Joshi B, Chaudhary A, Varma A, Tripathi S and Bhatia A. 2023. Elevated CO_2, O_3 and their interaction have differential impact on soil microbial diversity and functions in wheat agroecosystems. *Rhizosphere*. 1; **27**:100777.	9.44	3.437
8.	Chaudhary A, Prakash C, Sharma S K, Mor S, Ravindra K and Krishnan P. 2023. Health risk assessment of aerosol particles ($PM_{2.5}$ and PM_{10}) during winter crop at the agricultural site of Delhi, India. *Environmental Monitoring and Assessment* **195**(11):1297.	9	3.1
9.	Yadav PK, Tripathy SS, Chandra H, Taneja L, Kochar C, Krishna A, Pokhariyal J, Toppo DD, Raina S, Singh N and Singh B. 2023. Production and Certification of Toxic Metal-Induced Basmati Rice: An Indigenous Cultivated Rice CRM/BND. *Mapan*. **38**(4):815-25.	-	1.00
10	Kiruthika A, Vikram K V, Nivetha N, Asha A D, Chinnusamy V, Singh B, Kumar S, Talukdar A, Krishnan P and Paul S. 2023. Rhizobacteria Bacillus	10.30; S019	4.30

	spp. enhance growth, influence root architecture, physiological attributes and canopy temperature of mustard under thermal stress. *Scientia Horticulturae*. **318**:112052.		
11	Kokila V, Prasanna R, Saniya T K, Kumar A and Singh B (2023) Elevated CO_2 modulates the metabolic machinery of cyanobacteria and valorizes its potential as a biofertilizer. *Biocatal Agric Biotechnol*. **50**:102716.	10.00; B209	4.00
12	Panduranga G S, Sharma K, Sharma R K and Singh B. 2023. Enhancement of Mating Performance of Sterile Males of Melon Fly Zeugodacus cucurbitae (Coquillett) through Methoprene and Cue Lure. *Indian Journal of Entomology* **85**(3): 544-555	5.59; I061	-
13	Velayudhan A M, Singh B, Shrivastava M, Khandelwal A, Yadav P, Rohatgi B, Darjee S, Ramalingappa P L and Singh R. 2023. Development of low heavy metal− Linz-Donawitz slag for safe spinach cultivation. *Sustainable Chemistry for the Environment*. **18**; 1:100003.	-	-
14	Ts A, Srivastava A, Tomar B S, Behera T K, Krishna H, Jain P K, Pandey R, Singh B, Gupta R and Mangal M. 2023. Genetic analysis of heat tolerance in hot pepper: insights from comprehensive phenotyping and QTL mapping. *Frontiers in plant science*. **14**:1232800.	11.60; F107	5.60
15	Kokila V, Prasanna R, Kumar A, Nishanth S, Singh B, Rudra S G, Pal P, Pal M, Shivay Y S and Singh A K. 2023. Elevated CO_2 along with inoculation of cyanobacterial biofilm or its partners differentially modulates C–N metabolism and quality of tomato beneficially. *Heliyon* **9**(10).	10.00; H006	4.00
16	Yadav H, Banyal N, Singh M K, Singh K P, Panwar S, Singh B, Kumar S and Mandal B K. 2023. Optimization of in-vitro protocol for rapid mass multiplication of floribunda rose cv. 'Rose Sherbet', Ama, *Ama, Agricultural Mechanization in Asia, Africa & Latin America* 54 (9):15781-15788.	6.30; A128	0.30
17	Prakash C, Khan S A and Singh B. 2023. Spatial and temporal quantification of particulate matter (PM10)	4.96; P145	-

	and associated heavy metals in urban environment of Delhi. *Pollution Research* **42**(4):432-436.		
18	Kumar A, Ponmani S, Sharma G K, Sangavi P, Chaturvedi A K, Singh A, Malyan S K, Khan S A, Shabnam A A, Jigyasu D K and Gull A. 2023. Plummeting toxic contaminates from water through phycoremediation: Mechanism, influencing factors and future outlook to enhance the capacity of living and non-living algae. *Environmental Research* **11**:117381.	14.30	8.30
19	Biswakarma N, Pooniya V, Zhiipao RR, Kumar D, Shivay Y S, Das T K, Roy D, Das B, Choudhary A K, Swarnalakshmi K and Govindasamy P. Identification of a resource-efficient integrated crop management practice for the rice-wheat rotations in south Asian Indo-Gangetic Plains. *Agriculture, Ecosystems & Environment* **357**:108675.	12.60	6.60
20	Shrasti V, Anwesha K, Rai M P, Khan* S A, Zengling Ma, Munawaroh H S, Tang D Y Y and Show P L. 2023. Exploring the Pivotal Significance of Microalgae-Derived Sustainable Lipid Production: A Critical Review of Green Bioenergy Development. *Energies* **16**(1), 531.	9.25	3.25
21	Langyan S, Yadava P, Khan FN, Sharma S, Singh R, Bana R S, Singh N, Kaur V, Kalia S and Kumar A. 2023. Trends and advances in pre-and post-harvest processing of linseed oil for quality food and health products. *Critical Reviews in Food Science and Nutrition* **8**:1-24.	16.2	10.2
22	Ramalingappa P L, Shrivastava M, Dhar S, Bandyopadhyay K, Prasad S, Langyan S, Tomer R, Khandelwal A, Darjee S and Singh R. 2023. Reducing options of ammonia volatilization and improving nitrogen use efficiency via organic and inorganic amendments in wheat (Triticum aestivum L.). *The Journal of Life & Environmental Sciences* **11**: e14965.	8.07	2.7
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b) List of Research Papers Published in Conference, Symposia and Other Papers.

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- Bhupinder Singh and Kalidindi Usha (2023) Determination of plant mineral nutrients and heavy metals by Atomic Absorption Spectrophotometer (AAS) Using Atomic Absorption Spectroscopy, In proceedings of the IDP-NAHEP sponsored 10 days Training: "High Throughput Analytical Techniques for Phytonutrient Profiling" w.e.f. 22nd November to 1 st December, 2023 at School of Biotechnology, Sher-e Kashmir University of Agricultural Science and Technology of Jammu, Jammu pp 1-13.

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c) List of Books / Chapter in Books

Book

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1. Trainings/workshop/seminar organized

Sl. No	Name of programme	Training/ workshop/ seminar	Duration	Nature of trainees	Number of trainee (s)		
					Male	Female	Total
1	Crop simulation modelling for managing agriculture under changing climates' under UN Environment-GEF project	Training	5 days (22nd May- 26th May, 2023)	Scientists	20	5	25
2.	Training workshop on Climate Modeling for the Indian Himalayan region at ICAR-CAFRI, Jhansi Course Directors: Dr Naresh Kumar and Dr Arunachalam	Training	5 days 18-22 September 2023				15
3.	Entrepreneurship opportunities on Agricultural and Industrial Waste Management for environmental sustainability	Training	May 15-19th 2023	Students, Scientists, teachers, entrepreneur	15	10	25
4.	One- week training on Climate Modeling for the Indian Himalayan Region	Training	18-22 September, 2023	Scientists	9	5	14

5.	Farmers' training programme on "Agricultural residue management for income generation" Venue: village - Sarawa, Block - Hapur, District - Hapur (U.P.)	Training	13.10.2023	Farmers	200	100	300
6.	Scientific Advancement for Sustainable Environment, Herbal Medicines and Impact on Health: An Earth Day Celebration	National Conference at Institute of Medical Sciences, BHU, Varanasi,	22 to 23 April 2023	Scientist, Teachers and students	90	40	130
7.	Recent Trends & Challenges in Green Chemistry, Pollution Control and Climate Change [GPCC-2023]	National Conference at CSIR - National Botanical Research Institute, Lucknow	14 to 16 December 2023	Scientist, Teachers and students	150	60	210
8.	CBG slurry volarization by vermicomposting	Training	6th April 2023	Verbio CBG plant employee	10	0	10

2. Participation by scientists in scientific meetings, etc.

S. No.	Detail	Number only	Detail/description of each item
(i)	**In India**		
	Seminars		▪ Invited Speaker on "Process optimization and development of production technology for possible utilization of agri-waste biochar and hybrid fuel briquettes as part-replacement of coal and coke in steel industry" at Biochar-Greening of Steel through agro based products (BIOS-2023) organized by SAIL and ICAR-IIAB at RDCIS, SAIL Ranchi from 15-16 September 2023. (DOL: 16.9.23) (Dr. Bhupinder Singh) ▪ Invited Speaker, Radiotracers in Agriculture: Deciphering the Regulators of Plant Mineral Nutrition and Source-Sink Dynamics in Crops, 5th International Conference, *Application of RadiotraCers and Energetic Beams in Sciences* (ARCEBS-23); at Sidho-Kanho-Birsha Univ. and Kushal Palli, Ayodhya Hill, Purulia district during 31 January to 05 February, 2023 (Invited talk, DOL 5.2.23) (Dr. Bhupinder Singh) ▪ Invited speaker "Radiotracers in Agriculture: Understanding the Source-Sink Relationship and Mineral Nutrition of Crops" International Conference on the Growth of Biological Sciences in 21st Century' from March, 2-4, 2023 at Punjabi University Patiala (DOL 3.3.23) (Dr. Bhupinder Singh) ▪ Invited Speaker, Value addition of LD slag: A green technology for sustainable agriculture and environment during Conference on Valorization of Fly Ash & Steel Slag: Challenges, Innovations & Future Trend (V-FASS 22), organized by CSIR- National Metallurgical Laboratory and TSL at Jamshedpur 22-23 Sept 22. (Invited Talk DOL:22.9.23) (Dr. Bhupinder Singh)

			▪ Attended National Conference of Plant Physiology-2023 as delegate and also acted as member of various committee and acted as session rapporteur (Dr. Chandan Kumar Gupta) ▪ Rapid-Fire paper presentation on "Development of emission factor (EF) of nitrous oxide and greenhouse gas intensity (GHGI) from cauliflower cultivation systems" virtually in the National conference on "Agro-Ecology Based Agri-Food Transformation Systems" organized by FSRDA and ICAR-IIFSR in collaboration with CIMMYT and ICRISAT at ICAR-IIFSR, Modipuram, Meerut, India during 27-28, January, 2023. (Dr. Sandeep Kumar) ▪ Oral Presentation on the topic of "Assessing the Potential Health Risks of Heavy Metal Contamination in Vegetables from Designated Locations in Delhi NCR" at International Conference on Smart Consumption and Sustainable Living (ICSCSL 2023), 24-25 August, 2023, Miranda House, University of Delhi. (Dr. Sandeep Kumar) ▪ Invitation as Resource Person: Delivered a virtual lecture on Mitigation and Adaptation Approaches in Agriculture for Food Security in Regional Conference of Youth for Asian and the Pacific (RCOY-APAC) on November 9, 2023. (Dr. Ashish Khandelwal) ▪ Oral Presentation on the topic of "Impact of rice residue burning on soil ecosystem in Panipat and Karnal, Haryana" at International Conference on Smart Consumption and Sustainable Living (ICSCSL 2023), 24-25 August, 2023, Miranda House, University of Delhi. (Ms. Sunita Yadav)
	Scientific meetings		• Invited penalist and speaker "World of nanosciences: Opportunities in agriculture" at the Brainstroming session on "Emerging trends in nanobiotechnology" at Uttar Pradesh Pandit

			Deen Dayal Upadhaya Pashu Chiktsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura on 15.12.23 (DOL: 15.12.23) (Dr. Bhupinder Singh) • Assocham National Conference on Enhancing Agricultural Productivity: Integration of Improved Inputs and Technology October 26, 2023 at Hotel Taj Mansingh, New Delhi (Dr. Anita Chaudhary) • ACASA project inception Meeting-India Team- CRIDA, Hyderabad (Dr. Niveta Jain) • Conducted Comprehensive Viva-voce examination of Ph.D. students of Nano Science and Technology of TNAU, Coimbatore on 4.3.2024. (Dr.Manoj Shrivastava) • Serve as External Examiner of Ph.D. Student of Nano Science and Technology of TNAU, Coimbatore on 8.9.2023. (Dr.Manoj Shrivastava) • Serve as External Examiner of Ph.D. Student of Environment Science of University of Jammu, Jammu on 9.10.2023. (Dr.Manoj Shrivastava) • Expert member of Haryana Pollution Board (Dr.Manoj Shrivastava) • Helped in preparing a reply on behalf of Haryana State Pollution Control Board to THE HON'BLE NATIONAL GREEN TRIBUBAL PRINCIPAL BENCH, NEW DELHI (OA No.306/2022) with respect to all relevant aspects of sand mining in non-governmental/private agricultural land and make its recommendations regarding environmental safeguards/ measures for mining on agricultural land with the objectives to ensure sustainable development. (Dr.Manoj Shrivastava) • Advisor of Haryana Public Service Commission Serve as Advisor to the Public Service Commission of Haryana for conducting the interview for the post of Scientist (Dr.Manoj Shrivastava)

			• Attended the Secretary level GOBARdhan meeting conducted by Department of Drinking Water and Sanitation Ministry of Jal Shakti, Government of India. (Dr.Manoj Shrivastava) • Inception Meeting of ACASA project (25 to 27th April 2023) at NASC Complex, New Delhi-110012 (Dr. Bidisha Chakrabarti)
	Workshops/Training		• Innovative technologies for wastewater treatment, reuse and resource recovery (Dr. Shakeel A. Khan) • One-week training on "Enhancing Pedagogical Competencies for Agricultural Education" organized by National Academy of Agricultural Sciences (NAAS), at NAAS, New Delhi during 20-24 November, 2023. (Dr. Shakeel A. Khan) • One-week training on "Science and Technology for Disaster Risk Reduction" organized by Centre for Disaster Management in collaboration with the DST at Lal Bahadur Shastri National Academy of Administration, Mussoorie from 24-28 July, 2023. (Dr. Shakeel A. Khan) • One-week training on "Laboratory Assessor 's Training Course as per ISO/ IEC 17025:2017" organized by National Accreditation Board for Testing and Calibration Laboratories (NABL) at ICAR-NDRI, Karnal from 16-20 Jan, 2023. Qualified the exam and became Assessor of ISO/IEC 17025:2017 (Dr. Shakeel A. Khan)
	Symposia		▪ Invited Speaker "Micro-nutrient enrichment of agri-produce and enhancing their availability for addressing malnourishment" during **108th Indian Science Congress** (ISC 2023) from 3-7 January, 2023 at Nagpur (DOL 6.1.23) (Dr. Bhupinder Singh) ▪ Delivered invited talk on the topic "Applications of nuclear techniques for climate smart agriculture" The NAARRI International Conference NICSTAR-2023 was held at Kochi, Kerala during 9-12 January, 2023. (Dr. Manoj Shrivastava)

			▪ Oral Presentation on Effect of yellow gypsum from steel Slag on Soil Health and Tomato Yield at National Seminar on Development of Soil Science, organized by Indian Society of soil Science 2023, held in IISS, Bhopal during 2-6 October, 2023. (Dr.Manoj Shrivastava) ▪ Wastewater Treatment and Reuse: Challenges and Solutions in India". (Dr. Shakeel A. Khan) ▪ Invited lecture "Advanced techniques for in-situ ammonia measurements for nitrogen management in agriculture" 15th International Conference ICAHPS on 24-25 June 2023 in Delhi. (Dr. Renu Singh) ▪ Oral presentation "Scheduling and rate of nitrogen fertilization impacted ammonia volatisation losses and yield in maize-wheat field" 9th INI conference Guru Gobind Singh Indraprastha University in New Delhi, India, from February 5-8 2024. (Dr. Renu Singh) ▪ Invited keynote address "Biofuels from Agrowaste - Way Ahead for Sustainable Agriculture" at Department of Management Studies, RGIPT, ICSSR sponsored Two-Days International Seminar on "Net Zero & Energy Transition" on 17th-18th February, 2024 at the RGIPT Campus, Jais, Amethi. (Dr. Renu Singh)
	Any other		▪ Compiled the New Training Modules for the Technical Staff of various divisions of ICAR as Per Cadrae training Plan of ICAR. ISBN:978-81-7164-255-7. (Dr.Manoj Shrivastava) ▪ Invited to deliver a lead lecture on the topic "Climate smart nanofertilizers for sustainable agriculture" at Sher-e-Kashmir University of Agricultural Sciences and Technology – Jammu, JAMMU-organized by NAHEP-IDP, SKUAST-Jammu on August 1, 2023. (Dr.Manoj Shrivastava) ▪ Invited to deliver a Guest lecture on the topic "Role of radio-traces in soil fertlity" at TNAU, Coimbatore organized by Nano Science and

			Technology, TNAU on September 8, 2023. (Dr.Manoj Shrivastava)
(ii)	**Abroad**		
	Seminars/Conference		▪ AOGS Conference, Singapore (Dr. Niveta Jain) ▪ On Climate-Smart Agriculture, Virtually, held in Japan during 8-9 Nov 2023 (Dr. Niveta Jain)
	Scientific meetings		▪ IPCC Ag GHG Data and Editorial board meetings, Christchurch, New Zealand (Dr. Niveta Jain) ▪ UNFCCC meetings, London, United Kingdom (NC 8 –BR 5 review) (Dr. Niveta Jain) ▪ INMS –GCRF e-meeting of WP 4.1 and 4.4 (Dr. Niveta Jain) ▪ SANH-GCRF, Annual review meeting, Sri Lanka (Dr. Niveta Jain) ▪ ACASA, Kathmandu, Nepal (Dr. Niveta Jain) ▪ ACASA Annual Project Review and Planning Meeting (12-14 December 2023) and presented the project work in Kathmandu, Nepal. (Dr. Bidisha Chakrabarti) ▪ UKRI SANH Project Review Meeting at University of Peradeniya, Sri Lanka from 1-7 October, 2023.
	Workshops		• To attend the Meeting of the Intergovernmental Technical Panel on Soils, FAO, Rome, Italy (Dr. Ranjan Bhattacharya) • Spatial Crop Modelling Workshop" at Colombo, Sri Lanka (16-18 January 2024). (Dr. Bidisha Chakrabarti) • Hands on training on hydroponic plant culture' conducted by the Division of Plant Physiology, ICAR-IARI, New Delhi during 04-06 October, 2023 (as resource person) (Dr. Chandan Kumar Gupta) • Lecture on Minimum residue level, pesticide pesidue analysis, their quantification and importance of residue level for export of food commodities given on 30th July 2023 during Agri Input Training Program, conducted by AgMatrix. (Virtual mode)

9. Extension activities

- Interventions in farmers' fields in Mumtajpur village under NICRA Project is continue to handhold the farmers for gradual withdrawal to enable sustain the interventions. The raised broad bed cultivation of wheat was implemented in farmers' fields and evaluated its performance. (Dr. S Naresh Kumar)
- Resource person and Invited lecture "Smart nutrient and carbon use for sustaining productivity and nutritional quality under the climate change scenario" at training programme in On-line mode on "Tools and Techniques for Analysis of Biomolecules" for Scientific staff from ICAR Institutes/SAUs from 18th January to 31st January, 2023 at Division of Biochemistry, ICAR-IARI, New Delhi (DOL 30.1.23). (Dr. Bhupinder Singh)
- Resource person and expert lecture on "Determination of plant mineral nutrients and heavy metals by Atomic Absorption Spectrophotometer (AAS) Using Atomic Absorption Spectroscopy" in IDP-NAHEP sponsored 10 days Training: "High Throughput Analytical Techniques for Phytonutrient Profiling" w.e.f. 22nd November to 1st December, 2023 at School of Biotechnology, Sher-e Kashmir University of Agricultural Science and Technology of Jammu, Jammu (DOL: 1.12.23). (Dr. Bhupinder Singh)
- Resource person and invited lecture on "Challenges, opportunities and future of hydroponic farming in India at ZTMBPD and Division of Plant Physiology organized ADP on Hydroponic plant culture from October 3-6, 2023. (DOL: 5.10.23) (Dr. Bhupinder Singh)
- Resource person and invited lecture on "Determination of plant mineral nutrients and heavy metals and their significance" in 20th Advanced level training in soil testing, plant analysis and water quality assessment organized by Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi from 16 Aug, to 05 September 2023. (DOL: 23.8.23) (Dr. Bhupinder Singh)
- Resource person cum invited lecture on "Waste to wealth opportunities in solid waste management" at the Training Program on Valorization of Waste for Environmental Sustainability: Entrepreneurship Opportunity and Livelihood Security, organized by Pusa Krishi ZTM & BPD Unit and Division of Environment Science, ICAR-IARI, Pusa, New Delhi, from 15-19 May 2023 (DOL 15.5.23) (Dr. Bhupinder Singh)
- Participated in the MGMG programme; disseminated conservation agriculture

technologies (Dr. Ranjan Bhattacharya, Dr. Chandan Kumar Gupta, Dr. Sandeep Kumar)

- Dissemination of information of division level activities during the kisan mela 2023 (Dr. Manoj Shrivastava, Dr. Bidisha Chakrabarti, Dr. Sandeep Kumar)
- Performed duty during PUSA Krishi Vigyan Mela 2023 in thematic pandal (Dr. Manoj Shrivastava)
- Conducted field visits for students and farmers in Climate Change Research Facility of the institute (Dr. S. Naresh Kumar, Dr. Arti Bhatia, Dr. Bidisha Chakrabarti, Dr. Sunita Yadav)
- On 12th May 2023, in Turkapur village, Mumtajpur Cluster organized a training program for farmers to manage nitrogen in kharif crops, especially rice, under the UK-funded SANH project. Theme areas of training were Leaf colour chart, Nano urea application, Biofertilizers, pusa decomposer, Soil health card, and Insect/pest/diseases (Dr. Sandeep Kumar).
- Regularly participation in Swachh Bharat Abhiyan
- Conduated two business-oriented trainings for youth, farmers and entrepreneurs on waste management, value addition and food loss at IARI. 915-19thMay 2023; 22-31st Jan 2024 (Dr. Ashish Khandelwal)

- Lecture on Minimum residue level, pesticide pesidue analysis, their quantification and importance of residue level for export of food commodities given on 30th July 2023 during Agri Input Training Program, conducted by AgMatrix. (Virtual mode) (Dr. Ashish Khandelwal)
- National Secretary (General Coordination) and Convener, International Co-operation cell/global agri student club, All India Agricultural Students Association (Dr. Ashish Khandelwal)
- Country Representative, Young Professionals for Agrciltural Development (YPARD India) (Dr. Ashish Khandelwal)
- Secretary, Alumni Association of BHU Agriculture (Delhi Chapter) (Dr. Ashish Khandelwal)

Farmers' training for nitrogen management for Kharif crops/monsoon crops on in Turkapur village, Mumtajpur

Radio Talk at Akashawani

TV Talk at Doordarshan

Pusa Krishi Vigyan mela, 2023

Radio Talk at Akashawani

Interaction with farmers

Interaction with farmers

Pusa Samachar

Pusa Samachar

Pusa Krishi Mela

Interaction with farmers

Interaction with farmers

Interaction with farmers

Interventions for improving farmers' resilience to climate change under NICRA and NMSHE-TF-Ag projects

10. List of staff member

Scientific Staff	Technical Staff
Dr. S Naresh Kumar, Head	Dr. Parveen Sachdeva, T 9
Dr. K. Usha, PS	Dr. N.K. Singh, T-7/8
Dr. U.K Behera, PS	Sh. R.C. Harit, T-7/8
Dr. Bhupinder Singh, PS	Sh. Munish Bhatt, T-5
Dr. Navindu Gupta,PS	Dr. Vinod Kumar, T-4
Dr. Anita Chaudhary, PS	Mrs. Neeraj Panwar, T-3
Dr. Shiv Prasad, PS	Mrs. Bhawana Joshi, T-3
Dr. Dinesh kumar Sharma, Professor	Sh. Ankit Kumar, T-1
Dr. Arti Bhatia, PS	
Dr. Niveta Jain, PS	
Dr. Ranjan Bhattacharya, PS	
Dr. Manoj Shrivastava, PS	
Dr. S.A. Khan, PS	
Dr. Bidisha Chakrabarti, PS	
Dr. Renu Singh, PS	
Dr. Chandan Kumar Gupta, Sr. Scientist	
Dr. Ashish Khandelwal, Scientist	
Dr. Sandeep Kumar, Scientist,	
Dr. Sunita Yadav, Scientist,	

Administrative staff	Supporting Staff
Mr. Munesh Chand Meena, AAO	Sh. Mahesh K, Rai, SSS
Sh. Ravesh Ram, UDC	Mr. Ram Swaroop,SSS
Mrs. Vandana Rawat, Assistant	Smt Kaliya Devi, SSS
Mrs. Durgesh Sharma, Assistant	Mr. Sunil Kumar,SSS
Mrs. Ankita Kumari, PA	Mr. Sonu Kumar,SSS
Mr. Dinesh Kumar, LDC	

11. Divisional Committees

1. **Divisional Budget and Research committee**

1. Dr. S. Naresh Kumar Head & Pr. Scientist	-Chairman.
2. Dr. D. K. Sharma, Pr Scientist	-Member
3. Dr. (Mrs.). Niveta Jain, Pr. Scientist	-Member
4. Dr. Chandan Kumar Gupta, Scientist	-Member
5. Dr. Sandeep Kumar, Scientist	- Member Secretary

2. BOS committee

1. Dr. D. K. Sharma, Pr Scientist	-Chairman.
2. Dr. S. Naresh Kumar Head & Pr. Scientist	-Member
3. Dr. Manoj Shrivastava, Pr Scientist	-Member
4. Dr. Anita Chaudhary, Pr Scientist	-Member
4. Ms. Mathiyarsi K, Student	-Member
5. Dr Ashish Khandelwal, Scientist	- Member Secretary

3. **Divisional/ Local purchase committee**

1. Dr. (Mrs) Arti Bhatia, Pr. Scientist	-Chairman.
2. Dr. Shiv Prasad, Pr Scientist	-Member
3. Dr. (Mrs.).Niveta Jain, Pr. Scientist	-Member
4. Dr Ashish Khandelwal, Scientist	-Member
5. Sh Munesh Chand Meena, AAO	- Member Secretary

4. **Divisional Database Committee:**

1. Dr. (Mrs) Arti Bhatia,Pr. Scientist	-Chairman.
2. Dr Ashish Khandelwal, Scientist (SS)	-Member
3. Dr Sandeep Kumar. Scientist (SS)	-Member

4. Mrs Bhawana Joshi, Tech Asst -Member

5. Mrs. Neeraj Panwar, Tech Asst - Member Secretary

5. In-Charge Technical:

1. Dr. (Mrs) Arti Bhatia, Pr. Scientist

2. Dr. (Mrs) Bidisha Chakrabarti, Pr Scientist

6. Labour & Farm In-charge

1. Sh Ramresh Harit, ACTO

2. Dr Vinod Kumar, STA

12. Miscellaneous

Divisional field facilities:

Divisional Lab facilities:

ICP-AES, Gas Chromatography, HPLC and Spectrophotometer

Microbiological Lab Facilities


Air Pollution Measurement instruments
Respirable Dust Sampler (RDS) & PM2.5 sampler
NTPC - FARIDABAD
RESPIRABLE DUST SAMPLER
Envirotech
FINE PARTICULATE SAMPLER
Envirotech

Divisional facilities visit by foreign delegates

Biogas facility visit

PRT Team Visit at Dision

QRT Team Visit at Dision

Divisional facilities visit by Students and Trainees


Mushroom Production Unit

Educational tour and training by students

Foreign Deputations (2023)

Sr. No.	Scientist	Agenda & Place of visit	Date
1.	Dr. Niveta Jain	UNFCCC Expert Review Meeting, London, UK	24-28, April, 2023
2.	Dr. Niveta Jain	IPCC Editorial board meeting, Christchurch, New Zealand	14-19 May, 2023
3.	Dr. Niveta Jain	AOGS Conference, Singapore	29 July - 4th Aug, 2023
4.	Dr. Arti Bhatia	AOGS Conference, Singapore	29 July - 4th Aug, 2023
5.	Dr. Arti Bhatia	Annual Review Meeting of SANH Project at Sri Lanka	2-6 Oct, 2023
6.	Dr. Niveta Jain	Annual Review Meeting of SANH Project at Sri Lanka	2-6 Oct, 2023
7.	Dr. Shiv Prasad	Annual Review Meeting of SANH Project at Sri Lanka	2-6 Oct, 2023
8.	Dr. Sandeep Kumar	Annual Review Meeting of SANH Project at Sri Lanka	2-6 Oct, 2023
9.	Dr. S. Naresh Kumar	Annual review meeting of ACASA project funded by BISA-CIMMYT at Kathmandu, Nepal	11-14 Dec, 2023
10.	Dr. Arti Bhatia	Annual review meeting of ACASA project funded by BISA-CIMMYT at Kathmandu, Nepal	11-14 Dec, 2023
11.	Dr. Niveta Jain	Annual review meeting of ACASA project funded by BISA-CIMMYT at Kathmandu, Nepal	11-14 Dec, 2023
12.	Dr. Bidisha Chakrabarti	Annual review meeting of ACASA project funded by BISA-CIMMYT at Kathmandu, Nepal	11-14 Dec, 2023

Glimpses from foreign deputation

AOGS Conference Singapore


Dr. Niveta Jain, IPCC EB Member (Agriculture Sector)

Dr. Ashish Khandelwal, Youth representator at FAO

Annual Review Meeting of SANH Project at Sri Lanka


IPCC Editorial board meeting, New Zealand

SANH Project Team Sri Lanka Visit

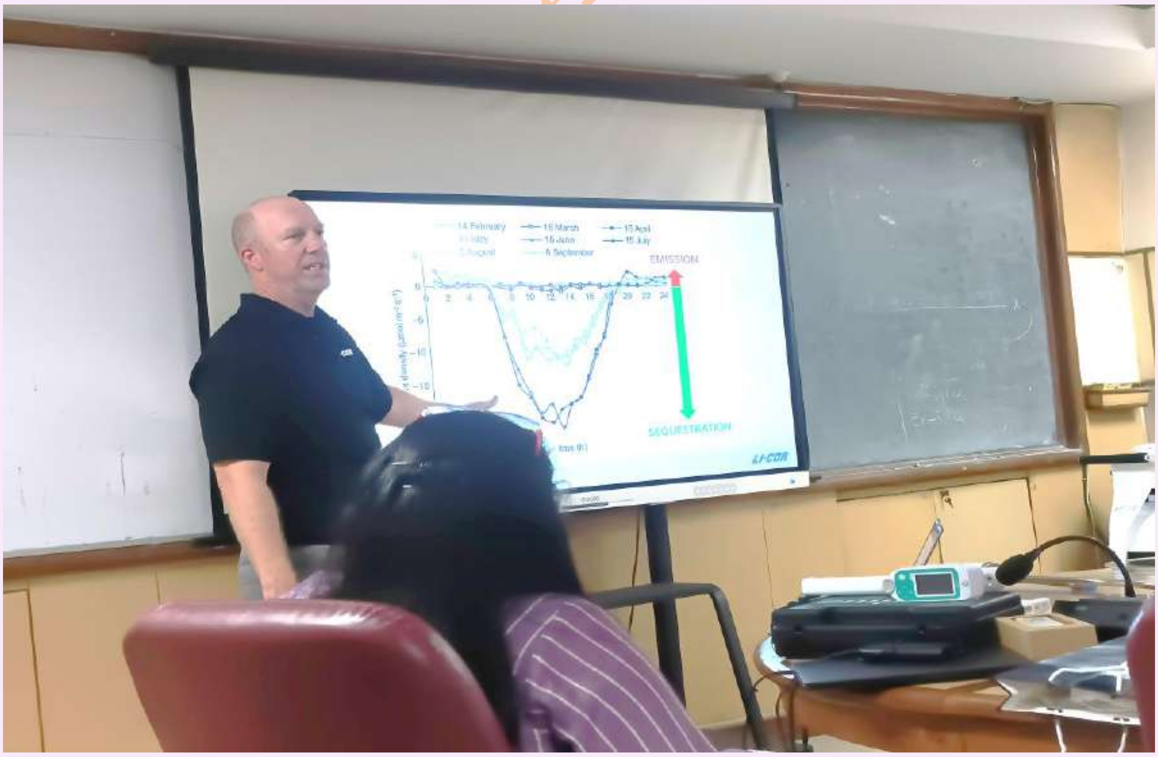
ACASA Project Meeting, Sri Lanka

SARDINIA 2023-19th International Symposium on Waste Management, Resource Recovery and Sustainable Landfilling (9 to 13th October 2023)

Annual Review Meeting of SANH Project at Sri Lanka

Training organised by Division

Training workshop for scientific staff 2022-23, Crop simulation modelling for managing Agriculture under changing climate

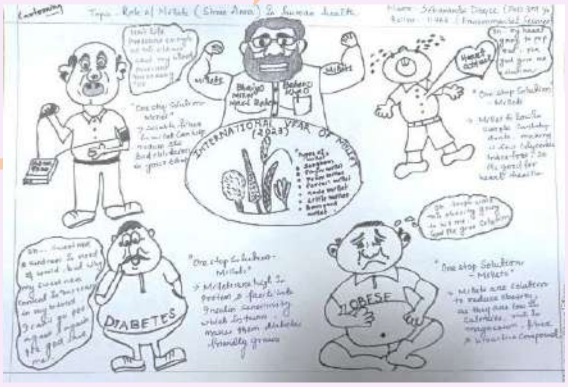


Training organized by LICOR Bioscience for the exposure of LICOR instruments

Training on “entrepreneurship opportunity in agricultural waste management for environmental sustainability”

Workshop on Environment and Human Health during the series of program of World Environment Day, 2023


CAFRI
Training Programme



Aappreciation Certificate for Pusa Samachar