ABSTRACTS

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National Seminar on Technological Innovations for Transforming Agriculture: The Role of Agrophysics

ICAR-Central Coastal Agricultural Research Institute, Goa
23-24 January 2025

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The Indian Society of Agrophysics
Division of Agricultural Physics
ICAR-IARI, New Delhi
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ICAR-CCARI, Goa

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on
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National Seminar on Technological Innovations for Transforming Agriculture: The Role of Agrophysics
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Best Placement of Soil Moisture Sensors in IoT-based Basin Irrigation System

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A field experiment was carried out at a Research farm, ICAR- Indian Agricultural Research Institute, New Delhi to identify the best placement of soil moisture sensors in an IoT-based basin irrigation system. The IoT-based basin irrigation system consists of a check gate to control water flow, a check gate controller, capacitance soil moisture sensors, a gateway, and a mobile app. Three soil moisture sensors were placed at three different depths at three locations in a level basin. The first soil moisture sensor was placed at 37.5 cm depth located at 25%of the field length, the second soil moisture sensor was placed at a 15 cm depth situated at 50% of the field length and the third sensor was installed at 7.5 cm depth located at 75%. Three irrigation schedules were done to evaluate the sensor placement on irrigation application efficiency. The results showed that the capacitance-based soil moisture sensors quickly responded to moisture changes and successfully sent data at predefined time intervals. The results also revealed that at least two soil moisture sensors should be placed to enhance irrigation application efficiency up to 85% in IoT-based basin irrigation systems. One sensor should be placed at a 15 cm depth situated at 50% of the field length for starting the irrigation event and another sensor should be placed either at a 75% distance situated at 7.5 cm depth for shallow-rooted crops or 25% of the field length at 37.5 cm depth in deep-rooted crops.

Keywords: Soil moisture sensors, irrigation system

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Effect of Foliar Application of Nitrogenous Fertilizers using Drone and Knapsack in Wheat Crop

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Foliar spray plays a pivotal role in modern agriculture by offering an efficient method to supplement soil-applied fertilizers. This technique facilitates quick nutrient uptake through leaves, enabling timely correction of deficiencies and boosting overall plant vigor. A field study was undertaken at ICAR-Indian Agricultural Research Institute, New Delhi to see the effect of spraying using drone and knapsack sprayer in wheat crop. In addition to the control, the treatments contained two foliar sprays of different nitrogenous fertilizers (nano urea, prilled urea and nano DAP) and 50% & 75% of the recommended dose of nitrogen (RDN, 150 kg/ ha). Two foliar sprays of these fertilizers were applied during crucial growth stages of nitrogen need i.e. the tillering and jointing stages using drone-based sprayer and knapsack sprayer to assess their impact on wheat growth and yield. Multispectral vegetation indices were calculated and their thematic maps were generated from the drone-based multispectral imagery to study the effect of sprayer type and different nitrogenous fertilizer sources. After the first spraying, there was a noticeable increase in NDVI and LCI particularly in treatments with drone spraying, which suggests improved plant vigor and chlorophyll content. The second spraying further enhanced NDVI and LCI values, with the highest readings observed in treatments combining 75% RDN+ 2 foliar sprays of nano-urea, prilled urea and nano-DAP. This progression underscores the effectiveness of foliar sprays using drones in enhancing vegetation density and health over time. The yield was found higher in treatment sprayed with drone 75% RDN +2 foliar spray of Nano-DAP. Foliar spray using drones has emerged as a game-changing innovation in agriculture, enabling targeted and time-efficient application of nutrients and pesticides. This method not only addresses challenges in conventional spraying but also optimizes crop health and productivity.

Keywords: Drone, precision, sprayers, smart agriculture, wheat

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Novel Spectral Indices for UAV-Based Apple Powdery Mildew Detection and Mapping

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Precision management of plant diseases necessitates rapid and accurate detection and mapping. This study developed novel spectral indices for apple powdery mildew detection using Unmanned Aerial System (UAS) multispectral imagery. Spectral analysis of healthy and infected leaves revealed significant differences in reflectance and spectral angles, particularly in the green, red-edge, and near-infrared (NIR) bands. Three novel indices were proposed: the Mildew Reflectance-to-Angle Index (MRAI), Mildew Spectral Angle Deviation Index (MSADI), and Geometric Mean Index for Mildew (GMIM). These indices, along with the existing MSR-blue index, were evaluated for disease severity mapping. A pre-trained Segformer model segmented the orchard background with 91% accuracy. Disease severity maps were generated using a hierarchical decision rule algorithm, achieving classification accuracies of 85%, 82%, 79%, and 65% for MRAI, MSADI, GMIM, and MSR-blue, respectively. The resulting prescription maps provide valuable information for growers to optimize powdery mildew management strategies in apple orchards.

Keywords: Disease, biotic stress, UAV, drone, precision agriculture

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Multistage Wheat Yield Estimation using Multiple Linear, LASSO, Elastic Net and Machine Learning Approach

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Wheat is the most important cereal crop grown during *Rabi* season in north-west part of the India. Weather parameters like maximum temperature, minimum temperature, relative humidity, rainfall, etc. have a great impact on crop yield. Weather is an important uncontrollable factor influencing crop growth and development. Therefore, crop yield prediction can be done precisely using weather parameters. Yield estimation is crucial for ensuring food security, planning agricultural policies, managing resources like irrigation and fertilizers and supporting farmers with actionable insights. Many techniques have been developed to predict crop production. In traditional methods, crop cutting experiments were widely used for crop yield prediction at different regions. Considering the challenge of food security at domestic and international level, it is desirable to develop an accurate and dynamic crop yield prediction model. Regularization and feature selection techniques enhance the prediction accuracy and prevent statistical over fitting in a predictive model. To overcome the problems of predicting non-linear and non-stationary time series dataset machine learning techniques has been used. Wheat yield and daily weather data during wheat crop growing period were collected from IARI, New Delhi for more than 35 years. Wheat yield estimation was done at tillering, flowering and grain filling stage of the crop by considering weather variables from 46^{th} to 4^{th}, 46^{th} to 8^{th} and 46^{th} to 11^{th} standard meteorological week. Model was developed by stepwise multiple linear regression (SMLR), least absolute shrinkage and selection operator (LASSO), elastic net, support vector regression (SVR), artificial neural network (ANN), PCA-ANN, PCA-SMLR, SMLR-SVR, LASSO-SVR. Analysis was carried out by fixing 70% of the data for calibration and remaining dataset for validation. R statistical software version 3.1.3 was used for developing wheat yield prediction models and making a comparison between the developed models. Results showed that percentage deviation of estimated yield by observed yield was ranged between -7.41 to 4.94, -6.98 to 9.07, -2.37 to 6.66% during tillering, flowering, and grain filling stage respectively. On the basis of percentage deviation and model accuracy LASSO, LASSO-SVR and SVR model was found better having nRMSE value less than 10 % hence can be used for district level wheat crop yield estimation at different crop growth stage.

Keywords: Wheat, machine learning, multiple linear

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Effects of Zinc Oxide and Ferric Oxide Nanoparticles on Growth, and Yield of Wheat under Heat Stress

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Elevated temperatures pose a significant threat to global wheat production, impacting both yield and quality. This study investigated the potential of ZnO and Fe_2O_3 nanoparticles in mitigating the adverse effects of heat stress on wheat crops (HD 3226 and HD 3298). Physiological parameters such as chlorophyll content, gas exchange, and antioxidant enzyme activity were evaluated. Results suggested that heat stress significantly ($p<0.05$) reduced chlorophyll content, photosynthetic rate, and stomatal conductance compared to ambient conditions. However, ZnO and Fe_2O_3 nanoparticle soil manipulation (25 mg kg^{-1}) effectively mitigated the adverse effects of heat stress on physiological parameters, restoring these parameters to levels comparable to those observed under ambient conditions. ZnO and Fe_2O_3-NPs soil manipulation enhanced the activities of antioxidant enzymes, including superoxide dismutase (SOD), catalase (CAT), and peroxidase (POD), thereby improving plant tolerance to oxidative stress induced by heat. Among the yield parameters spike length and the number of spikelets per spike were not significantly affected by heat stress in the control plants under heat stress over the ambient control. However, the number of grains per spike and grain yield per plant were significantly ($p<0.05$) reduced in the control plants under TGT compared to ambient conditions. ZnO and Fe_2O_3 nanoparticle soil manipulation significantly increased ($p<0.05$) grain yield in both cultivars under heat stress, restoring it to levels comparable to those observed under ambient conditions, particularly in the HD 3226 cultivar. ZnO and Fe_2O_3 nanoparticles increased notably Zn and Fe densities in plant parts of wheat over the ambient condition under heat stress.

Keywords: Wheat, heat stress, ZnO nanoparticles, Fe_2O_3 nanoparticles, antioxidant enzymes, chlorophyll, photosynthesis

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Effect of Graded Doses of Nano Urea in French Bean (*Phaseolus Vulgaris* L.): Yield, Nitrogen Use Efficiency and Distribution of Nitrogen Pools

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French bean is an important and highly profitable vegetable crop of North Eastern Hill Region of India. Application of Nano fertilizers helps in increasing the efficiency of nutrients, yield, quality, environment friendly and reduce nutrient stress that occur to the plant. The field-based research trial was set up in 2 years (2022 and 2023), to evaluate the effect of different methods of application and combinations of granular urea and nano urea on soil parameters, nitrogen dynamics, and yield attributes of French bean (*Phaseolus vulgaris*). The trial was arranged in a split-plot design with three replications, where the main plots represented application methods (S1: Two stages, S2: Three stages, S3: Four stages), and subplots included six fertilizer treatments (F1: No N, F2: Nano urea @ 2 L ha^{-1}, F3: Granular Urea @ 50 kg ha^{-1}, F4: Granular Urea @ 37.5 kg ha^{-1} + Nano urea @ 0.5 L ha^{-1}, F5: Granular Urea @ 25 kg ha^{-1} + Nano urea @ 1 L ha^{-1}, F6: Granular Urea @ 12.5 kg ha^{-1} + Nano urea @ 1.5 L ha^{-1}). The results of pooled data of two seasons revealed that a significant improvement in soil parameters, including available nitrogen, total nitrogen, ammonium and nitrate fractions, organic carbon content and root volume, across all growth stages (early vegetative, late vegetative and flowering) compared to initial soil and control plots. Among the application methods, four-stage application (S3) yielded superior outcomes in yield parameters. Similarly, the F6 treatment (Granular Urea @ 12.5 kg ha^{-1} + Nano urea @ 1.5 L ha^{-1}) consistently recorded the highest values for nitrogen uptake, yield, dry biomass, and nitrogen use efficiency. The interaction of S3 and F6 was particularly effective in enhancing soil nutrient availability, microbial biomass and plant growth parameters. Notably, the two-stage application (S2) with F6 treatment improved crude protein and total nitrogen concentration in roots, shoots, and pods, while S3 with F6 achieved the best results for overall nitrogen use efficiency and yield. This study highlights the potential of integrating granular and Nano urea in split applications to optimize nitrogen management, enhance crop productivity and improve soil health.

Keywords: French bean, nitrogen application, Nano urea, granular urea, split-plot design, yield attributes, nitrogen fractions, soil health

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Enhancing Maize Performance through Sustainable Agronomic Interventions in Mid-Hills of Meghalaya

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The Northeastern hill (NEH) region is endowed with rich natural resources like land, climate, water, and biodiversity and has tremendous potential for agricultural intensification. However, the climate change has a great impact on rainfed farming in recent years, *vis-a-vis* the productivity of crops and profitability of farmers. Optimization of crop management practices such as dates of sowing, nutrient management can be a sustainable alternative to enhance the productivity of crops. In this line, the Maize (RCM-76) was grown with four nutrient management strategies and three different dates of sowing (DOS) in Water management farm of ICAR RC for NEH, Umiam, Meghalaya (1010 m MSL). Three DOS were early (April, D1), normal (May, D2) and late (June, D3) and the nutrient management strategies were fully organic with FYM, 75% recommended dose of Nitrogen (RDN) + FYM (N1), 100% RDN+ FYM (N2), 125% RDN+ FYM (N3) along with one control(C). The results suggested that, management practices can induce a wide range of variability in Maize productivity. The grain yield (GY) of maize ranged between 1.58 (D3C) and 5.0 tons/ha (D1N3) while, the biomass yield (BY) varied from 11.1 tons/ha (D3C) to 19.5 tons/ha (D2N3). Among the nutrient management, the GY and BY increased significantly with the application of FYM and N dose upto N2. Whereas, the early sowing in April, significantly improved the productivity of Maize compare to normal or late DOS. The late sowing could reduce the GY by 3-26% and BY by 5-35%. Moreover, the application of higher N doses can alleviate the negative impact of late sowing. Therefore, the crop management practices *viz.* date of sowing modification with organic and integrated nutrient management can significantly influence the growth, yield and productivity of rainfed maize and sustainability of production systems.

Keywords: Northeast hill region, maize, nitrogen dose, sowing dates, sustainability

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Organic Carbon Dynamics and Sequestration Potential in Soils of Diverse Citrus Orchards

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This study evaluates the carbon sequestration potential of five citrus orchards, representing diverse species, under the project titled "Carbon Sequestration Potential of Different Citrus Orchards." Soil samples were collected from Nagpur Mandarin, Kinnow, Acid Lime (Fule Sarbati), Pummelo and Sweet Orange orchards. Carbon fractions were analyzed, including Very Labile Carbon, Labile Carbon, Less Labile Carbon, Non-Labile Carbon, and Total Carbon to understand their contributions to soil carbon storage. Results indicate significant differences in carbon fractions among the orchards. Acid Lime exhibited the highest total carbon content (2.23%), with Non-Labile Carbon contributing the largest fraction (1.29%), highlighting its superior long-term carbon storage potential. Pummelo followed with a total carbon content of 1.81%, primarily driven by Non-Labile Carbon (0.95%). Kinnow and Sweet Orange displayed moderate total carbon levels of 1.67% and 1.59%, respectively, with balanced contributions from labile and non-labile fractions. Nagpur Mandarin recorded the lowest total carbon content (1.53%), though its labile fractions were comparable to the other orchards. The findings underscore the influence of varietal and management differences on soil carbon dynamics, emphasizing the role of citrus orchards in carbon sequestration. Acid Lime and Pummelo emerged as promising candidates for long-term carbon storage, while other varieties demonstrated significant potential in active carbon cycling. These insights provide a foundation for optimizing orchard management practices to enhance carbon sequestration and soil health, contributing to sustainable citrus production and climate mitigation strategies. Future work will explore the temporal dynamics of these fractions and their relationship to orchard productivity.

Keywords: Carbon sequestration, citrus orchards, soil carbon fractions, Nagpur mandarin, organic carbon dynamics

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Assessing Nitrogen and Water Stress on Growth Dynamics of Drip-Irrigated Potato (*var. Kufri Jyoti*) using Visual Imaging

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Various aspects of growth dynamics during the crop life cycle are critical determinants for tuber yield, quality, and tuber size distribution in potato crops (*Solanum tuberosum L.*). These dynamics serve as crucial inputs for crop simulation modelling and yield forecasting. However, conventional destructive techniques are labour-intensive, resource-demanding for large sample sizes, and prone to subjective biases. To address these limitations, a field study was conducted during the *rabi* season of 2023-24 at ICAR-Central Potato Research Institute's Research Station in Jalandhar, Punjab (31°16'34" N, 75°32'51" E, ~230 m AMSL). The study evaluated the responses of drip-irrigated potato crops (var. Kufri Jyoti) to different nutrient management and irrigation scheduling regimes. Simultaneously, RGB images were captured weekly under natural light conditions using a ground-based handheld camera (Canon EOS 80D; DSLR; 24 MP). Green canopy cover (CC%), as an indicator of crop growth, was estimated using a deep learning algorithm trained on images processed via ImageJ software (ver. 1.53t), achieving a normalized root mean square error (NRMSE) below 2.5%. Key growth metrics-such as rates of early canopy expansion during initial crop growth (CGR), maximum canopy cover (CCx), time to reach CCx (Tccx), onset of senescence (Tsen), and canopy decline rates (CDR)-were computed following methods outlined in FAO Irrigation and Drainage Paper 66. A pooled analysis revealed mean values of CGR, CDR, and Tsen as 11.7% per day, 6.5% per day, and 79 days after planting (DAP), respectively, with a wide range observed between optimal (non-limiting) and stressed (limiting) environments. These findings underscore the utility of visual imaging techniques in providing accurate, non-destructive, and scalable estimates of growth dynamics. The study demonstrates the potential for integrating imaging-based analyses with precision agriculture tools to optimize water and nutrient use efficiency, enhance yield forecasting accuracy, and promote sustainable potato cultivation practices.

Keywords: Potato, canopy cover dynamics, drip irrigation, precision agriculture

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Evaluating Land Sustainability in Coastal Gujarat: Advancing Sustainable Development Goal 15.3.1 with Google Earth Engine

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A study was conducted to assess land sustainability in the coastal districts of Gujarat, focusing on SDG Indicator 15.3.1, which aims to achieve land degradation neutrality. Using free and open-source Google Earth Engine, the analysis evaluated changes in land productivity, soil organic carbon (SOC), and land cover to understand ecological and socioeconomic trends in the region. The results showed that of the 111,291 sq. km assessed, 71.9% (80,010 sq. km) demonstrated improvement, aligning with sustainable development trends, while 26.5% (29,482 sq. km) remained stable, and 1.6% (1,798 sq. km) was classified as degraded, indicating areas requiring targeted interventions. Land productivity improved over 73.5% (81,784 sq. km) of the area, while 25.3% (28,139 sq. km) remained stable, and 1.2% (1,368 sq. km) experienced degradation. SOC improvements were minimal, affecting only 0.11% (118 sq. km), with most areas remaining stable and no notable degradation. Land cover improvement was observed in 1% (1,100 sq. km), reflecting gradual ecological restoration. Population analysis revealed that 54% (22.9 million) of residents live in areas with improved land conditions, 40% (16.9 million) reside in stable zones, and 6% (2.5 million) remain in degraded areas, emphasizing the need for targeted strategies to enhance resilience. These findings also highlight the utility of the open-source remote sensing tools in monitoring progress toward achieving sustainable development goals.

Keywords: Sustainable development goals, Google earth engine, land degradation, organic carbon degradation, productivity state degradation

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Assessing the Spatiotemporal Dynamics of Land Use and Land Cover using Advanced Techniques on Google Earth Engine: A Case Study from the Eastern Himalaya

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Land degradation is intensifying due to land use and land cover (LULC) changes in East Siang (Arunachal Pradesh), resulting in significant impacts on ecosystem services, climate regulation, and livelihoods. Traditional image processing on medium resolution satellite data (like Landsat) cannot effectively analyse LULC dynamics because the Eastern Himalaya has multiple mixed land uses in small discrete patches and lacks pure pixels. We devised an integrated methodology: a machine learning (RF-random forest) algorithm was employed to analyse multi-date Landsat 8 satellite imagery on the Cloud-based Google Earth Engine (GEE) platform. This approach allowed us to analyse the spatial patterns of LULC changes over decades in East Siang with 85% classification accuracy and a kappa coefficient of more than 80%. The findings revealed a significant deforestation caused by the expansion of agriculture and urbanization, which led to a decrease in forest cover (5.34%) and eventually increased eroded degraded land (3%). These changes indicate the transformation of the region's landscape from a natural to a human-dominated one due to increased anthropogenic pressures. This study demonstrated how GEE can monitor and analyse LULC changes in predominant mixed-land use hill ecosystems by integrating large-scale satellite data and machine learning algorithms. Policymakers and stakeholders seeking to balance developmental objectives with ecosystem preservation in fragile mountainous regions will benefit from the insights gained from this study.

Keywords: LULC changes, land degradation, Google earth engine, random forest algorithm, eastern himalayas

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Revolutionizing Rice Crop Monitoring in Thrissur's *kole* Lands: Optimizing Remote Sensing for Enhanced NPP and Yield Predictions

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The *kole* lands are unique wetland ecosystems in Central Kerala designated as a Ramsar site, reclaimed and used for extensive paddy cultivation during October to May. *Kole* lands cover an area of 13000 hectares which lie mostly below the mean sea level ranging from 0.5m to 2.5m. The term *kole* denotes abundant yields with high returns in regional language and serve as one of Kerala's primary rice granaries. Biophysical parameters are crucial for precise crop monitoring and management. By accurately measuring these parameters, farmers can optimize irrigation, fertilizer and plant protection management to enhance crop yield and sustainability. The present study intends to explore the potential of net primary productivity (NPP) in estimating paddy yields in *kole* lands of Thrissur using Moderate Resolution Imaging Spectroradiometer (MODIS) remote sensing data. The temporal as well as spatial variation in biophysical parameter in computing yield were also analysed. Yield estimates of summer and winter crop of paddy in *kole* lands were estimated using net primary productivity from MOD17A3HGF.061 Terra Net Primary Production Gap-Filled Yearly Global data with 500 m resolution. The results were validated with on farm paddy yield data for the period 2018-2023 for two seasons. Regression analysis showed that the yield estimated through net primary productivity was in strong agreement with the actual yield and variation showed a root mean square error ranging between 1.30-5.68. Whereas in spatial studies, the variation accounted to root mean square error of 1.55-3.30. The results are indicative of the potential of utilising biophysical parameter like net primary productivity in estimating yield in advance of harvest thereby avoiding labour intensive, time consuming crop cutting surveys. Moreover providing accurate and timely yield predictions, empowers farmers with better decision-making capabilities, enables stakeholders to optimize resource allocation and supports policymakers in developing informed agricultural policies and insurance schemes.

Keywords: Net primary productivity, biophysical parameter, MODIS, paddy yield, *kole*

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Impact of Energy Consumption and Green House Gas Emissions for Onion Production in the Karnataka State of India

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Agriculture contributes 11% of total Green House Gas (GHG) emission in the world, with India contributing around 7% of this total. Implementation of new policies aimed at reducing the GHG emissions from agricultural sector is now a major concern in the world. To implement the Sustainable Development Goals (SDGs) 7.0 of United Nations in agriculture and allied sectors, it has become necessary to generate policies regarding implementation of modern renewable energy sources as a substitute of conventional sources. In this context, a study was conducted to determine the amount of energy used in Vegetable (onion) production in Karnataka state of India. Data on details of basic energy inputs and outputs were collected, and survey weighted point estimates were generated. Data Envelopment Analysis (DEA) was applied to distinguish between the efficient and non-efficient farm households in the study area. The constant to return scale, showed that only 7% farm households were efficiently using energy inputs. The calculation of technical efficiency of inefficient farm households was also done. The average technical efficiency for inefficient farm households was 0.77, which means around 23% of total resources might be easily saved without reduction in yield of the crop. Furthermore, the estimates of amount of Carbon-Di-Oxide (CO_2) produced from each process involved during the production of a crop emphasizes the urgent need for the formulation of policies aimed at sensitization farm households towards efficient use of natural resources to mitigate the problem of global warming.

Keywords: Estimates of CO_2 emissions, vegetable production, renewable energy, global warming, data envelopment analysis

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Effect of Conservation Agriculture on Aggregate Associated Phosphorus Fractions in an Inceptisol under Based Maize-Wheat System

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Despite the pivotal role of phosphorus (P) and its fertilization in global food production, there is a lack of understanding regarding how P changes occur in soils over time under conservation agriculture (CA) specially regarding P fractions across soil aggregates. Therefore, this study was undertaken to study the impact of CA on soil phosphorous fractions within soil aggregates under maize-wheat cropping system. Soil samples were collected from an ongoing CA experiment at the Indian Agricultural Research Institute (IARI), New Delhi, was established in 2008-09 with a split-plot design with main plots for tillage and nitrogen treatments (ZTRN125, ZTRN100, CTRN125) and sub-plots for phosphorus management options (P100, P75, P0) in an Inceptisol. ZTRN125 had the highest soil aggregate stability in both the 0-5 cm and 5-15 cm layers, with values 14.8% significantly higher than CTRN125. In both the soil layer, the labile P (H_2O-P, $NaHCO_3$-Pi, and $NaHCO_3$-Po), moderately labile P (NaOH-Pi and NaOH-Po) and non-labile P (HCl-P and Residual P) were significantly higher in ZTRN125 and P100 than in CTRN125 and P0 within macro and microaggregates. However, the labile P was higher in macro aggregates when compared to microaggregates. For HCl-Pi, ZTRN125 had 12.8% more in macroaggregates and 12.8% more in microaggregates than CTRN125 at 0-5 cm, and P100 showed an increase in both macro and microaggregates over P0. Residual-P within aggregates did not show any significant effect from tillage or residue management. ZTRN125 had the highest total-Pi and total-Po in both macro and microaggregates, with P100 higher than P75 and P0. In conclusion, P accumulation was higher in macroaggregates, particularly under ZTRN125, where P was more stable, while in microaggregates, with lower P adsorption, released P faster. Therefore, ZT with residue retention and N125, combined with P75, is recommended as a P fertilizer protocol for Inceptisols in maize-wheat system.

Keywords: Conservation agriculture, phosphorus, Inceptisol

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Impact of Rice Straw Biochar on Greenhouse Gas Emission and Carbon Balance from Rice-Wheat System of Jharkhand

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The conversion of rice straw to biochar and application to soil may have a positive effect on reducing the environmental impact of rice straw burning and greenhouse emissions. Biochar has been further reported to enhance soil carbon sequestration and crop yield. With this hypothesis, a two-year field experiment (2020-21 to 2021-2022) was undertaken at ICAR-IARI Jharkhand to evaluate the impact of rice straw biochar on greenhouse gas emission, carbon balance and crop yield under a rice-wheat cropping system. The experiment consisted of five treatments [farmer's practice of fertilizer application (T1), Recommended dose of fertilizer (T2); T2 along with biochar @ 5 t/ha (T3), T2 along with biochar @ 10 t/ha (T4) and; control without fertilizer and biochar (T5)]. The water holding capacity under biochar-applied treatments was about 18.5-24.2% higher compared to treatments with no biochar. The soil pH was found 12.8-16.9% higher in biochar-applied soil compared to the initial soil pH. The global warming potential was found to be lower in biochar-applied treatment compared to non-biochar-applied treatments and treatments followed a trend of T4 >T3>T1>T2>T5. Net ecosystem carbon balance was found to be significantly higher in biochar-applied treatment compared to non-biochar-applied treatments. Further significantly higher wheat yield was recorded in biochar-applied treatment than in other treatments.

Keywords: Biochar, rice straw, soil quality, acidic soil, carbon balance

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From Challenges to Opportunities: The Dual Impact of Climate Extremes on Land Use and Agriculture in Leh-Ladakh

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Ladakh, often referred to as the "Third Pole on Earth," is one of the most climate-vulnerable regions globally. The climatic events in this region not only have localized impacts but also pose significant repercussions for the broader Indian subcontinent. This study evaluates the unfolding effects of climate change and extreme weather events in Ladakh using long-term historical climatic data obtained from the India Meteorological Department (IMD) and the United States Geological Survey (USGS). Observed warming trends, reflected in increasing Growing Degree Days (GDD), Summer Days (SU), and mean daily temperatures (TXm, TNm, TMm), were closely linked to substantial shifts in land use and land cover (LULC). A decline in cold-related indices, such as Frost Days and Cold Spell Duration, indicated shorter cold periods, facilitating the expansion of settlements and bare areas. These changes were exacerbated by glacier retreat and heightened environmental stress. LULC analysis revealed significant transformations, including reductions in cropland and grasslands, alongside expansions in settlements and bare areas. These shifts have notably impacted agriculture, with a decline in traditional wheat and barley cultivation offset by the adoption of high-value crops and year-round vegetable production, supported by advanced greenhouse and polyhouse technologies. Increased heat availability has accelerated crop diversification, enabling agricultural practices to adapt to changing climatic conditions. This study highlights the intricate interplay between climate variability, land use dynamics, and agriculture, emphasizing the need for adaptive strategies such as sustainable water management, crop diversification, and agro-climatic zoning to build resilience in Ladakh's fragile ecosystem.

Keywords: Climate change, cold-arid ecosystems, climate extremes, LULC, agricultural adaptation

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Climate Risk Area Identification using Aquacrop for Pearl Millet Production in Rajasthan

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Climate change is affecting agriculture and food systems, and these impacts are expected to become more severe in the coming decades. It is altering temperature and precipitation patterns, which can affect crop yields, water availability, and pest and disease pressures. Rising temperatures and changing rainfall patterns can also lead to soil erosion, nutrient depletion, and reduced soil moisture, which can have serious consequences for agricultural productivity. The extreme weather events, such as droughts, floods, and heat waves, are becoming more frequent and severe due to climate change, leading to crop losses.

Pearl millet is widely grown in the driest regions of India, mainly in the arid tropics. It grows well in semi-arid and dry soils, but responds very positively to slight improvements in growing conditions such as changes in temperature and additional irrigation. Pearl millet is considered a crop for the future due to its many desirable characteristics that make it suitable for cultivation in a changing climate. While pearl millet is a hardy crop with many advantages, it is still vulnerable to the impacts of climate change. Climate change is expected to increase temperature and rainfall variability, which could affect the growth and yield of pearl millet. As this crop is grown primarily under arid conditions, strategies must be developed to promote efficient water use, which can be achieved through field trials and/or crop modelling.

The present study was carried out using Aquacrop model, a crop growth model developed by FAO's Land and Water Division to address food security and assess the effect of the environment and management on crop production. The water-driven AquaCrop model is used extensively for simulating crop growth and water use. A field experiment AquaCrop Model requires a minimal number of cropping parameters, aiming to balance simplicity, accuracy, robustness, and ease of use. In this study, we calibrate and validate his AquaCrop model under irrigated and rainfed conditions for an underutilized crop, pearl millet. The study was conducted using climate data from 1990 to 2022 and was calibrated using in-situ data collected from 3 research stations. The scope of study was extended to 10 agro-climatic zones. The study further propose methodology for assessment of area prone to production risk using weather and soil data.

Keywords: Pearl millet, aquacrop, water use, production risk, climate change impact

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Climate Extremes in Eastern India: Present and Future projection

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The dynamics of heatwave occurrences and rainfall erosivity was studied over the five meteorological subdivisions of Eastern India viz. Arunachal Pradesh (AP), Assam-Meghalaya (AM), Nagaland-Manipur-Mizoram-Tripura (NMMT), Sub-Himalayan West Bengal and Sikkim (SHWBS) and Gangetic West Bengal (GWB). Eastern India region. The historical IMD ground observations were analysed along with Coupled Model Intercomparison Project (CMIP5 and CMIP6) scenarios. Heatwave incidence was evaluated using IMD criteria, Excessive heat factor (EHF), and Heatwave magnitude Index daily (HWMId) followed by seasonal rainfall erosivity (R-factor). The RCP 8.5 and SSP5-8.5 scenario show an alarming increase in severe and ultra-extreme occurrences spanning AP, AM, and NMMT. Also, a considerable rise in rainfall trend is observed for RCP 2.6, RCP 4.5, and SSP5-8.5, suggesting a long-term increase in rainfall and erosivity, particularly in subdivisions such as AM, NMMT, and SHWBS, which intensifies hydrological change and increases, soil erosion risk. The eminent adverse impact on crop productivity was also evident from significant increase in heatwave severity and frequency was detected for the GWB and NMMT subdivisions under higher emissions scenarios. Our findings showed the future need to incorporate advance indices for more precise monitoring, mitigation measures for policy formulation to combat extreme events over Eastern India.

Keywords: Heat wave, rainfall erosivity, meteorological subdivision, crop productivity

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Application of Humic Substrate Solution in Soil Facilitated a Decrease in Urea Input During Indian Tea Production

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Tea *(Camellia sinensis L.)* is a perennial evergreen shrub which is used to make the most popular non-alcoholic beverage throughout the world and is consumed by over 2 billion cups per day, grows best in sub-tropical humid conditions with generally acidic soil (pH 4.5–5.5). For tea cultivation in northeast region of India, the standard advised urea application rate is 100 kg of nitrogen (N) ha^{-1}. However, research indicates that as much as 60% of the nitrogen from the applied urea can be lost to the environment through various pathways, including leaching, denitrification loss and ammonia volatilization. Humic substrates, which were obtained in this experiment by recycling tea factory waste, are highly polymerised forms of organic matter with carboxylic and phenolic groups as the dominating functional groups. This study aimed to increase soil N availability by applying a diluted solution of humic substrates (HS), which might potentially lower the amount of urea applied to the soil. According to the study, applying urea at the recommended dose (RD) significantly ($p < .05$) raised the amount of nitrate N in the soil. The enhanced culturable nitrifying and ammonifying bacterial population caused by the application of humic substrates in conjunction with urea was the cause of the greater nitrate nitrogen concentration in HS-treated soil. Therefore, HS treatment combined with lower urea dosages (75% and 50% of RD) enhanced the plants' absorption of nitrogen. According to analysis, HS application at an ideal rate of 12.5 kg ha^{-1} may lower the urea application rate by 17.4%. Additionally, the combination of 82.6% of RD of urea and HS application had demonstrated the ability to maintain tea production, which was 1.7% greater than the recommended urea treatment.

Keywords: Tea, urea, humic substrate solution

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Insights from Land Configuration with Mulching and Fertilizer Management in Rice-Based Cropping Systems in Konkan Region

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The field experiment was carried out during *kharif*, rabi and summer seasons of 2022-23 and 2023-24 at Instructional Farm, College of Agriculture, Dapoli. Dist. Ratnagiri (M.S.). The field experiments were laid out in strip plot design comprising of twelve treatment combinations replicated thrice. The vertical strips consist of four land configurations with or without mulch treatment (raised bed with mulch (M_1), raised bed without mulch (M_2), flatbed with mulch (M_3) and flatbed without mulch (M4)). Horizontal strips comprised three fertilizer management practices (RDF through straight fertilizer (F_1), Konkan Annapurna Briquettes (KAB) + Remaining N, P_2O_5 and K_2O through fertigation(F_2), RDF through fertigation (F_3). The variety Ratnagiri-1 of rice, variety Konkan bhendi of okra and variety Taiwan of green gram were used in experiment. The soil of the experimental plot was sandy clay loam in texture, low in available nitrogen, very low in phosphorus, medium in potassium, very high in organic carbon and acidic in reaction. In general, the season was favourable for the growth of rice, okra and green gram.

The treatment raised bed with mulch (M_1) produced higher system REY, gross and net returns (₹ ha^{-1}) and B:C ratio during both years of experiment and in pooled data, except treatment flat bed with mulch (M_3), which was statistically at par with treatment M_1 in respect of total system REY. Among fertilizer management practices, application of Konkan Annapurna Briquettes along with remaining N, P_2O_5 and K_2O through fertigation (F_2) recorded higher system REY, cost of cultivation, gross and net returns (₹ ha^{-1}) and best B:C ratio during both years of study and in pooled data, while treatment, RDF through fertigation (F_3) was statistically at par during second year in respect of total system REY. The interaction of raised bed with mulch and application of Konkan Annapurna Briquettes along with remaining N, P_2O_5 and K_2O through fertigation (M_1F_2) recorded higher system REY during 2023-24 and in pooled data, gross and net returns (₹ ha^{-1}) and B:C ratio during both years of study and in pooled data and was statistically at par with other treatment combinations such as raised bed with mulch and RDF through fertigation (M_1F_3), flat bed with mulch and Konkan Annapurna Briquettes plus remaining N, P_2O_5 and K_2O through fertigation (M_3F_2) and flat bed with mulch and RDF through fertigation (M_3F_3), making it most economically efficient option for rice-okra-green gram cropping system under Konkan region of Maharashtra.

Keywords: Rice-based cropping systems, mulching, fertilizer management

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Comprehensive Morphometric, Hypsometric, and Soil Erosion-based Watershed Prioritization using GIS and RS in the Mandovi River Basin of the West Coast of India

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Morphometric and hypsometric analyses are crucial for understanding the watershed dynamics, and their results are key to assess the soil erosion status. This study focuses on the geomorphology and hypsometric analyses of the Mandovi River Basin (MRB) on India's west coast. This study examined 28 parameters across 15 sub-basins using Shuttle Radar Topography Mission digital elevation model (SRTM DEM, 30 m) data, Geographic Information System (GIS), and remote sensing (RS) techniques. The morphometric analysis revealed that MRB has a 6th order stream as the highest order with moderate drainage density, ranging from 1.02 to 1.7 km/km^2, indicating a well-developed network of streams. Hypsometric curves and integrals indicated that most of the sub-basins of MRB are in a stabilized stage (Monadnock), except for sub-basins 8 and 14 (equilibrium /mature stage) and sub-basin 9 (inequilibrium/young stage). The hypsometric integral values ranged from 0.12 to 0.62, aligning with the hypsometric curve stages. The priority ranks were assigned to each sub-basin based on the results of quantitative morphometric analysis by considering 18 parameters using weighted sum analysis (WSA). The ranks were validated for each sub-basin by estimating the area under each soil erosion class using the Revised Universal Soil Loss Equation (RUSLE). From the total basin area of 1979.08 km^2, 74.77 km^2 falls under the moderately severe to extremely severe category, with 22% of this area located in sub-basin 8. Sub-basin 8 was ranked first, while sub-basin 11 was ranked last in both morphometric based as well as soil erosion-based priority ranking methods. To ensure the most erosion-prone areas are addressed first, interventions should be implemented based on the priority ranks. This study will be helpful for the effective planning and implementation of soil and water conservation measures in the most vulnerable sub-basins of the Mandovi River Basin to minimize soil erosion.

Keywords: Morphometry, hypsometry, geo-morphology, priority ranking, soil loss, RUSLE

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Landslide Susceptibility Mapping for Western Coastal Districts of India using Geospatial Techniques and Interpretable Machine Learning

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Landslide susceptibility mapping (LSM) assists in identifying probable zones for future landslide occurrences within a given location by considering various landslide-triggering factors. Most significantly, this mapping contributes to regional planning, adopting the landslide mitigation measures and raises public awareness on landslides. In the current study, LSM was carried out for western coastal districts of India using fourteen landslide-triggering factors. For locating landslide-susceptible areas and to identify the best performing model, a comparison between frequency ratio (FR), logistic regression (LR), machine learning (ML) and artificial intelligence models was performed. The ML models used in this study were random forest (RF), support vector machine (SVM), extreme gradient boosting (XGB) and deep neural network (DNN). The results revealed that most of the area was covered by very low class, i.e., 60.12% (112817.65 km^2) followed by low (13.50%; 25335.61 km^2), moderate (10.54%; 19787.36 km^2), high (8.04%; 15094.93 km^2) and very high (7.79%; 14619.55 km^2) classes, respectively. From the variable importance plots, it was found that factors such as slope, TRI, LS-factor, distance to road and rainfall were the most significant landslide-triggering factors. The area under the ROC curve (AUC) was utilised to validate the models. The results of the AUC revealed that the RF model showed an excellent accuracy rate of 0.993, followed by XGB (0.992), SVM (0.955), DNN (0.949), LR (0.919), and FR (0.906) model. The ranking based on multiple model evaluation parameters using validation dataset revealed DNN as the best-performing model. It was concluded that the performance of ML models was excellent compared to the FR model. The results of this study could help to identify landslide-vulnerable areas and adopt suitable preventive measures for mitigating the likely occurrence of future landslide events.

Keywords: Coastal ecosystem, deep neural network, landslides, logistic regression, random forest

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Downscaling of Satellite-derived Surface Soil Moisture through Machine Learning

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Soil moisture is a critical parameter in agriculture, playing a vital role in drought and flood monitoring, weather forecasting, irrigation scheduling, and crop yield prediction. However, the spatial and temporal variability of soil moisture poses challenges for accurate measurement using traditional *in-situ* methods over large areas. Remote sensing offers a promising alternative, but the coarse spatial resolution of existing satellite-derived soil moisture products—such as Soil Moisture Active Passive (SMAP) (9 km), Soil Moisture Ocean Salinity (SMOS) (50 km), and European Space Agency Climate Change Initiative for Soil Moisture (ESA CCI SM) (25 km)—limits their applicability at regional and watershed levels. This study aims to downscale the SMAP L4 surface soil moisture product from 9 km to 1 km spatial resolution for Berasia tehsil, Bhopal, using machine learning techniques. Ancillary dynamic data, including Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), surface reflectance in red and near-infrared (NIR) bands, and actual evapotranspiration, were sourced from MODIS at 1 km resolution from 2016 to 2023. Static data, such as soil texture, field capacity, permanent wilting point, and soil saturation limit, were obtained from ISRIC-SoilGrids having 1 km spatial resolution. These dynamic and static ancillary data were upscaled to 9 km for model training. Four machine learning models—Multiple Linear Regression (MLR), Artificial Neural Network (ANN), Support Vector Machine (SVM), and Random Forest (RF)—were developed using data from 2016 to 2023. The models were trained with ancillary data as predictors and SMAP L4 soil moisture as the target variable. The downscaled data was validated using *in-situ* soil moisture observations from 50 sampling sites within the study area. Results showed that the *in-situ* surface soil moisture ranged from 0.12 to 0.24 m^3/m^3, while downscaled values ranged from 0.12 to 0.17 m^3/m^3, closely following the SMAP L4 data. Validation metrics revealed RMSE values from 0.09 (RF) to 0.13 (MLR) and R^2 values from 0.08 (MLR) to 0.25 (RF). The findings suggest that the downscaling models could not accurately replicate the observed *in-situ* soil moisture variability, highlighting the limitations of using coarse-resolution satellite products for downscaling. This study recommends exploring direct estimation of soil moisture at finer resolutions from satellite data rather than relying on downscaling approaches. These insights contribute to advancing soil moisture monitoring at spatial and temporal scales.

Keywords: SMAP, surface soil moisture, remote sensing, downscaling, machine learning

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Assessment of High Minimum Temperature Stress on Green Gram and Black Gram using Controlled Chamber and Crop Simulation Model

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In Tamil Nadu, minimum temperatures have risen by approximately 0.16/ °C per decade in recent decades, with projections suggesting further increases of 1.1/ °C by the 2020s, 2.4/ °C by the 2050s, and 3.5/ °C by the 2080s relative to the 1970–2000 baseline. In this context, pot culture and field experiments were conducted during summer 2021 and 2022 at the Soil Plant Atmospheric Research (SPAR) system, Agro Climate Research Centre, TNAU, Coimbatore to investigate the effect of high night temperature (minimum temperature + 3^{o}C) (HNT) stress on green gram (CO7) and black gram (CO6). The pot experiments were laid out in a completely randomized design with 10 treatments: stress imposed from 7-14, 15-21, 22-28, 29-35, 36-42, 43-49, 50-56, 57-63, and 64-70 Days After Sowing (DAS), plus a control. The study revealed that yield components, such as grain yield, were significantly reduced in both crops under stress between 43 and 49 DAS. The DSSAT CROPGRO model was calibrated and validated for green gram and black gram cultivars using field data. Sensitivity analysis revealed that increasing the minimum temperature by 3°C during specific growth stages significantly impacted grain yield. The HNT stress reduced green gram yield by 8.5% and black gram yield by 7.6% during 43-49 DAS, followed by 50-56 and 36-42 DAS. As a result, HNT stress at different growth stages significantly impacted the grain yield of green gram and black gram. The DSSAT CROPGRO model simulations confirmed these findings, highlighting yield reductions under HNT stress.

Keywords: Minimum temperature, DSSAT, CROPGRO, green gram, black gram

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Aggregate Associated Soil Organic Carbon under Rice-based Cropping Systems of Saline Soil of West Bengal

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The soil organic carbon (SOC) sequestration through aggregation is an important indicator of soil management. Distribution of stable aggregates and aggregate-associated organic C as indicators of favorable soil structure is vital to SOC stabilization and storage and responds quickly to land-use changes. It is hypothesized that the cultivation of crops after rice alters soil aggregation, thereby changing aggregate-associated carbon content in the soil. Information on variations of different aggregate fractions, structural indices, and aggregate-associated carbon in rice-based cropping systems of saline soil of West Bengal is very scanty. Soil samples were collected from five cropping systems, three representative fields, and three soil depths, totaling 45 samples and analyzed for soil aggregate of different size fractions and C associated with them and soil physicochemical properties. Results showed significant depth-wise and cropping system-wise variations in almost all aggregate fractions, structural indices, and aggregate-associated carbon studied. The mean value of WSMicA, MWD, GMD, CMacAC, MesoAC, CMicAC, MacAC, MicAC, and SOC in bulk soil, irrespective of cropping systems, was highest and lowest in 0-20 cm and 40-60 cm soil depth, respectively. However, the mean value of WSMacA, AR, and silt+clay C showed no significant depth-wise variation. The mean value of MWD, GMD, CMacAC, MesAC, MacAC, and SOC, irrespective of soil depths, was highest in fallow land, and the mean value of WSMacA, AR, and AS was highest in rice-fallow. However, the mean values of CMicAC, MicAC, and WSMicA were highest in the rice-rice and rice-lathyrus cropping systems, respectively. However, the mean value of AS, GMD, CMacAC, MesAC, and MacAC was lowest in rice, and that of WSMacA, AR, MWD, and SOC was lowest in rice-Lathyrus. The correlation coefficient study showed that EC, available K_2O, and soil clay content were significantly and negatively correlated with MWD, CMacAC, MesAC, CMicAC, MacAC, MicAC, and bulk SOC. MWD and GMD showed a significant positive correlation with aggregate associated C. Again, except silt+clay C, all other aggregate associated C were significantly and positively correlated with each other.

Keywords: Saline soil, soil organic carbon, cropping system, aggregate associated carbon

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Prediction of pH, Electrical Conductivity and Soil Organic Carbon in Soils Using Vis-NIR Spectra and Machine Learning Models

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The present study was conducted from December, 2023 to December, 2024 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh (482004) , aimed to study physico-chemical properties such as pH, electrical conductivity (EC) and soil organic carbon (SOC) using Visible-near infrared (Vis-NIR) spectroscopy with machine learning models. We have collected two thousand two hundred sixteen (2216) Global Positioning System (GPS) based soil samples from depth of 0–15 cm from farmer's field of the Kymore Plateau and Satpura Hills zone of Madhya Pradesh . The laboratory analysis revealed that soil pH, EC and SOC ranged from 4.55 to 8.39, 0.03 to 0.97dS m^{-1} and 1.05 to 11.25 g $kg^{-1}$with mean values of 6.72, 0.25 dS $m^{-1}$and 5.51 g kg^{-1}, respectively. The spectral data were collected under laboratory conditions and analysed using machine learning algorithms, including Partial Least Squares Regression (PLSR), Support Vector Machines (SVM), Random Forest (RF), Artificial Neural Networks (ANN), XGBoost, LightGBM, CatBoost, and Extreme Learning Machine (ELM). The performance of the models was assessed using the coefficient of determination (R^2), root mean square error (RMSE), and ratio of performance to deviation (RPD). The results showed that the Random Forest, XGBoost and LightGBM models provided the best predictions for pH, EC and SOC, with a R^2 0.43, 0.41 and 0.53; RMSE values of 0.33, 0.05 and 0.47; and RPD values of 1.32, 1.25 and 1.46, respectively. The study demonstrates the potential of machine learning models to improve the accuracy of soil pH, EC and SOC predictions using spectral data.

Keywords: Prediction, soil pH, EC, SOC, spectral data, machine learning models

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Wheat Yield Estimation for Hisar District, Haryana Using a Semi-Physical Model

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Accurate estimation of crop yield is critical for effective agricultural planning and policymaking. This study focuses on the yield estimation of wheat crops in the Hisar district of Haryana , for the 2023 growing season. Using a combination of field survey data, remote sensing techniques, and statistical modeling, the study achieved an average estimated wheat yield of 4600 kg per hectare. The analysis involved integrating climatic factors such as temperature and rainfall, soil health data, and crop phenology information to ensure robust yield predictions. Results demonstrated consistency between modelled estimates and observed field yields, highlighting the reliability of the adopted methodologies. These findings provide valuable insights for local farmers, policymakers, and stakeholders, aiding in the optimization of wheat production and resource allocation in the region. Further research could focus on extending this methodology to other districts and incorporating advanced machine learning algorithms for improved prediction accuracy.

Keywords: Wheat, semi-physical model, Haryana

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Optimization of Date of Sowing and Planting Geometry of Oilseed *Brassica* using Modelling Approach

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In the 2022-2023 Rabi season, a field experiment on the RGN-73 Indian mustard variety was conducted at the Norman E. Borlaug Crop Research Centre, Pantnagar, Uttarakhand. Three sowing dates (November 12, 19, and 26) and three planting geometries (30 × 10 cm, 30 × 15 cm, and 45 × 15 cm) were tested. Results showed that mustard sown on November 12 with a closer spacing of 30 × 10 cm had the tallest plants, the highest leaf area index (LAI), and the greatest seed and biological yields, highlighting the advantage of early sowing with denser planting for maximizing yield. InfoCrop model was successfully calibrated and validated on days taken to germination, LAI, anthesis, and seed yield. Validated results measured on %RMSE and their values are 8.51, 27.88, 8.51 and 9.55 for days taken to germination, LAI, anthesis, and seed yield respectively. To optimize sowing dates and planting geometry, the InfoCrop model was successfully calibrated and validated using weather data from the previous five years. The model analysis revealed the ideal week for sowing in the Tarai region varied, with yield increases of 13.1% (2018), 14.6% (2019), 22.9% (2021), and 26.0% (2022) over 2020, and Using 30 × 10 cm (G1) as the base geometry, seed yields increased by 12.0% (30 × 15 cm, G2) and 21.1% (45 × 15 cm, G3) on 12th November, by 0.6% (G2) and 1.9% (G3) on 19th November, and decreased by 42.8% (G2) and 43.2% (G3) on 26th November, emphasizing the superior yield of G1 for late-sown mustard highlighting the need for adaptive sowing schedules to maximize productivity and providing valuable insights for planning mustard crop cultivation.

Keywords: Mustard, simulation modelling, InfoCrop

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Impact of Nano Urea Foliar Application on Nitrogen Uptake, Soil Residual N, and Yield Attributes in Rice

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A study was conducted at the IARI farm during the kharif season of 2022 to evaluate the impact of nano urea on nitrogen (N) uptake, apparent N balance, and plant biophysical attributes in basmati rice (var. Pusa Basmati-1692). The experiment, designed using both randomized block design (RBD) for field-grown rice and completely randomized design (CRD) for pot-grown rice, included three treatments: T1 [recommended dose of fertilizers (RDF), N120 P60 K40], T2 [N90 P60 K40 + 2% prilled urea foliar sprays], and T3 [N90 P60 K40 + 2 nano urea foliar sprays @ 4 ml L{ [1]], with four replications. Nitrogen fertilizers, whether applied to soil or through soil + foliar methods, had little impact on plant and root growth. Several yield attributes viz., panicle and flag leaf length, number of total and filled grains were higher with nano urea; however, the yield was comparable to soil application of urea-N. Soil application of urea resulted in higher total N-uptake, although grain N in rice was similar among treatments. Total residue N in soil and apparent N balance was comparable among the treatments; highlighting the potential of nano urea in sustaining soil fertility. However, further research is essential to establish long-term recommendations for integrating nano urea into rice nutrient management strategies.

Keywords: Rice, foliar application, nano urea, soil nitrogen

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Development of AI-Driven Weather-based Advisory for Pomegranate in Vijayapura District, Karnataka

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The development of weather-based agro-advisories for pomegranate cultivation, leveraging Artificial Intelligence (AI), represents a significant advancement in precision agriculture. This study focuses on Vijayapura district of Karnataka, a major pomegranate-growing region, to address challenges posed by weather variability and its impact on crop growth stages of fully established plantation: New Leaf Initiation (30 days), Flowering and Fruit Set (60 days), Fruit Development and Maturity (120 days), Harvesting (30 days), and Resting (120 days). Using Standard Meteorological Week (SMW) data encompassing parameters such as maximum temperature (Tmax), minimum temperature (Tmin), rainfall, relative humidity (RH_1 and RH_2) and wind speed, we developed a rule-based AI model to automate advisories tailored to each growth stage. The model integrates historical and real-time weather data to identify critical thresholds for stress conditions like heat, waterlogging, and humidity-driven pest outbreaks. Advanced AI techniques, including regression and classification models, predict weather trends and optimize decision-making. The automated advisory system, implemented in R, efficiently processes SMW data, assigns crop stages, and generates actionable recommendations. Field validation indicates significant improvements in crop management, with timely advisories enhancing yield quality and reducing losses. This study highlights the potential of AI-driven solutions to empower farmers with data-informed practices, ensuring sustainable pomegranate cultivation in semi-arid regions.

Keywords: Pomegranate, agro-Advisory, artificial intelligence, standard meteorological week, weather variability, Vijayapura district

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Forecasting Agricultural Drought Outlook for Karnataka by Machine Learning Models using Remote Sensing and Meteorological Inputs

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Timely and accurate monitoring and forecasting of drought severity, spatial extent, and progression are critical for its early warning to mitigate its impacts. This study introduces the development and application of a Composite Drought Index (CDI) to monitor and forecast agricultural drought in Karnataka . For the development of CDI, pixel-wise weightages were assigned to the computed input drought indices through Principal Component Analysis (PCA). The input drought indices were 3-month Standardized Precipitation Index (SPI-3) from precipitation, Standardized Evaporative Stress Ratio (SESR) from evapotranspiration, trend-adjusted Vegetation Condition Index (VCI_{Tadj}) from Normalized Difference Vegetation Index (NDVI), Standardized Normalized Difference Water Index (SNDWI) from Normalized Difference Water Index (NDWI), and Standardized Soil Water Deficit Index (SSWDI) from soil moisture. The CDI was computed from 2001 to 2023 at 1 km spatial and 16 days temporal resolutions during *kharif* crop season. Validation of the CDI against the Standardized Normalized Agricultural Gross Primary Productivity (SNGPP) demonstrated its ability to capture historical drought patterns, with correlations exceeding 0.6 across most regions, particularly during the mid to late *kharif* season. The CDI was subsequently utilized to forecast a 16-day agricultural drought outlook using machine learning models of Artificial Neural Networks (ANN), Classification and Regression Trees (CART), and Random Forest (RF). The input data used for forecasting of CDI outlook were CDI of the current and two previous time periods, forecasted weather data on precipitation flux, vapour pressure, cloud cover, maximum and minimum temperature of the next 16 days, and percentage of irrigated area. It was found that the RF model performed better than the CART and ANN models in generating CDI outlook with an average accuracy of 65%, which may be improvised further using hybrid techniques. The study is an advancement in developing a high resolution near-real time agricultural drought monitoring and forecast system for Karnataka. Adoption of such system by state agency may help in risk management of drought for agricultural sector by prioritizing timely initiating contingency measures and mitigation schemes.

Keywords: Crop, composite index, artificial intelligence, moisture stress

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Comparative Analysis of Agrometeorological and Remote Sensing Approaches for Rice Yield Estimation in Kuttanad, Kerala

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Rice, a staple crop for over half of the global population, requires accurate and timely yield estimation to ensure food security and optimize resource allocation. This study focuses on spatial rice yield prediction in the Kuttanad region, the rice bowl of Kerala, during the 2023–24 *Puncha* season, utilizing agrometeorological indices, optical remote sensing, and Synthetic Aperture Radar (SAR) imagery.

Agrometeorological indices were developed using long-term weather and crop yield data. Multiple linear regression models showed a significant negative correlation between rainfall and yield in Pulikeezhu ($r = -0.71$) and between minimum temperature and yield in Vaikom ($r = -0.87$) and Kaduthuruthy ($r = -0.75$). PBIAS analysis indicated deviations within ±10% for 4 of 16 blocks, demonstrating the reliability of these models.

Using MODIS-derived cumulative NDVI (ΣNDVI), optical remote sensing demonstrated a strong relationship with rice yield ($R^2 = 0.885$). PBIAS deviations for optical-based predictions were within ±10% in 12 of 16 blocks, with Veeyapuram Panchayath recording the highest yield (4800 kg ha^{-1}) and Kavalam the lowest (2600 kg ha^{-1}).

SAR data from Sentinel-1A provided all-weather imaging, with dual-polarization backscatter coefficients (σp VH and σp VV) showing a strong correlation with NDVI during the reproductive stage. This correlation was used to calculate a corrected ΣNDVI, which showed a robust polynomial relationship with rice yield, achieving an R^2 of 0.8957. PBIAS analysis for SAR-based predictions indicated deviations within ±10% in 13 of 16 blocks.

The integration of optical and SAR remote sensing effectively captured spatial and temporal variability, providing improved yield predictions compared to standalone approaches. These findings highlight the potential of advanced remote sensing techniques for sustainable agricultural planning in regions vulnerable to climate variability.

Keywords: Remote sensing, rice, kerala

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Integration of Remote Sensing and DSSAT CSM for Sorghum Yield Estimates at Regional Scale

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India's village-level agricultural data plays a pivotal role in shaping policies for a resilient crop insurance sector. This study blends the precision of remote sensing with the analytical strength of simulation models to enhance crop monitoring and yield prediction. Sentinel-1A SAR data, with its ability to penetrate clouds and capture spectral information every 12 days, was instrumental in this analysis. Ground truthing, conducted at over 140 points in Karnataka, estimated rabi sorghum acreage for 2022-23 with a commendable kappa index of 0.74 and 87.2% accuracy. The DSSAT crop simulation model was employed to estimate LAI and yield at selected monitoring locations, with simulated LAI and yield ranging from 2.6 to 4.65 and 749 to 1097 kg/ha, respectively. Validation against observed data revealed an agreement above 85%, with RMSE below 9% and R^2 exceeding 72%. Robust correlations were also established between VH polarized SAR values and LAI ($R^2 > 0.70$), as well as between spatially derived LAI and simulated yield ($R^2 > 0.72$). Crop Cutting Experiments further validated the findings at key verification sites. The resulting spatial maps of LAI and yield stand as practical tools, guiding agricultural decision-making and strengthening the foundations of crop insurance strategies. This research underscores the synergy of technology and data in addressing the challenges of modern agriculture.

Keywords: Village-level statistics, kappa index, DSSAT and LAI

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Impacts of Strategic Tillage on Rice Productivity, Soil Health and Environmental Sustainability under Long-term Conservation Agriculture

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In some systems of conservation farming adopting only no-tillage (NT) without residue has led to problems/difficulties of soil compaction, weed flora shift, and accumulation/ congregation of nutrients and organic matter in surface layer of soil. In NT systems, strategic tillage (ST) has been employed as a soil management technique in an effort to overcome these obstacles. However, very less study has been undertaken to understand about how ST does affect environmental and agronomic performance of a crop under conservation agriculture (CA). Keeping all these in view, this field study was carried out during 2024-25 *kharif* at ICAR-Indian Agricultural Research Institute, New Delhi with the objective to evaluate strategic tillage effects on rice productivity, profitability, and resource-use efficiency under conservation agriculture and its impact on environment and soil health. The experiment was laid out in a randomised block design (RBD) with three replications with five tillage and establishment practices. They were wheat residue retention (WRr) + zero till direct seeded rice (ZTDSR) – RR (rice residue retention) + ZTW (T_1); strategic tillage (ST) + wheat residue incorporation (WRi) + DSR– RR + ZTW (T_2); mungbean residue retention (MbRr)+ ZTDSR– ZTW +RR – mungbean (Mb) + WRr (T_3); ST+ mungbean residue incorporation (MbRi) + DSR– RR+ZTW – WRr +ZTMb (T_4) and puddled transplanted rice (PTR) – conventional till wheat (CTW) (T_5), respectively. The PTR–CTW system (T5) as usual gave significantly higher yield of rice than in other treatments. However, among the CA and ST treatments, the strategic tillage (ST) + wheat residue incorporation (WRi) + DSR– RR + ZTW (T_2) resulted in highest yield was next to the PTR –CTW (T5). But, with respect to GHGs emission, the T_2 resulted in lower value than in the T5. Also, higher total organic carbon was found in T_3. The ST had no significant effect on overall microbial activity, but it could improve the microbial biomass carbon in soil. Additionally, ST led to better weed control. Therefore, the strategic tillage (ST) may be a promising option for promoting and maintaining the sustainability of rice production under long-term conservation agriculture.

Keywords: Occasional tillage, weed management, establishment method, direct seeded rice

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Long-term Effects of Conservation Agriculture on Soil Physical Properties in Pigeon Pea-Wheat System

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Conservation agriculture (CA) practices, including minimal soil disturbance, permanent organic cover, and crop diversification, offer benefits such as carbon sequestration, improved soil properties, and enhanced crop productivity. In the Indo-Gangetic Plains (IGP), the conventional rice-wheat system poses challenges to food security and sustainability. Replacing rice with short-duration pigeon pea in CA could be crucial. This study, conducted over 12 years at ICAR-IARI, New Delhi, assessed the impact of a CA-based pigeon pea-wheat system on soil properties. Treatments were conventional till flatbed (CT), zero till (ZT) permanent narrow bed with and without residue (PNBR & PNB), broad bed with and without residue (PBBR & PBB), and flat bed with and without residue (PFBR & PFB). Further, the residue treatments had 75% and 100% of the recommended N for wheat grown during 2021-22 (i.e., PNBR75N, PNBR100N; PBBR75N, PBBR100N; PFBR75N, PFBR100N). The results indicated that CA practices significantly influenced soil physical properties, such as bulk density, soil aggregation, and soil temperature, at both 0-5 cm and 5-15 cm depths. Residue retention under CA improved soil aggregation, with a higher proportion of small macroaggregates compared to other aggregate fractions. Additionally, the CA-based raised bed system reduced bulk density (BD) by 7.4-9% at 0-5 cm and 2.5-3.1% at 5-15 cm compared to conventional tillage (CT). The CA treatments also moderated soil temperatures during the morning and afternoon. These residue retention practices not only enhanced soil properties but also saved resources compared to no residue and CT treatments. Therefore, implementing CA-based pigeon pea-wheat systems with 75 or 100% nitrogen application could be a sustainable practice, improving productivity and soil health in the Indo-Gangetic Plains (IGP) of India.

Keywords: Conservation agriculture, soil physical properties, pigeon pea-wheat system

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Non-Invasive Detection of Bacterial Leaf Blight in Rice Using Spectral Reflectance

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Bacterial Leaf Blight (BLB), a devastating disease in rice crops caused by *Xanthomonas oryzae pv. oryzae*, poses a significant threat to global food security. Early and accurate detection of BLB is critical for effective management and minimizing yield losses. This study focuses on identifying sensitive spectral regions using multispectral reflectance data to differentiate between BLB-infected and healthy rice plants in controlled laboratory condition. The experiment involved 16 pots inoculated with BLB and 4 control pots without the disease. Spectral reflectance data were collected on the day of inoculation, spanning wavelengths from 400 to 1600 nm. Qualitative analysis of spectral curves revealed significant differences between infected and healthy plants in the visible (550–680 nm), red-edge (700–750 nm), near-infrared (750–1300 nm), and shortwave infrared (1400–1600 nm) regions. These changes were attributed to chlorophyll degradation, red-edge shifts, cellular structure damage, and alterations in water and biochemical content. Statistical and machine learning approaches further validated these spectral regions as sensitive indicators for detecting BLB. The study highlights the potential of hyperspectral and multispectral sensors for early-stage disease identification, offering a non-invasive, efficient, and scalable solution for crop health monitoring.

Keywords: Bacterial leaf blight, rice, spectral reflectance, hyperspectral imaging

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Effect of Magnetic Treatment of Seeds on Biophysical Parameters and Yield Characteristics of Wheat Grown under Different Irrigation Conditions

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Magnetic field exposure of seeds influences the physiological and biochemical process in seeds and thereby. improved the yield without adversely affecting the environment. An experiment was conducted with an aim to study the effect of pre-sowing wheat (Var. HD-3086) seed treatment by magnetic field on biophysical parameters, radiation use efficiency, water productivity and yield. Initial experiments were conducted to standardize the magnetic field and duration for maximum enhancement of germination characteristics. Wheat seeds were treated to magnetic field of 50 mT to 250 mT in steps of 50 mT for ½ hour and 1 hour in all the field strengths by electromagnetic field generator. Results showed that magnetic field application enhanced seedling shoot length, seedling root length, seedling dry weight, seedling vigour I and seedling vigour II over control. Seed treated by 150 mT for ½ h followed by 100 mT for ½ h was found best among all the ten magnetic treatments. Seeds treated by 150 mT for ½ hour and 100 mT for ½ hour were sown in the field along with untreated control under five, three and two irrigations. The plants raised from seeds treated by 150 mT for ½ hour and 100 mT for ½ hour showed enhancement in biophysical parameters, yield, radiation use efficiency and water productivity as compared to control. Plant raised from seed treated by magnetic field had significantly higher value of total root length, root surface area, root volume and root average diameter as compared to corresponding value in control at different growth stages in all irrigation levels. The photosynthesis rate, stomatal conductance and transpiration rate at flowering and late jointing stage were greater in plant raised from seed treated by magnetic field than control. Plant raised from seed treated by magnetic field had higher value of relative water content, radiation use efficiency, IPAR and fIPAR as compared to control in all irrigation levels. Water productivity was found to be higher in plant raised from seed treated by magnetic field as compared to corresponding value in control in all irrigation levels. Water productivity had higher value in two irrigation followed by three and five irrigation in all the treatments. Plant raised from seed treated by magnetic field 150 mT for ½ hour performed better than plant raised from seed treated by magnetic field 100 mT for ½ hour in all irrigation levels. Hence it may be concluded from this study that seeds treated by magnetic field 150 mT for ½ hour and 100 mT for ½ hour improved germination characteristics. Also improved LAI, chlorophyll concentration, root parameters and biomass led to enhanced seed yield, radiation use efficiency and water productivity as compared with corresponding value in control under different irrigation conditions.

Keywords: Biophysical parameters, wheat, magnetic treatment

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Drone based Multispectral Sensing for Precision Nitrogen Monitoring of Wheat

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Accurate assessment of leaf nitrogen content (LNC) is essential for optimizing nitrogen management in wheat production. This study, conducted under the ICAR-Network Program on Precision Agriculture (NePPA), examines potential use of some nitrogen-sensitive vegetation spectral indices for LNC estimation, narrowing down to two commonly used indices namely the Normalized Difference Vegetation Index (NDVI) as well as the Normalized Difference Red Edge Index (NDRE). The analysis was performed at two critical growth stages (Flowering and Grain Filling) across three wheat varieties: DBW-187, HD-3086, and PBW-826. NDVI and NDRE values were derived from drone-based multispectral imagery, while LNC was determined using a CHNS analyzer. Pearson correlation analysis revealed strong positive correlations between NDVI and LNC (R^2 = 0.61 to R^2 = 0.75) and NDRE and LNC (R^2 = 0.63 to R^2 = 0.80) across growth stages and varieties. Notably, the correlation was stronger for NDRE across all varieties, particularly during the Grain Filling stage, indicating that NDRE is more sensitive to nitrogen content at later growth stages than NDVI. Regression models revealed variety-specific differences in both NDVI-LNC and NDRE-LNC relationships, underscoring the need for tailored calibration models for precise nitrogen management. These results highlight NDRE as a more reliable indicator of LNC than NDVI, particularly during key phenological stages, and emphasize its application in site-specific nitrogen management strategies for sustainable wheat production.

Keywords: Leaf nitrogen content, NDVI, NDRE, UAV multispectral imaging, precision nitrogen management, sustainable wheat production

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Effect of Different Conservation Agriculture-based Practices on Soil Quality and Wheat Crop Yield

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In the present study, the soil health indicators, root growth parameters and wheat yield were assessed under a long-term CA based rice -wheat cropping system with 7 treatments i.e., T1, ZTDSR-ZTW; T2, ZTDSR + BM-ZTW; T3, ZTDSR+ Wheat residues (WR)-(R) +ZTW; T4, ZTDSR+(WR) +BM-RR+ ZTW; T5, ZTDSR-ZTW- ZTMB; T6, ZTDSR+MBR- ZTW+RR-ZTMB+WR; T7, TPR -CTW. PCA based SQI was developed and SQI and crop yield was plotted for different treatments and for different soil depths. Triple cropping system with residue retention (T6) showed a significant decrease (5.1%) than triple cropping system without residue retention (T5) in bulk density (BD) in the surface soil layer. Increase macroaggregates, water-stable aggregates (WSA), hydraulic conductivity (HC) and mean weight diameter (MWD) were observed under T6 treatment. Among residue retention plot, T6 (triple cropping system) showed significant increase in both MWD and soil organic carbon (SOC). T6 had shown maximum increase (i.e., 81.3 and 316.3%) for acid phosphatase activity and (68.3 and 96.6%) for alkali phosphatase activity over T7 for 0-15 cm and 15-30 cm, respectively. Our result revealed that ZT practices like T4, T5 and T6 showed a significant increase in yield i.e., 14.2, 15.84 and 16.02% over T7 (CT). The T6 showed significant increase (23.5, 25.2, 75, 47.3%) over T7 (CT) in root mass density (RMD), root length density (RLD), root surface area density (RSAD), root diameter (RD) for 0-15 cm, respectively. T6 treatment showed maximum SQI values and soil alkali phosphatase, available P and BD were included in SQI based on the weightage obtained from PCs. Relationship of wheat yield and SQI from the field experiment data showed positive relation with a R^2 value of 0.58. Farmers should be motivated to adopt CA practices as it enhances the soil's physical, chemical, and biological health indicators, root growth and crop yield.

Keywords: Soil quality, conservation agriculture, wheat

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Effect of Nitrogen Levels on Performance of Promising Entries of Dual Cut Oat (*Avena sativa* L.)

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In the present study, different nitrogen levels were assessed on the performance of dual cut oat. The experiment was laid out in split plot design with three replications. Main plot treated with different oat varieties (OL-1876-2, OL-1906, HFO-611, JHO-17-4, JO-10-506, UPO-212, JHO- 822) and sub plot treated with four levels of nitrogen (35 kg, 70 kg, 105 kg, & 140 N kg ha^{-1}) with cutting schedule I^{st} cut at 55 days after sowing (DAS) and II^{nd} cut at 35 days after first cut. The oat crop was sown date on 27 November 2019. Seed was used @ 100 kg ha^{-1} in each plot. The data revealed that green fodder yield (28.0 t ha^{-1}), dry fodder yield (4.2 t ha^{-1}) was obtained in UPO-212 with the application of 140 N kg ha^{-1} at 55 DAS fallowed by OL-1906 with the application of 105 N kg ha^{-1}. Similar trend were found in case of growth parameter like plant height, number of tillers, leaf area index (LAI), fresh weight of plant. However, in cutting schedule as influenced by different varieties, oat maximum total green fodder yield (76.0 t ha^{-1}) was recorded in UPO-212 and in case of different nitrogen levels, green fodder yield (71.5 t ha^{-1}) was maximum with application of 140 N $kgha^{-1}$ which was significantly higher over rest of the treatments. The maximum nitrogen uptake (99.87 kg ha^{-1}) at I^{st} cut and (162.56 kg ha^{-1}) at II^{nd} cut were observed in UPO-212 variety with application of 140 N kg ha^{-1}.

Keywords: Nitrogen, dual cut oat

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Sulphur Distribution and Fractionation in Calcareous Soils: Impact of Long-Term Organic and Inorganic Inputs in Rice-Based Systems

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This study examines the long-term effects of organic and inorganic fertilizers on soil sulphur (S) dynamics and fractionation in rice-based cropping systems on calcareous soils, addressing critical gaps in understanding S distribution and availability. The findings reveal that prolonged fertilization significantly influences S content across various soil depths, with the most pronounced increases in available S occurring at 30-45 cm, particularly in plots treated with compost. Compost amendments were especially effective in enhancing S availability, promoting greater S accumulation compared to inorganic fertilizers alone. The fractionation analysis highlighted that fertilization strategies and cropping systems affected different S fractions, with organically bound sulphur being the dominant form. Total S content increased substantially with the application of both organic and inorganic fertilizers, with compost at 5 t ha^{-1} showing the greatest impact. The study also demonstrated that S concentrations increased with soil depth, influenced primarily by organic inputs such as compost. These results emphasize the crucial role of organic inputs, particularly compost, in improving S availability and its distribution within the soil profile, which is essential for optimizing nutrient management in rice-based cropping systems. The research underscores the importance of adopting long-term fertilization strategies that combine organic and inorganic inputs to enhance soil health, sustain crop productivity, and ensure the efficient cycling of essential nutrients like sulphur. By providing insights into the interplay between fertilization practices and sulphur dynamics, the study offers valuable guidance for sustainable agricultural management in rice-based systems, particularly in calcareous soils, where the use of compost can significantly boost available S levels and improve overall soil fertility.

Keywords: Compost, cropping systems, sulphur, integrated plant nutrient system, organics

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Impact of Combined Organic and Inorganics on Nutrients Uptake & Achieving Targeted Rice Yield in Rice Based Cropping Systems in Calcareous Soil

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This study evaluated the effects of combining organic and inorganic nutrient management strategies on nutrient uptake and rice yield within calcareous soil conditions in Bihar . Conducted as part of the AICRP on Soil Test Crop Response, the experiment nine treatments, incorporating various levels of nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) using the Integrated Plant Nutrient System (IPNS) under examined three cropping systems—Rice-Wheat, Rice-Mustard, and Rice-Winter Maize and a control setup without IPNS. The experimental design was a split-plot setup with 81 treatment combinations, implemented with nine treatments, including IPNS applications (T7, T8, and T9). Among these, Treatment T9 (Y3 with IPNS) consistently achieved the highest nutrient uptake and yields. The IPNS treatment significantly improved nutrient availability, resulting in enhanced yields, with T9 producing 46.64 q ha^{-1} in grain yield, meeting and exceeding the target yield of 45 q ha^{-1}. The analysis revealed that the Rice-Winter Maize system had superior nutrient uptake and yield, with the Rice-Wheat system showing comparatively lower values. Statistical analyses, including ANOVA, highlighted significant differences among treatments and cropping systems. Notably, the IPNS treatments led to higher plant height, increased tiller count, and a greater number of grains per panicle, all essential factors contributing to higher yields. T9 recorded the highest straw yield (6.20 t ha^{-1}), biological yield (10.58 t ha^{-1}), and the tallest plants (111.7 cm). Furthermore, IPNS treatments demonstrated efficient nutrient recovery, particularly for N and P, critical in calcareous soils with limited nutrient availability. This study underscores the efficacy of IPNS in calcareous soils for optimizing nutrient uptake, achieving yield targets, and promoting sustainable agriculture. Findings suggest that incorporating organic inputs with inorganic fertilizers can significantly enhance rice productivity, especially in systems prone to nutrient constraints. The IPNS approach, especially T9, emerges as a promising strategy for improving soil fertility and achieving high yields, supporting sustainable agriculture in nutrient-deficient calcareous soils. These findings underscore the importance of balanced nutrient management for sustainable agriculture.

Keywords: Integrated plant nutrient system, STCR - Soil test crop response, rice yield, calcareous soil, cropping systems

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Mapping Banana Plantation from Fixed wing UAV Remote Sensing through Machine Learning

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Banana is one of the most widely consumed fruits globally, serving as a vital food source and an economic crop. This study investigates the feasibility of using multispectral data integrated in a fixed wing UAV through machine learning models for large-area detection of banana plantations under ICAR-Network Program on Precision Agriculture (NePPA). The aim is to improve classification accuracy across heterogeneous landscapes while assessing the performance of four machine learning models: Support Vector Machine (SVM), Artificial Neural Network (ANN), Random Forest (RF), and K-Nearest Neighbor (KNN). The workflow was divided into five key steps: (1) UAV multispectral data acquisition with a spatial resolution of 8 cm. (2) Data pre-processing included radiometric corrections, mosaicking, NDVI calculation. (3) Image segmentation was performed to determine training and validation data. (4) Pixel-based classification with optimized hyperparameters for each model, determined through running several experiments. (5) Finally, accuracy assessment metrics such as overall accuracy, and the kappa coefficient. Among the models tested, Random Forest (RF) emerged as the most effective, achieving a classification accuracy of 94.34%, attributed to its robust ability to handle high-dimensional data and avoid overfitting. KNN demonstrated moderate performance with an accuracy of 86.35%, followed by ANN (81.55%) and SVM (81.39%). The comparative analysis underscores the strength of ensemble-based methods like RF for high-accuracy classification in large, multi-field areas with varying crop and vegetation conditions. The study highlighted the potential of UAV-based multispectral data and machine learning models for efficient crop monitoring, offering valuable insights for precision agriculture and effective plantation management.

Keywords: Precision agriculture, machine learning, unmanned aerial vehicle (UAV), image classification

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Optimizing the Sowing Time of Groundnut Over Rayalaseema, a Rainfed Region of India

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Crop productivity in rainfed areas is highly vulnerable to intra-seasonal rainfall variability. Field experiments were conducted to study the influence of weather parameters during different phenophases on the growth and performance of groundnut (cultivar K6) during 2015-2020 at Agricultural Research Station, Ananthapuramu district, Andhra Pradesh in view of increasing intra-seasonal rainfall variability over Rayalaseema region falling in semi-arid region of India. The results indicated that the amount and distribution of rainfall during different phenophases were the parameters that most influence dry matter production, phenology, and pod yield in groundnuts. The amount of rainfall received during pod initiation to pod maturity stage was most critical to reap higher pod yield than the rainfall received during other phenophases (sowing-emergence, emergence-50% flowering, and 50% flowering-pod initiation). The analysis of rainfall pattern during 2015-2020 indicated that the rainfall received synchronized with pod initiation to maturity stage of crop sown on the second fortnight (IIFN) of July resulting in higher dry matter production (456 g m^{-2}) and pod yield (1123 kg ha^{-1}). On the other hand, the pod initiation-pod maturity stage with I FN of August sown crop was exposed to less rainfall that led to soil moisture stress during the stage and resulted in lower dry matter production (335 g m^{-2}) and ultimately registered lower pod yields (815 kg ha^{-1}). The correlation between the pod yield and dry matter production during the pod initiation-pod maturity stage was significantly positive (r=0.57). In addition to reduced dry matter production, the duration of the pod initiation-pod maturity stage with I FN of August sown crop was considerably less (47 days) as compared to II FN July (54 days) and I FN of July (50 days) sown crops, thereby reducing the pod filling period that drastically affected the pod yield. Hence, in the context of change in intra-seasonal rainfall pattern, the present sowing time needs to be advanced from I FN of August to II FN of July to mitigate the terminal moisture stress during pod initiation-pod maturity stage and for maximizing groundnut pod yields in rainfed areas of Rayalaseema region in semi-arid India.

Keywords: Groundnut, rainfed, India

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Impact of Water Regimes on Growth and Yield of Three Major Millet Crops in Delhi Region

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Millets are some of the world's oldest cultivated crops, and are primarily consumed by traditional communities in rural and tribal areas. India is the leading producer of millets in the world followed by Niger and China. These have a wide capacity for adaptation as they can grow from coastal regions to moderately high altitudes of North-eastern states and hilly regions of Uttarakhand. Due this versatility, millets are known as climate resilient crops. An experiment was conducted during kharif season 2023 the experimental field of the Division of Environmental Sciences, ICAR-Indian Agricultural Research Institute, New Delhi. The experimental field has sandy loam soil on which the performance of major millet crops like sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*) and finger millet (*Eleusine coracana*) under irrigated and rainfed conditions with recommended fertilizer (NPK) dose for respective crops. In the rainfed conditions, all three crops had early flowering by about 6-10 days and physiological maturity by 10-15 days as compared to the irrigated ones. On the other hand, plant height and biomass was significantly higher in irrigated condition. The TDM increased by 17.9% and 13.15% in sorghum, pearl millet and finger millet respectively in irrigated conditions as compared to rainfed condition.

Keywords: Water regime, millet, Delhi

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First Derivative and Red-edge Analysis of Wheat Yellow Rust (*Puccinia striiformis* f.sp. *tritici*)

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The potential of hyperspectral reflectance data was explored to assess the severity of yellow rust disease (Biotroph *Puccinia striiformis*) of winter wheat in the present study. The hyperspectral remote sensing data was collected for 10 wheat (Triticum aestivum L.) genotypes at different levels of disease infestation (0 to 9 Disease Score) using a field spectroradiometer over the spectral range of 350 to 2500nm. First derivative of spectral responses was calculated to identify the sensitive band or the sensitive range of the whole spectra responsible for yellow rust severity assessment. Specifically, 530-580 nm region in yellow band; 670 - 740 nm in the transition zone of visible-NIR region; and 995 nm to 1195 nm in NIR range showed distinct response among all the severity levels. Red Edge Value (REV) and Red Edge Position (REP) both exhibit a significant connection with stress level. Distinct difference among all the stress levels was clearly depicted in 730 nm region, known as red edge value. The result showed that the identified spectral region had a great potential for precise delineation and detection of yellow rust disease in winter wheat crop.

Keywords: Wheat yellow rust, hyperspectral reflectance, disease score, first derivative, REV, REP

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Do Climate Extremes Threaten the Success of the Indian Dairy production? A Five-Decadal Assessment of Their Impact on a Key Winter Forage

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Numerous studies worldwide have highlighted the complex and multifaceted effects of climate change on crops and agricultural production systems. Among these, the Indian scenario presents one of the most challenging contexts due to its vast agroclimatic and ecological diversity. The country's agricultural sector, which supports a significant proportion of the population, is particularly vulnerable to the severe repercussions of climate variability and extremes. Despite this, the specific impact of climate extremes on intensive fodder production in India remains underexplored, primarily due to the lack of continuous, long-term crop production datasets for fodder crops. In this study, we utilized a unique long-term crop production dataset maintained by ICAR-NDRI, spanning from 1973 to 2022, to evaluate the effects of climate attributes and extreme weather events on fodder oat production. Historical climate data from the India Meteorological Department (IMD) were analyzed to identify trends, extreme events, and patterns using 25 climate and extreme weather indices. The assessment employed several non-parametric statistical methods to explore the relationships between climatic factors and fodder production. Our findings revealed that minimum temperature, rainfall distribution, diurnal temperature range, and the frequency of summer days significantly influenced fodder oat production. These results underscore the critical role of specific climatic variables and their extremes in shaping agricultural outcomes. This study not only highlights the vulnerabilities of intensive fodder production systems to climate variability but also emphasizes the importance of developing contingency strategies to mitigate potential impacts.

Keywords: Climate change, extreme weather events, fodder oat, winter fodder, commercial dairy production

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An Ensemble Machine Learning Approach for Estimating Farm Scale Profile Soil Moisture Stock Using Remote Sensing and Soil Physical Properties

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A timely and accurate evaluation of soil moisture (SM) is crucial for developing science-based water management strategies in water-limited arid and semi-arid regions. However, most existing studies focus on surface soil moisture (SSM). In contrast, the prediction of profile soil moisture (PSM) has been overlooked due to the lack of long-term field observations. Though PSM has been successfully predicted at regional or global scale using theoretical and empirical models derived from remote sensing data, those available at coarser resolution are unsuitable for farm-scale operations. This study aims to map PSM up to a 1 m depth at a 30 m spatial resolution in a semiarid farm by integrating optical-thermal remote sensing data from Landsat 8/9 with soil physical properties and elevation information in machine learning (ML) models, like random forest (RF), Cubist, Gradient Boosting Machine (GBM), and ensemble ML approaches. The study identified key variables for PSM prediction across all soil depths using Boruta feature selection. The results indicated that the ensemble model outperformed the standalone ML models, predicting PSM with correlation coefficients (r) of 0.83, 0.85, 0.86, and 0.85 and root mean square errors of 3.11%, 2.76%, 2.65%, and 2.48% for soil depths of 0-20 cm, 0-40 cm, 0-60 cm, and 0-100 cm, respectively. It was observed that SSM's influence on PSM prediction is significant only up to a depth of 60 cm, with soil physical characteristics and elevation data also being important. Interpretable machine learning (IML) analysis revealed a direct relationship between SSM and PSM and an inverse relationship between land surface temperature (LST) and spectral bands. SHapley Additive exPlanations (SHAP) analysis confirmed that remote sensing variables were most influential in predicting PSM up to 60 cm depth. This study can thus be used for regional PSM monitoring and water resources management.

Keywords: Profile soil moisture, machine learning, interpretable machine learning, landsat, remote sensing

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Ecosystem Service Calculator (ESS CAL): A User-friendly Interface to Quantify Monetary Value of Ecosystem Services for an Arable Agroecosystem

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As the largest engineered ecosystem, agriculture has become the world's most extensive land use, comprising over 40% of the total global land area but relying upon services provided by natural ecosystem practices. An ecosystem services calculator (ESSCAL) must be developed to quantify soil ecosystem services under different farming systems and agricultural management practices and translate the existing soil ecosystem services (or their absence) into quantifiable classes. In the research, an ecosystem service calculator was created with the goal of offering an engaging and easy-to-use tool for stakeholders to compute ecosystem services. The web application has been developed using Hyper Text Markup Language (HTML), Cascading Style Sheet (CSS) and JavaScript. The HTML is used to structure and layout the user interface (UI) of the application, which was designed to ensure a smooth user experience. Different components of UI were also created using the HTML such as navigation, menus, forms, buttons, user interaction points, etc. All the mathematical calculations and equations were implemented using the JavaScript language. The ESS CAL was developed to quantify four major categories of ecosystem services i.e. provisioning, regulating, supporting and cultural services as per Millennium Ecosystem Assessment and ecosystem disservices. Under provisioning service, it quantifies value of grain and by product yield and under regulating service it quantifies monetary value of SOC accumulation, available N, P, K, and water holding services. In case of supporting services, it considers soil formation, soil fertility, ground water recharge and biological control of pest and GHG emission and soil erosion as ecosystem dis-services. As a whole ESS CAL gives an overall outlook, that how much return from a arable agroecosystem could be obtained in monetary terms.

Keywords: Ecosystem services, monetary value, supporting services, regulating services

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Development of Tillage and Residue Mulching Module in InfoCrop to Simulate Yield, Water and Nitrogen Productivities in Wheat under Changing Climate

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Food and nutritional security are the most important pillars for achieving sustainable development goals (SDGs). Both these are challenged because agricultural production is constrained by competition for input resources (water and nutrients), land, and labour and super-imposed by climate change. Tillage and crop residue mulching have profound influence on soil properties, crop productivity, and input use efficiencies. The InfoCrop V2.1 model, an indigenous generic crop simulation tool, has limited ability to replicate the impacts of different tillage and residue mulching practices. In this study, an attempt was made to develop the tillage and residue mulching module in InfoCrop model V2.1 to simulate its effect on crop growth, water productivity (WP) and nitrogen productivity (NP) of wheat under different tillage [conventional tillage (CT) and no-tillage (NT)], residue mulching (with residue mulching (R+) and without residue (R0)], nitrogen [50% (N50%), 100% (N100%) and 150% (N150%) RDN] and irrigation [full irrigation (IF) and deficit irrigation (ID)] management practices for different climate scenarios. The tillage induced dynamic changes in bulk density and the ensuing effects of altered soil hydraulic characteristics in surface and subsurface soil layers were the primary focus of the tillage implementation. Using parameters such as residue application timing and amount, as well as residue mulching coverage, the residue mulch module was implemented with an emphasis on how mulch affects soil evaporation and the ensuing implications of altered soil water characteristics. The evaluation of modified InfoCrop model showed that it could account 84% variation in the observed wheat grain yield with an RMSE of 382 kg/ha and nRMSE of 8.6%. It also showed satisfactory result for validation of WP and NP with R^2 0.82 and 0.97, RMSE of 0.11 and 4.67 and nRMSE of 6.3 and 8.5% respectively. NTR+IFN100% treatment significantly improved all of the yield, WP and NP as compared to farmer's practice under both baseline and RCP4.5 climate change scenarios.

Keywords: Tillage, changing climate, wheat

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Drone-Based Water Stress Monitoring under Varied Irrigation and Nitrogen Levels in Wheat (*Triticum aestivum* L.)

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The growth of wheat (*Triticum aestivum* L.) is heavily dependent on two critical factors: water and nitrogen. Drone-based thermal imagery offers an efficient method for monitoring crop water stress in real-time, facilitating precise irrigation management and optimized water usage. A field experiment was conducted to evaluate water stress through drone-based thermal remote sensing and understanding its relationship with varying irrigation and nitrogen levels in wheat crops. The study included three irrigation treatments (I1: no irrigation, I2: two irrigations, I3: five irrigations) and six nitrogen levels (N1-N6: 0-200 kg N ha{ ^{1}), arranged in a split-plot design. Thermal and multispectral images were captured using a drone-mounted camera system, enabling the extraction of precise canopy temperature data. By co-registering the Normalized Difference Vegetation Index (NDVI), pure canopy temperature data were successfully isolated, which correlated strongly with ground truth measurements ($R^2 = 0.92$). Using drone-based thermal imagery, the Simplified Crop Water Stress Index (CWSIsi) was derived to assess water stress in wheat, showing strong correlations with relative leaf water content (RWC, $R^2 = 0.73$), stomatal conductance (Gs, $R^2 = 0.63$), transpiration rate (Ts, $R^2 = 0.73$), and a moderate correlation with surface soil moisture ($R^2 = 0.56$) during the reproductive stage. RWC, Gs, and Ts significantly increased with both irrigation and nitrogen application up to 120 kg N ha^{-1}. Notably, CWSIsi was highly sensitive to water and nitrogen stress, with higher canopy temperatures corresponding to increased water stress in non-irrigated treatments and reduced stress under higher nitrogen applications. The CWSIsi index also exhibited strong negative correlations with both grain yield ($r = -0.846$) and biological yield ($r = -0.848$), suggesting its potential for predicting crop yields. This study highlights the potential of drone-based monitoring to accurately assess water stress in wheat, providing valuable data to guide irrigation and nitrogen management decisions. Ultimately, this approach can improve crop water productivity and reduce the environmental impact of wheat farming.

Keywords: Crop water stress index, drone, irrigation management, thermal imagery, wheat

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Integrated Application of Municipal Solid Waste Compost and Fertilizer Improves Soil Nutrient and Nutritive Value of Dual Purpose Barley Fodder

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A field experiment was carried out during the *Rabi* season of 2017-18 and 2018-19 at the Research Farm of Agronomy section, ICAR- National Dairy Research Institute (ICAR-NDRI) Karnal, Haryana to assess the effectiveness of municipal solid waste compost (MSWC) in combination with fertilizer with respect to soil nutrient and nutritive value of barley fodder. The soil of the experimental field (0-15 cm) was clay loam in texture, neutral to slightly alkaline in reaction, medium in organic carbon and available K, low in available N and high in available P. The experiment was laid out in RCBD with three replications and 18 treatments viz.,T_1: Control, T_2: 100% RDF + 20 kg ZnSO4/ha (RP), T_3: 5 t FYM + 100% RDF, T_4: 5 t MSWC + 100% RDF, T_5: 5 t MSWC + 75% RDF, T_6: 5 t MSWC + 50% RDF, T_7: 6.25 t MSWC + 100% RDF, T_8: 6.25 t MSWC + 75% RDF, T_9: 6.25 t MSWC + 50% RDF, T_{10}: 7.50 t MSWC + 100% RDF, T_{11}: 7.50 t MSWC + 75% RDF, T_{12}: 7.50 t MSWC + 50% RDF, T_{13}: 8.75 t MSWC + 100% RDF, T_{14}: 8.75 t MSWC + 75% RDF T_{15}: 8.75 t MSWC + 50% RDF, T_{16}: 10 t MSWC + 100% RDF, T_{17}: 10 t MSWC + 75% RDF, T_{18}: 10 t MSWC + 50% RDF.

Experimental results showed that crude protein and neutral detergent fiber (NDF) content of dual purpose barley fodder were affected significantly with the integrated use of MSWC and fertilizer. The higher value of CP content was observed with the application of T_{16} (10.4%) over other treatments, but remained at par with $T_{13}T_{17}$ and T_{14} (10.2, 9.96 & 9.90%, respectively). While in case of NDF, T_{16} found with lower NDF content of fodder over other applied treatment, however it was at par with the treatments T_{13}, T_{17} and T_{10} (43.6, 45.6 & 45.8%, respectively). With respect to soil studies, further application of T_{16} treatment recorded noticeably higher $KMnO_4$-N (187.5 kg/ha) amongst all, but being at par with T_{13}, T_{17}, $T_{14}$and T_{10} (185.2, 184.7, 183.9 & 180.7 kg/ha, respectively). The similar result was also found with respect to NH_4OAc-K. In case of Olsen-P, T_{16}, T_{13}, T_{17}, T_{14} and T_{10} were found to be statistically at par with each other, but superior over recommended practice (29.3 kg/ha).

Keywords: Green fodder, crude protein, neutral detergent fiber, soil nutrient

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Integrated Use of Organic and Inorganic Nutrient Sources Improves the Soil Fertility under Fodder Maize-Oats Cropping Sequence

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Cultivation of fodder maize-oats cropping sequence in the Indo-Gangetic Plain (IGP) regions of India exhaust higher soil nutrients due to their higher uptake capacity which lead to diminishing soil fertility. Further, the use of sole chemical fertilizers also causes soil pollution and various other environmental issues. Therefore, the judicious and appropriate combination of organic and inorganic nutrient sources could be an alternative option for sustaining the soil fertility. Keeping this in view, a field experiment was conducted at Research Farm of Agronomy Section, ICAR–National Dairy Research Institute, Karnal, Haryana (India) during *Kharif-Rabi* seasons of 2018-19 and 2019-20. The experiment was carried out in split plot design with three replications. Three varieties fodder maize, viz., African Tall, J-1006 and P-3396 in *Kharif* followed by Oats cv. Kent in *Rabi* season as main plot treatments, four nutrient management practices viz., control, 100% RDF, 75% RDF + PGPR + Panchagavya and 50% RDF + 25% FYM + PGPR + Panchagavya were studied as sub plots treatments. Experimental results indicated that main plot treatments did not show any significant effect on physico-chemical and biological properties of soil after the harvest of both crops. However, the sub-plot treatments (nutrient management) exerted significant effect on the soil fertility parameters. Integrated use of organic and inorganic nutrient sources (75% RDF + PGPR + Panchagavya spray or 50% RDF + 25% FYM + PGPR + Panchagavya spray) enhanced the soil organic carbon, available N, P, K and $CaCl_2$-extractable S over control. Based on the findings of two years of experimentation, it can be concluded that integrated use of either 75% RDF, PGPR and Panchagavya spray or 50% RDF + 25% FYM + PGPR + Panchagavya spray helps in maintaining/ enhancing the soil fertility.

Keywords: Nutrient management, Panchagavya, PGPR, soil fertility

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Effect of Water Management on Resource Conservation Technologies on Water Productivity and Carbon Footprint in Maize-Sunflower Cropping System

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A field experiment was carried out in a two-year-old ongoing field experiment on maize-sunflower cropping system during the year 2023- 24 to evaluate water productivity and carbon footprint of maize-sunflower sequence under different water management practices in resource conservation technologies in a sandy clay loam soil of ICAR – Indian Institute of Water Management research farm, Bhubaneswar. The treatments comprised of different combinations of resource conservation technologies and irrigation methods viz., (T1) CTFBF: conventional-till flatbed flood irrigation; (T2)PBBF: Permanent broad-bed and furrow irrigation; (T3) PBBF +R: permanent broad-bed and furrow irrigation with residue; (T4) PNBF: permanent narrow-bed and furrow irrigation ; (T5) PNBF +R: permanent narrow-bed and furrow irrigation with residue ; (T6) ZTDI: zero-till drip irrigation; (T7) ZTDI +R: zero-till drip irrigation with residue; (T8) ZTFBF +R: zero-till flatbed flood irrigation with residue; (T9) ZTSDI: zero-till sub-surface drip irrigation and (T10): ZTSDI +R: zero-till sub-surface drip irrigation with residue. It was observed that resource conservation technologies improved grain yield and water productivity of maize and sunflower than conventional tillage under flood irrigation. Drip irrigation and subsurface drip irrigation resulted in higher grain yield and water productivity of maize and sunflower than flood irrigation. Under conventional tillage with flood irrigation, carbon input was higher but carbon output, carbon efficiency and carbon sustainability index were lower than the resource conservation technologies. Zero till subsurface drip and drip irrigation registered significantly higher carbon efficiency, carbon sustainability index and carbon efficiency ratio than flood irrigated plots. Carbon efficiency, carbon sustainability index and carbon efficiency ratio of sub surface drip irrigation were higher than drip irrigation for both maize and sunflower crop. Spatial carbon footprint and yield scale carbon foot print under conventional tillage with flood irrigation was higher than that of resource conservation technologies for both maize and sunflower crop. Residue retention resulted in higher carbon input and lower carbon efficiency, carbon sustainability index and carbon efficiency ratio than residue removal. Subsurface drip and drip irrigation plots registered significantly lower yield scale carbon footprint than flood irrigated treatments for both maize and sunflower crop. Thus, the present study recommends resource conservation technologies with drip irrigation for improving yield and water productivity, improving carbon efficiency and reducing carbon footprint in maize-sunflower cropping system.

Keywords: Resource conservation technology, water productivity, carbon efficiency, spatial carbon footprint, yield scale carbon foot print

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Soil Health under Conservation Agriculture-based Pigeon pea-Wheat System

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The Indo-Gangetic Plains (IGP) of India faces challenges like declining soil fertility, excessive groundwater depletion, and increasing greenhouse gases emission in conventional rice-wheat system. Conservation agriculture (CA) offers a sustainable alternative by emphasizing minimum soil disturbance, crop residue retention, and crop diversification. A long-term 12-year study conducted at ICAR- Indian Agricultural Research Institute, New Delhi, investigated the impact of replacing rice with pigeon pea in a pigeon pea-wheat rotation under CA practices. Data on several soil parameters and pigeon pea crop were collected from the pigeon pea-wheat system. Treatments were conventional tillage (CT), permanent narrow bed with and without residue (PNB+R & PNB-R), broad bed with and without residue (PBB+R & PBB-R), and flat bed with and without residue (PFB+R & PFB-R) replicated thrice in a randomized complete block design. The results indicated that residue retention significantly improved soil health and crop productivity. The lowest bulk density (1.32 Mg/m^3) was observed in the PBB+R treatment, which showed a 17.5% reduction compared to that in CT (1.60 Mg/m^3). Total organic carbon recorded highest (10.47 g kg^{-1}) under the PBB+R, which was 40.5% higher compared to that in CT (7.44 g kg^{-1}). Hydraulic conductivity got maximized in PBB+R (71.57 cm/day), a 24.3% improvement over CT (57.59 cm/day). Similarly, the number of pods per plant was maximum in PBB+R (157.0), a 46.7% increase compared to CT (107.0), and the number of branches per plant was highest in PBB+R (18.0), an 80% improvement over CT (10.0). These findings underscore the potential of CA-based pigeon pea-wheat system in addressing sustainability challenges in the IGP. Enhanced soil structure, nutrient availability, and water-use efficiency not only promote resilient agriculture but also ensure food and nutritional security for the region. The integration of legumes like pigeon pea, combined with no tillage and residue management, is an effective strategy for sustainable intensification in South Asia's most vital agricultural landscape.

Keywords: Conservation agriculture, residue, conventional tillage, organic carbon, pigeon pea

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Evolution of India's Agricultural Drought Monitoring and Declaration Protocol: Bringing Science to Policy

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Drought is a normal part of Indian climate and every year it affects one or the other State of India leading large drop in agricultural production and farm income. Large parts of India have been traditionally vulnerable to droughts owing to the extreme dependence of agricultural operations on monsoon rainfall coupled with patchy irrigation from surface and ground water resources. Though Central and State governments implemented many measures for drought management but they continued to face a major challenge in scientifically monitoring and then objectively declaring drought in an administrative unit in a crop season.

This paper presents how the drought monitoring and declaration protocol in India evolved overtime. Starting from the traditional approaches of "eye estimates" of crop yield loss-based criteria to the first attempt made by experts in "Manual for Drought Management - 2009" in proposing use of scientific technologies for drought monitoring. A major paradigm shift came with the revised "Manual of Drought Management - 2016" in which both "causative" and "impact" technological indicators were proposed for use, how they should be collected, agencies responsible, their weightages and timelines for different activities were formulated for major "kharif" agricultural season. Expanding on the adoption by States and success of these protocols, the drought monitoring and declaration protocol for "rabi" crop season was also proposed in 2018. The details on now these protocols were evolved, how they were modified based on inputs from stakeholders and challenges remaining will also be presented. Another major paradigm shift in drought monitoring, declaration and management policy was the recommendation of establishing "Drought Monitoring Centre" (DMC) in each State to provide technical support to the drought activities. The role of "Agrometeorology" subject is central to meet the objectivities and activities of DMC. Developing drought related indices and indicators (precipitation, SPI, evapotranspiration, soils, landuse etc.); setting up and maintaining network of agro-weather stations; undertaking vulnerability analysis of agricultural sector; formulating and implementing crop contingency plans; and scientifically undertake impact assessment of drought are some of the major activities in which role of science and technology will be presented.

Keywords: Drought, remote sensing, crops, drought manual, India

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Reclaiming Coastal Salt-affected Soils of the West Coast using Land Shaping and Integrated Farming Systems

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Coastal salt-affected soils, particularly *Khazan* lands in Goa, face multiple challenges, including excessive salinity due to saltwater intrusion, water logging, rice mono-cropping, and abandonment of agriculture. Spanning approximately 18,000 hectares in state of Goa, only 40–50% of these lands are cultivated with rice during the *Kharif* season, leaving the rest fallow year-round. The coexistence of soil acidity (pH 5.6) and salinity (EC_e 14.9 dS m{ [1]) with varying levels of nutrients are unique management challenges. Additionally, salinity fluctuates seasonally, decreasing during monsoons and peaking in summer, further limiting productivity. A holistic land-shaping and integrated farming system (IFS) approach was implemented on an experimental field at Merces, Tiswadi *taluk*, Goa. The experimental site (3,450 m²) was transformed using farm ponds (10% of the area), raised bunds (25%), and low-lying areas (65%). This intervention facilitated the diversification of crops, including salt-tolerant rice varieties in both *Kharif* and *Rabi* seasons, increasing cropping intensity from 100% to 300%. The net income rose by 346% compared to mono-cropping rice in *Kharif* alone. In the first year of experiment, net income reached [1] 39,451, excluding the fisheries component yet to be incorporated. Additionally, sustained use of freshwater for irrigation and regular saline water skimming reduced field salinity by 72% (from 29.6 to 8.2 dS m^{-1}) over six years restoring cultivable land. The success of this pilot attracted the attention of the GCCI,Directorate of Agriculture, Government of Goa and NABARD. Subsequently, a multi-institutional, farmer-participatory demonstration project, *Land Shaping Methods and Integrated Farming System Approach for Improving Livelihood Security of Farmers under Khazan Lands of Goa*, funded by NABARD was launched. This project aims to replicate and demonstrate the approach on 4-5 beneficiary farmers' fields in a cluster mode, creating awareness and enhancing productivity and income from these historically underutilized lands.This initiative highlights the potential of sustainable land management practices to revitalize coastal saline agriculture, ensuring food security and livelihood improvements for farming communities.

Keywords: Climate change, coastal saline soils, integrated farming system, salinity management

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Harnessing Remote Sensing for Abiotic Stress Monitoring in Coastal Region

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Abiotic stresses such as drought, salinity, nutrient imbalances, temperature extremes, and flooding pose significant challenges to agricultural productivity, particularly in coastal regions of India. Traditional methods for monitoring these stresses are labor-intensive, destructive, and provide limited spatial coverage. Remote sensing, on the other hand, provide fast, non-destructive, and extensive spatial assessments, offers a promising solution for effective stress monitoring and management. Based on this background, remote sensing was integrated with advanced machine learning (ML) and artificial intelligence (AI) techniques to monitor abiotic stresses in coastal agriculture. Spectral indices derived from hyperspectral remote sensing data were used to assess key biophysical and biochemical parameters of crops under stress. Indices such as the Ratio Spectral Index (RSI) and Normalized Difference Spectral Index (NDSI) were optimized through correlation analyses and tested for their performance in stress characterization. Various multivariate models like Partial Least Squares Regression (PLSR), Random Forest (RF), and Artificial Neural Networks (ANN) were calibrated and validated for prediction of the parameters affected by abiotic stresses. The results revealed that for laboratory experiments linear models like PLSR performed the best while for field experiments nonlinear machine learning models were the best performer. The findings emphasize the potential of spectral and ML-based approaches to enhance phenotyping, improve genotype selection, and optimize crop management in saline and drought-prone soils.

Keywords: Remote sensing, abiotic stress monitoring, coastal region

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Evaluation of the Effect of Salinity on Soil Structural Stability, Hydraulic Properties and Carbon Pools

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To evaluate the effect of soil salinity on structural stability and hydraulic properties, total 121 soil samples were collected from 0-15 and 15-30 cm of soil depths from eighteen villages of Nilokheri, Nissang and Assandh block of Karnal district, Haryana. Result showed that in 0-15 cm soil depths, soil pH varied from 8.24 to 10.08 and EC of 0-15 cm soil layer varied from 2.46 to 16.4 dS/m. The range of MWD varied from 0.18 to 1.21 mm and showed high variability. Fractal dimension of the soil particles ranged from 2.59 to 2.97 and it has lowest variability among all the parameters. The results of D showed that D is positively related with the clay and silt % but negatively related with sand %. Hydraulic conductivity (HC) of the study area varied from 1.59 to 19.16 cm/hr with a SD of 3.72 and highly variable in nature. Out of 121 soil samples, 65.3% (79) were under low carbon category, whereas, 14.87 % (18) were under medium and high carbon content classes. Total organic carbon (TOC) in class 2 (pH>9.5) soils were 0.02% more than class 1 (pH= 8-9.5) soil, though the difference was not statistically significant. Average MWD was 0.11 mm more in class 2 soils as compared to class 1 soils. Glomalin content had positive correlation with HC and sand content and negative correlation with BD, clay and silt %, but the correlations were not significant. No significant correlation was obtained with MBC and other soil parameters. The soil pH had significant negative correlation with sand content whereas, it showed significant positive correlation with sand content. Soil EC showed a strong positive correlation with soil pH. Labile pool of 0-15 cm soil was 3.13 gC/kg soil and was 15.49% more than 15-30 cm. Recalcitrant pool of 0-15 cm soil layer was 2.85 gC/kg soil and was 21.79% more than 15-30 cm.

Keywords: Saline soil, aggregate stability, hydraulic conductivity, carbon pool

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Groundwater Potentiality Mapping using Bivariate Statistical and Machine Learning Models for Coastal Region of India

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Groundwater is a key resource in coastal regions, where surface water availability is often limited, making its proper management essential for sustainability. Water resource management in coastal area is crucial due to its sensitivity to climate change, urbanization, and other environmental factors. This research focuses on the assessment of groundwater potentiality across the entire coastal region of India. The primary objective of this study is to develop a comprehensive groundwater potentiality map that can serve as a strategic guide for sustainable water resource management in coastal region of India. To achieve this, we considered 12 factors: drainage density, distance to lineament, annual rainfall, digital elevation model (DEM), geomorphology, soil texture, depth, land use land cover (LULC), curvature, aspect, slope, and topographic wetness index (TWI), terrain ruggedness index (TRI), slope length (LS), normalized difference vegetation index (NDVI). These factors were combined using a variety of methods, including statistical analysis like frequency ratio and machine learning models to create a groundwater potentiality map. The groundwater potentiality maps were validated using the locations of wells collected from Central Ground Water Board (CGWB). The output of the current study allows for the identification of high, moderate, and low groundwater potential zones, providing a strong instrument for efficient groundwater management.

Keywords: Frequency ratio, land use land cover, digital elevation model, NDVI

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Assessing Soil Erosion using Revised Universal Soil Loss Equitation (RUSLE) for Coastal Region of India

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In coastal areas, soil erosion is an important environmental issue, which can cause ecological imbalance, productivity loss, and land degradation. Inappropriate farming methods, uncontrolled grazing, and deforestation are the causes of increased soil erosion. In this study, the Revised Universal Soil Loss Equation (RUSLE) is being used to map and quantify the possible soil erosion. This study aims to map soil erosion in the coastal region of India using the Revised Universal Soil Loss Equation (RUSLE) model, which incorporates factors such as rainfall erosivity (R factor), soil erodibility (K factor), land use land cover map (C & P factor) and elevation data for slope length steepness (LS factor). The formula for the RUSLE model, which is frequently used to determine the average annual soil loss per unit land area due to sheet and rill erosion is A=R*K*LS*C*P. The input layers for RUSLE are created using remote sensing data and geographic information system (GIS) tools, which allows for the measurement of total annual soil loss throughout the coastal region of India. There was a significant spatial variation in erosion intensity from very low to very high in the coastal region of India. The results highlighted the necessity of region-specific strategies for efficient planning of soil and water conservation measures to mitigate erosion in the coastal region. In addition to supporting sustainable land management techniques, this research advances our understanding of the dynamics of soil erosion in the coastal regions of India.

Keywords: Rainfall erosivity, soil erodibility, land use land cover, elevation, slope length

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Strategies for Agricultural Productivity Enhancement on Gravelly Lateritic Soils of the West Coast of India

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The soils of the west coast region of India are predominantly lateritic, which are characterized by low fertility and poor water-holding capacity. Agricultural lands in this region often exhibit gravel (particles >2 mm) proportions reaching up to 80%, drastically reducing the soil volume available for plant growth and water retention. This study evaluates the extent of soil gravelliness in the state of Goa with the aim to propose targeted strategies for crop cultivation, nutrient and water management. Geo-referenced soil samples were collected across varied land uses using conditioned Latin Hypercube Sampling technique. Gravelliness, expressed as a percentage, varies significantly across different land use types, highlighting the influence of land cover on soil characteristics. The overall gravelliness across all land uses ranges from a minimum of 5.79% to a maximum of 68.66%, with a mean value of 39.41% and a coefficient of variation of 33.05%, indicating moderate variability. Cropland exhibits the highest mean gravelliness (45.16%) with a relatively low coefficient of variation (22.22%), suggesting a more consistent distribution. In contrast, forested areas show the lowest mean gravelliness (36.32%) but exhibit higher variability (41.02%). Grasslands and barren lands also show notable gravelliness, with mean values of 43.30% and 37.83%, respectively, and relatively low variability. The results underscored the challenges posed by high gravel content in terms of soil fertility and water use efficiency. Additionally, the study will explore the potential of remote sensing techniques to characterize soil-hydraulic properties, providing a foundation for precision irrigation strategies. By integrating these findings with tailored agronomic practices, this research aims to mitigate the limitations of gravelly soils and enhance agricultural productivity in the west coast region.

Keywords: Climate change, gravel content, irrigation strategies, lateritic, nutrient management

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Assessment of Nitrogen Use Efficiency through Foliar Sprays of Nano-Urea and Urea for Wheat in Inceptisol

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Assessment of Nitrogen Use Efficiency through Foliar Sprays of Nano urea and Urea for Wheat in Inceptisol was studied by conducting a pot culture experiment at Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune during *rabi* 2021. The object of this experiment is to synthesize and characterize nano-urea at post graduate laboratory of Soil Science and Agricultural Chemistry, College of Agriculture, Pune and which is named as COAP (College of Agriculture, Pune). Further synthesised nano-urea was compared with IFFCO and conventional urea along with different levels of recommended doses of nitrogen. The experiment consisted of twenty one combinations of treatment based on 3 levels of recommended doses of nitrogen (0, 50, 75%) and six nitrogen levels for foliar sprays and water spray as a control which was replicated twice in factorial completely randomized Design (FCRD). The foliar sprays of nitrogen consisted of four levels of COAP nano-urea @ 50, 100, 150 and 200 ppm, IFFCO nano-urea @ 160 ppm and conventional urea @ 10,000 ppm applied at 30 and 50 DAS. Nano-urea was synthesized from granular conventional urea and characterised for size of nano particles by using scanning electron microscope.

It could be revealed that average size of COAP (22.419 nm) and IFFCO (22.773 nm) nano-urea was almost same. Further, the pH and EC of COAP nano-urea in different concentration (from 50, 100, 150 and 200 ppm), IFFCO nano-urea (160 ppm) and conventional urea (10,000 ppm) were ranged between 6.55 to 7.11 and 0.12 to 1.25 d Sm^{-1} respectively. Results revealed that conjoint application of 75% nitrogen along with two foliar sprays of conventional urea @10,000 ppm, COAP nano-urea @ 200 ppm and IFFCO nano-urea @ 160 ppm taken at 30 and 50 DAS for wheat recorded significantly higher plant height, leaf area and number of tillers at 35 and 55 DAS.

Significantly higher spike length, number of grains $sipke^{-1}$ and test weight (1000 grain weight) was obtained with the application two foliar sprays of conventional urea @ 10,000 ppm, COAP nano-urea @ 200 ppm and IFFCO nano-urea @ 160 ppm taken at 30 and 50 DAS for wheat. Consistent increase in plant height, leaf area, number of tillers, spike length, number of grains $spike^{-1}$ and test weight of wheat was increased with increasing levels of COAP nano-urea from @ 50 to 200 nm.

Conjoint application of 75% RDN along with two foliar sprays (taken at 30 and 50 DAS) of either COAP nano-urea @ 200 ppm (9.05 and 5.63, 8.83 and 7.56 and 8.26 and 7.95 mg g^{-1} fresh weight) or IFFCO nano-urea @ 160 ppm (9.12 and 5.74, 9.07 and 7.60 and 8.44 and 8.16 mg g^{-1} fresh weight) or conventional urea @ 10,000 ppm (9.26 and 5.94, 9.21 and 7.81 and 8.55 and 8.38

mg g^{-1} fresh weight) recorded at par and significant interaction for accumulation of chlorophyll a, b and total chlorophyll at 35 and 55 DAS respectively.

Application of 75% recommended dose of nitrogen along with two foliar sprays of 10,000 ppm conventional urea recorded significantly higher grain (45 g pot^{-1}) and straw yield (65.39 g pot^{-1}) of wheat which was found to be significantly at par with 75% RDN + IFFCO nano-urea @160 ppm (44.91 and 62.87 g pot^{-1}) and 75% RDN + COAP nano-urea @ 200 ppm (44.83 and 60.66 g pot^{-1}). Foliar application of COAP nano urea @ 50, 100,150, 200 ppm reported increasing trend for nitrogen (2.49, 2.62, 2.72 and 2.81), phosphorus (0.82, 0.86, 0.88 and 0.93) and potassium (1.73, 1.98, 2.05 and 2.18) uptake by wheat in Inceptisol. Combine application of recommended nitrogen levels and foliar sprays of COAP and IFFCO nano-urea and conventional urea reported significant interaction for nitrogen while phosphorus and potassium did not reported significant interaction. Recommended dose of nitrogen @ 75% significantly affected iron, manganese, zinc and copper uptake by wheat while foliar application of nano-urea either of COAP or IFFCO affected, zinc and manganese uptake. Application of 75% RDN along with IFCCO nano-urea @ 160 ppm, COAP nano-urea @ 200 ppm and conventional urea @ 10,000 ppm recorded significantly higher Fe, Mn, Zn, Cu uptake by wheat in Inceptisol. Crude protein content in wheat was found significantly higher with the combine application of 75% RDN + two foliar sprays of conventional urea @ 10,000 ppm (10.95 %). This was found to be at par with 75% RDN + two foliar sprays of IFFCO nano-urea (10.95 %)and COAP nano-urea (10.80 %).

Foliar application of conventional urea @10,000 ppm reported significantly higher nutrient use efficiency (24.57%) which was closely followed and significantly at par with IFFCO nano-urea @ 160 ppm (22.25 %) and COAP nano-urea @200 ppm (21.20 %). Among the different levels of COAP nano-urea, application of 200 ppm reported almost two times more nutrient use efficiency over COAP 50 ppm nano-urea. Combine application of 75% RDN along with foliar sprays of conventional urea @ 10,000 ppm reported significantly higher nutrient use efficiency (38.19%) which was found to be at par with IFCCO nano-urea @160 ppm (37.86 %) and COAP nano-urea @ 200 ppm (37.62%).

Foliar concentration of conventional urea was 10,000 ppm which was 50 times more than COAP and IFFCO nano-urea. Application of COAP nano-urea @ 200 ppm reported 28, 38 and 43 times higher nutrient use efficiency than that of conventional urea foliar spray @ 200 ppm. It could be concluded that application of nitrogen through foliar sprays in nano form was far superior and efficient for enhancing the yield and quality of wheat.

Soil available nitrogen and phosphorus at harvest of wheat were significantly influenced by the application of recommended dose of nitrogen along with foliar sprays of nano-urea from COAP, IFFCO and conventional urea however other soil properties did not affect significantly. Magnitude of increase in soil available nitrogen was found higher with the application of RDN levels and foliar application of nano-urea from IFFCO and COAP along with conventional urea over initial (165 kg ha^{-1}).

Keywords: Nitrogen use efficiency, foliar sprays, nano-urea, wheat

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Vegetation Health Index: A Composite Index for Monitoring Crop Health with Sentinel 2 Data

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Remote sensing data is crucial for monitoring crop health in real-time and applying precision agriculture to enhance crop conditions. Applying a composite index, developed by ensembling multiple significant health indicators, would provide a comprehensive insight into crop conditions. This study created a Vegetation Health Index (VHI) to assess crop health using key biophysical variables: Leaf Area Index (LAI), Canopy Chlorophyll Content (CCC), and Canopy Water Content (CWC). The Indian Agriculture Research Institute (IARI), a premier agricultural research institute under the Indian Council of Agriculture Research (ICAR), with an extensive experimental farming area of over 250 hectares, was used as the study area. The biophysical variables were estimated from the Sentinel-2 surface reflectance dataset using the biophysical processor, a well-validated and calibrated process-based tool available in the Sentinel application platform – commonly known as SNAP, a free software provided by the European Space Agency (ESA). The biophysical variable values were estimated from the Sentinel 2 dataset captured on 23rd Feb 2023, a cloudless day, and in the peak of Rabi season, when the crops are generally at their best growth stage. The estimated LAI from the tool was compared to the in-situ LAI data measured across the IARI on the same day using Li-COR LAI 2200c plant canopy analyzer and an R-Squared value of 0.68 was observed. The estimated CWC and CCC were taken as such from the model and were used to build the VHI. The three variables were normalized using the minimum and maximum standardization methods. The VHI dataset was created using a linear sum aggregation method, with each standardized variable weighted equally at 1/3. The resulting VHI dataset ranged from 0 to 1, indicating bad to good crop health conditions.

Thus, the composite index could be widely used for monitoring crop health over the other approaches.

Keywords: Composite health index, remote sensing, biophysical variables, Sentinel 2, LAI, CCC, CWC, SNAP

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