National Symposium
on
Digital Farming:
The Future of Indian Agriculture

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2-3 February 2023

BOOK OF ABSTRACTS

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Spatial Scale Estimation of Evapotranspiration in Wheat using Remote Sensing through Surface Energy Balance Approach

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Water is one of the major natural resource and evapotranspiration (ET) is an important aspect in water resource management. The Operational Simplified Surface Energy Balance (SSEBop) model was used to estimate evapotranspiration of ICAR – IARI farm using Landsat – 8 (OLI) data. Field experiment on wheat (variety: HD 2967) were undertaken in experimental farm of ICAR - IARI during *rabi*, 2019- 20 & 2020-21. In both seasons, homogeneous crop was grown and micrometeorological data were collected from a micrometeorological tower in which temperature, humidity, and wind speed sensors at five different levels (0.5 m, 1 m, 2 m, 4 m, and 8 m) and net radiation and PAR sensors were installed at 2 m height. Temperature and wind speed were lower within the crop canopy up to a certain height. More turbulence was observed inside maize crop. During active growing seasons, a rapid increase in crop height increases aerodynamic roughness. At the early stage soil evaporation was the contributor of the latent heat flux due to less vegetation at sowing time. Rn and LE were reached the higher value at midday (12.00 hrs.) and there was a 2-hour time lag between the highest Rn of the day and the highest sensible heat flux (H) and ground heat flux (G) in the afternoon (14.00 hrs.) during all the crop growing seasons. In the wheat crop growth seasons 2019-20 and 2020-21, the actual ET estimated using the SSEBop model could account for 82 to 83% of the variations of ET calculated by BREB method. Bowens ratio was larger at the start of both crops, and declined in the middle, and then increased again. The Bowens ratio was negative at night and positive during day time; it increased from 6.00 hrs. to 11.00 hrs. and then decreased till evening (19.00 hrs.).

Key words: Evapotranspiration, Wheat, Remote Sensing

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Mustard Yield Prediction using Multiple Linear, LASSO, Elastic Net and Machine Learning Approach

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Mustard is the most important oilseed 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. 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. For developing models, daily weather data during crop growing period as well as mustard yield data for the period of 1984-2019 for IARI, New Delhi were used. Model was developed by stepwise multiple linear regression (SMLR), least absolute shrinkage and selection operator (LASSO), elastic net, variable selection using SMLR and artificial neural network (SMLR-ANN), variable selection using SMLR and support vector machine (SMLR-SVM), variable selection using SMLR and random forest (SMLR-RF), variable extraction using principal component analysis (PCA) and ANN (PCA-ANN), variable extraction using PCA and SVM (PCA-SVM), variable extraction using PCA and RF (PCA-RF) techniques. 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 mustard yield prediction models and making a comparison between the developed models. On evaluation of overall performance of different models used for mustard crop yield prediction, PCA-SVM model have lowest nRMSE value followed by elastic net, PCA-ANN, LASSO, SMLR, SMLR-SVM, SMLR-ANN, SMLR-RF and PCA-RF. From this study it may be concluded that PCA-SVM and elastic Net performed excellent having nRMSE value less than 10%, hence can be used for district level mustard yield prediction.

Key words: Mustard, LASSO, SMLR

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Spatio-temporal Analysis of Trends of Climatic Variables and its Extremes over India

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Recent climate change and variability has affected the temperature and rainfall patterns in the world. A comprehensive analysis of both the climatic variables as a discrete parameter as well as in combination is still required to assess the pattern of climate variability. This analysis is even more important in a country like India which is witnessing the frequent occurrence of weather extremes in recent past. Daily gridded (0.5°×0.5°) temperature and (5km×5km) rainfall data (1981–2019) were used to detect spatial patterns of temporal trends of several climatic variables and its extremes over the crop growing season (kharif and rabi). The climatic variables include minimum and maximum temperature, growing degree days (GDD), rainfall amount and number of rainy days etc. The climatic extremes include the monthly, seasonal and annual frequencies of temperature extremes (hot days, hot nights, cold days, cold nights), rainfall extremes and standardised precipitation evapotranspiration index etc. A non-parametric (Mann–Kendall test) method was used to test for monotonic trend at each grid level. The direction of trends and magnitude were found to be varying spatially across different parts of Indian region. For example, a significant increasing trend of change in seasonal rainfall was observed in western ghat regions whereas, a decreasing trend was observed in eastern and north-eastern part of India. Similarly, a significant increasing trend of hot days and GDD was observed in central and eastern parts of India. The overall study indicates that climate variability is leading to change in rainfall and temperature pattern which may affect the agricultural production of crops in India in near future.

Key words: Climatic variables, Spatio-temporal analysis

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Use of Geographic Information System (GIS) and Remote Sensing (RS) Technology to Enhance Income by Optimization of Resource Use in Agriculture

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In present situation, the cost of production is increasing due to increase in the input cost such as fertilizer, irrigation, insecticide, pesticide, etc. Therefore, the government is giving lot of importance to precision farming (optimum utilization of resources). GIS and RS technology can play a very important role in optimization of resource use and resultantly in reduction in cost of cultivation. In this paper, it has been demonstrated that using GIS and RS technology, how nutrients can be applied judiciously. Further, it has been shown that if fertilizers are applied in scientific manner, then there was monetary benefit to farmers. This has been demonstrated with the help of a case study in a selected district. Similar approach can be applied to a state / country where one can estimate available soil nutrients using GIS and RS technology and area can be demarcated under deficit nutrients. In this way, one can concentrate more on these areas. Equations have been developed by IISS, Bhopal conducting several experiments in different parts of the country to obtain optimum dose of fertilization (including manures also) for a targeted yield. These developed equations can be utilized in whole country to prescribe balance fertilization which will improve soil health also. The web based online nutrient recommendation system has been developed which provides an easy mechanism to recommend the major fertilizers N, P, K and manures for various crops based on available nutrients in the soils and for targeted yield of crops.

Key words: Geographic Information System, Remote Sensing, Agriculture

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Spatial Distribution and Management Zones in Rice Cultivated area using Fuzzy Clustering Analysis

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The efficient management of soil nutrients is possible by delineation of soil management zones by increasing the crop productivity The present fertilizer recommendations in the study area are typically symmetric for large regions without considering the spatial variability of soil nutrients. This leads to the under application of fertilizers in zones with low nutrient contents and over applications in zones with high nutrient contents. Therefore, this study was conducted to asses soil management zones (MZs) in the study area for effective soil nutrient management. Alwarthirunagiri block of Thoothukudi district in Southern India was selected as the study area for the present study and soil samples were collected on 1 kilometre grid. Soil samples were processed and analysed for pH, soil organic carbon, available nitrogen, available phosphorus, available potassium, DTPA extractable micronutrients i.e iron, zinc, copper and manganese. Soil properties coefficient of variation (CVs) widely varied from low (9.72%) to high (74.60%). Ordinary kriging and semivariogram analysis showed differed spatial variability patterns for the soil properties with spatial dependence ranged from moderate to strong. Management zones were delineated by performing principal component analysis (PCA) and fuzzy K-means clustering. Three principal components with eigen values more than 1 dominated 58.40% of the total variance, so they were retained for clustering analysis. Three management zones were delineated based on the two criteria modified partition entropy (MPE) and fuzzy performance index (FPI). The studied soil properties differed significantly among management zones. The delineated management zones provide a basis of information for site specific fertilizer management in rice cultivated fields in the study area.

Key words: Spatial distribution, Fuzzy clustering analysis, principal component analysis

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Assessment of the Spatial Variability of Physico-Chemical Properties in the Malwa Belt of Madhya Pradesh

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Soil mapping is an important operation because it contributes to understanding soil nutrients and how they can be managed sustainably. Knowledge of the soil variability of any region is crucial for the development of site-specific nutrient management practises (SSNM) for good soil health and to enhance crop productivity. In Ujjain Tehsil, Ujjain District, Madhya Pradesh State, India, the present study was carried out to investigate the spatial distribution of soil physico-chemical parameters. In total, 150 georeferenced surface soil samples were collected from the study area. These samples were analysed using a standard protocol for selected soil properties, viz. pH (1:2.5), electrical conductivity (1:2.5), soil organic carbon (%), particle size distribution (sand, silt, and clay), available nitrogen (Av-N), available phosphorous (Av-P), and available potassium (Av-K) in the laboratory.

In this study, it was recorded that the soil pH, EC, SOC, available nitrogen, available phosphorous, available potassium, sand, silt, and clay ranged from 7.01 to 8.15, 0.10 to 0.79 dSm-1, 0.30 to 0.60%, 139.00–235.00 kg ha^{-1}, 8.00–25.60 kg ha^{-1}, 301.00–463.00 kg ha^{-1}, 9.15 to 24.06%, 24.00 to 41.55%, and 40.20 to 58%, respectively.

The data were analysed using classical statistics and geo-statistics by constructing semi-variograms and mapping them using ordinary kriging (OK) techniques. Semi-variograms were calculated for soil characteristics, and their spatial distributions were mapped. For modelled variables with strong and moderate spatial dependences, the best-fit models were exponential, spherical, circular, and Gaussian, with a nugget/soil (C_o/C_o+C) ratio. The distribution maps of soil attributes could be utilised as a guide for site-specific crop management in similar soils. Further, this study demonstrates the usefulness of GIS applications in soil variability studies.

Key words: Soil properties, soil variability, geo-statistics, spatial dependence, and Ordinary kriging

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Prediction of Hydraulic Conductivity in Saline Soil using Machine Learning Approaches

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The inability to maintain proper soil Hydraulic Conductivity (HC) and soil organic carbon levels can seriously hamper soil health and crop production. Soil salinity can degrade soil quality, decrease crop yields. To predict the soil hydraulic conductivity using other easy to measurable soil properties, total of 121 soil samples were collected from 0-15 and 15-30 cm of soil depths from eighteen villages of Nilokheri, Nissing, and Assandh block of Karnal district, Haryana. Several soil parameters like BD, soil texture, fractal dimension (D), Organic Carbon (OC), pH, Electrical conductivity (EC), and glomalin content are used as an input to five machine learning approaches, Multi Linear Regression (MLR), Artificial Neural Network (ANN), Support Vector Machine (SVM), Classification and Regression Trees (CART) and Random Forest (RF). Two sets of data points of 121 samples, one with texture data (Dataset 1) and the other with D data replacing texture (Dataset 2) were used. The total dataset was divided into 4:1 training and testing datasets. Machine learning algorithms were used by R software. HC is successfully predicted by above-mentioned machine learning approaches. The models were evaluated by statistical parameters like Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Nash–Sutcliffe model efficiency (NSE), Root Mean Square Error (RMSE), and correlation coefficient. In the case of ANN, for both the input sets, ANN with three hidden layers performed better. Inclusion of D in the input set in ANN, the RMSE value was reduced by 17% in the training dataset whereas, 25.12% in the testing dataset. The inclusion of fractal dimension in the input dataset of CART has no improvement in both the training and testing datasets. RF performed better both in datasets 1 and 2 and proved to be better models in the prediction of HC as compared to CART. The results showed that among all the models, SVM with dataset 2 performed best based on the statistical evaluation criteria. SVM models predicted the HC with more satisfactory performance as compared to the other models owing to their more flexibility and capability to model non-linear relationships. A Comparative study can be made in the future to find out the prediction efficiency of different geostatistical techniques and machine learning approaches.

Key words: Hydraulic conductivity, Saline soil, Machine learning approaches

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Comparison of GIS Interpolation Methods to Estimate Extent of Arsenic Contamination in Soils of Nadia West Bengal

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Arsenic (As) is classified as a class (I) carcinogen, which poses a serious concern from an environmental and human health point of view. Arsenic contamination in soil and water affects several sustainable development goals directly or indirectly. Hence, understanding the spatial distribution of As in soil and its uptake by the crop is of utmost importance for efficiently managing contaminated sites. In this study, spatial variability of As was quantified in major paddy-grown areas using different interpolation methods. Ordinary Kriging (OK), Inverse Distance Weighted (IDW), Radial Basis Function (RBF), Empirical Bayesian Kriging (EBK), and Co-Kriging (Co-K) are employed to quantify the spatial variability. Olsen extractable As content in soil varied from 0.48 to 3.57 mg kg^{-1} with a mean value of 1.45 mg kg^{-1}. Rice grain samples contained As in the range of 0.20 to 0.61 mg kg^{-1} with a mean of 0.43 mg kg^{-1}. Based on geostatistical analysis, the northern side of Nadia has relatively high contamination, while the southern side showed relatively lower contamination. The Root Mean Square Error (RMSE) of OK, IDW, RBF, and EBK for As contamination in soil were 0.54, 0.53, 0.53, 0.52, while corresponding mean CV values were 0.004, -0.005, -0.003, 0.008. The predicted minimum and maximum values of As in soil were in close agreement with the measured As in IDW interpolation, followed by kriging, RBF, and EBK. The Root Mean Square Error (RMSE) values of OK, IDW, RBF, EBK, and Co-K for grain As content were 0.10 while mean CV was 0.001, -0.005, -0.002, -0.003, and 0.001. The predicted minimum and maximum value of grain As were in close agreement with measured As in kriging interpolation followed by RBF, Co- kriging, IDW, and EBK. Statistical findings reflect that IDW and OK consistently delivered the most precise predictions of As pollution in the soil, while Co-K precisely predicted grain As content throughout space.

Key words: Arsenic; Soil, Grain, Rice, GIS

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Classifying Water Stress using Deep Convolutional Network from Digital Images

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Timely irrigation is essential for crop survival and optimal productivity. Crop exhibit stress symptoms when soil wetness is insufficient to the crop. To address this problem experiments were conducted to capture water stress symptoms for automating the process of identifying stress from digital images. Captured 1,00,500 RGB from plant phenotyping facility from Maize Stress experiments. Plant photographs were taken from side view 0 degrees, side view 90 degrees and top view. A software tool was developed in MATLAB for extracting features and quantifying the biomass from high throughput RGB digital imageries database. Captured 2000 field stress and healthy digital images. Image classification has been further accelerated with advent of Transfer Learning. Transfer learning allows us to use a pre-existing model, trained on a huge dataset, for this task. Consequently, reducing the cost of training new deep learning models. In this work pre-trained Image Classification model VGG-16 was used. The model has 13 convolutional layers, 5 pooling layers, 3 dense Layers. In all the permutations best accuracy values (0.855) was obtained when the image resolution is equal to 512 pixels, the optimisation algorithm is SGD, ReLU activation function and the batch size is 32.

Key words: Digital images, Water stress

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Field Scale Nitrogen Application in Wheat using Satellite Remote Sensing and Simulation Modelling

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In India wheat is the largest per hectare N consuming cereal and second largest consumer of total nitrogen (N) (23.3%) but its nitrogen use efficiency (NUE) is very low of about 30% due to improper N management. Accurate determination of N stress, proper interpretation of results, judicious management strategies most often limit one of the 4R's of site specific nutrient management (SSNM). Globally, several N-management strategies synchronizing the needs of the crop has been investigated to enhance NUE. In our study, satellite Remote sensing and crop simulation modelling was used to optimize the amount and timing of N fertilizer in wheat together basing on the critical N (Nc) dilution curve (CNDC) approach during the year 2021-22. The CNDC was formulated using total N(%) and aboveground biomass (tons ha^{-1}) obtained from five N-doses viz. 0, 60, 120, 180 and 240$kgha^{-1}$ during 2020-21 wheat season. The variety HD-3086 of wheat was grown in a 35m *42m area with basal N dose of 60Kg ha^{-1}. The N requirement (timing and amount) was computed using Sentinel-2 multi-spectral imager (MSI) images (10m resolution and 5 days repetivity) input into PROSAIL radiative transfer model, N dilution curve and INFO-CROP model simulated crop biomass. The grain yield (GY), biomass (BY), NUE and N_2O emission was compared with recommended N management practice (RNM) [N@120$kgha^{-1}$ at 50:25:25 ratio as Basal, CRI and Jointing, respectively]. Based on the image analysis of the field at every 5 days intervals, a total of 95.7 $kgha^{-1}$ of N was applied in three splits 60 $kgha^{-1}$ as basal, 17.7 $kgha^{-1}$ at tillering and 18 $kgha^{-1}$ at late jointing stage. The final GY and BY of the crop was 6.60 tons ha^{-1} and 13.71 tons ha^{-1}, respectively whereas, in RNM the GY and BY were 6.27 tons ha^{-1} and 12.33 tons ha^{-1}, respectively. The partial factor productivity of N (PFPN) was 68.97% against 52.25% in RNM. The total N_2O emission was also reduced by 18% compared to RNM plot. Therefore, this experiment proved that remote sensing, simulation modelling and CNDC based N management approach could be a promising alternative for site-specific N management in Wheat to improve the NUE, lower the cost of N fertilization and reduce environmental pollution which can be scaled-up over a large region with minimum cost.

Key words: Nitrogen, Fertilizer, wheat, use efficiency, remote sensing, simulation model

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Fabrication of Nanosensor based on Engineered Nanostructures for Agricultural Applications

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Agriculture is the backbone of global economy. Presently in agriculture there is an excess supply of macronutrient fertilizer, such as nitrate or phosphate, during crop production. This in future not only reduces the quantity of produce per hectare of land, but can also decrease food quality and shelf life. Nanosensors play an important role in revolutionizing agriculture through the development of next-generation diagnostic tools and techniques. The engineered nanoparticles in nanosensor fabrication further provide added advantage of enhanced performance and sensitivity. The characterization of synthesized nanoparticles and nanocomposite was performed using various spectroscopy (UV-Vis, FTIR) and electron microscopic (SEM, TEM) techniques. In our present work a nanosensor based on hematite nanostructure is reported. The nanosensor demonstrated good sensitivity (63.87 ìA/log(mg/L)/cm^2) and lower detection limits (0.09 mg/L) for nitrate detection in soil extracts. Thus the study explored the futuristic application of the nanosensor for the fast, accurate and in-field assessment of excess of agrochemicals in water, plants, soil and food.

Key words: Nanosensor, engineered nanostructures, agriculture, nanocomposite, food

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Effect of Zinc Oxide (ZnO) and Ferric Oxide (Fe_2O_3) Nanoparticles on Plant Growth and Yield of Soybean (*Glycine max* L.)

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In the modern era nanotechnology is being used in almost all existing science fields. If any dimension of a particle comes within a range of 1-100 nanometers (nm) comes under nanotechnology. The size of material in nano-range increases its biocompatibility, surface area, electrical conductivity and antimicrobial activities, which makes it suitable for multi-uses. Among the various NPs, zinc oxide (ZnO)-NPs and ferric Oxide nanoparticles (Fe_2O_3-NPs) are being used widely in agriculture. We conducted a pot study using ZnO (30 nm) and Fe_2O_3 (50 nm)-NPs separately as well as combinedly to assess the growth and yield of two cultivars of soybean (SLA 958 & PSL 1347) vis-à-vis bulk zinc sulfate ($ZnSO_4$) and ferrous sulfate ($FeSO_4$) as conventional fertilizers during 2022 at ICAR-Indian Agricultural Research Institute, New Delhi, research farm. We applied ZnO and Fe_2O_3-NPs @ of 25 mg kg^{-1} vis -a-vis equivalent amount of in $ZnSO_4$ and $FeSO_4$ (terms of Zn and Fe available in ZnO-NPs & Fe_2O_3-NPs) in the pot soil separately as well as interactively. Results revealed that photosynthetic rates, SPAD and specific leaf area (SLA) (gm cm^{-2}) of both crop plants in increased significantly ($p<0.05$) under the ZnO-NPs and Fe_2O_3- NPs treatments over the control. The specific leaf area (gm cm^{-2}) (SLA) was significantly increased under ZnO and Fe_2O_3-NPs (7.0-10.7%) as well as $ZnSO_4$ and $FeSO_4$ (10.7-21.6%) treatments over the control. Yield attributes such as pods ($plant^{-1}$), grain yield ($plant^{-1}$) and grain weight ($plant^{-1}$) were significantly (1-15%; $p<0.05$) higher under the combined treatment of ZnO and Fe_2O_3 -NPs over the control. The Zn and Fe concentrations in grains are being determined.

Key words: Nanoparticles, Zinc oxide, Soybean

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Zn Enriched Biochar Production through Pyrolysis of Paddy Straw

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Paddy straw was selected as raw material for preparation of biochar owing to its abundant availability. Paddy straw samples were sundried and then grinded using hammer mill to an average size of 1.2 mm. Pyrolysis of grinded paddy straw was carried out in batch type reactor at four different temperatures viz. 300°C, 400 °C, 500 °C, and 600 °C. Proximate and nutrient analysis of prepared biochars along with chemical properties were carried out. Quality of biochar was satisfactory in terms of carbon and nutrient contents. Fixed carbon content was found to be 53.5% and K was found high in paddy straw biochar prepared at 500°C. Biochar prepared at 500°C was selected for Zn adsorption experiments as it showed superior quality in terms of iodine and methylene blue values. Zn was added to biochar through incipient wetness method through Zn based salts. The Zn release patterns of Zn enriched biochar were determined using the sequential leaching method. Further, a pot experiment was also carried out to find out Zn release pattern to soil. Zn adsorption by the biochar was found to the tune of 130 PPM. Water desorption study showed Zn release upto 45 PPM after 48 hours. Zn release in soil was found to decrease slowly till 60 days. When applied as Zn enriched biochar it showed highest Zn release as compared to other forms of Zn applications.

Key words: Biochar production, Paddy straw, Pyrolysis

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Spatial Variability Assessment of Jute Fibre Quality using Geo-informatics in Selected Districts of West Bengal

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Jute, the golden fibre is one of the important natural fibers after cotton in terms of cultivation and usage. Jute cultivation is confined to the eastern and north eastern States coming under humid and sub humid regions. Present study aimed to develop methodology to assess the spatial variability of jute fibre quality over major districts of West Bengal using geostatic approach. Geostatistics were used to show the spatial dependence of jute fibre quality and its interrelationships with various soil properties. The study was carried out over major jute growing districts like Nadia, North-24 Parganas, Hooghly, Murshidabad and Jalpaiguri of West Bengal, India. Ground truth data like GPS points, crop information, soil samples and fibre samples of the 505 points were collected. The collected soil samples and jute fibre samples were analyzed to estimate different fibre quality parameters and to measure the content of different soil nutrients. The IDW and kriging interpolation methods were applied to develop thematic maps of fibre quality parameters and soil nutrients in GIS platform. The performance of the maps was evaluated using Mean square error (MSE). Laboratory analysis of fibre samples in respect of different quality parameters showed different level of spatial variability in terms of coefficient of variation ranging from 15-53%.The root content and bundle strength showed higher variability than fibre fineness. The results showed that the soil properties like available phosphorus and potassium have high variability interms of coefficient of variation (C.V >50%) & nitrogen, OC etc were all moderately variable (C.V<30%).Best quality jute fibre of North 24 Parganas district was found to be associated with availability of higher quantity of specific macro and micro-nutrients. Iron content influenced the heaviness/bulk density of the fibre. Available potassium showed positive correlation with the fibre strength. Fibre quality varied from TDN3+35%'!to TDN1+10%'! in North 24 Parganas , TDN4+30%'!to TDN2 in Nadia, TDN3+26% '! to TDN1 in Murshidabad and TDN3+60% '! to TDN2 in Jalpaiguri district. Inverse distance weight (IDW) showed higher efficiency than Kriging as a prediction method for mapping the fibre quality properties in the study area.

Key words: Spatial variability, jute fibre quality, IDW, Kriging, interpolation

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Soil Compaction Impact on Wheat with and without Artificial Vertical Macropores

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Multiple experiments were conducted to study the soil compaction on the roots of the wheat crop. The whole-soil compaction reduced root length, volume, and weight by 30-50% and the root diameter by ~15% compared to the non-compact soil. The effect was less in clay loam compared to sandy loam soil. There was a large reduction in the transpiration rate with a concomitant increase in intercellular CO_2 content in leaves. The impact was greater with a limited water supply. The compacted subsoil layer restricted root growth, although higher surface area and volume of roots were recorded in the overlying non-compact layer. Artificial vertical macropores through the compact layer facilitated the roots to grow profusely in the loose soil below. Documentation of root responses to the heterogeneous soil layers will help in devising strategies to minimize the adversity of soil compaction.

Key words: Root length, Root diameter, Soil water, Soil texture, Rhizobox, Macropores

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The Critical P Dose in Seedling Root-Dip Method for Enhancing P Uptake in Rice

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Seedling root dip in soil:water slurry amended with nutrient element prior to transplantation of is an efficient rhizosphere based approach for management of plant nutrition in problematic saline soils for sustaining low input agriculture. It reduces the P fixation in saline soil and increase the use efficiency.

The current study was undertaken to evaluate the critical dose of P in soil:water slurry on rice in two different soils (*i.e*. Alluvial, pH, 7.17 and *Vertisol*, pH, 8.37) prevalent in rice cultivated area of north and central India. Phosphorus (SSP) was applied to soil:water slurry to form graded doses of 0 to 200 mg kg^{-1} at 25 mg kg^{-1} interval with incubation duration of 10 h. After incubation, the P content and uptake in rice seedling biomass were determined to derive the relative P uptake and the critical P dose using Cate and Nelson critical curve approach.

The critical doses of P for rice (PB-1) in soil:water slurry was 164 mg kg^{-1} in *Vertisol* and 112 mg kg^{-1} in Alluvial soil. Phosphorus content and uptake in rice seedlings was higher in *Vertisol* than the Alluvial soil. The uptake of P in rice seedling increased due to seedling root dip in P amended soil:water slurry. The P uptake increased 25.5% in Alluvial soil and 22.0% in *Vertisol* over no P control. Study conclude that the critical dose of P for amending soil:water slurry depend on soil types and the P nutrition in rice can be improved through seedling root-dip method.

Key words: Alluvial, Phosphorus nutrition, Relative P uptake, Rice, *Vertisol*

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Effect of Heating and Duration of Heating on Soil Aggregate Stability

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Soil heating is a key factor in changing the physicochemical properties of soil. Extensive experiments have been conducted to identify the heating effects on soil aggregate stability. However, selecting the temperature and timing of exposure are critical in laboratory experiments. In this study, soil is exposed to higher temperatures (Control, 35, 42, 46, 54, 60, and 100°C) in an incubator and oven for varying lengths of time (24, 48, 96, and 192 hours). The effect of the temperature for different durations on aggregate stability was also analysed. After 24 hours of different temperature exposure to the soil sample, no effect was observed; however, after 48 hours of different temperature exposure, the 1000C soil sample showed a slight improvement in the aggregate stability. The soil exposed to 1000C for 192 hours showed significantly increased water aggregate stability. This study found that soil exposed to lower temperatures for a short period of time has no effect on aggregate stability, whereas soil exposed to higher temperatures (100ºC) for a long period of time has a significant effect.

Key words: Soil aggregate stability, soil temperature, and heating effect

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Adsorption of Dissolved Organic Carbon by Mineralogically Diverse Soil Clay Fractions

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Mechanisms of soil organic carbon (SOC) stabilization has received much focus recently due to its relevance in controlling the global C cycle. Through various mechanisms such as, electrostatic attraction, H-bonding, ligand exchange, polyvalent cation bridging and van der Waals forces, phyllosilicate minerals stabilize SOC. Previous studies mainly focused on clay organic interaction derived from geological deposits. However, the effect of interactions among pedogenic phyllosilicate clay minerals, native organic carbon (OC) and sesquioxides (Fe/Al oxides) on the adsorption-desorption of dissolved organic carbon (DOC) is poorly understood. Keeping that in view, a set of batch adsorption-desorption experiments were conducted using pedogenic clays extracted from soils dominated by smectite and kaolinite-illite, and the adsorption data was fitted into Freundlich isothermal model. The clay samples were sequentially treated to remove native OC and sesquioxides, and tested for adsorption-desorption of DOC. The maximum DOC adsorption capacity (K_f) of the soil clay fractions (SCF) maintained the order: Smec > Kaol-Ill. DOC adsorption showed a positive relationship with specific surface area (SSA), and sesquioxides provided the largest contributions to the SSA in the SCF. The removal of sesquioxides from the SCF decreased SSA and thus DOC adsorption, whereas the removal of native OC increased SSA and thus DOC adsorption. This study highlighted the ability of 2:1 expanding clay mineralogy to sequester labile C in natural pedogenic environment.

Key words: Organic carbon, Soil clay fractions

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Effect of Tillage and Nitrogen on Soil Bulk Density, Total Porosity, Soil Aggregate Stability Indices, and Aggregate associated Total Carbon in Maize (*Zea mays* L.) - Pigeonpea (*Cajanus cajan* (L.) Millsp.) Crop Rotation

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This study was aimed to assess the impact of tillage and nitrogen on soil bulk density, total porosity, soil aggregate stability indices and aggregate associated total carbon in maize-pigeonpea crop rotation. This study comprised of three tillage practices i.e., no-tillage (NT), reduced tillage (RT) and conventional tillage (CT), and four nitrogen levels viz., control (N_0), 75% of the recommended dose of the nitrogen (RDN) (N_{75}), 100% of RDN (N_{100}) and 125% of RDN (N_{125}) of crops. Experiment was established in 2012 and soil samples were collected during 2018 (after seven years) from 0-7.5, 7.5-15 and 15-30 cm soil depths. Results showed that NT and RT recorded significantly (p d" 0.05) higher aggregate mean weight diameter (MWD), water stable aggregates (WSA), water stable micro-aggregates (WSMacA), aggregate ratio (AR), aggregate associated total carbon and soil total porosity as compared to the CT. While, significantly (p d" 0.05) higher water stable micro-aggregates (WSMicA), silt+clay fraction and bulk density was recorded in CT as compared to the NT and RT. Similarly, added levels of nitrogen (N_0, N_{75}, N_{100} and N_{125}) significantly (p d" 0.05) increased the MWD, WSA, WSMacA AR and soil porosity, and decreased the WSMicA, silt+clay fractions and bulk density. The order of different size fractions with respect to carbon content was as follows: 0.106-0.053>0.5-0.25>0.25-0.106> 1-0.5> 2-1>4.75-2 mm> silt+clay at all the soil depths studied, irrespective of tillage and nitrogen levels. Further, the results of this study also showed that the amount of crop residue added had positive and significant (p d" 0.05)) correlation with MWD, WSA, WSMacA, AR, macro- and micro-aggregate associated C, silt+clay C, WSMacA C_{stock}, and soil total porosity and negative correlation with WSMicA, silt+clay fraction, soil bulk density, WSMacA C_{stock} and silt+clay C_{stock} at all the depths studied.

Key words: no-tillage, reduced tillage, conventional tillage, nitrogen, soil depth, correlation

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Design and Development of CIAE Economy Seeder: An Innovative 3-In-1 Stubble Management Solution for Combine Harvested Paddy Field and Alike

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Ex situ and in situ management methods are performed for straw management. The developed equipment is an in-situ technology in which the three operations—chopping of the residue, tilling the soil and mixing the chopped residue, and seeding—can be done simultaneously. The chopping and seeding units are attached to the rotary tiller unit. The equipment is fabricated in such a way that either all three operations can be done in a single pass, or in a quick detachment and attachment process, the residue chopping, rotary tilling, and seeding can be done independently as separate operations with independent equipment. The chopping mechanism consists of a set of vertical shafts, each with two pairs of serrated blade flanges, one above the other. The standing and loose paddy straw are cut with the chopping unit, then the pieces of straw are mixed into the soil with the rotary tiller, and seeding is done in the loosened soil. The machine was evaluated in verisol in a combine-harvested paddy field, a field with standing maize plant residue, and also in a standing okra field. Sowing of Bengal gram has been done in the standing maize residue, and sowing of wheat has been done in the standing okra and rice residue. The machine performed satisfactorily in all three conditions. From the primary observation, it was found that there was absolutely no effect on the germination of the seeds. The performance of the CIAE economy seeder was also compared to that of existing straw incorporation machines such as the super seeder, mulcher integrated with a rotavator, and rotavator solely in a freshly combine harvested rice field. All of the machines were evaluated on the basis of mixing index (MI), pulverization index (PI), or mean weight diameter (MWD) and bulk density at 3 km/hr forward speed, 40% soil moisture, and 17% straw moisture. The PI of the superseeder, mulcher integrated with rotavator, rotavator alone, and CIAE economy seeder were found to be 9.03, 8.60, 10.20, and 8.42 mm, respectively, whereas the MI were found to be 85.18, 91.18, 28.38, and 96.59%, respectively. The bulk densities of the loosened soil were found to be 1.365, 1.360, 1.390, and 1.32 g/cm3 for the superseeder, mulcher integrated with a rotavator, rotavator alone, and CIAE economy seeder, respectively. A paired t test was performed to test the significance difference among the results, and it was revealed that the CIAE economy seeder outperformed all the equipment.

Key words: Chopping, mixing index, mean weight diameter, Pulverization index

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Automatic Seedling Pick-up Mechanism using Robotic Manipulator for Use in Robotic Transplanter

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Application of robotics in agriculture has increased automation in the field of many agricultural operations. Transplanting being one of the most cumbersome and time talking operation which is mostly done manually and hence high labour requirement and timeliness of operation is major constraints as the vegetable seedlings are more susceptible to climatic condition. As labour was not available during the peak season so a robotic based technology is a good option to ensure timeliness in operation. Due to lack of manpower during transplanting operation and to ensure timeliness in operation, a seedling pick-up mechanism using robotic arm was developed for robotic transplanter for plug-type vegetable seedlings. The mechanism consists of main frame for XY-axis, stepper motor, manipulator, end-effector and control unit. The stepper motor attached to main frame moves the manipulator in XY-axis whereas the manipulator moves in the Z-axis. The end-effector attached on the manipulator has a gripper which is mounted on the servomotor. The seedling picking mechanism is integrated with the manipulator with computer programming using Microchip-16F877. The end-effector grasp the seedling, pick-up and moves to the XY (0,0) coordinate, and release the seedling. The developed mechanism can extract 3 seedlings/ min. The potential use is to enhance input use efficiency for sustainable productivity and reduce drudgery by avoiding manual practice.

Key words: Automatic, Robotics, Transplanting, Seedling Pick-up, Manipulator, End-effector

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UAV-based Imaging Spectroscopy for Predicting Wheat Leaf Nitrogen

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Quantitative estimation of crop nitrogen is the key to its site-specific management for enhanced nitrogen use efficiency. Alternate to the conventional approach through wet chemistry, sensor-based non-invasive, rapid, and near real-time assessing crop nitrogen at the field scale has been needed for precision agriculture. The present study attempts to predict wheat leaf nitrogen through spectroscopy using a field portable spectroradiometer (with a spectral range of 350 to 2500nm) and imaging spectrometer (with a spectral range of 400 to 1000nm) from UAV with the objective to evaluate (i) four multivariate spectral models, i.e. artificial neural network (ANN), extreme learning machine (ELM), least absolute shrinkage and selection operator (LASSO) and support vector machine regression (SVR); and (ii) between two sets of hyperspectral data collected from two platforms and different sensors. In the former part of the study, ELM outperforms the other methods with maximum calibration and validation R^2 of 0.99 and 0.96 respectively. Further, the image dataset acquired from UAV gives a higher performance as compared to field spectral data. Also, significant bands (399, 520, 668, 691,767, 774, 803, 827, 830, 848, 904 and 922 nm) are identified using step-wise multiple linear regression (SM-MLR) and the derived equation is used to generate a thematic map of wheat leaf nitrogen of the whole experiment.

Key words: Hyperspectral remote sensing, Imaging spectrometer, spectroradiometer, spectral modelling, Unmanned aerial vehicle (UAV)

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Application of Geostatistics and GIS Technique to Characterize Spatial Variabilities of Available Nutrients in Soils of Experimental Farm

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Soil is an important source of available nutrients. Either shortage or surplus of available nutrients in the soil would limit growth of crops. Understanding the spatial variability of experimental farm and distribution patterns of soil available nutrients is essential for management of the soil and application of fertilizers. Geostatistics has been proved as a successful method to study distributions of soil nutrients. The objectives of this study were to analyse the spatial dependency and explain the variation mechanism of available nutrients in the soils of experimental farm; and map the spatial distribution of available nutrients in the soil. To understand the spatial dependency of available nutrients in soils of experimental farm of Agricultural college, Killikulam, 83 surface soil samples were collected from 0-15 cm depth at a 200 x 200 m grid and GPS coordinates were recorded. The samples were air dried and ground to pass through 2mm sieve. Processed soil samples were analyzed for various physico-chemical properties such as pH, EC, organic carbon, available N, P, K and DTPA extractable Fe, Mn, Cu and Zn using standard procedures. Desscriptive statitics and geostatistical analysis were performed. The results reveal that pH of soils varied from 6.08 to 8.73 with CV of 10.21 per cent. The EC exhibited high variability. The available N, P, K exhibited moderate variability. All the available micronutrients showed the higher variability except DTPA-Cu which recorded moderate variability.

Geostatistics was used to estimate and map soils in unsampled areas . The semivariogram of soil properties *viz*., pH, available N, K, DTPA-Fe, Cu and Zn were well defined by spherical model. Soil properties such as EC and DTPA-Mn were well fitted by exponential model whereas organic carbon and available P were fitted by gaussian model. The spatial dependence classes were strong for EC, organic carbon, exchangeable Ca and DTPA-Cu, whereas all other soil properties exhibited moderate spatial dependence except available S which showed weak spatial dependence. Spatial distribution maps of soil properties from each location were made using Arc GIS software.

Key words: Geostatistics, GIS technique, Soils

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Automatic Fertigation Controller for Water and Nutrient Management in Soilless Cultivation

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Soilless grow bag cultivation inside the protected structure are used for round the year production of high-value horticultural crops. To maximizing water and nutrient use efficiency, automatic fertigation controller need to be developed for effective fertigation scheduling inside the coco-peat grow bag cultivation. For this purpose, a prototype of weight sensing system with a load sensor was designed and developed to detect weight loss and gain due to transpiration and fertigation application. This system was used to control real time preparation and application of nutrient solution. The programmable microcontroller-based circuit was designed for automatic fertigation with integrating the sensors and keypad as inputs components and output components consist of pumps, solenoid valve, LCD display to ensure automatic preparation and application of fertigation in a soilless grow bag system. Also, user interface was created for modification and calibration of input data as well as changing the irrigation mode and various user-defined conditions. The developed system will be worked in both sensor and timer-based condition. The user can opt for sensor or timer based control of fertigation scheduling of the crops in the functional control mode. The performance of the indigenous automatic fertigation controller was evaluated during cucumber cultivation in coco-peat grow bags and it was found capable of detecting water loss, which was helpful for automatic fertigation scheduling and preparing the nutrient solution in real time.

Key words: Soilless cultivation, Greenhouse, Microcontroller, Nutrient solution, Fertigation scheduling

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Water Productivity and Economic of Deficit Irrigation in Cumin Crop Grown in Arid Western Rajasthan, India

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Cumin (*Cuminum Cyminum* L.) crop (var. GC 4) is generally grown in winter season in arid region of India under irrigation system. Keeping in mind the scarcity of water in the region, performance of this crop has been assessed under deficit irrigation levels at the experimental farm of ICAR-Central Arid Zone Research Institute (ICAR-CAZRI), Jodhpur during winter season of 2020-2021 and 2021-2022. For this purpose, mini-lysimeters based on single load-cell (size 0.50 m × 0.50 m × 0.55 m and a resolution of 0.2 mm) was used. Four levels of irrigations were applied in the experiment and these are 100%, 80%, 60% and 40% of cumulative pan evaporation (CPE), which was considered 50 mm in our study. Irrigations were applied using mini-sprinkler system operated by 1 hp mono-block water pump with a suction head of 1.2 m. Daily actual crop evapotranspiration (ET_c) was recorded and the mean value of the measured ET_c at 100, 80, 60 and 40% irrigation levels was computed as 368, 331, 262 and 208 mm, respectively and the corresponding crop yields were 1090, 1030, 772 and 483 kg ha^{-1}, respectively. On comparing crop yield at full irrigation (100% irrigation level) with that at deficit irrigation, a yield reduction of 5.8, 33.4 and 60.0% was found at 80, 60 and 40% irrigation levels, respectively. Water productivity was found higher, 0.31 kg m^{-3}, at irrigation level equivalent to 80% CPE or a deficit level of 20% as compared to control for which the yield was 0.30 kg m^{-3}. Further the economics of irrigation water application was computed to show the benefits of deficit irrigation apart from improving water productivity. Cost of irrigation water application has been computed for two steps. First, the cost involved in lifting the groundwater to a surface water reservoir. Second, the cost involved in distributing the surface water from reservoir to filed through pressurized irrigation system. It has been found that for 1 ha-mm irrigation in field, it costs about Rs 28.63/- which is majorly contributed by the cost involved in lifting the groundwater (Rs 24.00/-) as compared to its distribution in field (Rs 4.63/-). From this study, it may be inferred that by adopting 20% deficit irrigation level in cumin, there is possibility to conserve water whereas yield reduction was only 5.8%. Further, the deficit irrigation level saves money involved in application of additional irrigation water in the field and therefore increases net return from cumin cultivation. Therefore, a deficit irrigation of 20% can be recommended for growing cumin during winter season in the arid zone of India.

Key words: Water productivity, Mini-lysimeter, Deficit irrigation, Cumin and Arid region

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Spectral Vegetation Indices and Their Relationship with Chlorophyll, Nitrogen and Yield of Wheat (GW-366) as influenced by Inorganic, Organic and INM Practices

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A field study was carried out at research farm of Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in the year of 2018-19. The soils of the experimental site belongs to medium black clayey (Vertisol), pH 7.42, EC 0.16 dSm^{-1}, available N 164 $kgha^{-1}$, P 33.6 $kgha^{-1}$, K 200 $kgha^{-1}$,DTPA extractable Zn 1.18 mg kg^{-1} and hot water soluble B 0.49 mg kg^{-1}. The treatments were comprised of 3 sources of nutrient chemical, organic and integrated (chemical and organic) as main treatments and 5 fertility levels control, 100% NPK, 150% NPK, 200% NPK, and Based on soil test value for target yield of 6 t ha^{-1} as sub treatments in split plot design and replicated thrice. The wheat crop sown in *Rabi* season on dated 13.12.2018 with spacing of 22.5 cm row to row and harvested on dated 13.04.2019. Four irrigations were applied to crop at crown root initiation (CRI), tillering, flowering and seed formation stages of wheat.

The canopy spectral reflectance crop was recorded in region 350 to 1150 nm under different treatments on dated 28 February and 14 March 2019. The marked differences in reflectance were observed in the visible region and the NIR region over control. The result revealed that the sources and nutrients levels significantly increased the chlorophyll content in the leaves, SPAD, LAI, Nitrogen content in leaf, T_{leaf} and T_{air}, yield attributes and yield over control. The results also showed that the Chlorophyll, SPAD and LAI, were significantly related with yield and N content in leaves at 21,45,60and 90 DAS on both dated 28 February and 14 March 2019.

Vegetation index have been used for the non-destructive estimation of chlorophyll content. Top most significant spectral index was found *viz.*, Boochs, PWI and TVI for chlorophyll, Boochs, MTVI and TVI for SPAD, DPI, Datt3 and EVI for LAI and TVI for N content at 21,45,60 and 90 DAS, respectively. TVI and Boochs were also found significantly correlated for yield on dated 28.02.2019.

While top most significant spectral index was found *viz.*,Carter, Sum_Dr1 and Datt4 for chlorophyll a, D1, CI, MSAVI and Carter5 for chlorophyll b and Carter, Boochs, Sum_Dr2 and Datt4 for total chlorophyll; Carter and Sum_Dr2 for SPAD; Carter and PRICI2 for LAI and Carter and Sum_Dr2 for N content at 21, 45, 60 and 90 DAS, respectively. Carter index was found significantly correlated for yield on dated 14.03.2019.

Thus, optical sensors can help to understand nutritional status of the plant, and scientifically guide the fertilization management to ensure a good crop quality and yield. This practice has an important significance for the modern precision agriculture. However, further studies are required to test this index with more diverse datasets and different crops.

Key words: SPAD, LAI, Chlorophyll, Vegetation Index, Wheat, Nitrogen, Inorganic, INM, Organic and Fertility Levels

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Rainfall Trend Analysis for Bhopal in Perspective of Climate Change

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The objective of the paper was to assess the changes in rainfall pattern in Bhopal. For this purpose, primary data collected during 1983 to 2022 by agro-meteorological observatory, ICAR-Central Institute of Agricultural Engineering, Bhopal was used. Trend analysis was done using Mann-Kendall test. The change point detection was performed using Pettit test and slop was estimated using Sen's slop estimator. The average annual rainfall in Bhopal was estimated to be 1076(±120) mm. There was no any trend detected in annual rainfall (p value 0.47). In addition, month wise rainfall data also showed no increasing or decreasing trend over the year. Sen's slop estimator showed an insignificant increment in annual rainfall 1.17 mm/year. An insignificant decrease in rainfall in the month of June and August over the year estimated to be 0.32 and 0.79 mm/year, respectively.

Key words: Annual rainfall, trend analysis, Mann-Kendall test, change point detection, Sen's slop estimator

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Climatic Conditions for Desert Locust (*Schistocerca gregaria)* Invasion in India

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Desert Locust *Schistocerca gregaria* is an occasional, polyphagous, trans-border migratory pest. It devastates all the green vegetation of the area through which it migrates. Its outbreak occurs frequently in African and Arabian countries and occasionally in Indian sub-continent. Weather condition plays a very important role in oviposition, development and migration of desert locust. Extreme weather like cyclones and off-season rainfall, wind speed and direction, soil moisture and soil temperature are utmost important to decide the outbreak. A study was conducted on its climatic relationship and chances of outbreak in India with the secondary data collected through literature.

The Arabian Sea cyclonic storm (extreme weather) data on timing and severity have been collected from secondary sources (WMO, FAO) for last 50 years. Simultaneously, desert locust outbreak data were also collected. The role of extreme weather, cyclonic storm at Arabian Sea was studied for outbreak of desert locust. It has been found that back-to-back cyclones within a month time or severe cyclonic storms originated at Arabian sea and hitting Arabian Peninsula (Oman and Yemen) or the Horn of Africa (Kenya, Somalia and Ethiopia) had created favourable environment for oviposition and hatching of eggs into nymphs. The nymphs transformed into adults and migrated along with the wind in huge numbers. Wind direction decided where it could migrate. Some years it could come to deserts of Iran and Pakistan. In 2018 and 2019, there was back-to-back cyclones which landed at Oman and Yemen.

Western disturbances or the low-pressure system development in Mediterranean sea facilitated further breeding in Iranian desert and migration through winds of western disturbances to reach NW India during November to April. Amount of *rabi* season rainfall and number of rainy days at NW India (Delhi) acted as a favourable factor and it can be used as an indicator. During the *rabi* season of 2019-20, 306.5mm of rainfall occurred over 18 rainy days. Frequent cyclonic activity at Arabian sea hitting at Arabian Peninsula followed by frequent western disturbances led to outbreak of desert locust in Iran, Pakistan, Afghanistan and India in 2019-20.

Key words: Climatic conditions, Desert Locust, India

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Effect of Climate Change on Crop Production and its Adaptation and Mitigation Strategies

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Climate change is one of the biggest challenges to Indian agriculture. Changes in climate can be expected to have significant impacts on crop yields through changes in weather parameters such as temperature and moisture. Changes in rainfall distribution and patterns, rising temperatures, increased CO_2 levels in the atmosphere, and the dispersal of pests and diseases that affect plants also might have a negative impact on agricultural output as a result of changing climatic patterns. The average global temperature has been rising at an average rate of 0.15–0.20 °C per decade since 1975 and is expected to increase by 1.4–5.8 °C by 2021. The CO_2 concentration in the atmosphere had increased to 411.43 ppm in 2019 from 315.98 ppm in 1959. CO_2 is a major proportion of greenhouse gases, is increasing at an alarming rate, and has led to higher growth and plant productivity due to increased photosynthesis, but increased temperature offsets this effect as it leads to increased crop respiration and transpiration rates as well as higher pest infestations, shifting weed flora, and reduced crop lifespan. The purpose of mitigation and adaptation measures is therefore to attempt a gradual reversal of the impacts caused by climate change and to sustain development under the inescapable effects of climate change. There are several adaptation and mitigation strategies, like resource-conservation based technologies, cropping-system based technologies, biodiversity, water harvesting, and socio-economic or policy interventions. Climate change will also severely affect agricultural markets, causing a reduction of 0.26% in global GDP. There would be a projected annual loss of 0.2–1% in household welfare if the climate predicted for the 2080s occurred today.

Key words: Climate change, green house gases, adaptation, mitigation, crop production

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Fuzzy- Analytical Hierarchy Process based Geospatial Mapping of Rainwater Harvesting Suitable Zones

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Rainwater harvesting (RWH) is a well-known technique that could address the problems of the gradual decline of surface water resources and overexploitation of groundwater resources. The demarcation of rainwater harvesting suitable zones is essential for efficient implementation of water harvesting structures and to solve the water scarcity issues. The comprehensive methodology was applied to determine the suitable zones for RWH in Kanhar river catchment by using the fuzzy analytic hierarchy process (FAHP) and geographic information system (GIS). The thematic layers of rainfall, slope, soil, land use/land cover, and drainage density were selected. Using FAHP, suitable weights were assigned to selected themes and their subclasses. The themes were integrated using the weighted overlay tool in the ArcGIS environment to demarcate the potential zones for RWH. The developed map of the rainwater harvesting suitable zone was categorized into five classes: 'very good', 'good', 'moderate', 'poor' and 'very poor' potential. The highest percentage area (32.2%) was identified under 'moderate' potential, followed by 'good' (28.2%) and 'poor' (25.2%) potential. The 38 locations were found to be suitable for check dam construction and a total of 277.8 km^2 area was found to be appropriate for farm pond sites. The delineated suitable zones/sites for RWH may help policymakers and planners to effectively implement the water harvesting strategies in the Kanhar river catchment.

Key words: Fuzzy analytic hierarchy process; geographic information system; Rainwater harvesting; Weighted overlay tool

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Energy Efficiency and Carbon Footprints of Maize-Wheat System under Long-Term Tillage and Nitrogen Management Scenarios in Vertisols of Central India

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The ongoing degradation of natural resources mainly due to anthropogenic activities led to increased greenhouse gas (GHG) emission. The annual GHG emission from both agricultural and natural ecosystems is estimated to be similar to 5.9 Gt carbon dioxide equivalents (CO_2-eq) per year. Recently research focussed on energy dynamics and carbon footprints estimation under prominent mono-cropping systems of rice-wheat-maize etc. Those studies mainly focussed on tillage impact that is energy intensive field operation. Maize-wheat (MW) system occupy about 2 million ha (Mha) mainly by small holders farmers and is the third most important cropping system in India. The present investigation was undertaken to assess the long term impact of tillage and various nitrogen fertilizer options on energy auditing and climate change indices of maize-wheat system. The treatments used for assessing the energy dynamics indices, green house gas parameters and carbon footprints includes, 150% N, 100% N, 50% N and 0% N under no tillage (NT) and conventional tillage (CT) applications in maize-wheat system. The data revealed that total input energy was found to be higher in CT over NT in all the N treatment scenarios. Further, the output energy in terms of grains and straw was higher in CT over NT in all the treatments, with variation in energy use efficiency (EUI). The energy productivity (EP) was found to be 0.43 kg/MJ in 150% N under CT compared to NT with 0.45 kg/MJ might be due to more inputs in CT over NT. The Net energy return (NER) which is the difference between energy output and input was observed to be higher under CT over NT. While, the Energy Profitability was 17.73 in 150% N in NT over 17.58 in CT. The operation wise input energy under varying tillage and N management options depicts maximum contribution through fertilizer application followed by inputs in terms of seeds, irrigation then harvesting and threshing and land preparation in CT while, the order was fertilizer application > Irrigation/ Seed > harvesting and threshing > Pesticide application in NT. The percentage share of green house gas emissions (GHGs) from different management practices suggests maximum

contribution through fertilizer application followed by seed in both CT and NT. Thus, the practice of no tillage under balanced dose of nutrient may serve quite beneficial in terms of energy dynamics and mitigation of climate change by lower GHG emissions under maize-wheat rotation in Vertisols of Central India.

Key words: Carbon footprints, Energy indices, Maize-Wheat cropping system, Sustainability, Vertisols

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Enrichment of Soil Health, Productivity and Grain Quality under Long-Term Organic Nutrient Management in Rice Cultivation

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Organic manures, often preferred as a low-cost and easily accessible nutrient source for improving the soil's physical-chemical-biological parameters, and better access to soil nutrients for long-run (Kassam *et al*. 2011). So far more emphasis was given on the INM approach, however the present study highlights the significance of sole ONM for achieving a sustainable agriculture. The experiment is being maintained with *kharif* rice since 2016 at institute farm, while the particular plot has been cultivated avoiding chemical fertilizers from more than a decade. The eight distinct organic nutrient treatments constituted with FYM and azolla, green manure, vermicompost with 50% and 100% replacement. Different N-responsive and aromatic rice varieties were grown over the years in split-plot design. To assess the impact of ONM on soil health several soil parameters, physical (BD, moisture content) physico-chemical (pH, EC), fertility (SOC, TOC, C-fractions, available N, P, K and micronutrients), soil microbial activity (MBC, soil enzymes, glomalin content) was studied. Besides, biochemical analyses of grain quality parameters (amylose, protein and water uptake) were also taken into consideration. Yield data (both grain and straw) was recorded at the harvesting of every season. Results showed that both the cultivars had responsiveness towards organic sources of nutrients, while grain yield most improved in a tune of 25-33% by effect of green manure and FYM+ vermicompost treatments. Majority of soil parameters including SOC, TOC, C-fractions, availability of major and micronutrients and C-N mineralization were found significantly better in FYM+ Azolla/Green manure/ Vermicompost. Likewise, similar treatments also enhanced microbial activities like dehydrogenase, urease, acid and alkaline phosphatase, â-glucosidase, aryl sulfatase and fluorescein diacetate hydrolysis enzymes. This particular study emphasizes that organic manures could enrich the rice-cultivated soil that reflects in nutrient availability, soil inhabiting microbial activity and grain quality so that it can be proposed as a long-term strategy for agricultural sustainability. Besides the INM, the practice of sole ONM can also be alternatively adopted among the rice farmers considering its importance in soil fertility management.

Key words: Soil health, Rice cultivation, Nutrient management

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Effect of Elevated CO_2 and Temperature on Chlorophyll Content and Yield in Rice-Wheat Cropping System in *Vertisol* of Central India

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The rice-wheat cropping system is mostly adopted cropping system in India predominantly in Central India. The current study was undertaken to evaluate the effect of elevated CO_2 and temperature on plant growth specially the chlorophyll content and yield of rice-wheat cropping system in *Vertisol* of Central India. A field experiment was conducted under Free Air CO2 Enrichment (FACE) system with 6 treatments: T1 (Control (Ambient CO_2 and Temperature)); T2 (Ambient temperature + Elevated CO_2 (600ppm)); T3 (Ambient CO_2 +Elevated temperature (2°C)); T4 (Ambient CO_2 + Elevated temperature (3°C)); T5 (Elevated CO_2 (600ppm) + Elevated temperature (2°C)) and T6 (Elevated CO_2(600ppm) + Elevated temperature (3°C) along with 4 replication. The plots are arranged in randomized block design. The effect of elevated CO2 and temperature response differently in wheat and rice crops. The chlorophyll content in wheat (*i.e.* Chl a, Chl b, Total chl and carotenoid) at full vegetative stages was significantly higher in T5 than others while in rice T3 was significantly higher than the other treatments. The plant height at fully vegetative stage of rice was not significantly difference among the treatments while in wheat T2 was significantly higher than the other treatments. In both rice and wheat crop, the highest value was accorded in T2 (Ambient temperature + Elevated CO_2 (600ppm)) in terms of shoot and root biomass, yield and no. of grain/panicle. The yield increased over control was highest in T2 (16.24%) in rice and (17.40%) in wheat. Study suggests that climate change factors would affect the productivity of rice-wheat cropping system significantly.

Key words: Elevated CO_2, temperature, rice-wheat, chlorophyll, *Vertisol*

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Soil Organic Carbon Dynamics and CO_2 Emissions during Wheat Growth under Different Tillage and Residue Management

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Soil organic C (SOC) has long been acknowledged as an important determinant of soil quality and is a key factor in determining the productivity and long-term stability of agricultural production systems. Tillage and crop residues retention have a great influence on soil organic carbon dynamics and CO_2 emissions through the changes of soil properties depending on the straw amount, type and returning mode. A study was conducted in this view during the year 2020-21 in a long term field experiment being conducted in a Typic Haplustept at the Indian Agricultural Research Institute, New Delhi since 2014 to study the effect of tillage, crop residue mulching, and nitrogen interactions on soil organic carbon dynamics and CO_2 emissions during wheat (cv HD 2967). The experiment was laid out in split–split plot design with two levels of tillage (Conventional tillage (CT) and No tillage (NT)) as main plot factor, two levels of mulching (with or without crop residue mulch @ 5t ha^{-1}) as sub plot factor and three nitrogen doses (50, 100 and 150% of the recommended dose of N) as sub-subplot factor. It was observed that soil organic carbon (Walkley black) was 17.2%, 1.17% and 17.63% higher in NT than under CT for 0-5, 5-15 and 15-30m of soil layers, respectively. Residue retention plots had ~10% higher values of SOC for both NT and CT at all the three depths. A similar pattern was also observed for total organic carbon. The effect of NT was more spectacular in case of soil carbon pools. The labile and the recalcitrant pools were found to increase in case of NT as compared to CT for all the three depths. Residue retention plots had greater labile pools for both NT and CT plots. Microbial Biomass Carbon was found to be 43% higher for NT with residue than for CT with residue. The CO_2 emissions from the wheat field were significantly influenced by tillage and residue treatments. CO_2 emissions decreased for residue retention plots than for residue removal plots under NT whereas under CT residue retention increased CO_2 emissions compared to residue removal. Thus, from this study it may be concluded that wheat may be grown under no tillage with crop residue mulch @ 5t ha^{-1} and 100% of recommended dose of N to obtain improved soil organic carbon dynamics and reduced CO_2 fluxes from wheat fields in Inceptisols.

Key words: Soil organic carbon, CO_2 emissions, Wheat growth

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Sustainability of Cropping Sequences under Projected Climate: An Assessment with Crop Simulation Modelling

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The impact of projected climate on six cropping sequences (rice-mustard-groundnut, rice-lentil-groundnut, rice-potato-groundnut, rice-wheat-groundnut, rice-maize-groundnut and rice-mustard-fallow) of New Alluvial Zone, West Bengal was evaluated using multiple GCMs, long term crop sequence modelling using DSSAT and multi-criteria decision analysis tool. The crop management data for individual crops were collected from secondary sources from the study region to perform the model calibration. The validation of the models was performed using RMSE, nRMSE and MBE. Sequence analysis module in DSSAT was used to simulate growth and yield of six cropping sequence during baseline (1980-2010). Future climate scenarios were developed using 29 GCMs from which a subset of 5 representative GCMs were selected for mid-century (2040-2069) and end-century (2070-99) under RCP4.5 and RCP8.5 emission scenarios. To identify most sustainable cropping sequence in future, yield, total seasonal ETa and nitrogen fixed by the cropping sequences were considered. Weighted average ensemble yield, ETa and nitrogen fixed by all cropping sequences for the study period were estimated. A multi-criteria decision analysis tool, 'TOPSIS' was used to rank the cropping sequences. The multi-model (29 GCMs) ensemble mean seasonal rainfall is projected to increase during *kharif* (except during mid_rcp4.5) and summer seasons. Tmax and Tmin during mid and end-centuries are projected to be consistently higher than baseline period for *kharif*, *rabi* and summer seasons. Under all the time periods, rice-lentil-groundnut had highest weighted average ensemble yield, followed by rice-wheat-groundnut. Rice-lentil-groundnut fixed highest quantity of nitrogen, followed by rice-maize-groundnut. Ranking of cropping sequences by TOPSIS method for sustainability indicated that during mid-century (under both RCP4.5 and 8.5), rice-lentil-groundnut sequence will be the most sustainable cropping sequence. But, during end-century, rice-wheat-groundnut sequence will be the most sustainable cropping sequence, followed by rice-lentil-groundnut under both RCP4.5 and 8.5 for new alluvial zone of West Bengal.

Key words: Crop simulation modelling, Projected climate

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Response of Paddy Straw Mulch and Different Sources of Nutrient on Yield and Economics of Rice and Potato Crops under Rice - Potato Cropping System

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A two years (2020-21 and 2021-22) field study was carried out at ICAR-CPRI-RS, Gwalior, to evaluate the response of paddy straw mulch and different sources of nutrients on yield and economics of rice and potato crops under rice - potato cropping system. The experiment was conducted in randomized block design with three replications. The treatment combination consisted of two factors such as paddy straw mulch and different sources of nutrients. The highest rice grain yield of 3754 and 3857 kg/ha during 2020-21 and 2021-22 were recorded with 100% RDF (NPK) which was 24.88 and 23.41% higher than FYM @25 t/ha + Jeevamrut @500 l/ha during 2020-21 and 2021-22, respectively. The highest tuber yield of 25.72 and 27.14 t/ha were recorded during 2020-21 and 2021-22 which was 8.98 and 11.68% higher than FYM @25 t/ha + Jeevamrut @500 l/ha during 2020-21 and 2021-22. Paddy straw mulch @5 t/ha with 100% RDF (NPK) resulted in higher rice grain and potato tuber yield than without mulched treatment. But differences among the interaction of treatments did not reach to the level of significance. Application of FYM @25 t/ha + Jeevamrut @500 l/ha with paddy straw mulch @5 t/ha obtained the highest net returns (₹ 44012 and 50820 /ha) in rice and (₹ 231304 and 259822 /ha) in potato during 2020-21 and 2021-22, respectively. Thus organic production of rice – potato system proved economically viable option.

Key words: Paddy straw mulch, Nutrient, Rice, Potato

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Technological Evaluation of Selected No-till Seed Drill under Conservation Agriculture

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Conservation agriculture (CA) identified by the practice of minimum soil disturbance, diversified crop rotations, and maintenance of organic soil cover reinforces ecosystems services through a number of interrelated pathways. Currently no-till machines are available to achieve the goal of high productivity with reduction in input cost. In this study four machines namely happy seeder, slit till drill, mulcher cum seeder and zero till planter with herbicide application evaluated and demonstrated to the farmers and researchers. The performance was evaluated at institute research farm as well as at farmer's field and the same has been compared with farmers practice. The yield, energetics and economics of wheat crop were evaluated. The wheat variety of HI-1544 was sown in the *Rabi* season under rice residue conditions. The energy consumption was maximum in the case of sowing with a conventional seed drill (11040 MJ/ha) including two-pass of a cultivator and one pass of rotavator, which was followed by of slit-till-drill (10037.03 MJ/ha) and happy seeder (10096 MJ/ha). The cost of operation of slit-till drill, happy seeder and conventional seed-cum-ferti drill was Rs. 1564/ha, Rs. 1673.0 ha and Rs. 2302 /ha. The still-till drill could save 32% on the cost of operation and 10% in energy as compared to conventional seed-cum-fertilizer drill. The yield of wheat variety of slit-till drill was at par with happy seeder and higher as compared to conventional method.

Key words: Slit-till drill, happy seeder, Conservation Agriculture, operational cost and Energy consumption

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Soil Aggregation and Organic Carbon Status in an Organic Rice-Wheat Cropping System

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The long-term impact of organic farming on soil aggregates and organic carbon pools was evaluated in a rice-wheat (R-W) system with or without mung bean in rotation at IARI, New Delhi (an Inceptisol). Organic nutrients resulted in higher stability of soil aggregates in the top layer (0-7.5 cm), and more so when mung bean was included in the rotation, although the change in mean weight diameter was larger in the R-W rotation in both top and the 7.5-15 cm layers. The farmyard manure (FYM) with crop residues had the highest total organic carbon (C_{TOC}) in both layers (~2%) while particulate organic matter-C (C_{POM}) was higher in treatments where FYM or vermicompost (VC) was combined with crop residues and biofertilizer. The mean weight diameter of aggregates correlated with C_{POM} (r=0.51) among the C pools, while AS showed the highest correlation with C_{TOC} (r=0.53). The impact of crop residue application with VC or FYM emerged as the best combination for improving soil physical condition and soil C status in the rice-wheat cropping system in Inceptisol.

Key words: Aggregate Stability, Soil Organic Carbon, Organic Farming, Rice-Wheat

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Crop Establishment Methods and Weed Management Practices Influence Weed Dynamics, Productivity and Soil Health in Maize-Wheat-Greengram Cropping System

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Maize-wheat-greengram is an important cropping system that is significantly affected by weed infestation. Though, prevalence of weed largely dependent on management practices. Therefore, a field study was conducted at ICAR-Directorate of Weed Research, Jabalpur (M.P.) to know the effect of crop establishment methods and weed management practices on weed dynamics, productivity, and soil health in maize-wheat-greengram cropping system. The experiment was laid out in a split-plot design and replicated thrice, where main plots were assigned to crop establishment methods [conventional tillage (CT)-CT-CT and zero tillage coupled with previous crop residues (ZTR)-ZTR-ZTR] and in sub-plots weed management practices [weedy check, recommended herbicide (RH), integrated weed management (IWM) and herbicide rotation (HR)]. Results reveal that regardless of crop adoption of ZTR-ZTR-ZTR recorded a reduction in weed density by 9.6-16.9%, whereas biomass reduction was 16.8-22.5% over CT-CT-CT system. Among weed management practices, adoption of HR and IWM was comparable that controlled weed density by 82-99.7% and biomass by 91-99.9% over weedy check. System productivity in ZTR system was higher [14.4 t/ha of maize equivalent yield MEY)] but was comparable to CT system (14.05 t/ha). System irrigation and water productivity were higher with ZTR system over CT system. System profitability were also measured more with ZTR system than that of CT system. In the maize-wheat-greengram system, adoption of herbicide rotation and IWM controlled large groups of weeds. Among weed management practices, adoption of integrated weed management obtained highest system productivity in terms of MEY, system irrigation and water productivity and system profitability these were followed by HR. All system indices were recorded as the lowest with weedy check. Therefore, it can be concluded that the adoption of ZTR system with either herbicide rotation or integrated weed management will provide better weed control, higher system crop-water and energy productivity and profitability in maize-wheat-greengram cropping system.

Key words: Weed management practices, Soil health

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Conservation Agriculture in Cereal-Based Cropping Systems: Impacts on Crop Productivity, Profitability and Soil Health

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The world faces the challenges of food and nutritional security *vis-à-vis* the proclamation 'zero hunger' by 2030 (Sustainable Development Goal 2/SDG2) of the United Nation has been emphasised to meet up the challenges of hunger and malnutrition. The cultivation of crops depends on several natural and man-made resources such as, soil, water, nutrients, labour, energy, and pesticides. Injudicious use of the natural resource bases has resulted in numerous problems such as stagnating yield and farm income, declining natural resources, soil degradation, accumulation of toxic substances in water and air, besides the concerns of climate change. Addressing these problems in a holistic manner a sustainable and climate resilient cereal crops-based production system is needed for sustainable crop production with a suitable balance in agricultural ecosystem. Therefore, conservation agriculture (CA) based rice-wheat, maize-mustard, maize-wheat, cotton-wheat and pigeon pea-wheat systems under 12 years old long-term experiments were evaluated for productivity, profitability, water, nutrients, energy use efficiency, carbon sequestration, soil physical, chemical and biological properties and greenhouse gases emission at ICAR-IARI, New Delhi. In a 12-year old rice-wheat system, it was observed that a triple zero-till cropping system (TZT) involving zero-till direct seeded rice (ZTDSR) with summer mungbean residue (MBR)- ZT wheat (ZTW) with rice residue (RR)– ZT summer mungbean (ZTMB) with wheat residue (WR) was consistently superior to puddled transplanted rice (PTR) - conventional till wheat (CTW) system on wheat yield, system productivity and net returns. It led to ~16% higher wheat yield, ~34% higher system productivity although had ~9% lower rice yield than TPR-CTW system. This triple ZT system could save almost 60 kg N/ha in rice-wheat system per year. Similar results were obtained under another long-term CA-based maize-mustard cropping system. Under the CA-based maize-wheat system, all the CA-based ZT permanent broad, narrow, and flat beds with residue resulted in significantly higher yields of maize, wheat and system productivity than conventional tillage (CT) system. The ZT permanent broad bed with 100% N led to significantly higher maize yield by ~46%, wheat yield by ~10% and system productivity by ~23% than CT system. This practice with 75% N was comparable with it, leading to a saving of 25% N. This CA-based maize-wheat system could be a promising crop diversification option for rice-wheat system and an important adaptation

and mitigation strategy to climate change.The triple zero-till conditions in rice-wheat-mungbean system resulted in 30-35% savings in irrigation water and 91% higher system water productivity (kg grain/m^3 of water) compared to conventional rice-wheat system. In maize-wheat cropping systems, the system water productivity (SWP) was highest in zero-till broad bed with residue. The CA practice in all cropping system significantly improved the soil physical, chemical and biological properties. Practices such as permanent broad (PBB) and narrow (PNB) beds with and without residue and ZT with residue retention reduced bulk density (BD), increased saturated hydraulic conductivity (K_{sat}) and significantly improved soil water retention at field capacity (FC) over CT. A significant improvement in total SOC concentration was noticed under all CA-based cropping systems. Preventing residue burning and improving nitrogen-use efficiency would help to reduce CO_2 and other greenhouse gases emission. The PBB+R treatment had significantly lower GHG intensity (0.20-0.23 kg CO_2/kg grain) than others. Thus, these CA-based cropping system-specific practices need to be upscaled under small holders' farms in a participatory mode. Awareness and positive mind set of users are needed for adoption of CA. Frequent training, counseling, and working-together attitude would improve farmers' acquaintance with CA equipment/machineries and smoothen CA adoption.

Key words: Conservation agriculture, Crop productivity, Soil health

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Influence of Tillage and Nitrogen Regime on Microbial Activity and Diversity in Maize Based Cropping System

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Maize is an emerging *kharif* crop in central India (Madhya Pradesh) due to its adaptability to wide range of edaphic and climatic conditions. The yield and performance of crop varies with methods of seedbed preparations and management practices adopted. Studying microbial dynamics under given management is very crucial not only for understanding the soil productivity and sustainability but also for development of new management strategies to reverse declining soil organic matter (SOM) content and improving soil fertility. Thus, in present study we evaluated the long term effect of tillage, residue management and different levels of nitrogen fertilization on soil biological properties under Maize-Wheat (MW) and Maize-Chickpea (MC) cropping system by measuring soil enzymes activity as well as genomic techniques. With increase in nitrogen dose, soil dehydrogenase activity increased. Soil Fluorescein diacetate (FDA) hydrolysis activity was found significantly higher in no tillage (NT) compared to conventional tillage (CT). The activity of â-Glucosidase in soil was found to be the highest in NT-MW system at 100% N ($p<0.05$; 155.77 μg PNP/g soil/h), 150% N ($p<0.05$; 148.48 μgPNP/g soil/h) which was at par with CT-MW at 150% N ($p<0.05$; 146.40 μgPNP/gsoil/h). Based on genomic fingerprinting RFFLP, MC-CT-0% sample had unique fragment in digestion profile of bacterial 16S rRNA gene with three restriction enzymes used which was not present in any other samples. Similarly for fungus diversity study, a band of approximately 600bp size was present in all the samples but not in sample MW-CT-0% which indicates probable elimination or lower abundance of representing taxa in this treatment. One unique band at approximately 550bp was found in MC-CT-100% sample which was not present in any other soil samples. The findings indicated that prokaryotic microbial (bacterial) diversity was more influenced by cropping system and nutrient level whereas eukaryotic microbial (Fungal) diversity appeared to be more affected by crop residue and tillage practices.

Key words: Tillage, Microbial diversity, Fingerprinting, Soil enzymes, Nitrogen regimes

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Impact of different Crop Covers on Soil and Nutrients Losses in Vertisols of Central India

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A field experiment was conducted to study the effect of different crop covers and its combinations on soil and nutrient losses through runoff in a Vertisol at research farm of ICAR-Indian Institute of Soil Science, Bhopal. This experiment consisted of seven crop covers namely- soybean, maize, pigeon pea, soybean + maize, soybean + pigeon pea, maize + pigeon pea and cultivated fallow with a randomized block design. Results revealed that the runoff and soil loss were significantly higher (289 mm and 3.92 Mg ha^{-1}) under cultivated fallow than those under cropped plots. Among various crop covers, sole pigeon pea recorded significantly higher runoff and soil loss (257 mm and 3.16 Mg ha^{-1}) followed by sole maize (235 mm and 2.85 Mg ha^{-1}) and lowest runoff and soil loss were recorded under soybean sole crop (194 mm and 2.27 Mg ha^{-1}). However, among the intercrops recorded relatively low runoff and soil loss like maize + pigeon pea (211 mm and 2.47 Mg ha^{-1}), soybean + maize (202 mm and 2.38 Mg ha^{-1}) and soybean + pigeon pea (195 mm and 2.15 Mg ha^{-1}). The data on nutrient losses indicated that the highest losses of soil organic carbon (SOC) (25.83 kg ha^{-1}), total nitrogen (N), phosphorus (P), and potassium (K) (7.76, 0.96, 32.5 kg ha^{-1}) were recorded in cultivated fallow as compared to those from sole and intercrop treatments. However, sole soybean and its intercrops recorded the minimum losses of SOC and total N, P, and K, whereas the maximum losses of nutrients were recorded under pigeon pea.

The system productivity in terms of soybean grain equivalent yield (SGEY) was higher in maize + pigeon pea (3358 kg ha^{-1}) followed by soybean + pigeon pea (2191 kg ha^{-1}) as compared to sole soybean. Therefore, maize + pigeon pea (1:1) intercropping is the promising option in reducing runoff, soil-nutrient losses, and enhancing crop productivity in the Vertisols of Central India.

Key words: Soil and nutrients losses, Vertisols, Crop covers

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Effect of Flyash Application on Soil Properties, Crop Productivity and Water Use Efficiency of Maize-Wheat Cropping System in an Inceptisol

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Safe disposal of huge quantity of flyash produced by the thermal power plants of India is a great problem due to its limited utilization in civil urbanization activities and agriculture can be a potential user of flyash but its consequences needs to be assessed properly. Keeping this in view a long term field experiment was initiated during the year 2021-22 on an Inceptisol at Indian Agricultural Research Institute, New Delhi to study the effect of flyash (received from Tanda power plant, NTPC) application on soil properties, productivity and water use efficiency of maize-wheat cropping system. Maize crop (cv PMH1) was grown in the *khrif* season with the following treatments viz., (T1: Control (only recommended NPK to every crop); T2: FYM @ 5t/ha (every kharif season) + Recommended NPK (every crop); T3: Ash 10 t/ha (every year) + T2; T4: Ash 20 t/ha (every year) + T2; T5: Ash 40 t/ha (every year) + T2; T6: Ash 20 t/ha (every alternate year) + T2; T7: Ash 40 t/ha (every alternate year) + T2; T8: Ash 80 t/ha (every alternate year) + T2; T9: Ash 100 t/ha (once) + T2; T10: Ash 200 t/ha (once) + T2; T11: Ash 400 t/ha (once) + T2; T12: Ash 20 t/ha (every year) + T1). Wheat crop (cv HD2967) was grown in *rabi* season to study the residual effect of flyash application. It was observed there was no significant difference in grain yield of maize among the treatments T1 to T11 whereas in the treatment T12 there was significant reduction in grain yield of maize. This indicates that flyash application has no negative impact on yield of maize crop when it is used along with FYM but when it is used without FYM, there was significant reduction in grain yield of maize crop (T12). It was observed there was no significant difference in grain yield of wheat among the treatments. This indicates that residual effect of flyash application has no negative impact on yield of wheat crop. It was observed that there was improvement in the water holding capacity of soil by 28.2% due to flyash application and maximum water holding capacity of the soil was recorded in T11. The effect of flyash application on water use efficiency of maize and wheat crop was statistically similar. So from this study it may be inferred that flyash should be applied along with FYM for obtaining higher yield without any adverse effect on soil health in maize-wheat cropping system in Inceptisol.

Key words: Flyash application, Water use efficiency, Inceptisol

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Impact of Long Term Fertilizer and Manure on Soil Health, Soil Quality and Yield Sustainability in LTFEs in India

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Soil health and quality are the foundation of agriculture and overall farming and therefore maintenance of soil biological status is one of the crucial components of this agro-ecosystem. In that context, a study was undertaken with the objective to study effect of fertilizer and manures on soil physical condition, soil health, soil quality and yield sustainability of major crops in our country under the aegis of AICRP on Long Term Fertilizer Experiments (LTFE). The findings emerged from the long term investigation indicated that the long term fertilizer application along with organic manure led to a significant improvement in soil biological condition in which soil microbial biomass carbon (SMBC) is key parameter. The SMBC at Coimbatore, Pantnagar and Pattambi revealed that, irrespective of the treatments, 100% NPK+FYM (INM) registered significantly higher SMBC. Similarly, significantly higher soil quality index (SQI) was exhibited by100% NPK+FYM in comparison to other nutrient management options at Coimbatore and Pantnagar. However, in rice-rice system of Pattambi, 100% NPK+FYM and 100% NPK+ green manure (Dhaincha) recorded higher SQI compared to imbalanced nutrient management. Thus, sustainability of nutrient management options derived in terms of sustainable yield index (SYI) for finger millet-maize in Inceptisols of Coimbatore, in rice-wheat system in Mollisols of Pantnagar and rice-rice system in Alfisols of Pattambi indicated that imbalanced nutrient application (i.e., Control, 100% N, 100% NP and 50% NPK) recorded significantly lower values compared to balanced and integrated nutrient management. The lowest SYI was observed in 100% N alone in Alfisols of Pattambi. Integration of inorganic fertilizers with organic manures and balanced nutrient applications proved as the best way for restoring and maintaining soil quality, crop productivity and microbial activity in LTFE. Thus, integrated nutrient management through 100% NPK+FYM improved soil quality as well as sustained crop productivity of major crops and cropping systems in major soils of India.

Key words: Soil health, long-term, soil quality, sustainable yield index, yield sustainability

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Long-term Effect of Fertilizer and Manure on Soil Quality and Yield Sustainability of Soybean-Wheat Cropping System in Vertisols and Alfisols

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Results emanated from long-term fertilizers experiments on soybean-wheat cropping system under Vertisols of Jabalpur and Alfisols of Ranchi under AICRP LTFE indicated that integrated application of fertilizer along with FYM i.e. INM (100% NPK + FYM) is vital for sustaining productivity of soybean and wheat as well as maintaining soil health. Response to N, P and K was 16, 55 and 11% in soybean and 26, 125 and 26% in wheat, respectively. However, response to FYM was 23 and 16% in soybean and wheat in Vertisols at Jabalpur, respectively. In Alfisols maximum yield was recorded with 100% NPK+FYM (2040 kg ha^{-1}) than 100% NPK (1690 kg ha^{-1}), while the lowest yield was found in control (520 kg ha^{-1}) and 100% N alone (567 kg ha^{-1}). Thus, balanced application of fertilizers with or without FYM also stabilizes and enhances yields of major crops. Imbalanced use of fertilizers i.e. application of N alone or NP had adverse effect on yield sustainability and soil health. The 100% N alone found to be deleterious in Alfisols of Ranchi. Such soils can be restored with the application of FYM or lime. The sustainable yield index was maximum with 100% NPK+FYM in Vertisols as well as Alfisols. Soil quality in terms of chemical, physical and biological parameter got improved with balanced nutrient application. Further, soil quality improved with an application of 100% NPK+FYM or lime in Alfisols as well. Thus, integrated nutrient management (100% NPK+FYM) is the suitable nutrient management option to sustain soil quality and soil health that in turn stabilizes crop productivity.

Key words: Crop productivity, fertilizer, long-term, Vertisols, Alfisols

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Smart Agri Project- Leveraging Technology for Self-Subsistence to Enterprise Farming: An Initiative by Solidaridad with support of Vodafone Idea Foundation and Indus Towers

Solidaridad Regional Expertise Centre (SREC)

In the last few years, digitalization and ICT solutions have made a significant contribution and advancements across various sectors. In the agriculture sector too, digital applications have a high potential towards a holistic transformation of the sector for a sustainable food production. Although, in the current scenario, most of the farmers lack access to technology driven agriculture tools and practices due to which the widespread adoption of scientific farm management practices is constrained. On the other side, due to lack of proper knowledge, excessive use of agro-chemicals has generated adverse effects on soil and human health. In this context, a shift from traditional agricultural extension delivery channels to ICT-enabled channels is the need of the hour. Thus, to address this, Solidaridad with support of Vodafone Idea Foundation and Indus Towers have developed an integrated programme- "Smart-Agri Project" since 2020, to bring the change by leveraging technology in agriculture to move it from subsistence to enterprise. The main objective of the project is to enhance the livelihood of about 550000 farmers spread across 10 states of the country through sustainable farming approaches and use of SMART technologies.

The project has been implemented in a phase wise manner and is enabling smallholder farmers through improved practices by adopting IOT based solutions. Around 469 IoT Based AWS (Automatic Weather Station) equipment have been installed in the project areas with the help of which periodic weather and crop-based advisory support is provided to the farmers that has helped in maximizing their farm output. For an effective extension approach, Farmer Field School (FFS) is promoted to reach out to the targeted project farmers. To facilitate farmers' access to inputs and markets, farmers owned producer companies and rural enterprises is also promoted. In addition to this, the project also addresses the cross-cutting issues related to gender and nutritional security of women and children in the project areas. Through the project, the capacity of the farmers has been built on the use of IT solutions in combination with good practices and efficient technologies. For the long-term sustainability and benefits for the communities, the project is promoting digital literacy and digital content- driven training for better uptake of advisory.

Key words: Smart agriculture and technologies, IOT based solutions, AWS (Automatic Weather Station), Sustainability

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Evaluation of Mechanical Composition of Soil Samples and to Prepare the Fertility Map of Mendakichak Village of Dewas District of Western M.P.

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Looking at the crop production and soil related constraints in Mendakichak village of Dewas District of Madhya Pradesh we found it important to characterize the soils of the village. For this purpose surface soil samples were collected from 130 locations in Mendakichak village. Soil fertility maps in GIS environment using software Arc GIS version 10.4 were prepared for Sand, Silt and Clay. The GPS points were also collected for preparing the spatial distribution maps of textural classes were analysed. For soil analysis standard methods were adopted. The clay content in 130 soil samples ranged from 35-61 percent, with a mean value of 49.56 percent having standard deviation 6.28 percent with 12.67 percent coefficient of variation. The silt percent ranges from 18-44% with a mean of 29.54% standard deviation 5.81 and CV% 19.66. The sand particle range was 13.40-30.25 percent with a mean of 20.73% standard deviation 3.57% and CV 17.0%. Among these three soil particles silt content showed highest variability followed by sand and minimum in case of clay content. it is found that all the soils of Medkichak village are clayey in nature having lot of variability in the relative percentage of sand , silt and clay.

Key words: Soil fertility maps, GIS, GPS

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Soil Amendments: Impact on Resource Conservation, Soil Properties and Crop Productivity in Chambal Tablelands

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Soil erosion worsened by poor crop and soil management have adverse impact on sustainability of crop production. A field study with various combinations of organic and inorganic amendments in soybean-based cropping system was carried out for three years with the objectives to evaluate the effect of soil amendments on soil erosion, crop yield and soil properties. Various treatments were Control (without fertilizers and amendments-T_1); Recommended Dose of Fertilizer (RDF) for soybean (T_2); RDF + Gypsum (T_3); RDF + FYM (T_4); RDF + crop residue (CR) (T_5); RDF+ Gypsum + CR (mustard crop residue) (T_6); RDF+ Gypsum + FYM (T_7); RDF + Gypsum + CR+ FYM (T_8). Comparing the effect of amendments on runoff and soil loss, it seems that relative to control, gypsum alone and combined with FYM+ CR was effective in reducing runoff and soil loss during kharif season. Runoff percentage ranged between 10-37% and soil loss varied from 18-52% compared to control plots. Significant changes in soil pH, organic carbon and available nutrients were recorded in sole and combined amendment treatments. Organic amendment applied plots significantly improved organic carbon and water stable aggregates which reduced soil erosion losses and improved crop productivity. Highest soybean grain yield was observed in combined amendments viz., T8 (1.31 t ha^{-1}), T7 (1.26 t ha^{-1}), T6 (1.25 t ha^{-1}) treatments which was statistically par with each other, followed by sole amendment T4 (1.14 t ha^{-1}), T3 (1.05 t ha^{-1}) treatments. Increase in grain yield was associated with the improvement in soil properties and reduction in soil erosion. Combined and sole application of easily available soil amendments showed positive effect on soil erosion reduction, improvement in crop productivity and soil health in degraded semi-arid regions.

Key words: Amendments, runoff, soil loss, crop productivity, soil properties

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Response of FYM on Yield of Pearlmillet-Mustard Cropping Sequence in Typic Ustochrepts

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In northern plains of India, pearlmillet-mustard is efficient, potential and sustainable cropping system. There are indications of stagnation or even decline in the productivity of pearlmillet-mustard cropping system due to decline in soil organic matter, deficiency of secondry and micronutrients and non-availability of cost effective fertilizers. In order to bring the soil well supplied with all the essential plant nutrients and also to maintain it in good health, it is necessary to use organic source like FYM in conjunction with fertilizers. FYM, not only supply macronutrients but also meet the requirement. Keeping these points in view, the experiments were conducted during 2018-19 on pearlmillet-mustard with sixteen treatments in R. B.D. with three replications.

Maximum grain yield (2966.6 kg ha^{-1}) of pearlmillet was observed with 100% NPK +FYM +Azo+ PSB (T_{16}) treatments followed by 100% NPK + FYM and both were significantly higher to yield obtained with inorganic fertilizers applied treatments. Treatment 100% NPK +FYM +Azo+ PSB (T_{16}) also recorded significantly higher grain yield as compared to 150% NPK treatment. Maximum grain yield of mustard (2155.3 kg/ha) was recorded under the treatment 100% NPK +FYM+ Azo+ PSB which was statistically at par with the yield obtained with100% NPK + FYM and 150% NPK treatments but significantly higher to 100% NPK treatment. This indicates that some micronutrients like zinc and iron were becoming yield limiting factors. These nutrients are provided by FYM besides supplying additional quantities of NPK and it has beneficial effect on the physical and biological properties of soil.

Key words: Pearlmillet, mustard, FYM, yield, micronutrients

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Subsoiling Effect on Drainage, Soil Properties and Productivity of Soybean Grown in Vertosols

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The investigation entitled, "Subsoiling effect on drainage, soil properties and productivity of soybean grown in Vertisols'' was carried out in the Department of Soil Science and Agricultural Chemistry, RVSKVV, College of Agriculture, Indore as well as on farmers' fields at Indore, Dewas, Ujjain and Dhar Districts of Madhya Pradesh.There were four treatments T1-Sub Soiling (SS) + Sowing by precision seed drill, T2- Tillage by Cultivator twice(CT), T3- Deep Tillage by M.B. plough(DT) and T4- Reduced Tillage + Crop Residues (RT+CR 30% of previous crop). The results indicated that T1-Sub Soiling (SS) treatment bulk density, penetration force was decreased upto the 40 cm soil depth while, in case of, DT and RT+CR were found effective up to 20 cm soil depth only. Mean weight diameter was higher in case of T1-SS. Soil chemical properties did not changed much due to various treatments. The highest leaf area index and dry weight/plant was recorded in treatment T1-SS at all the growth stages and lowest in case of Deep tillage. The nodule weight per plant was maximum in case of treatment T1-SS and minimum in case of treatment T3-DT. The root length density was found significantly higher in case of subsoiling as compared to other treatments under study. The highest test weight was recorded in treatment T1-SS (15.84) and minimum in the treatment T3-DT (13.69). The highest energy balance was found in the treatment T1-SS (input, output and energy balance) and was found minimum in treatment T3-DT and in case of input energy in treatment T2. The water use efficiency was maximum in case of treatment T1- SS (1.22Kg ha^{-1} mm^{-1}) and lowest in case of treatment T3-Deep Tillage (0.73Kg ha^{-1} mm). The uptake of NPK by soybean seeds and straw was maximum in treatment T1 and was found minimum in treatment T3.The overall conclusion drawn from the study is that due to continuous mechanization and use of heavy machinery a compact layer was observed even in case of Vertisols which restricts root growth, reduces infiltration rate, thereby, causes water logging during rainy season. The poor soil aeration results in reduction in soybean productivity in Madhya Pradesh.

Key words: Subsoiling, Drainage, Soybean

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Status of Different Physico-Chemical Properties of Soils of Ashoknagar District of Madhya Pradesh

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Generally, different physico-chemical properties of soils are depending on the timing period and sources of irrigation system. In Ashoknagar District, the main classes of soil are black, brown and bhatori (stony) soil. The volcanic, clay-like soil of the region owes its black colour to the high iron content of the basalt from which it is formed. Keeping in view, One hundred twenty five GPS based surface soil samples (0-15 cm) were collected from five blocks (Mungaoli, Chanderi, Ishagarh, Ashoknagar and Sadora) of Ashoknagar district during April to May 2018. Soils were studied for their physical and chemical characteristics and status of different physico-chemical properties of soils. The different physico-chemical properties of soils i.e. mechanical compositions (sand, silt and clay), soil pH, soil EC, organic carbon, calcium carbonates and total-N were observed in the range of 36.6 – 56.7 (sand), 3.9-38.0 (silt), 25.2 – 42.4 (clay), 7.2 – 8.6 (Soil pH), 0.32-0.62 dSm^{-1} (Soil EC), 2.14-7.06 g kg^{-1} (OC), 0.5-3.5% ($CaCo_3$) and 0.01-0.24% (total N) under different villages of investigated area with the average value of 8.0 (Soil pH) , 0.45 dSm^{-1} (EC), 4.35 gkg^{-1} (OC) 1.7% ($CaCo_3$) and 0.011% (total N) respectively. The soil of Ashoknagar district of Madhya Pradesh is slightly alkaline in reaction and normal to soluble salts. Surface soil samples were non calcareous with low organic carbon content. The pH and electrical conductivity of all the blocks were observed in normal range. Low calcium carbonate content in the surface soil might be due to leaching of soluble salts in the lower layers of the soil profile it might be due to incorporation of higher amount of organic matter in these soils due to higher foliage by good yield of irrigated crops. The soil requires less irrigation because of its high capacity for moisture retention and nitrogen metabolism in plant is regulated by physico-chemical properties of soils and consequently better yields are recorded in all types of crops. Such relationship suggests that a physico-chemical property exists in a state of dynamic equilibrium in these soils.

Key words: Physico-chemical properties, organic carbon, GPS, surface soil, Ashoknagar district

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Innovative Trend Analysis of Seasonal Rainfall and it's relation with Crop Yield in Bihar

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An innovative trend analysis (ITA) with a significant test was proposed for detecting the seasonal variation trends of rainfall in 38 districts in Bihar during 1990-2020. The results of long-term trends and their magnitudes obtained from the ITA method were compared with traditional Mann-Kendall (M-K), modified Mann-Kendall (mM-K), and linear regression analysis (LRA) methods. Significant spatio temporal trends in seasonal rainfall were detected in almost all districts of Bihar. Both Kharif and rabi rainfall showed decreasing trends in most districts of Bihar. Results of M-K, mM-K and LRA corresponded with the trends detected by ITA. Meanwhile, many significant trends (71-81% more) that cannot be effectively detected by LRA or M-K or mM-K test can be identified using ITA. Therefore, ITA could detect hidden-trends that cannot be observed using traditional LRA and M-K test. Subsequently, for identifying the relationship with major crop yield, rice (in Kharif season) and wheat (in Rabi season) for all districts of Bihar were correlated and regressed with kharif and rabi rainfall respectively. The results showed the existence of a significant correlation (r2) in different districts in Bihar both for the kharif and rabi season. R2 showed a significant negative ($p<0.01$) relation for kharif, however, nonsignificant relation was found for rabi season.

Key words: Innovative trend analysis, Trend, Bihar, Mann-Kendall

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Soil Physical Quality as Evaluated by S-index under different Land Configuration and Tillage System in Maize Chickpea Cropping System of Central India

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Soil physical quality is one of the three important aspects of soil quality, besides biological and chemical quality. Decline in soil physical quality can have serious consequences on biological and chemical properties thereby making it relevant to study soil physical quality for maintaining soil health in long run. In this study, we have used Dexter-S index to evaluate soil physical quality under different land management practices. This study consists of three tillage systems namely conventional tillage (CT), reduced tillage (RT) and no tillage (NT) and two land configuration system namely, broad bed and furrow system with NT (BBF-NT) and broad bed and furrow system with RT (BBF-RT). To study the effect of these management practices, soil samples were collected at 0-5 and 5-10 cm depths from the experimental field of ICAR-IISS, Bhopal after completion of five crop cycles. The results of soil physical quality assessment at 0-5 cm and 5-10 cm value of S-index varied significantly, that indicates differential impact of imposed tillage and land configuration systems. At surface layer (0-5 cm), the highest value of S- index was observed under BBF-NT system followed by NT system, representing better soil physical environment for crop growth, whereas lowest value of S- index was appeared under CT. S- value under BBF-RT and RT was non-significant. Overall trend of S- index at 0-5 cm depth was BBF-NT>NT>BBF-RT>RT>CT. At 5-10 cm depth, BBF-NT and CT treatments showed higher and lower S-value, respectively. At this depth, value of S-value under BBF-RT, NT and RT were statistically at par. Further, S- value obtained under different tillage and land configuration system were significantly (Pd"0.001) correlated with mean weight diameter (MWD), water stable aggregates (WSA), soil organic carbon dehydrogenase activity (DHA) and Fluorescein diacetate hydrolysis (FDA).

Key words: Cropping system, soil quality, soil health and tillage system

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Quantitative Evaluation of Soil Quality under Different Cropping Systems in the Harda District of Madhya Pradesh

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Quantification of soil quality (SQ) is crucial for evaluating land uses and soil management practices. In the Harda district of Madhya Pradesh, farmers are practising different cropping systems. Therefore, we have undertaken this study to quantify the soil quality under the different cropping systems in Harda district of Madhya Pradesh, India. The major cropping systems in the study area are: (i) soybean-wheat, (ii) soybean-wheat-moong, (iii) soybean-chickpea, (iv) soybean-chickpea-moong, (v) sugarcane, and (vi) horticultural. A total of 303 geo-coded composite surface soil samples were collected during 2014–2015. The soil samples were analysed for: pH (1:2.5), electrical conductivity (1:2.5), soil organic carbon (SOC), calcium carbonate ($CaCO_3$), available nitrogen (Av-N), available phosphorous (Av-P), available potassium (Av-K), available sulphur, micronutrients, i.e., DTPA extractable Zn, Cu, Fe, Mn, and hot water-soluble boron, using standard laboratory protocol. Furtherance's SQI was derived using the following three main steps: (i) identification of the minimum data set (MDS); (ii) transformation into a score; and (iii) interpretation into SQI. The weighing factors are derived from principal component analysis for each soil variable. Based on PCA, SOC, $CaCO_3$, available phosphorous, available sulphur, and extractable Fe were identified for SQI calculation. The SQI showed that soil under soybean-chickpea and soybean-wheat-moong cropping systems has better environmental conditions for plant growth. It is also possible to conclude that including legumes in the cropping system improved soil health during cereal rotation.

Key words: Cropping systems, soil health, Principal component analysis (PCA), SQI

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Downscaling Satellite Land Surface Temperature to the Farm Scale

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Downscaling of land surface temperature (LST) from space-borne imagery is crucial for many finer-scale applications such as monitoring the state of crops and vegetation, soil moisture estimation, or as an indicator of the physics of land-surface processes at local to global scales. However, the downscaling accuracy of LST is strictly prohibited by different geographical and environmental factors. This paper made a comparison between machine learning (Random Forest, RF) and classical algorithms (TsHARP and TPS) to downscale the medium resolution (100 m) Landsat-8 LST to 10 m. It was validated by the MODIS LST 1000 m product, using images derived from semi-arid (IARI), arid (CAZRI), and per-humid (UBKV) agricultural farm areas. The RF algorithms produced higher accuracy in the *rabi* season 2020-21 with R^2 values of 0.55-0.83, RMSE 1.59-5.35, and nRMSE 0.53-1.75 compared to TPS and TsHARP. The performance of TsHARP was poor during the initial period at IARI because of a weak indication of the Normalized Difference Vegetation Index (NDVI). The TPS methods showed a smoothing effect on the LST. The machine learning algorithm RF appeared promising to achieve a universal framework that can downscale LST for an area within the training data from long spatiotemporal sequences.

Key words: Land Surface Temperature, Downscaling, satellite Remote Sensing, Agricultural Farm

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The Effect of Long-Term Manure and Fertilizers Application on Status of Humus Fractions under Soybean-Wheat Sequence Grown on Vertisols

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Long-term experiments are the primary source of information to determine the effect of cropping systems on soil quality attributes. The humic substances play a very important role in soil conditioning and plant growth. Physically, it promotes good soil structure and increases the water-holding capacity of the soil. Biologically, it increases the growth of useful soil organisms. In this study, was carried out on an experiment site at the Research Farm of the Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur with aim to study changes in soil quality, crop productivity and sustainability in Soybean-Wheat cropping system during Kharif season 2018-19. The experiment consists of ten treatments i.e., T_1 50% NPK, T_2 100% NPK, T_3 150% NPK, T_4 100% NPK + HW, T_5 100% NPK + Zn, T_6 100% NP, T_7 100% N, T_8 100% NPK+FYM, T_9 100% NPK–S and T_{10} control with four replications in a randomized block design. The result data indicated that the soil pH and EC were remain unaltered even after continuous application of variable amounts of fertilizers either alone or in combination. A significant positive change in soil organic carbon, available N P K and S content was observed with continuous additions of balanced fertilizers and manures over imbalanced and unfertilized treatments. Humus fractions have a propensity to increase with application of fertilizer, in this connection highest content of humus fractions (humin, humic acid and fulvic acid) were observed in integrated fertilizer with organic manure over control as well as other fertilizer combination. Application of 100% NPK+FYM over a decade showed greater accumulation of humic acid and fulvic acid in both surface and sub surface soils over imbalanced fertilizer addition. Whereas the lowest humic acid and fulvic acid present in unfertilized control treatment. The positive correlation was observed among most of the humus fractions. Interrelationship among the fraction with soil properties and yield of soybean-wheat established a positive relationship which indicates that the improvement in various fraction resulted in enhancement of nutrient storage capacity thereby improving the health of soil that may ultimately resulted in increment in productivity of crops grown on Vertisol.

Key words: Long Term Fertilizer addition, humus fractions, nutrient availability

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Effect of Land Configuration and Tillage Systems on Soil Chemical Properties in Maize-Chickpea Cropping System of Central India

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A field experiment was conducted for long-term conservation agriculture which was established during August 2011 at the research farm of ICAR-Indian Institute of Soil Science, Bhopal. Experimental site comes under 23°18′N and 77°24′ E, with 485 m above mean sea level and has sub-humid tropical climate with a mean annual air temperature of 25°C and annual rainfall of 1208 mm and black soil. It has also been a major contributor to global greenhouse gas emissions, biodiversity and soil fertility loss, soil degradation, and even desertification. Permanent beds have been proposed as a viable solution to achieve sustainable farming in this plain. The observations recorded in this study were soil organic carbon (SOC), Available Nitrogen (Av-N), Available Phosphorus (Av-P) and Available Potassium (Av-K). The SOC content was significantly affected by different tillage and land configuration system. At 0-5 cm, higher SOC was found under BBF-NT (6.43 g kg^{-1}) and the lowest was observed under the CT (5.43 g kg^{-1}). The Av-N was recorded higher surface layer compared to lower depth. At 0-5 cm, higher Av-N was observed under BBF-NT followed by BBF-RT and NT and lowest Av-N was observed in CT treatments. Further, at surface layer (0-5 cm), Av-P was significantly affected by the tillage and land configuration system. At 0-5 cm, maximum Av-P was observed under BBF-NT (46.01 kg ha^{-1}) followed by BBF-RT (41.18 kg ha^{-1}) and NT (40.26 kg ha^{-1}), whereas minimum Av-P was recorded in CT (33.01 kg ha^{-1}). Although highest Av-P was recorded under BBF-NT, it is statistically at par BBF-RT and NT. Across tillage and land configuration, Av-K varied from 498.29 to 420.59, 444.61 to 397.92 and 422.27 to 377.04 for 0-5, 5-10 and 10-20 cm soil depth respectively. From the mean data, it revealed that surface layer (0-5 cm) recorded higher available K compared to lower soil depths and the value decreased with increasing soil depth across all the treatments.

Key words: Tillage System, Soil Organic Carbon, Available Nitrogen, Available Phosphorus, Available Potassium

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Soil Fertility Mapping Using GPS and GIS in Jhabua District of Madhya Pradesh, India

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A study was carried out to determine fertility status in tribal dominated Jhabua district of Madhya Pradesh. For this purpose, about 303 GPS based surface soil samples (0-15cm) were collected from 5 different tehsils namely Jhabua, Meghnagar, Petlawad, Ranapur and Thandla of Jhabua. Soils samples were analyzed for pH, EC, SOC, $CaCO_3$ and available nutrients (N, P and K). Soil analysis data indicated that the soil pH, EC; SOC and $CaCO_3$ varied from 5.42 to 7.95; 0.05 to 0.58 dS m^{-1}; 1.04 to 13.92 g kg^{-1} and 5.0 to 125.0 g kg^{-1} with mean values of 6.86; 0.21 dS m^{-1}; 5.14 g kg^{-1} and 53.33 g kg^{-1} respectively. The available N, P and K content in soils varied from 100 to 432.5 kg ha^{-1}; 1.05 to 65.87 kg ha^{-1} and 97.7 to 971.2 kg ha^{-1} with mean values of 221.2; 18.3; and 293 kg ha^{-1}, respectively. Results revealed that about 69.6, 38.0 and 57.8 percent soil samples of the region were deficient in N, P and respectively. Results indicated that pH had significant positive correlation with SOC (r=0.15*). Electrical conductivity (EC) had significant positive correlation with K (r=0.13*). The soil organic carbon (SOC) had significant positive correlation with available N (r=0.14*) but it had significant negative relationship with $CaCO_3$ (r= -0.19**). Study results highlighted that geo-referenced soil samples collection and characterization of soils greatly helped in preparation of soil fertility maps prepared using GIS platform. This in turn helps in site-specific nutrient/fertilizer recommendation, balanced application of nutrients for soil health management and sustaining crop productivity in the tribal dominated Jhabua district of Madhya Pradesh.

Key words: Major nutrients, Mapping fertility maps, GIS, GPS, Nutrient Deficiency

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An Evaluation of Crop Evapotranspiration Models over a Semi-Arid Irrigated Agricultural Farm using Satellite Remote Sensing

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Spatiotemporal coverage of crop evapotranspiration (ET) can be best used for irrigation water management over an agricultural farm. With the availability of multi-temporal high-resolution satellite datasets and remote sensing-based surface energy balance models, near-real-time estimation of ET becomes a reality. This paper evaluates six energy balance models viz., Surface Energy Balance Algorithm for Land (SEBAL), Surface Energy Balance Index (SEBI), Simplified Surface Energy Balance (SSEB), Simplified Surface Energy Balance Index (S-SEBI), Surface Energy Balance System (SEBS), and Two-Source Energy Balance (TSEB) with inputs from LANDSAT-8 (16 cloud-free dates) to estimate ET at 30 m spatial resolution over the post-monsoon period (2021-22) agricultural farm at ICAR-IARI, New Delhi and the models were validated with Bowen-ratio ET estimates from MICROMET tower datasets. Remote sensing-based ET estimates were satisfactorily correlated with observed ET. The model performance was evaluated and ranked based on the correlation coefficient (r) and RMSE. The TSEB (r = 0.919, RMSE = 1.347 mm/day) performed the best followed by SEBI (r = 0.731, RMSE = 0.874 mm/day), SSEB (r = 0.776, RMSE = 1.481 mm/day), SEBS (r = 0.479, RMSE = 1.048 mm/day), S-SEBI (r = 0.625, RMSE= 1.349 mm/day) and SEBAL (r = 0.755, RMSE = 1.863 mm/day) respectively. Spatiotemporal ET maps were generated, and the areas with high, moderate, and low irrigation water requirements were delineated. Our findings suggested that the remote sensing-based models have the potential for accurate estimation of ET leading to improved water use efficiency.

Key words: Evapotranspiration, Surface Energy Balance, Satellite Remote Sensing

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New Norm of Digital Agriculture: *Vegetable Farmers Forum* – A Smartphone based ICT

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Living in perilous time of corona pandemic, witnessing massive disruptions in all walks of life was very common. Needless to cite, practically agriculture sector was also a victim in this pandemic. Farmers were deprived of direct contacts and consultancies of agriculture officials/professionals in time of need. To address this issue, ICAR-IARI Regional Station, Pune came up with this novel idea of smartphone based tool a WhatsApp group – the *Vegetable Farmers Forum* (VFF). This complimented the much-hailed national campaign launched by our Hon'ble Prime Minister on *Digital Agriculture*, in collaboration/partnership with an NGO – DIIL (*Domain for Intellectual & Imaginative Littles*) Durbaar and other stakeholders.

Planned and projected to reach at least 10,000 farmers in first place, it has reached >2500 farmers. In a significant contribution, the First National Web Conference, *Vegetable Farmers Forum: Post Lockdown with Particular Emphasis on Plant Protection* was conducted for during 25 – 26 June 2020. Full filling the Digital India mantra, >800 participants were there online (Zoom platform). Virtual Visits to two organic/natural farmers, cultural-cum-motivational children programme organized by DIIL are cite-worthy. The collaborating institutes for this Web Conference led by VFF were one Maharashtra SAU (*VNMKV, Parbhani*), WASME (*World Association of Small & Medium Enterprises*, New Delhi), Ni-MSME (*National Institute of Micro, Small & Medium Enterprises*, Hyderabad), the ESI (*Entomological Society of India*); and OLM (*Odisha Livelihood Mission*). VFF has gained much popularity and many subject experts from ICAR and SAUs, Patanjali Foundation, Organic farmers, startup agencies, and farmers including students are members. VFF supported few more local/regional groups with the whatsapp admin being the National Contact Point Person (NCPP) catering to the need of regional farmers on linguistic and thematic basis. One student NCPP was selected; first author of this paper. Learning modules, themes are shared for students in the VFF, time to time.

AI & ML (*Artificial Intelligence & Machine Learning*) is the major thrust area in all STEM subjects. The first author himself is keenly interested in data science and analytics, relevant to agriculture/vegetable farming. He is pursuing the BS-Engineering degree at IISER-Bhopal, aiming at taking suitable research projects in this line in future.

Key words: Digital agriculture, Smartphone, ICT

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Performance of Nitrogen Sources and Zinc Fertilization on the Productivity of Rice

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An experiment was conducted at ICAR-IARI Research farm, New Delhi to evaluate the performance of nitrogen sources and zinc fertilization on the productivity of rice during *the rainy* season of 2020–21. The treatment consists of four nitrogen sources in the main plots i.e. control, 130 kg N/ha (100% N through urea), 97.5 kg N/ha (75% N through urea) + nano-urea @ 1.25 litres/ha (2 foliar sprays), 65 kg N/ha (50% N through urea) + nano-urea @ 1.25 litres/ha (2 foliar sprays) and in sub-plot treatments i.e. control, soil application @ 5 kg Zn through $ZnSO_4.7H_2O$, 0.1% foliar sprays of nano-Zn oxide, cyanobacterial priming (*Anabaena sp*.) of seeds, and foliar application at maximum tillering stage, anthesis or pre-flowering stage and initiation of grain filling stage. This experiment was conducted using a split-plot design with 3 replications. Among nitrogen sources and levels, the highest grain and straw yield was recorded with the application of 100% N through urea in 3 splits followed by 75% N through urea in 2 splits + nano urea 2 foliar sprays and in different zinc fertilization treatments, the highest grain and straw yield was recorded with 0.1% foliar spray of nano-Zn oxide at maximum tillering, anthesis or pre-flowering and initiation of grain filling stage followed soil by application @ 5 kg $ZnSO_4.7H_2O$ and cyanobacterial priming, the lowest grain and straw yield was recorded with control. Application of 130 kg N/ha through urea has recorded 33.7% higher grain yield compared to the control followed by application of N through urea 97.5 kg/ha + nano-urea (2 foliar sprays) which were 28.6% higher grain yield over the control.

Key words: Nano urea, Nano-Zn oxide, Cyanobacterial priming, Foliar spray, Yield

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Weed Dynamics, Wheat Growth and Productivity in a Long-Term Conservation Agriculture-based Cotton-Wheat System

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Conservation agriculture (CA) is becoming more and more popular on a global scale as a means of maintaining food security and agricultural sustainability in response to climate change and the depletion of natural resources. Studying the system-based CA approaches and location-specific suitable crop rotations is necessary to make the most of CA to its best potential. The present study was conducted in a 12-year long CA-based cotton-wheat system at ICAR-Indian Agricultural Research Institute, New Delhi to appraise weed dynamics, growth and productivity of wheat. The experiment was laid out in a randomized complete block design involving 10 treatments with three replications. The treatments included control (Farmers practice - conventional tillage) and different crop establishment methods such as permanent narrow bed (PNB), broad bed (PBB) and zero till flat bed (ZTFB) with and without residue. The residue retained plots of PNB, PBB and ZTFB were accommodated with two N doses (~75% and 100% N). Results revealed that the grassy and broad-leaved weeds were more dominant than sedges in wheat. Among grassy weeds, *Phalaris minor* and among broad-leaved weeds, *Chenopodium album*, *Coronopus didymus* and *Sonchus arvensis* were more dominant than other weeds. The CA-based ZT permanent beds with residue treatments led to significantly lower weed density and dry weight than the plots without residue and CT. The residue retention treatments/plots, i.e., PBB+R and PNB+R with 100%N or 75%N significantly reduced weed growth compared to ZTFB+R plots. Highest grain and straw yields were recorded in the PBB+R+100N treatment, followed by the ZTFB+R+100N, PBB+R+75N and ZTFB+R+75N. The CA-based practices increased wheat grain and straw yields by 13.1%-27.9% and 5.8%-16.9%, respectively compared to CT. Both N doses under the PBB+R treatments were comparable with respect to wheat grain yield, which indicates a 25% N saving under PBB+R+75N practice without compromising crop productivity.

Key words: Conservation agriculture, Permanent narrow bed, Permanent broad bed, Zero till flat bed, weed density

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Response of Wheat Varieties to Elevated Carbon Dioxide and Temperature Interaction

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Two wheat varieties, one *aestivum* (HD 3086) and one *durum* (HI 8627) were grown inside Open Top Chambers in the experimental fam of Indian Agricultural Research Institute. There were four treatments, viz., ambient, elevated carbon dioxide (CO_2), elevated temperature and elevated CO_2 and elevated temperature interaction. Daily temperature was recorded using digital thermometers placed inside the OTCs. Seasonal mean temperature in elevated temperature treatment was found to be 2.2-2.4°C higher than ambient treatment. Duration of the crop in the varieties decreased under elevated temperature condition. Photosynthesis rate and leaf area index was recorded in all the treatments. Leaf area index of the crop decreased in elevated temperature treatment. Plant biomass decreased in elevated temperature treatment but elevated CO_2 was able to compensate the loss. Yield decrease under elevated temperature conditions was more in HI 8627 variety.

Key words: Wheat varieties, Carbon dioxide, Temperature interaction

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Prediction of Long-Term SMAP Root Zone Soil Moisture using Random Forest for Agricultural Drought Assessment in India

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Soil moisture is an important indicator for monitoring and prediction of crop water stress. Agricultural drought is considered to begin when the soil moisture availability to plants drops to such a level that it adversely affects the crop yield and, hence, agricultural production. Satellite derived SMAP L4 root zone soil moisture product can be used for monitoring of soil moisture status as it is available at 9 km spatial resolution and at 3-hourly temporal interval. But this product is available only from 31st March, 2015 which makes it infeasible for agricultural drought assessment as its long time-series data is required for developing a applicable index. Therefore, in this study, the long-term SMAP L4 root zone soil moisture product from 2001 to 2015 was predicted at 9 km grid and 16-day interval using random forest technique for India, and that predicted soil moisture was used for the computation of Soil Moisture Condition Index (SMCI), a widely used index for agricultural drought assessment. For prediction of SMAP L4 root zone soil moisture, season-wise random forest regression models were developed using the data of 2016 to 2020, and the validation was done using the data of 2021. For development of random forest regression model, SMAP L4 root zone soil moisture content was used as the dependent variable whereas actual evapotranspiration (AET), Normalized Difference Water Index (NDWI), precipitation from CHIRPS data, ESA CCI surface soil moisture content, NOAH GLDAS root zone soil moisture content, SRTM DEM, soil texture, field capacity, permanent wilting point and soil saturation limit were used as independent variables. Random forest model was able to predict the SMAP L4 root zone soil moisture with acceptable level of accuracy with R^2 varying between 0.66 and 0.84, and maximum frequency of error was between -0.05 to 0.05. The average R^2 was 0.79, 0.77, 0.72 and 0.71 for winter, pre-monsoon, monsoon and post-monsoon seasons, respectively. ESA CCI surface soil moisture had higher variable importance for all the seasons. NOAH GLADAS root zone soil moisture content had second higher variable importance for pre-monsoon, monsoon and post-monsoon seasons, whereas, SRTM DEM had higher importance in case of winter season. Soil texture, NDWI and CHIRPS

precipitation had comparatively lower importance. SMCI was computed for India for *kharif* season using SMAP L4 root zone soil moisture data for the years 2001 to 2021 where original SMAP L4 data was used for the years 2016 to 2021, and predicted data using random forest models was used for the years 2001 to 2015. SMCI indicated that most of the area of India were affected by agricultural drought during the years 2002, 2009, 2014, 2015, 2017 and 2018. Thus, use of machine learning based predicted and satellite observed SMAP L4 root zone soil moisture content is a promising strategy for assessment of agricultural drought.

Key words: SMAP, soil moisture, random forest, soil moisture condition index, agricultural drought

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Changes in Soil Physical Properties with Long-term Application of Soil Test Crop Response Target Yield based Organic and Inorganic Nutrients Management

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Fertilizers and manures affect the physical properties of soils directly or indirectly. A study was conducted to evaluate the effect of STCR based fertilizer application either alone or in combination with organic manures on selected soil physical properties under an 8-year old pearl millet–wheat cropping system. The experiment was laid out in Randomized Block Design with seven treatments: Control; FYM (15 t ha^{-1}); RDF (Recommended dose of fertilizers); TY5.5/3.0 (STCR-based fertilizer for grain yield target of 5.5 t ha^{-1} of wheat and 3.0 t ha^{-1} of pearl millet); TY6.0/3.5 (STCR-based fertilizer for grain yield target of 6.0 t ha^{-1} of wheat and 3.5 t ha^{-1} of pearl millet); FYM + TY5.5/3.0 (STCR-based FYM and fertilizer for grain yield target of 5.5 t ha^{-1} of wheat and 3.0 t ha^{-1} of pearl millet), and FYM + TY 6.0/3.5 (STCR-based FYM and fertilizer for grain yield target of 6.0 t ha^{-1} of wheat and 3.5 t ha^{-1} of pearl millet), and replicated thrice. Results showed sole (FYM) or integrated application of FYM (FYM + TY 5.5/ 3.0, FYM + TY 6.0/3.5) for 8 years resulted an increase in organic carbon by 148% and 62%, respectively at 0–15 and 15–30 cm compared to control. Organic treatments with or without fertilizers significantly lower the bulk density and penetration resistance, and improved the infiltration rate, saturated hydraulic conductivity, water stable aggregates and mean weight diameter significantly over the control. The soil moisture retention at a given suction was more in FYM and integrated nutrient management treatments at both surface and subsurface depth. The organic carbon content showed a high positive correlation with field capacity (r = 0.973**), permanent wilting point (r = 0.922**), hydraulic conductivity (r = 0.938**), infiltration rate (r = 0.973**), and water stable aggregate (r = 0.979**); and is negatively correlated with bulk density (–0.955**) and penetration resistance (–0.820*). This study conclusively proves that long term use of STCR target yield equation based organic and inorganic nutrient management not only achieve the yield target and improve the soil chemical properties, it also improves the soil physical properties as well.

Key words: Soil physical properties, Soil test crop response

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Effect of Tillage, Residue, Irrigation and Nitrogen on Growth, Yield and Nitrogen Use Efficiency of Wheat in an Inceptisol

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Optimization of tillage, residues, irrigation and nitrogen management is essential for improving resource use efficiency in agriculture. Field experiments were conducted in a sandy loam soil (Typic Haplustept) under a seven year old long-term tillage experiment on maize-wheat cropping system during rabi season, 2021-22 at the ICAR-IARI experiment farm, New Delhi to study the effect of tillage, residue, irrigation and nitrogen management practices on root morphology, shoot growth, yield and nitrogen use efficiency of wheat (cv HD 2967). It was observed that No-tillage significantly improved root length density (RLD) and root mass density (RMD) at 0-15 cm soil depth. Crop residue mulch significantly improved, RMD at 0-15 cm depth over no mulching by 39.6% at milking stage. RLD, RMD and root diameter (RD) increased significantly at 0-15 cm and 15-30 cm soil depths with increase in nitrogen level. Full irrigation (IF) significantly improved RLD over deficit irrigation (ID) by 21.3% at and RD by 20.3% at 0-15 cm soil depth at flowering stage. Maximum crop growth rate (CGR) and net assimilation rate (NAR) was attained during 71-90 DAS from jointing to flowering stage which declined at later crop stages. Crop residue, full irrigation and 150% recommended dose of nitrogen (RDN) improved CGR, LAI, RLWC and total leaf chlorophyll content. Grain yield of wheat was not significantly influenced by either tillage or residue treatments. However, there was significant increase in grain yield with increase in nitrogen level but no significant difference was observed due to application of RDN 100% and RDN 150%. Under full irrigation treatment (5 irrigations), grain yield was significantly higher than plots under deficit irrigation (3 irrigations).The partial factor productivity of nitrogen (PFPN) and nitrogen utilization efficiency (NUtE) decreased significantly at higher nitrogen indicating less than proportionate yield increase and higher losses of nitrogen at higher application rates. At flowering stage, RLD at 0-15 cm soil depth significantly positively correlated with Nuptake (r=0.60**) and grain yield of wheat (r=0.47*). Integrating long-term NT system with maize residue as mulch and recommended dose of nitrogen could improve root and shoot growth and enhance nitrogen use efficiency of irrigated wheat in the Indo-Gangetic Plains region.

Key words: Tillage, Residue, Irrigation, Nitrogen use efficiency, Wheat

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Lentil Production in India: Outcome and Exegesis

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The majority of people in India follow a vegetarian diet and rely on plant-based sources to meet their daily nutritional needs. The highest proportion of the nation's total production of pulses is produced in Madhya Pradesh (24.0%), followed by Uttar Pradesh (16.00%), Maharashtra (14.00%), Andhra Pradesh (10.00%), Karnataka (7.00%), and Rajasthan (6.00%), which together account for 77.00% of the nation's total pulse production. According to reports, there is room to expand the area planted with lentil during the *rabi* season since, under water-scarce and resource-poor situations, they offer higher net returns and a lower cost per hectare than rival crops like wheat, gram and mustard. This article covered a number of the problems that affect the production of lentil, including unfavourable weather, unusual soil, various agronomic restrictions, pests and diseases, the blue bull problem and related regulatory difficulties, credit availability and pulse marketing. Adopting all of the supporting technological elements as a whole will help to address issues like soil health risks and technology's slow response to India's large lentil production.

Key words: Outcome, exegesis, water-scarce and resource-poor situations

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Soil Fertility Index under Organically Grown Sweet Corn-Green pea-Sponge gourd Cropping System in a Vertisol

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It is often argued that in the long run organic farming can improve and maintain the soil fertility. Hence, a study was conducted at ICAR-DWR to evaluate the effect of organic, integrated and conventional nutrient and weed management methods on soil fertility index under sweet corn - greenpea - sponge gourd cropping system in a black cotton soil. Ten treatment combinations, namely, (T1) vermicompost + stale seed bed + 1 mechanical weeding (MW) at 45 DAS, (T2) vermicompost + crop residue mulch @ 5 t ha^{-1} + 1 hand weeding (HW) at 45 DAS, (T3) vermicompost + fresh Glyricidia leaf mulch @ 10 t ha^{-1} + 1 HW at 45 DAS, (T4) vermicompost + Sesbania (grown in situ) biomass mulch at 30 DAS + 1 MW at 45 DAS, (T5) vermicompost + blackgram, radish and radish intercropping respectively during kharif, rabi and summer seasons as weed control measure, (T6) vermicompost + black polythene mulch + 1 HW at 45 DAS, (T7) vermicompost +2 MW at 25 and 45 DAS respectively, (T8) vermicompost + no weed control, (T9) NPK + herbicide and (T10) 50% vermicompost + 50% NPK + herbicide fb 1 HW, were laid out by following randomized block design with three replications. In case of T1 – T8, vermicompost was added @ 5, 2.5 and 2.5 t ha^{-1} respectively to sweet corn, green pea and sponge gourd; the respective crops received NPK application @ 120-60-40, 0-30-60 and 120-60-0 kg ha^{-1} under T9. Soil samples were collected from 0-15 and 15-30 cm depths after completion of 3 crop rotations and analyzed for pH, EC, soil organic carbon, available N, P, K, Fe, Mn, Zn and Cu contents. In the surface layer (0-15 cm), the highest SOC (8.70 g kg^{-1}), available N (175 kg ha^{-1}), available P (77 kg ha^{-1}) and available K (449 kg ha^{-1}) content was recorded in T3, T10, T9 and T2, respectively; the lowest values of the corresponding parameters were observed under T1 (6.5 g kg-1), T6 (142 kg ha^{-1}), T5 (44 kg ha^{-1}) and T7 (347 kg ha^{-1}) respectively. In the sub-surface layer (15-30 cm) the SOC, available N, available P and available K contents ranged from 5.02-5.78 g kg^{-1}, 113-131 kg ha^{-1}, 13 -30 kg ha^{-1} and 273-308 kg ha^{-1}, respectively. Similarly, the available Zn, Cu, Fe and Mn contents of surface soil ranged from 0.72-1.39, 2.04-2.45, 5.12-5.45 and 1.47-1.91 mg kg^{-1} across the treatments, and 0.39 -0.90, 1.35 -1.78, 3.06 -3.68 and 0.92 -1.39 mg kg^{-1} in the sub-surface soil, respectively. Soil fertility index was calculated to monitor the changes in soil fertility status among various treatments. Principal component analysis

indicated that available Fe, SOC and available K were the key indicators for soil fertility index. The overall soil fertility index ranged from 0.71 – 0.76 across the given treatments and the values were statistically similar. The findings thus indicated that the conventional method of crop establishment using recommended NPK+herbicide was similar to organic methods in terms of overall soil fertility maintenance under sweet corn-field pea-sponge gourd cropping system.

Key words: Soil fertility index, sweet corn, green pea, sponge gourd, Vertisol

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Effect of Long-Term Application of Organics on Carbon and Soil Microbial Activity under Vertisols

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Organic practices of crop production are gaining popularity as it sustains crop productivity and soil health without harming the environment. There is paucity of data available on the long-term organic farming practices on performance of beneficial microorganisms. In a long-term network project on organic farming (NPOF, since 2004) experiment at ICAR-IISS, Bhopal, we evaluated the effect of organic management on soil organic carbon and microbial activity under soybean-wheat based cropping systems. The experiment consists six treatments (M_1 (Organic; 100% Organic), M_2 (Integrated; 50% Inorganic +50% Organic), M_3 (Conventional with recommended dose of mineral fertilizers), M_4 (50% Organic + 50% Natural Farming), M_5 (25% N organic + 25% inorganic + Natural Farming), M_6 (State recommendation used by farmers).The results revealed improvementin soil carbon content, microbial activity and the availabilityof nutrients to the crop.The soil organic carbon recorded was 11.3 g kg^{-1} and soil enzyme activities viz., dehydrogenase activity (DHA, 76.2 µg TPF/g soil/24 h), fluorescein di-acetate hydrolysis (FDA, 19.8 µg fluorescein /g soil/h), MBC (308 mg CO_2-C/ kg soil) which was significantly higher in the plot managed organically followed by integrated, chemical practices and state recommendation used by farmers.

Key words: Organic farming, soil enzyme activity, soil microorganisms

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Assessment of Soil Salinity on Soil Hydraulic and Physico-Chemical Properties in Karnal District of Haryana

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To evaluate the effect of soil salinity on structural stability and hydraulic properties, and to predict those 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.

Key words: Soil salinity, Physico-chemical properties

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Evaluation of Bio-efficacy and Phytotoxicity of Penconazola 1.1% + Mancozeb 50% DF against Disease of Mango Crop

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The experiment was conducted for evaluation of bio-efficacy and phytotoxicity of Penconazola 1.1% + Mancozeb 50% DF against disease of Mango crop at Horticulture Nursery of C.S. Azad University of Agriculture and Technology, Kanpur during 2019 and 2020. The fungicide formulation Penconazola 1.1% + Mancozeb 50% DF was tried at different concentrations (20, 30 and 40 g/10 lit of water) was evaluation for its bio-efficacy and phytotoxicity against disease of Mango crop and were compared with control. The experiment was laid out in Randomized Block Design with three replications and mango variety Dussehri was used. The fungicide treatments were applied to Mango crop as foliar spray with high volume knapsack sprayer fitted with hollow cone nozzle. The first spray was given when the initial symptoms were noticed and the second spray after 15 days. The outcome of the above experiment was indicated by the data taken of Mango yield ranged from 84.98 – 117.45 kg/tree. Significantly higher yield was recorded in Penconazola 1.1% + Mancozeb 50% DF @ 40 g/10 lit of water (117.45 kg/tree), followed by Penconazola 1.1% + Mancozeb 50% DF @ 30 g/10 lit of water (115.89 kg/tree) and Penconazola 1.1% + Mancozeb 50% DF @ 20 g/10 lit of water (108.70 kg/tree). Highest cost: benefit ratio was observed in Penconazola 1.1% + Mancozeb 50% DF @ 30 g/10 lit of water (1:1.52 during first season & 1:1.92 during second season). From the above data it is clear that Penconazola 1.1% + Mancozeb 50% DF at all doses gave effectively control against all the disease available in the field along with significant increase in yield. It also did produce any phytotoxic symptoms on Mango crop. Therefore, on the basis of two year studies it may be concluded that Penconazola 1.1% + Mancozeb 50% DF @ 30 g/10 lit of water can be used for effective control of overall disease problem in Mango crop along with increase in yield.

Key words: Bio-efficacy, Phytotoxicity and Mango

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Soil Testing: Vital Way to Enhance Soil Health and Production Efficiency

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A Soil test is a process by which elements are chemically extracted from the soil and measured for their "plant available" content within the sample. The quantity of available nutrients in the sample determines the amount of fertilizer that is recommended. A soil test also indicates soil p^H, humic matter, and exchangeable acidity. Soil testing report is given in form of a Soil health card (SHC). SHC is field specific detailed report of soil fertility status and other important soil parameters that affect crop productivity. Soil testing is helpful in accessing the nutrient-supplying power of the soil, crop response to added plant nutrients, and amendment needs. Soil testing is the single most important guide to the profitable application of fertilizer and lime. When soil test results are combined with the information from the soil profile about the nutrients that are available to the various crops, the farmer has a reliable basis for planning the fertility program each field soil test is used to monitor the impact past fertility practices on changes in a field's nutrient status. It is advisable to repeat soil testing after every three years.

Key words: Soil testing, SHC, Amendment

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Impacts of a Long-Term Conservation Agriculture-based Pigeon Pea-Wheat System on Soil Physical Properties and Carbon Sequestration

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Conservation agriculture (CA) practice with minimal mechanical soil disturbance, permanent organic soil cover and crop diversification offers a plethora of benefits that include carbon sequestration, improvement of soil properties, increased resource-use efficiency, and enhanced crop productivity and profitability. Several emerging issues/ concerns pertaining to conventional agriculture in the Indo-Gangetic plains (IGP) threaten the food security and sustainability of the most dominant rice-wheat system. A CA practice that could substitute less sustainable rice with short-duration pigeon pea during rainy season might be of utmost importance in the IGP of India. Therefore, the effects of a long-term (~12 years) CA-based pigeon pea-wheat system (PWS) on soil physical parameters and total organic carbon (TOC) were investigated at ICAR-Indian Agricultural Research Institute, New Delhi, India. 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 (i.e., PNBR75N, PNBR100N; PBBR75N, PBBR100N; PFBR75N, PFBR100N). Results showed that CA-practices had significant impacts on soil physical properties (bulk density, soil aggregates and soil temperature) at 0-5 cm and 5-15 cm soil depths. CA-based residue retention treatments significantly improved soil aggregation, higher proportion of small macroaggregates were observed than other aggregate fractions. Also, CA-based raised bed planted treatment had significantly lower BD and registered 7.4-9% and 2.5-3.1% lower BD than in CT in 0-5 cm and 5-15 cm soil layers, respectively. Moderation in morning and afternoon soil temperature under CA- based residue retention treatments was observed. These treatments also showed significantly higher TOC across soil depths (0-5, 5-15 and 15-30 cm), PBBR100N being superior to others. The residue retention treatments resulted in improved soil properties, resource saving than without residue and CT treatments. Hence, CA-based PWS at 75 or 100% N application could be a sustainable practice leading to higher productivity, and improved soil health and should be adopted in the IGP of India.

Key words: Conservation agriculture, Soil physical properties, Carbon sequestration

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Sustainability of the Soil Health under Organic Agriculture

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The effects of organic farming on the environment favour agro-ecosystem interactions that are essential for both agricultural production and nature preservation. It is now widely accepted that soil that has been managed organically has more soil organic carbon and total nitrogen, lower nitrate leaching, and higher biological soil quality than soil that has been managed conventionally. In organic farming, the impact of agricultural activities on the agriculture ecosystem is taken into account throughout the medium and long term. In order to avoid decreased soil fertility, it seeks to produce food while establishing an ecological balance. Rather than dealing with issues as they arise, organic agriculture adopts a preventative approach. The core of organic agriculture is soil development, which includes techniques like crop rotation, intercropping, symbiotic relationships, cover crops, organic fertilisers, and minimal tillage. These techniques enhance the activity of soil organisms i.e. soil flora and soil fauna which maintains the fertility of soil by providing it proper structure, texture and increase soil stability. A combination of crop residue mulching and no-tillage increases soil fertility, crop production, and control soil erosion. Additionally, residue decomposition increases the amount of organic matter in the soil, which helps to decrease soil hydrological responsiveness and raise soil water repellency, both of which help to lower infiltration rates. Higher soil microbial biomass is ensured through the use of organic inputs such as human urine, sewage sludge, municipal trash, deep litter, bovine slurry, and animal manure, among others. Consequently, sewage sludge and household trash contribute to the soil's highest level of colony-forming heterotrophic bacteria. With increased microbial activity, increased competition, parasitism, and predation in the rhizosphere, organic farming decreases the likelihood of plant disease infestation.

Key words: Organic farming, soil, agriculture, crop

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The Primary Advantage of Nanotechnology and its use in Agriculture

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A direct and indirect source of food for people is agriculture. Use of contemporary technology, such as bio and nanotechnologies, in agricultural sciences is required due to the growing global population. Regarding materials, systems, and processes, nanotechnology has been defined. Nanomaterials are crucial components of various biotic and abiotic remediation systems and play a significant impact in the fate, mobility, and toxicity of soil pollutants. Nanomaterial efficiency and fate are greatly influenced by their characteristics and interactions with soil components. Studies on the use of nanoparticles in soil remediation and their fate in soil are still rare and primarily restricted to laboratory research. The impacts of nanomaterials on nutrient release in target soils, soil biota, soil organic matter, and plant morphological and physiological responses are examined in the context of how they may affect soil quality and plant growth once they have been introduced to the soil system. The basis for supplying food, feed, fibre, and fuels is the application of nanotechnology to the study of materials, as well as biomass conversion technologies in agriculture. Future food consumption will explode, yet there will only be so much land, water, and fertile soil available because of our limited resources. Due to the finite amount of fuel reserves, including natural gas and petroleum, the price of production inputs such chemical fertilisers anticipated to rise alarmingly. Precision farming is a superior solution to get over these limitations in order to improve output (agricultural production) while lowering production expenses. There are numbers of trimming methods for improving precision farming practises that are now possible, thanks to advances in nanotechnology that will enable control at the nanometre scale. Micronutrients or macronutrients can be found in nanomaterials called "nano fertilizers", which can also serve as carriers or additions for the nutrients by, for example, combining with minerals. To understand the destiny of nanomaterials in the environment, a long-term evaluation of each crop-nanoparticle system is necessary.

Key words: Nanotechnology, nanomaterials, agriculture

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Impact of Irrigation and *Jeevamrit* Fertigation Scheduling on Soil Hydro- physical Properties and Yield of Tomato in a Naturally Ventilated Polyhouse

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An experiment was carried out in a naturally ventilated polyhouse during spring summer (2020) and autumn winter (2020-2021) on tomato *(Lycopersicum esculentum)* as test crop at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The objective was to ascertain the effect of different irrigation schedules and *jeevamrit* fertigation on soil hydro-physical properties and crop yield. The treatments comprised of two drip irrigation schedules, five *jeevamrit* fertigation schedules and control. The five different fertigation schedules e.i 3 days, weekly, 2 weeks, 3 weeks and 4 weeks intervals with 10% solution of *jeevamrit* was applied. The control was treated with recommended doses (150:120:55; N: P_2O_5: K_2O kg/ha) as basal (25% RDF) and through fertigation (75% RDF) at weekly intervals. The eleven treatment combinations were imposed in a completely randomized design replicated three times. The results indicated that the infiltration rate as well as cumulative infiltration were lower in the control as compared to the other treatment combinations. Among different fertigation schedules, the low infiltration rate under 3 DF and 1 WF was due to due to increased porosity, water holding capacity as well as improvement in mean weight diameter, which enhanced soil water retention as compare to other treatments. Similarly, the highest fruit yield was recorded in 0.8 PE and 3DF as compared to other treatments.

Key words: Yield, *jeevamrit*, fertigation, infiltration rate and hydro- physical properties

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Effect of Drip Irrigation and Nutrient Scheduling on Yield and Water Use Efficiency of Tomato under Protected Conditions

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Irrigation system is one of the most important components affecting the yield and quality of agricultural produce for greenhouse farming system. The present study was conducted at experimental farm of CSK HPKV, Palampur during the year 2015 with the objectives of evaluating the effects of drip irrigation on soil and plant water behavior and the effects of nutrient schedules on productivity at varying drip irrigation levels of tomato under protected condition. The treatments comprised of (a) Three drip irrigation levels ; $DI_{2\&4}$ (Daily drip irrigation @ 2.0 litre/ m^2 once in a day during first two months and @ 4.0 litre/ m^2 thereafter), $DI_{1\&2}$ (Daily drip irrigation @ 1.0 litre/ m^2 once in a day during first two months and @ 2.0 litre/ m^2 thereafter) and DI_{1+1} (Daily drip irrigation twice a day with 6 hours interval at @ 1.0 litre/ m^2) and (b) Three nutrient schedules viz., NPK_{75} (75% of RDF of which 25% applied as basal and rest 75% through fertigation at 15 days interval), NPK_{100} (100% of RDF of which 25% applied as basal and rest 75% through fertigation at weekly interval) and NPK_{150} (150% of RDF of which 25% applied as basal and rest 75% through fertigation twice a week) and (c) Farmers' practice(FP)- IFFCO @15 g m^{-2} applied as basal and 19:19:19 @ 2 g/litre through fertigation at 15 days intervals and drip irrigation @ 2 litres/ sqm daily. The results indicated that the soil water content and soil water stock were higher under DI_{1+1} and $DI_{2\&4}$ and lower under $DI_{1\&2}$ treatments. However, the RLWC was significantly higher in $DI_{2\&4}$ than $DI_{1\&2}$ and DI_{1+1} whereas, the marketable yield and WUE were significantly higher in $DI_{1\&2}$ than $DI_{2\&4}$ and DI_{1+1}. Among nutrient schedules, RLWC, marketable yield, WUE were significantly higher under NPK_{150} nutrient schedule than NPK_{100} and NPK_{75}. The study concluded that $DI_{1\&2}$ (Daily drip irrigation @ 1.0 litre/ m^2 once in a day during first two months and @ 2.0 litre/ m^2 thereafter) was most economical irrigation schedule since this treatment had higher marketable yield with less water use leading to highest water use efficiency.

Key words: Tomato, drip irrigation, fertigation, yield

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Effect of Drip Fertigation and Sub Surface Drip and Fym Placement with Varying Irrigation Schedule on Yield and Water Use Efficiency (WUE) of Marigold

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The drip irrigation is an efficient method for maintaining a constant supply of moisture and nutrients and thus promoting plant growth. The present study was conducted in naturally ventilated polyhouse of CSK HPKV, Palampur during the year 2021 with the objectives of evaluating the effects of drip fertigation and sub surface drip and FYM placement with varying irrigation schedule on yield and water use efficiency (WUE) of marigold. The treatments comprised of T1: 100% N fertigation and P & K as basal + surface drip @ 0.8PE, T2: 25% NPK basal + 75% NPK fertigation+ surface drip @ 0.8PE, T3: 50% NPK basal + 50% NPK fertigation + surface drip @ 0.8PE, T4: 100% N fertigation and P & K as basal + vermiwash fertigation @ 75 ml/sqm + surface drip @ 0.8PE, T5: 25% NPK basal + 25% NPK Fertigation + vermiwash fertigation @ 75 ml/sqm + surface drip @ 0.8PE, T6: 100% NPK through conventional methods + Weekly vermiwash fertigation @ 75 ml/sqm + surface drip @ 0.8PE, T7: 100% N fertigation and P & K as basal + sub surface drip @ 0.6PE, T8: 25% NPK basal + 75% NPK fertigation+ sub surface drip @ 0.6PE, T9: 50% NPK basal + 50% NPK fertigation + sub surface drip @ 0.6PE, T10: 100% N fertigation and P & K as basal + Weekly vermiwash fertigation @ 75 ml/sqm + sub surface drip @ 0.6PE, T11: 25% NPK basal + 25% NPK Fertigation + Weekly vermiwash fertigation @ 75 ml/sqm + sub surface drip @ 0.6PE, T12: 100% NPK through conventional methods + Weekly vermiwash fertigation @ 75 ml/sqm + sub surface drip @ 0.6PE. The results indicated that the yield was significantly higher under T8 treatment followed by T2 and T9 treatment. The water use efficiency (WUE) was significantly higher in the treatment T8 followed by T9 treatment. The study concluded that the significant higher marketable yield and water productivity can be obtained with the sub-surface irrigation and fertigation as compared to the conventional method of fertilizer application

Key words: Marigold, subsurface, drip irrigation, yield

National Symposium on Digital Farming: The Future of Indian Agriculture
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Effect of Long-Term Conservation Agriculture on Soil Organic Carbon, Aggregation and Associated-Carbon

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Climate-smart agriculture management practices such as no-tillage (NT), crop residue management and diversified cropping system have been widely applied and are expected to bring multiple benefits (e.g., improvement in soil properties/soil health, yield stability, soil carbon sequestration and climate resilience). Thus, we examined the potential effect of long-term conservation agriculture (CA) on soil organic carbon, aggregation and aggregate-associated carbon in a vertisol of central India at the Research Farm of ICAR-Indian Institute of Soil Science, Bhopal, India. The study was conducted in split plot design with three tillage systems (TS), reduced tillage (RT), no tillage (NT) with retention of crop residues and conventional tillage (CT) together with four cropping systems (CS), namely soybean (Glycine max L.) + pigeon pea (*Cajanus cajan* L.) (2:1), soybean–wheat (*Titricum durum* L.), maize (*Zea mays* L.) + pigeon pea (1:1), and maize–chickpea (*Cicer arietinum* L.) replicated three times. Soil samples were collected at three depths: 0–10, 10-20 and 20-30 cm from the experimental field after completion of ten crop cycles. Results indicated that tillage, cropping system and soil depth had a significant (<0.05%) effect on soil organic carbon, mean weight diameter (MWD) and water stable aggregates (WSA). The NT recorded significantly higher SOC content values than RT and CT. The MWD of 1.00, 0.94 and 0.85 mm were larger for NT than RT (0.96, 0.93 and 0.81 mm) and CT (0.81, 0.80 and 0.77 mm) at 0–10, 10-20 and 20-30 cm depths, respectively. Water-stable aggregates (WSAs) were also higher for NT (73.34%) and RT (71.44%) than CT (62.32%) at 0–10 cm. Tillage practice, cropping system and their interaction had a greater effect ($P<0.05$) on the content of aggregate-associated C for large macroaggregates (LM) and small macroaggregates (SM). There was more aggregate-associated C for NT and RT than for CT. Thus, CA practices help in improving aggregate associated carbon, aggregate stability, soil organic carbon and soil health.

Key words: Conservation agriculture, soil organic carbon, aggregation

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Effect of Fertigation Doses on Nutrient Content, Nutrient Uptake and Yield of Garlic Crop

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Garlic crop belonging to family Alliaceae has a shallow rooting system and is sensitive to moisture stress throughout the growing season. So, use of fertigation technique along with mulch helps to regulate accurate and optimum amount of water and nutrient supply inorder to meet the crop requirement, thus increasing the water use efficiency. Hence, field experiment was conducted to study the influence of fertigation doses and mulch on nutrient content, nutrient uptake and biological yield of garlic crop at the Experimental Farm of Department of Soil Science and Water Management, Dr Y.S Parmar University of Horticulture and Forestry, Solan, (HP). The field experiment was laid out in randomized block design with three replications and eight treatments viz., F_1M_0 - fertigation at 100% recommended dose of fertilizer (RDF) through water soluble fertilizer, F_2M_0 - fertigation at 80% RDF through water soluble fertilizer, F_3M_0 - fertigation at 60% RDF through water soluble fertilizer, F_4M_0 - surface irrigation at 100% RDF, F_1M_1 - fertigation at 100% RDF through water soluble fertilizer + polyethylene mulch, F_2M_1- fertigation at 80% RDF through water soluble fertilizer + polyethylene mulch, F_3M_1-fertigation at 60% RDF through water soluble fertilizer + polyethylene mulch, F_4M_1 -surface irrigation with 100% RDF through water soluble fertilizer + polyethylene mulch. The results revealed that the maximum N (1.65%), P (0.39%), K (2.63%) content in garlic leaves was recorded under F_1M_1, while S (0.38%) was recorded under F_1M_0 and F_2M_1. The nutrient content N (1.53%), P (0.54%), K (1.90%) and S (0.72%) in garlic bulb was noted to be highest in F_1M_1. The nutrient uptake N (44.35 kg ha^{-1}), P (14.16 kg ha^{-1}), K (59.91 kg ha^{-1}) was maximum under treatment F_1M_1, while S (18.86 kg ha^{-1}) was found out to be maximum under F_1M_0.The biological yield was reported to be maximum (27.33 t/ha) under F_1M_1. Thus, it was concluded that fertigation at 100 per cent recommended dose of fertilizer through water soluble fertilizer + polyethylene mulch (30 micron thickness) proved to be superior as compared to other treatments.

Key words: Garlic, fertigation, mulch, nutrient, fertilizer

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Optical Sensors Based Study of Spectral and Biophysical Characteristics, Yield and Nitrogen Content of Wheat (GW-273) Grown in a Vertisol of Central India under STCR-IPNS Approach

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The study was carried out in *Rabi* season of 2021-22 under All India Coordinated Research Project on "Soil Test Crop Response" at Research farm of Department of Soil Science, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The six treatments were comprised *viz.*, Control, General Recommended Dose (GRD), Target yield of 45 q ha^{-1}, 60 q ha^{-1}, 45q with 5 t FYM ha^{-1} and 60 q with 5t FYM ha^{-1} in Randomized Block Design (RBD) with four replications.

The SPAD, LAI and LCC shade value, fPAR and N content in leaf were significantly increased by treatments over control. The maximum SPAD value (40.35) was observed at 60q ha^{-1} target while maximum LAI (0.64, 1.82, 1.88, 2.71 and 2.74), LCC shade value (3.86, 4.73, 4.75, 4.60 and 4.58), fPAR(0.35, 0.73, 0.75, 0.77 and 0.80) and N content in leaf (2.69, 2.14, 1.99 and 1.53) were obtained at 60q ha^{-1} target with addition of FYM 5t ha^{-1} at critical stages, respectively. The maximum value of number of tillers $plant^{-1}$ (7.00), length of earhead (15.14 cm) and number of grains $earhead^{-1}$ (65.25) were obtained at 60 q ha^{-1} + FYM 5t ha^{-1} while the lowest value of these were obtained at control. The maximum values of grain yield (5052) and straw yield (5969 kg ha^{-1}) were observed in target yield of 60q ha^{-1} + FYM 5t ha^{-1} but the lowest values of grain (961 kg ha^{-1}) and straw (1445 kg ha^{-1}) were found in control. The targets of 45 q ha^{-1} without and with 5 t FYM were achieved with yield of 4219 and 4586 kg ha^{-1} with deviation of -6.25 and +1.90%, respectively.

The results revealed that when inorganic fertilizers with or without FYM were applied to achieve targets, absorbed more intensely in the visible region and have higher reflectance in the near-infrared region and *vice versa* in control. The marked differences in canopy spectral reflectance were observed in the visible region and the NIR region under STCR-IPNS approach.

The LAI, SPAD and LCC were significantly related with yield and N content in leaves. The spectral indices *viz.,* Carter2, ClAInt, mSR, NPCI, SIPI and SRPI were significantly correlated with plant height, LAI, nitrogen content in leaf, grain and straw yield. The NPCI and SRPI vegetation spectral indices showed relationship Y= -28819.9x+18568.84 with R^2 = 0.56 and Y=33838.92x-7139.21 with R^2 = 0.55 for the prediction of grain yield, respectively. The NPCI index was found significant for the prediction of leaf N content (Y=-5.2692x+4.950755 with R^2 = 0.34 at tillering stage. The model Y=12.12x-20.0406 with R^2 = 0.55 and Y=12.21x-2.63013 with R^2 = 0.51 was generated for the prediction of LAI by using PWI and SRPI indices, respectively.

Key words: SPAD, LAI, Spectral Vegetation Indices, Wheat, STCR-IPNS approach

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Effect of Zn and Fe Enriched FYM on Yield and Yield Attributes of Cowpea [*Vigna ungiculata* (L.) wilczek] under Sodic Water Irrigation

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A pot experiment was conducted during *kharif* 2018 at S.K.N. College of Agriculture, Jobner (Rajasthan) to study the "Effect of Zn and Fe enriched FYM on nutrient irrigation" to evaluate the effect of different sodic water and sources of Zn and Fe on yield attributes and yield of cowpea on loamy sand soil. The experiment comprising of 15 treatment combinations replicated three times, was laid out in completely randomized block design with three levels of sodic water(2, 4 and 6 mmol L^{-1}) and five levels of sources of Zn and Fe (0, $ZnSO_4.7H_2O$, $FeSO_4.7H_2O$, Zn enriched FYM, Fe enriched FYM) as variables. Results revealed that under 6 mmol L^{-1} RSC of irrigation water, the number of total and effective nodules, nodule index, plant height, number of pods per plant, number of seeds per plant, seed index, seed and straw yield of crop decreased significantly with all levels of sodic water and maximum reduction was recorded with the application of 6 mmol L^{-1} of sodic water. The number of total and effective nodules, nodule index, plant height, number of pods per plant, number of seeds per plant, seed index, seed and straw yield of crop increased significantly due to application of Zn enriched FYM.

Key words: Zn and Fe enriched FYM, plant height, nodule index, seed index, Yield

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Effect of Different Tillage and Nutrient Management Practices on Productivity and Profitability of Maize (*Zea mays* L.)

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An investigation was carried out at Agricultural research farm of Banda University of Agriculture and Technology, Banda, U.P. during the Kharif season 2021. The comprehensive aim of experiment was to explore the most appropriate tillage practices for the maize crop that could produce optimum yield more remunerative along with better profitability and also to find out effective nutrient management practices that suited well to the region. The experiment comprises of two factor treatments conducted in split plot design with three main plot factors and three subplot factor. The total combination of treatments was nine and each treatment replicate thrice. The main plot consisted of the tillage practices namely, zero tillage, conventional tillage and permanent bed. Further, each main plot had divided in to 3 sub-plots held three nutrient management practices viz. 33% recommended dose of nitrogen (40 kg N ha^{-1}), 100% recommended dose of fertilizer (N:P:K-120:60:50 kg ha^{-1}) and site specific nutrient management (N:P:K-160:50:60 kg ha^{-1}). The soil in which experiment conducted was silty clay and their pH value 7.89, EC 0.55 dSm^{-1} and total organic carbon was 0.76%. During the field study it was observed that the highest growth parameter viz. plant height, number of leaves $plant^{-1}$, dry matter accumulation and maximum yield attributes namely, cobs ha^{-1}, grains cob^{-1}, seed index and greater profitability in terms of economic return were recorded under the zero tillage practice employed to the maize. Among the nutrient management practices the site specific nutrient management (SSNM) practice produced maximum growth, yield (economic yield and biological yield) and yield attributes and also economic return (gross return, net return).

Key words: Tillage, Conventional, Seed Index, SSNM

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Effect of Various Nutrient Management Practices on Yield and Economics of Blackgram

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The field experiment was carried out at AICRP on Dryland, Kuthulia Farm, JNKVV, Rewa (M.P.) during the *Kharif* season, 2018 on response of integrated nutrient management on yield and economies of Black gram (*Vigna mungo* L.). The treatment comprised nine organic-cum-inorganic sources of nutrients. These treatments were randomly arranged in each replication keeping in all three replications as T_1-Control, T_2-100% N (inorganic) 20 kg N/ha, T_3-100% N (compost) 20 q/ha, T_4-50% N (inorganic) + 50% N (compost), T_5-50% N (inorganic) + 25% N (compost), T_6-25% N (inorganic) + 50% N (compost), T_7-50% N (inorganic) + 25% N (compost) + *Rhizobium*, T_8-25% N (inorganic) + 50% N (compost) + *Rhizobium*, T_9-50% N (inorganic) + 50% N (compost) + *Rhizobium*. The experimental results revealed that maximum grain yield (8.93 q ha^{-1}), net monetary returns (20582 Rs. ha^{-1}) and B:C ratio (1.79) were recorded under treatment T_3-100% N through 20 q compost/ha as compared to rest of the treatments.

Key words: Black gram, Yield, Economies and Nutrients combination

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Impact of Different Sources of Nitrogen on Growth and Yield, of Potato (*Solanum tuberosum* L.) Kufri Chipsona-3 under Bhopal Region of Madhya Pradesh

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The present experiments was conducted at the Horticulture Nursery Farm, Fruit Research Station, Entkhedi, Bhopal (M.P.) during the *Rabi* seasons of 2018-19. The topography of the field was uniform with proper drainage system. The soil of the experimental field was sandy-loam. The experiment was conducted in the randomized block design with three replications. The six treatment of nitrogen and 01 control such as T_0- No Nitrogen, T_1- Nitrogen 20 kg/ha, T_2- Nitrogen 60 kg/ha, T_3- Nitrogen 100 kg/ha, T_4- Nitrogen 140 kg/ha, T_5- Nitrogen 180 kg/ha and T_6- Nitrogen 220 kg/ha. The growth characteristics observation was recorded under the research trials such as days of germination, no. of shoots per plant, height of plant (cm) andnumber of compound leaves per plant at 30, 60 and 90 days. The yield characteristics like days to maturity,no. of tubers per plant,no. of tubers per plot (kg/ha),yield of tuber kg/plant, yield of tuber kg /plot and yield of tuber q/ha. Quality parameter like dry matter and moisture content per cent.Economical parameters like gross return (Rs/ha), Net return (Rs/ha) andBenefit:Cost ratio.

Keywords: Nitrogen, Potato, Kufri Chipsona-3 and Economics

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Effect of Natural and Organic Farming Practices on Soil Health under Soybean-Wheat Cropping Systems in Central India

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The growing food demands for food in developing countries have led to tremendous pressure on agriculture sector around the globe. The modern agricultural activities increase the number of agro-products produced and this has led to an increase in environmental degradation by excessive uses of agro-chemicals has resulted in loss of soil biodiversity, genetic erosion, reduced soil fertility and adverse impact on soil health. An experimental trial was conducted at Research Farm of ICAR-IISS (All India Network Program Organic Farming- AINP-OF), Bhopal, during *Kharif-Rabi* season (2021-22) to assess the impact of natural and organic farming practices on soil health parameters under soybean-wheat cropping system. The experiment consisted of five nutrient management treatments (T_1-Control, T_2-Complete Natural Farming, T_3-AINP-OF package, T_4-Integrated Crop Management with Natural Farming (ICM-NF) and T_5-Integrated Crop Management with pesticides (ICM-P) with four replications. Surface and sub-surface soil samples were analyzed for soil enzymatic activities such as dehydrogenase activity, fluorescein di-acetate hydrolysis, acid and alkaline phosphatase, â-glucosidase and glomalin enzymes. Further, depth-wise at 0-15 and 15-30 cm, the soil enzymatic activities were found significant improvement under AINP-OF package followed by ICM-NF, ICM-P over the unfertilized control. ICM-P recorded maximum soybean and wheat grain yield with 53.05%, 129.47%, followed by ICM-NF and AI-NPOF package with 48.98, 118.10%; and 39.98%, 78.47% respectively over unfertilised control. Complete natural farming recorded 33.46% more yield in soybean crop and 34.11% yield in wheat crop as compare to control. The integrated crop management practices (ICM) with different organic supplements *i.e.*, *jeevamrit*, *ghanjeevamrit, beejamrit* and also organic based pesticidal application (*agniastra, brahmastra and neemastra*) provided a balanced and holistic management for soil health, and provided a protective environment towards diseases and pests incidence for enhancing crop productivity.

Key words: Organic farming, natural farming, enzymatic activities, soil health, soybean, wheat

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Spatial Distribution of Soil Properties by Different Interpolation Methods: A Case Study of Jajmau Industrial Area, Kanpur

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A study was conducted to interpolate the analysis of spatial variability of soil organic carbon, pH and EC in Jajmau industrial area, Kanpur district. A total of 120 soil samples (0-25 cm) were collected grid wise at an interval of 250 m using GPS. After normalization, data were interpolated by Ordinary Kriging (Spherical, Exponential and Gaussian). The performance of methods was evaluated using Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Goodness of prediction (G) obtained from a cross-validation procedure. The best model is selected based on low MAE, low RMSE and highest G percentage.The results showed that Ordinary Kriging (Spherical Model) was the best method with strong spatial dependence to estimate soil organic carbon followed by Exponential and Gaussian model. Gaussian Model fits well with highest precision for estimation of soil pH and EC in this study area with moderate spatial dependence followed by Spherical and Exponential model. Cross validation of kriged map showed that spatial prediction of soil properties using semi variogram parameters is better than assuming mean of observed value for any un-sample location. Therefore, it is a suitable alternative method for accurate estimation of soil properties in unsampled positions as compared to direct measurement which has time and costs concerned.

Keywords: Spatial variability, Cross validation, GPS, Semivariogram, Geostatistics

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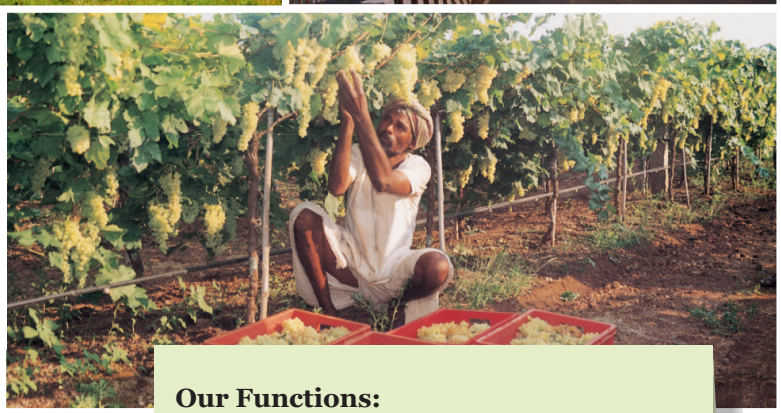

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