NATIONAL SEMINAR

ON

DEVELOPMENTS IN SOIL SCIENCE – 2021

ABSTRACTS

85th Annual Convention
Indian Society of Soil Science
16-19 November 2021

85th ANNUAL CONVENTION

November 16-19, 2021

held at the

Visva-Bharati (Central University)
Sriniketan, West Bengal

Abstracts

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March 2022

Edited by
K.K. Bandyopadhyay
D.R. Biswas

Published on behalf of the Indian Society of Soil Science by:

Dr. K.K. Bandyopadhyay
Secretary, Indian Society of Soil Science
Ist Floor, A Block
National Agricultural Science Centre Complex
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Land Resources Inventory of Gujarat Coastal Plain: A Case Study of Dholka Block of Ahmedabad District, Gujarat

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Detailed soil survey was carried out to characterize and map the soil resources of Dholka blocks, Ahmedabad, Gujarat on 1:10000 scale for optimal agricultural land use planning, using geo-spatial techniques. Geomorphologically, the study area represented the flat topography (0-1% or 1-3% slope) with regional slope towards south. The regional slope takes a tilt from east to west and shifting of channels and courses of Sabarmati river over a period of times. The southern part of block is ends in Arabian Sea. The major portion of the block covered with recent and sub-recent formations. It is a part of Cambay sedimentary basin. The sedimentation continued in the basin from Paleocene onwards under varying depositional environments. The study area belongs to agroecological subregion (AESR) 4.2, Northern Plain and Central Highlands including Aravalli's, hot semi-arid ecoregion, with alluvium-derived soils; GP 90-150 days. It covered 95,766 ha area. The study area was delineated in four landforms and the soils were classified in 11 series with 19 mapping units. Soils of Dholka block were strongly alkaline (pH 8.5-9.0) to very strongly alkaline (pH>9.0) in reaction and majority of soils (74.3%) were medium in organic carbon content. The majority of soils were very poor to imperfectly drained and there was no remarkable problem of soil erosion. Low-lying area were suffering from moderate to strong salinity or/and sodicity problems. Soils were moderate to high in available water content (AWC) and capable to sustain the crops under moderate drought. The detailed report and soil maps of study area are available on BHOOMI Geoportal (http://www.bhoomigeoportal-nbsslup.in) in public domain. The reported soil survey data are useful for various purposes like installation of soil drainage systems, salinity and sodicity amelioration and land use planning.

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A Novel Soil Morphology Index (SMI) Method for Rapid Assessment of Soil Quality in Coastal Agroecosystems

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The use of soil morphological properties in soil quality evaluation is limited because they are measured by categorical descriptors. However, it is essential to recognize their importance since they are the visual indicators of soil quality. Further, they can serve as potential soil quality indicators particularly in coastal agroecosystems where they change relatively faster than their inland counterparts. This study aims to explore the potential of soil morphological properties as a measure of soil quality indicators, with the objectives to (1) select a minimum data set (MDS) of soil morphological properties for quantifying the soil quality in coastal ecosystems, (2) to evaluate the morphological soil quality under major coastal land-use systems. A dataset with 18 soil morphological properties from 468 soil profiles, representing five land-use types (cotton + pigeon pea, sugarcane, rice, plantation, and grassland) of the north-western coastal region of India, was used to select the MDS. The categorical data was transformed into quantitative values using optimal scaling process and subjected to categorical principal component analysis. The MDS comprised of pore abundance and size, structure size, drainage, and colour (value) and a soil morphology index (SMI) was calculated using the transformed numerical values of the MDS properties. The SMI varied from 0.26 to 0.99 (mean 0.76) for the surface soils, and from 0.11 to 0.94 (mean 0.67) for the subsurface soils. The soils under plantation crops, sugarcane, and grassland had higher MSI than the soils under rice, and cotton + pigeon pea system. Specifically, the rice-growing soils were poor in their morphological quality due to structural degradation. The MSIs showed a significant relationship (R^2=0.58) with the saturated hydraulic conductivity of the soils, suggesting that the MDS can help in the assessment of soil quality by the farmers, and non-experts in the coastal regions.

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Evaluation of TRApezoid Models for Surface Soil Moisture Estimation in Humid Terai of West Bengal

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Surface soil moisture (SSM) estimation using passive remote sensing data is a new but well-accepted domain of soil science due to its high precision, large spatial coverage and low-cost data availability. In this study, investigation demonstrates the feasibility to assess spatial dynamics of SSM using Landsat 8 data in a part of humid terai region of West Bengal. Unequal seasonal rainfall distribution causes surface runoff and flood in this region in monsoon months while the crops faces moisture stress in winter and pre-monsoon season. We employed the research in four blocks of Cooch Behar district in a dry winter month (December, 2020). Two trapezoid models - Thermal-Optical TRAapezoid Model (TOTRAM) and OPtical TRApezoid Model (OPTRAM) were parameterized based on pixel-distribution within Normalized Difference Vegetation Index (NDVI)-Land Surface Temperature (optical-thermal spectral domain) and NDVI-Shortwave Transformed Reflectance (optical domain) plots, respectively. Ground tested volumetric SSM values were validated using simulated dry and wet edges of pixels acquired from dense data cloud of trapezoid spaces. Outcomes indicated good SSM estimation over the study area by both the models (TOTRAM: $r = 0.92$, $R^2 = 0.85$, RMSE = 0.129; OPTRAM: $r = 0.91$, $R^2 = 0.83$, RMSE = 0.123). Spatial distribution was tested employing ordinary kriging interpolation. Ground measured SSM values were best fitted in rational quadratic semivariogram model (RMSE = 0.145). Evaluations of semivariograms for the models provide RMSE of 0.081 and 0.151 for OPTRAM and TOTRAM, respectively. The performance indices infer similarity among the approaches with OPTRAM capturing spatial SSM variability better in validation sites.

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Lithosequential Influence on Soil Nutrient Indices of Tamil Nadu Uplands

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Assessment of soil fertility is important for judicial use of fertilizers for sustainable crop production and land management. A study was conducted to evaluate the fertility status of soils developed from various parent materials in Palani block, Dindigul district, Tamil Nadu representing semi-arid Tamil Nadu uplands using nutrient indexing. The study area has three different parent materials like granitic-gneiss, calcic gneiss and colluvio-alluvial. Totally 130 surface fertility samples were collected from the study area based on parent material, landform and landuse. Fertility soil samples were analyzed for soil reaction (pH), electrical conductivity, organic carbon, macro and micronutrients. The soils of the study area varied from very strongly acidic (pH-4.5-5.0) to strongly alkaline (pH-8.3-9.0) in soil reaction and non-saline. The average content of OC, available P, available K, available S and available B are 0.49%, 31.5 kg ha^{-1}, 211 kg ha^{-1}, 11.74 ppm and 0.20 ppm respectively. Parker's nutrient indexing was used to compare the fertility values of organic carbon, available phosphorus, available potassium, available sulphur and available boron of different parent materials in single unit. The nutrient index rating was high (>2.33) for phosphorus, medium (1.67-2.33) for potassium and low (<1.67) for organic carbon, available sulphur and boron in soils of granitic gneiss. The soils of calc-gneiss parent material has nutrient index of high (>2.33) for available K, medium (1.67-2.33) for organic carbon and phosphorus and low (<1.67) for available sulphur and boron. The soils of colluvio-alluvial parent material has high nutrient index (>2.33) for organic carbon, available phosphorus and sulphur, medium index (1.67-2.33) for available K and low index (<1.67) for available boron. Among the studied soils, the soils of colluvio-alluvial parent material has high nutrient index than other. Irrespective of the parent materials, the available boron was low in nutrient index. This study revealed the importance of parent material towards soil fertility. The variations in soil fertility status are controlled by soil genesis, landform, landuse and fertilizer management. The fertility limitations of different soils should be rectified by adopting appropriate management options like organic manure and fertilizer application and suitable crop cultivation based on the extent of limitations for better crop production.

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Machine Learning Techniques in Predicting Soil Properties

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Numerous technological advancements have assisted us to secure the vital key for scientific predictions in various fields and soil science is no exception. Soil has always been chosen an indispensable component by the scientists, environmentalists and policy makers for shaping a sustainable present and a secure future. Evidently a huge amount of soil spatial data is required and generated in the process to attain the desired outcomes. However, the paucity of time and resources pose several challenges. To address those challenges, state-of-art technologies like Machine Learning (ML), Deep Learning, *etc*. come as saviors. The recent, highly advanced algorithms and models have helped us to gain better insights about the soil along with widening our perspective for its better management. Digital Soil Mapping (DSM) is one such algorithm assisted predictive mapping which is rapidly gaining popularity among the scientific communities. Moreover, algorithms have also equipped us with the capabilities to solve the global issues like desertification, ecological stability, carbon pool management, *etc.*in a holistic and integrated manner keeping soil at one of the foci. In the present study, we evaluated three machine learning algorithms for mapping of soil depth over 16.2 M ha of Andhra Pradesh state, South India. Cubist, Support Vector Machine (SVM), and Random Forest (RF) models were evaluated using 2267 soil profile datasets collected over the study area. Along with Landsat-8 data and climatic datasets, terrain attributes such as plan curvature, profile curvature, topographic wetness index (TWI), topographic position index (TPI), Multi-resolution Index of Valley Bottom Flatness (MrVBF), and Multi-resolution Ridge Top Flatness (MrRTF) were used as environmental covariates. The validation results showed that RF outperformed all other models for the prediction of soil depth and explained 40% of the variation with RMSE of 34 cm. MrVBF was identified as the top predictor for the prediction of soil depth followed by annual precipitation. The present outputs are highly useful in spatial crop planning, hydrological studies and environmental and crop modelling studies.

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Soil Resources of Muribahal, Bangomunda and Turekela Blocks, Bolangir District, Odisha - their Assessment for Formulating Agricultural Landuse Plan

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The Muribahal, Bangomunda and Turekela blocks of Bolangir district, Odisha covering 105668 ha occurring in the hot moist subhumid agroecological subregion (AESR 12.1) developed on Eastern Ghat Super Group of rocks consisting of Khondalites, Charnokites and Gneissic rocks/Magmatites along with quaternary alluvium deposits was selected to develop block level Land Resource Information System (LRIS) in GIS environment. Interpretation of IRS LISS-IV and Sentinel II data followed by digital terrain analysis lead to delineation of five major landforms in the block *viz.*, hills, upland, pediments, valley and alluvial plains. The land use data of the block shows that forest lands occupied 19.3% of TGA of the study area while agricultural lands under single cropped lands occupy 50.1% of TGA and double crops were only confined to 13.0% of TGA in the study area. Forty eight Landscape Ecological units (LEU) were identified by interpreting various land uses with the landforms at different slope conditions. Based on detailed soil survey on 1:10,000 scale, seventeen soil series have been identified and are classified under loamy-skeletal, coarse loamy, fine loamy and fine textural classes under, Haplustepts, Endoaqueps, Haplustalfs, Paleustafs and Rhodustalfs, great groups. Physico-chemical properties of the surface soils show that moderately acidic soils pH 4.5-5.5 occur in about 25% of TGA while soils having sandy loam texture and low organic carbon content (<0.5%) is observed in 37% and 39% of TGA respectively. About 75% of TGA are having moderate to severe erosion constraints while soils with shallow depth occur in about 12% of TGA.The major constraints are soil acidity, low organic matter, moderate to severe erosion hazards which along with erratic rainfall and undulating topography adversely affects the crop growth and productivity.

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Characterization and Classification of Different Rice Growing Soils in Barind Region of West Bengal

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Barind region is a major physiographic unit in the Bengal Basin formed during Pleistocene era. It is spread in the eastern part of Maldah district of West Bengal. *Kharif* rice is the dominant crop of this region followed by mustard/wheat/potato/fallow depending on the availability of the irrigation water in Rabi season. A detailed study of land resource inventory at 1:10000 scale was conducted in the above mentioned region to characterize and classify the different soils under rice based cropping systems. It was observed that, in the gently and very gently sloping old alluvial plain, there was a formation of Alfisols, which had not been reported in the earlier soil resource inventory and mapping by any of the National Institutes. These soils were classified as Fine loamy Aeric Epiaqualfs, Fine Typic Haplustalfs, Fine-silty Typic Haplustalfs etc. The formation of Alfisols in this region was influenced by the comparatively higher elevation than the adjacent areas, non-occurrence of flood, stable landform characteristics, which subsequently promoting clay illuviation and its enrichment in sub-soil region. Inceptisols (Fine Vertic Haplustepts, Fine-silty Oxyaquic Haplustepts etc.) and Entisols (Coarse loamy Typic Ustorthents) were also found in nearly level young alluvial plains of this region. Soil were slightly acidic to neutral in reaction (pH ranges from 4.7 to 7.5) with low to medium soil organic carbon (OC ranged from 0.2% to 0.7%) content, low cation exchange capacity (CEC), low to medium nitrogen and potassium, low phosphorus and sufficient micronutrient levels.

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Characterization of Soils of Mud Volcanic Flats of Andaman and Nicobar Islands towards Climate Resilient Agriculture

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Andaman and Nicobar Islands represents India's only vulnerable Tropical Bay Islands under Rain Forest Ecosystem, situated in the agro-ecological sub region of 20.1. Mio-Pliocene limestones, shallow marine volcaniclastic sandstones, Andaman flysch and volcanic mud flats were the major geological formation in the coastal plains of the Bay Islands. The present endeavour has been dealt with characterization of mud volcanic soils occurring in the coastal plains of the region. Land resource inventory has been conducted using Sentinel-2 and SRTM-DEM data in unrestricted arable lands of North and Middle Andaman district covering 23975 hectare area (6.88% of TGA of the district). The district comprises large area under coastal plains occupying 71264 hectare land (20.47% of TGA of the district). Volcanic mud flats were scattered in Coastal plains of North and Middle Andaman district, located in Nilambur village of Rangat block and Shyamnagar village of Diglipur block, covering a total of 3073 hectare land (0.89% of TGA of the district). They have formed from volcaniclastic sandstones by weathering under tropical rain forest environment. The soils were very deep, somewhat poorly drained and gleyed with dark gray coloured soil matrix. They have low bulk density ranging from 0.98 to 1.08 Mg m^{-3}. They were strongly alkaline in reaction (pH 8.8 to 9.0), medium in EC (0.95-1.38 dS m^{-1}), medium in organic carbon (0.56-0.62%), silty clay loam in texture with high silt (58.1-66.6%) and clay content (32.0-38.3%), high in CEC (15.6-17.0 cmol kg^{-1}) and high base saturation (93-94%) due to enrichment of calcium (10.4-11.6 cmol kg^{-1}) in soil exchange complex. They were low in available nitrogen (124-243 kg ha^{-1}), low in available phosphorus (10.3-15.4 kg ka^{-1}) and high in available potassium (1033-1074 kg ha^{-1}). The soils comprise high amorphous iron extracted by ammonium oxalate (3.30-3.62 cmol kg^{-1}), indicating their pedogenesis from secondary minerals like allophanes and imogolites from volcaniclastic sandstones and mud flats. The soils were classified as Aquandic Endoaquepts, Aquandic Endoaqualfs and Typic Tropaqualfs. Frequent cyclonic events, high tides, prolonged sea water inundation, strong soil salinity and damage of mangroves are the severe environmental threats in the Islands. Most vulnerable coastal plains from cyclonic hazards may be protected by mangrove rejuvenation programme, enrichment of indigenous multipurpose trees (MPTs) along with beetle nut and coconut plantation and agro-forestry Raised bedded cultivation system may be adopted as suitable soil conservation measures for vegetable cultivation in *Rabi* season.

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Saturation Capacity and Recalcitrant Pool of Soil Organic Carbon can be Determined from <20 µm Particle Size Fraction of a Soils using Large Scale (1:10000) Soil Survey Data Base

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Based on field survey data base in May, 2019 in the Mal block of Jalpaiguri district, a total 21 soil series was identified. The moderately weathered tea plantation in upper foot soils shows the horizon sequence of Ap-Bw-Bt having high organic carbon content with umbric epipedon and classified as Coarse loamy Humic Hapludalfs. The soils of Mal block were classified as Alfisol (03 no.) Entisol (06 no.) and Inceptisol (12nos.) in the order level. Soils of these area were varied from coarse silty to coarse loamy, but dominant was coarse loamy. Umbric epipedon features were observed in Alfisol and Inceptisol groups of soils. Soils were mostly classified as Humic Hapludalfs and Typic Hapludalfs in the Alfisol, whereas Typic Humudepts, Humic Dystrudepts, and Typic Fluvaquepts in Inceptisol; and Humic Endoaquents and Typic Udipsamments were observed in Entisol soil order. The organic carbon and finer particle size of fine silt plus clay (<20 µm) data base of another nutrient mapping study (2008) in the same block soils of the district with a total of 392 geo-referenced 1 km x1 km grid data point of 30 cm top soils was used to find out the saturation capacity of soils vis-a-vis saturation deficit. The relationship between the percentage of soil particles <20 µm and the soil C content showed liner in the form of $Y = 3.67+ 0.37X$, $R^2 = 0.807$. The determination of saturation capacity of the soils will help in carbon input as well as soil management particularly tillage type and frequency. Another two sets of soils samples of detailed soil survey were processed for soil organic carbon fractions in model soil profiles of identified 21 series in fine silt and clay (<20 µm) as well as bulk (<2 mm) process soils in two root zone depths (as the depth in the profiles). The relationship between observed and predicted recalcitrant pools of SOC in both above (ARZD) and below root zone depth (BRZD) statistically significant indicating recalcitrant pool can be estimated from <20 µm particle size fraction of any agroclimatic zone soils and the developed methodology can be extended elsewhere as determined for pedogenic soils.

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Pedogenesis and Soil Classification of Major Mango Growing Soils of Southern Karnataka

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Indian peninsula, consisting of some of the oldest rocks of the earth crust is changing in a continuous process due to changes in climatic and physiographic characteristics. As these soils are very important on their agricultural and horticultural land uses, taxonomic classification in relation with edaphology and pedogenic development is important to be focused. Our study comprises major mango growing soils of southern Karnataka representing four major agro climatic zones with climatic and physiographic variability. Morphological, physical and chemical properties were analyzed for taxonomic classification up to family level according to the Keys to soil taxonomy and numerical classification was done using cluster analysis for better idea of distinctness of horizons. Study showed Ultisols representing Rhodic Kandiustults dominated with desilication process with sub active clay minerology in control section manifest the highest degree of weathering. Pedons representing Alfisols, clay illuviation and leaching of bases is the major pedogenic process along with rubification feralitization and ferrugination. Principal component analysis showed, soil exchangeable properties, clay content, clay minerology impact most for pedogenesis which is also reflected in agglomerative clustering of similar horizonation under order Alfisol and Ultisol. Whereas distinct clustering of Dystric Haplustepts representing Inceptisol showed active erosion and deposition process causes maximum vertical differentiation of physiochemical and clay minerology. Though all pedons are formed on acidic granitic and gneissic parent material, with much similar land use and topography, climate and time of soil formation stands out as dominant factor effecting various pedogenic processes and soil types.

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Digital Salt Affected Soil Mapping in Kaithal Villages of Haryana

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Soil alkalinization/salinization is the common land degradation process in the Ghaghar basin of Haryana, where the use of poor quality sodic (with high RSC) groundwater is a common practice for irrigated agriculture. Use of high RSC groundwater in the study area of Kaithal villages increases the soil pH and reduces crop production drastically. Monitoring of the degraded area by visual mapping techniques requires huge time to delineate, capital for survey and analysis. To overcome the limitation of frequent monitoring and assessment of salt-affected soil (SAS), the application of digital soil mapping (DSM) techniques is seen as an efficient alternative advance tool. The sampling sites were decided based on different environmental covariates like terrain parameters (Slope, LS factor, CNBL, Valley depth, Curvature), climatic parameters (rainfall, temp.), land surface reflectance data (principal component analysis was used for reducing the number of spectral indexes calculated from Landsat 8 data), geology, land use/cover and old soil data etc. Total 240 geo-referenced soil samples were identified, collected and analyzed. The 70% samples were used for prediction of SAS parameters like EC_e (R^2-0.69), pH_s (R^2-0.82), ESP (R^2-0.76). The Quantum Random Forest was used for prediction of SAS parameters in 'R' software. Rest 30% samples were used for validation. The surface (0-0.3 m) SAS map was characterized as 7 categories *viz*. Moderate Salinity, Moderate Sodicity, None, Saline Sodic, Slight Salinity, Slight Sodicity, and Strong Salinity. Slight Sodicity covers major area of 2952 ha (90% of the total study area). Rest of the areas is covered by other minor classes. Overall classification accuracy of surface SAS was 57%. The uncertainity map of SAS indicates the error presence in map which help for identification of new sampling point for further update of map with minimum error and high accuracy.

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Prediction of Soil Quality Parameters using VNIR-SWIR Spectroscopy Coupled Random Forest Technique in Semi-arid Tropical Regions of India

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Visible, near, and short wave infrared (VNIR-SWIR) reflectance spectroscopy is a promising tool that allows rapid acquisition of soil attributes in the lab as well as field at the quantitative and qualitative level. The study assessed the VNIR-SWIR spectroscopy coupled random forest regression technique for the prediction of soil properties such as pH, EC, soil organic carbon (SOC), cation exchange capacity (CEC), exchangeable sodium percent (ESP), field capacity (FC), and permanent wilting point (PWP). The spectral data was acquired for about 228 profile samples collected from the semi-arid region of the Southern Karnataka plateau using the VNIR-SWIR spectrometry. The soil properties were predicted using the random forest regression (RF) model. The RF model fits well for soil particle size class such as clay (R^2 = 0.65; CCC = 0.76), sand (R^2 = 0.60; CCC = 0.72) and CEC (R^2 = 0.74; CCC = 0.82). Similarly, water retention characteristics *viz.*, FC (field capacity), and PWP (permanent wilting point) are also well predicted by the RF model (R^2 = 0.65 and 0.72; CCC = 0.76 and 0.81, respectively). The SOC was poorly predicted with an R^2 of 0.22, CCC of 0.4, and RPD of 1.2 due to its lower content (0.04 mg kg^{-1}) and narrow range (0.008 to 0.2 mg kg^{-1}) in the soils of the southern Karnataka plateau under semi-arid conditions. Thus, the VNIR-SWIR spectrometry coupled random forest regression technique could be a useful supplementary method for rapid prediction of soil particle size (sand and clay), CEC, and water retention characteristics (FC and PWP).

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Prediction of Soil Hydraulic Properties Using VIS-NIR Spectral Data in Semi-arid Region of Northern Karnataka Plateau

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Field capacity (FC) and permanent wilting point (PWP) are the important soil hydraulic properties which determine the availability of water for plant growth. Conventional estimation of soil hydraulic properties is tedious and expensive which are normally derived from pedo-transfer functions. Visible and near-infrared (Vis-NIR) spectroscopy is a low-cost, non-destructive alternative method for rapid estimation of soil properties. The present study was carried out to predict soil hydraulic properties using Vis-NIR spectral data in semi-arid region of the Northern Karnataka plateau. Spectral data of 558 soil samples were acquired using Field Spec ASD Spectroradiometer and three models (support vector machine, random forest and partial least square regression) were evaluated for prediction of FC and PWP. The models were calibrated using 80% of total observations and validated using 20% of observations. The validation results showed that RF and SVM performed well compared to the PLSR model. Permanent wilting point was predicted well (R^2 = 70-74%, RMSE = 5.44-5.74%) compared to field capacity (R^2 = 66-69% and RMSE = 7.25-7.51%). Among the soil orders, FC and PWP of Vertisols were poorly predicted by Vis-NIR spectra (R^2 = 27&34%) and moderately predicted for Alfisols (47&68%) and Inceptisols (51&63%). The present results showed that Vis-NIR spectroscopy is helpful for fast estimation of hydraulic properties in semi-arid regions of the country with high accuracy.

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Canal Irrigation through Pressurized Irrigation System and Associated Changes in Soil Properties in Hot Arid Ecosystem of India

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High demographic pressure in the Thar Desert of India resulted in intensification of agriculture in order to meet the food production targets. Traditionally agricultural production system in the region is majorly dependent on rainfed cultivation along with little dependency on well and tube well irrigated cultivation. The introduction of Indira Gandhi Nahar Pariyojana (IGNP) in late 60s and Narmada Canal Project (NCP) in 2008 with the region experienced major developments in irrigation facility. In the present study, soil properties in canal command area of Narmada Canal Project (NCP) in Rajasthan India having 2.46 lakh ha command area with pressurized irrigation network were assessed through field sampling followed by laboratory analysis. Soil physicochemical properties [pH, soil organic carbon content (SOC) and electrical conductivity (EC)] and soil chemical properties (contents of N, P, K, Fe, Cu, Zn and Mn) were determined for 200 soil samples collected from topsoil covering both irrigated and rainfed land use from NCP area. Soils were found alkaline in reaction with pH value ranging from 7.62-9.98. Average OC content of soils have been observed as 0.14% with a range of 0.03-0.42%. Organic carbon (OC) content of soils were observed highest under irrigated crop lands and lowest in rainfed croplands may partly be due to low ground coverage through vegetation and thus less addition of biomass residue on soil surface and less addition of organic matter by external application. Available P content in soils showed wide variability with a range 1.41 and 47.84 kg ha^{-1}. Phosphorus content was significantly higher ($p<0.05$) under irrigated croplands than rainfed croplands. Contrary to the situation of P, the mean status of K is the lowest in the irrigated croplands (178.26 kg ha^{-1}) followed by rainfed croplands (178.26 kg ha^{-1}) Soils were found deficient in available Fe and Zn and adequate in available Mn and Cu in the command area across the land uses. The DTPA-extractable Zn varies from 0.08 mg kg^{-1} to 2.40 mg kg^{-1}, with a mean of 0.38 mg kg^{-1}, which is low and Fe ranged from 0.85mg kg^{-1} to 13.46 mg kg^{-1}, with a mean of 3.47 mg kg^{-1} and could be considered as low. Overall, the command area is well supplied with Mn and Cu contents. Principal component analysis (PCA) reduced the dimension of data to four major principal components (PCs). Few of these PCs were found to vary significantly across land use categories and NCP command zones. K-means clustering of observations showed that it can be segregated to either two or three clusters, however clustering efficiency was not good. Most of the observations lied in a single cluster indicating that all soil properties are almost similar to each other. Most of the extreme observations belonged to irrigated land use indicating that irrigation in few pocketed areas have been leading to deterioration of soil properties but can be managed through proper canal lining and excluding saline groundwater as a source of irrigation.

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Land Capability and Suitability Evaluation of Ber (*Ziziphus mauritiana*) Growing Soils of Rewari District, Haryana, India

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Eight pedons from ber growing orchards in Bhurthla (P1), Zahidpur (P2), Boriya Kamalpur (P3), Lodhana (P4), Khaliawas (P5), Jiwra (P6), Rajawas (P7), and RRS Bawal (P8) villages of Rewari district were exposed and their morphological, physico-chemical characteristics were studied and classified as per Soil Taxonomy. Land capability classification and suitability of soils were also assessed as per standard procedures. Soil texture varied from sandy loam to loamy sand having bulk density of 1.33 to 1.59 Mg m^{-3} and particle density ranged from 2.22 to 2.63 Mg m^{-3}. The moisture content varied from 5.5 to 8.98 at 0.03 MPa and 2.92 to 4.26 MPa at 1.5 MPa. Soil reaction varied from neutral to moderately alkaline (pH 7.93 to 9.23) having EC 0.07 to 1.13 dS m^{-1}. The exchangeable cations, Na+, Mg^{2+}, Ca^{2+} and K^{+}, varied from 0.4 to 5.6, 0.2 to 3.12, 0.1 to 1.56 and 0.01 to 0.1 (cmol (P^{+}) kg^{-1}), respectively, however sodium and magnesium were found as dominant cations. The organic carbon varied from 0.09 to 0.78% and decreases down the depth. Available N, P and K ranged from 33.6 to 126, 2 to 29.50 and 75.75 to 150.25 kg ha^{-1}, respectively. The DTPA-extractable Fe, Mn, Zn and Cu varied from 1.07 to 2.58, 0.2 to 0.78, 0.21 to 2.44 and 0.14 to 0.544 mg kg^{-1}, respectively. The soils of the study area were classified as Sandy mixed Hyperthermic Typic Ustipsamments (Pedon 1,2,3,6,7,8), and Sandy mixed (Calcareous) Hyperthermic Typic Ustorthents (Pedon-4) and Coarse Sandy mixed (Calcareous) Hyperthermic Typic Ustipsamments (Pedon-5). According to criteria of land capability classification, the soils were classified as LCC II (Pedon-1,8), LCC IIIe (Pedon-2), LCC IIIs (Pedon-7), LCC III (Pedon-3,4,6) and LCC IVes (Pedon-5). AS per the soil suitability criteria Pedon-1, 2, 3, 4, 6 and 7 were assessed as moderately suitable (S2), pedon 5 was classified as marginally suitable and Pedon-8 was highly suitable.

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Understanding the Soil-forming Processes in Response to the Micro-climatic Variations Across an Eastern Indian Catena

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A catena refers to a series of topographies across the same landscape, having the same parent material, climate, level of biological activity, and the same age of weathering. In nature, catena plays an important role in creating the micro-climate variations across land types, as a result of which complex soil-forming processes operate at the same time leading to the generation of differential soil properties across landscapes. Hence, understanding the soil-forming processes in a complex system like catena can provide shreds of evidence to identify and interpret the complexity that can ever exist in a soil system. In this context, this experiment identifies and explains the soil-forming factors and processes across an Eastern Indian catena located in the Mid-Central Tableland agro-climatic zone of Odisha. Three soil profiles were exposed at three different landforms *viz.* mid-upland, medium land, and low land and were studied for their parent materials, mineralogy, age of weathering, geo-morphology, and physico-chemical properties. The results reveal that the internal and external movement of clay particles, ions, organic carbon, and nutrient elements as a result of its natural position and external processes like rainfall etc. have created micro-climate variations across the landscape. The differential micro-climate has affected the active soil formation processes at different landforms. Colluviation and alluviation are the major soil-forming processes that have led to the development of the local variations across the catena.

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Spatial Variation of Soil Properties and Digital Soil Mapping Approach for Sustainable Management of Soils in Agricultural Farms of Hot Arid Zone of India

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Soil properties varies largely at spatial domain. Therefore, approximating an estimate of soil properties based on measurement at few locations within a farm is a difficult task. Furthermore, in case of site-specific farming, such approach of measuring soil properties at multiple locations to get information on soil properties at each possible locations within the farm are always not feasible. Therefore, identification of spatial variation of soil property and then estimating it at unsampled location using the spatial pattern may be a potential solution. Keeping in view this background, identification of spatial variation of soil pH and EC was targeted at the research farm of ICAR-Central Arid Zone Research Institute (ICAR-CAZRI) with an area of about 206 ha. Soil samples were collected from 925 locations of the farm at two depths (0-15 cm and 15-30 cm). Soil pH and EC was measured in laboratory using soil:water suspension (1:2) by digital pH meter and EC meter, respectively. Soil pH at 0-15 cm and 15-30 cm soil layers varied from 7.1 to 8.9 and from 7.0 to 9.1, respectively. Soil EC at 0-15 cm and 15-30 cm soil layers varied from 0.06 to 0.68 dS m^{-1} and from 0.01 to 0.88 dS m^{-1}, respectively. Spatial variation of measured pH and EC revealed that nugget component of soil pH was 60%-70% of sill whereas in case of EC it was 72-75% of sill. Range parameter was found about 500-600 m for both pH and EC. Digital soil maps were prepared through ordinary kriging which showed that the north-eastern corner of the farm was high in soil pH (>8.0) and also in soil EC (>0.21 dS m^{-1}) as compared to rest part of the farm. These digital soil maps can be used for sustainable soil management of the farm.Soil properties varies largely at spatial domain. Therefore, approximating an estimate of soil properties based on measurement at few locations within a farm is a difficult task. Furthermore, in case of site-specific farming, such approach of measuring soil properties at multiple locations to get information on soil properties at each possible locations within the farm are always not feasible. Therefore, identification of spatial variation of soil property and then estimating it at unsampled location using the spatial pattern may be a potential solution. Keeping in view this background, identification of spatial variation of soil pH and EC was targeted at the research farm of ICAR-Central Arid Zone Research Institute (ICAR-CAZRI) with an area of about 206 ha. Soil samples were collected from 925 locations of the farm at two depths (0-15 cm and 15-30 cm). Soil pH and EC was measured in laboratory using soil:water suspension (1:2) by digital pH meter and EC meter, respectively. Soil pH at 0-15 cm and 15-30 cm soil layers varied from 7.1 to 8.9 and from 7.0 to 9.1, respectively. Soil EC at 0-15 cm and 15-30 cm soil layers varied from 0.06 to 0.68 dS m^{-1} and from 0.01 to 0.88 dS m^{-1}, respectively. Spatial variation of measured pH and EC revealed that nugget component of soil pH was 60%-70% of sill whereas in case of EC it was 72-75% of sill. Range parameter was found about 500-600 m for both pH and EC. Digital soil maps were prepared through ordinary kriging which showed that the north-eastern corner of the farm was high in soil pH (>8.0) and also in soil EC (>0.21 dS m^{-1}) as compared to rest part of the farm. These digital soil maps can be used for sustainable soil management of the farm.

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Prediction of Soil Particle Size in Meghalaya Plateau of India using Digital Soil Mapping Technique

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Soil particle size and texture map of Ri-Bhoi district, Meghalaya was prepared using digital soil mapping (DSM) approach in six standard depths *i.e.,*0-5, 5-15, 15-30, 30-60, 60-100 and 100-200 cm. Quantile random forest modeling was used to predict the sand, silt, and clay percentage in each standard depth utilizing environmental covariates and the datasets collected under LRI project. The present study was carried out in part of part of Meghalaya plateau, which is located in 25° 48' to 26° 04' N latitude and 91° 20' to 92° 16' E longitude with an area of 2448 km^2. About 95 profiles were studied and the depth wise soil samples were analyzed for soil particle size. The profile horizons were synthesized into the six standard depth classes using mass preserving spline function of R. Twenty primary and secondary terrain derivatives were derived from SRTM (30m) DEM using Saga-GIS 6.3.0 version. Along with DEM attributes, twenty years mean NDVI, mean kharif NDVI, mean rabi NDVI, and mean summer NDVI, EVI were calculated from the MODIS data. Nineteen bioclimatic variables derived from monthly climatic data from worlclim were also used as the climatic covariates. The performance of models for different depths was evaluated by calculating uncertainty indicators *viz.* coefficient of determination (R^2), root mean square error (RMSE), mean error (ME), bias and Lin's concordance correlation coefficient (LCCC). Strong correlation (R^2> 0.81, up to 0.90) between the observed and predicted data were observed by the cross validation for each variable at each depth. Higher LCCC (> 0.75) also suggested good fit of model and prediction by the RF models for all the variables. After getting the sand, silt, and clay percent for each pixel, the soil textural class for Ri-Bhoi district was developed using R.

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Mineralogical Composition of Soils of Marathwada Region Maharashtra

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Marathwada region of Maharashtra is situated in between 17° 35' to 20° 40' N latitude and 74° 40' to 78° 15' E longitude having 300 to 900 meter height over MSL and hot, semi arid climate. The XRD analysis of silt fractions of Entisols, Inceptisols and Vertisols indicated that the silt fraction contains smectite, vermiculite, mica, kaolin, feldspars, quartz, zeolites, chlorite and plagioclase. The presence of small amount of zeolites in silt fraction improves internal drainage and act as soil modifier. The mica is composed of both biotite and muscovite due to the ratio of peak height of 001 (10 nm) and 002 (0.5 nm) reflection of mica is more than one and close to two. The XRD analysis of total clay fractions indicated that the total clay fraction of smectite, vermiculite, chlorite, kaolinite, polygorskite, mica and feldspar. The smectite was found to be little chlorite as evidenced by broadening towards lower angle side of 10 nm peak after heating the K saturated sample at 550°C. This smectite is low charge one as confirmed by the expansion of smectite beyond 1.4 nm after glycolation K saturated heated at 300°C. The mica of total clay is more towards the muscovite character as evidenced from closeness to unity of the ratio of peak height at 001 to 002 reflections. Thus, the presence of biotite in silt fraction and its absence in total clay fraction indicated depletion of biotite during natural weathering. The presence of 1.4 nm peak in K saturated samples and heated at 550°C indicates the presence of chlorite and pedogenic in origin.

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Soil-Landform Relationship of Flood Plain Soils of Katihar District, Bihar

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Alluvial flood plain soils are one of the major soil groups in northern Bihar and are highly heterogeneous as a result of the hydromorphic environment in which they are formed. Flood plain soils as a natural resource can only be properly managed with actual understanding of its characteristics. But the knowledge about soil types in relation to landforms and factors responsible for their formation and pedogenesis are lacking in the flood plain soils of Katihar district, Bihar. Therefore, the present study has been undertaken to understand the soil"landform relationship and their genesis. Six broad landform units were identified viz. old alluvial plain, young alluvial plain, active alluvial plain, point bar and char land. To understand the soil variability in the study area, 200 soil profiles were selected whose exact location was determined by using handheld Global Positioning System (GPS). The soils of active alluvial plain (meander plain) have both A and A-B horizons, moderately well to somewhat poorly drained with matrix colour ranging from 10 YR to 2.5 Y hue, value from 3 to 5 and chroma 1 to 2. Texture of the soils varied widely along their structure and showed with presence of redoximorphic features. The soils of active alluvial plain (flood plain, char land and point bar) showed wide range of soil morphological properties. Soils were deep with lithological discontinuities having A and A-B horizons. Soils have loamy sand to silty clay texture and showed gleying due to high groundwater level their by indicating prolonged reducing condition. The study on pedogenic indices in the study area showed that the particle size, chemical and exchange ratio doesn't follow the trend in the flood plain as compared to nearly stable land. This may be due to the effect of shifting of river course and their tributaries in the selected two window areas across the different landforms. To overcome the above mentioned problems in soil-landform relationship in the study area, the identified landforms were further sub-divided based on the local factors like percentage of crop cover and moisture content. In revised landforms soil types present in each landform showed soil-landform relationship. Thus, the knowledge on soils in relation to landforms vis-à-vis their pedogenesis is useful in understanding their potentials and problems for sustainable land use planning.

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Soil Water Transmission and Maize Growth as Affected by the Use of Organic Amendments

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Biochar can be used as a tool to improve soil physical environment as well as water retention in the soil along with crop growth parameters. Therefore, a field experiment was conducted on maize during 2019 and 2020 in a split plot design with three replications. Main plots cover six soil; amendment applications *i.e.* BN1 (biochar @ 7.5 t ha^{-1} + N @ 75 kg ha^{-1}, BN2 (biochar @ 7.5 t ha^{-1} + N @ 150 kg ha^{-1}, FN1 (farmyard manure @ 20 t ha^{-1} + N @ 75 kg ha^{-1}, FN2 (farmyard manure; @ 20 t ha^{-1} + N @ 150 kg ha^{-1}, N1 (N @ 75 kg ha^{-1} and N2 (N @ 150 kg ha^{-1} and sub plots cover two irrigation regimes *i.e.* Irrigation Water over Cummulative Pan EvaporationasI0.6 (IW/CPE: 0.6) and I0.9 (IW/CPE: 0.9). Impact of these treatments was determined on soil moisture retention as well as on growth parameters of maize. Irrespective of irrigation regimes, BN2 resulted in significant increase of SPAD value, crop biomass and water productivity of maize by 20.4%, 25.2% and 41.3%, respectively over control treatment *i.e.*, alone application of nitrogenous fertilizer. The soil water holding capacity increased by 7.3% in BN1 over control (N1) plots, respectively. Deficit irrigation *i.e.*, I0.6 resulted in higher water productivity of maize over I0.9. Saturated hydraulic conductivity was also found to be significantly higher under biochar over FYM and N alone. BN1 increased saturated hydraulic conductivity by 22.03% and 53.46% over FN1 and N1. It is thus, concluded that biochar as soil amendment retain more water (30% more water retained in BN2 than N1 treatment), hence may help in sustaining and optimizing the limited water available for crop production in north west India.

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Long-term Application of Organic and Inorganic Fertilizers on Structural and Mechanical Properties of Soil in Sorghum-Fallow Crop Rotation

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Long-term experiment with integrated nutrient management helps to study the changes in soil physical environments for the sustainable and healthy development of soil fertility over time. An investigation was carried out to study the long-term impact of organic and inorganic fertilizers on structural and mechanical properties of soil in rabi sorghum (Sorghum bicolor)-fallow cropping system at Solapur. The soil samples were collected from 0-60 cm at 20 cm depth intervals from treatments of control (No NPK), 50%NPK, NPK+FYM, NPK+GLM of the experimental site. Integration of organics and inorganics produced significantly higher aggregate stability and mean weight diameter with plenty of soil organic carbon, exerting higher friability and lesser tensile strength. Applied organics reduced the bulk density with an enormous influence on liquid limit and volume expansion. The addition of organic substrates through the application of NPK+FYM and/or NPK+GLM in this clayey soil significantly improved the amount of macroporosity for better transmission of water. Correlations among the studied soil properties revealed that the integration of a balanced dose of inorganic fertilizer along with organic manure improved the soil physical environments for the sustainable development of soil quality.

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Evaluation of Ground Water Suitability for Irrigation in Navsari District of South Gujarat

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Determination of water quality is the most important aspect to determine its suitability to grow crops. Mapping of groundwater quality become one of the best approach which provide the information about the suitability of the water for irrigation purpose. Water Quality Index (WQI) is a very useful and efficient method to evaluate the suitability of water quality and for communicating the information on overall quality. A total one hundred twenty groundwater samples were collected before and after monsoon in the year 2020-2021 from 6 talukas *viz.*, Navsari, Vansda, Chikhli, Khergam, Gandevi and Jalalpore of Navsari district of South Gujarat. From each taluka, ten villages were selected for the collection of water samples. The percentage of surveyed samples were found falling in no restriction to medium restriction category of irrigation water followed the order of Vansda (70%) > Chikhli (60%) > Khergam (50%) > Gandevi (50%) > Jalalpore (40%) > Navsari (40%) before monsoon. While percentage of groundwater samples under no restriction to medium restriction category of irrigation water mostly decreased and followed the order of Navsari (65%) > Vansda (45%) > Khergam (30%) > Jalalpore (20%) > Gandevi (15%) > Chikhli (5%) after monsoon. Overall in Navsari district, 52.49% and 29.99% of surveyed water samples were found falling in no restriction to medium restriction category of irrigation during before and after monsoon respectively.

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Effect of Bulk Density on Air Entry Potential, Hydraulic Conductivity and Plant Available Water Content of Some Soil Groups of India

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Soil water retention curve (SWRC) is essential for understanding the hydrologic behaviour of soil and modelling of flow and transport processes within the vadose zone. The drying event of the average water retention of soils with changing bulk densities, *viz.* 1.2, 1.4, and 1.6 Mg m^{-3} of different soil groups, *viz.* new alluvial, black and red-laterite were measured. Soil rings were saturated with water and then drained using a hanging water column for low pressure (0 to 5 kPa) and a pressure plate apparatus for medium to high pressure (10 to 1500 kPa). The SWRCs were fitted to Campbell's model to predict unsaturated hydraulic conductivity. The results showed that lower soil bulk density of 1.2 Mg m^{-3} increased water retention capacity and available water content for any soil groups under study. Black soil with higher clay content retained significantly 17% higher plant available water content as compared with new alluvial and red-laterite soils. No significant differences in permanent wilting point were observed with varying densities under red-laterite soils. A higher bulk density of 1.6 Mg m^{-3} had the poorest retention capacity at the lowest suction but showed an inverse pattern at higher suction. The SWRCs for compacted (high bulk density) and non-compacted soils tend to converge in the high suction range. Higher bulk density soils had a lower air-entry value and specific water capacity, with an increased 'b' value of Campbell's constant. Red-laterite soils had a lower storage index, lower air entry suction, and higher air capacity as compare to new alluvial and black soils. Pore size distribution showed significant differences among density and soils. Unsaturated hydraulic conductivity was significantly higher at lower bulk density with lower suction and decreased with decreasing soil moisture content. The SWRCs were suitable to fit other models to predict pedo-transfer functions.

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Use of Black Polythene Mulch as a Climate Smart Technology on Performance of Winter Cucumber and Resource Conservation in Terai Agro-climatic Zone of West Bengal

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Though cucumber is mainly grown during *pre-kharif* and *kharif* season, but farmers of *Teesta* flood plains of *Terai* region prefer to grow this very crop during *rabi* season because of its high market demand and price during this period of year. This region experiences extreme cold during January and February, when maximum and minimum temperature falls below 22°C and 8°C respectively, average being around 13°C. As a result fruit setting and development is badly affected in cucumber. In order to cope with this problem of low temperature following study was conducted at Khagribari village of Cooch Behar district of West Bengal, India during 2015-16 and 2016-17 under a National network project entitled National Innovations on Climate Resilient Agriculture (NICRA) to assess effect of black polythene mulch in winter cucumber. Fourteen innovative and receptive farmers were selected from the village for conducting the trial ensuring their active participation. Each farmer had one plot of 0.13 ha. Two treatments were taken (i) Demonstration: use of black polythene mulch (ii) Control: Conventional practice of growing cucumber without any mulch. Observations were taken on irrigation water requirement, soil temperature, days taken to flower, flower drop percentage, fruiting period, yield and net profit. Two independent sample t-test were performed to compare two treatment for all parameters. Experiment result indicated lesser irrigation water (26.5%) and fuel requirement (30.9%). Night soil temperature under mulch was higher (upto 4.1°C). Advanced fruiting (by 5 days) and expanded fruiting period (by 10 days) along with reduced fruit drop (upto 10%) were observed in demonstration. Higher yield (29.1 t ha^{-1}) and net profit (Rs. 1,08,100) were also recorded with use of black polythene mulch.

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Evaluation of Aggregate Stability Under Long Term Conservation Agricultural Practices in Acid Alluvial Soils of Eastern India

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Degeneration of soil structure and onset of land degradation can be indicated by reduction in soil aggregate stability. Prolonged cultivation of land by conventional agricultural practices and unfavourable soil physico-chemical properties can result in destruction of soil aggregates. Variations in soil organic carbon (SOC), clay content and total nitrogen can act as potential indicators in determining the extent of aggregation. SOC assists in aggregation by forming linkage with clay, organic matter and polyvalent cations and stabilising the aggregates with microbial products. Further, the amount and type of clay present in soil is also an important factor in stability of soil. We examined the structural stability of soil from a long-term experimental field from the following treatments zero tillage (ZT), zero-tillage (ZT) + residue (R),conventional tillage (CT),conventional tillage (CT) + residue (R). The soil was collected from 0-5, 5-15, and 15-30 cm depths. The soil texture was sandy loam. The soil samples were air-dried at room temperature, and were separated into five aggregate fractions, 2, 1-2, 0.5-1, 0.25-0.5 mm and <0.25 mm by wet sieving procedure. We found that the aggregates from CT were less stabilized and disintegrated faster when in contact with water than those of the ZT treatments. For 0-5 cm depth, macro-aggregates were highest in the soil under ZT and lowest in CT. However, the amounts of micro-aggregates were maximum at 15-30 cm depth, and were found higher in CT and least in ZT. Tillage practices had a significant effect (Pd-0.05) on MWD and GMWD throughout the three depths and the values decreased in the order, ZT>ZT + R > CT + R > CT. Therefore, there was less structural stability due to long-term cultivation. However, zero tillage improved structural stability by increasing macro-aggregates, and aggregate mean weight diameter, and decreasing micro-aggregates at all the three depths in this soil.

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Spatial Assessment of Annual Soil Loss by RUSLE Model in Tumsar Tehsil of Maharashtra using RS and GIS

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The continuous detachment, transportation and deposition is shifting the cultivable land to degraded land due to soil erosion. The eroded soil includes top fertile soil, soil nutrients, reduction in crop yields as well as pesticides and harmful chemicals which gets into river and ground water resources. For that purpose, the assessment of soil erosion losses is very important in planning land conversation strategies. In the present study, Revised Universal Soil Loss Equation (RUSLE) model of soil loss estimation was used, which was integrated with Remote sensing and Geographic Information System to estimates soil loss in Tumsar region, Maharashtra during 2015 to 2018. The five major data sets were prepared using the Remote Sensing satellites and used *viz.*, Rainfall Erosivity Factor (R), Soil Erodibility Factor (K), Slope Length and Steepness Factor (LS), Cover and Management Factor (C) and Support Practice Factor (P). All the data layers were prepared using ArcGIS 10.4.1. The results showed that, mean R factor was 467.41 MJ ha^{-1} mm^{-1} in 2015, 396.95 MJ ha^{-1} mm^{-1} in 2016, 359.51 MJ ha^{-1} mm^{-1} in 2017 and 440.19 MJ ha^{-1} mm^{-1} in 2018, soil erodibility factor ranged from 0.13-0.28, LS factor map is prepared using Cartosat-1 satellite. The cover factor (C) and support practice factor (P) were estimated using Sentinel 2A satellite. The results showed the average soil loss of ranged from 0.03-110.46 t ha^{-1} yr^{-1} in 2017, 0.01-108.73 t ha^{-1} yr^{-1} in 2017, 0.017-71.38 t ha^{-1} yr^{-1} in 2017 and 0.05-58.80 t ha^{-1} yr^{-1} in 2017.

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GIS Mapping of Groundwater Quality for Irrigation of Sonipat Block of Sonipat District, Haryana, India

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A study was conducted at different villages of Sonipat block of Sonipat, district, Haryana during 2019-2020 to evaluate the quality of groundwater for irrigation for different crops. In order to ascertain the quality of groundwater, water eighty five samples were collected and analyzed for various haydrochemical parameters pH, EC, (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-}) by using standard procedures. Irrigation indices such as SAR, RSC, were calculated for these samples. The pH, EC, SAR and RSC in groundwater ranged from 6.50 to 10.36, 0.28-23.20 (dSm^{-1}), 2.30 to 45.70 $(mmoll^{-1})^{1/2}$ and 0.00-5.70 (mel^{-1}), respectively. The trend among the average ionic concentration of cations and anions were Na^{+}> Mg^{2+} > Ca^{2+} > K^{+} and anions were Cl^{-}> SO_4^{2-} >HCO_3^{-} > CO_3^{2-}. According to AICRP,1989 In Sonipat block of Sonipat district 44.9, 17.3, 9.2, 15.3, 5.1 and 8.2 per cent samples were found in good, marginally saline, high SAR saline, marginally alkali, alkali and highly alkali categories, respectively Spatial variability maps of EC, SAR and RSC of ground water used for irrigation in the district were also prepared.

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Modelling the Effect of Climate Change on Maize Productivity under the Different Nitrogen Management Strategies

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The impact of present and future climates on maize grain yield and biomass under different long term N management scenarios was studied in Madhya Pradesh. The results showed that maize yield under different N management scenarios differs substantially. The N0%, N50%, N100%, N150% and 100% organic treatments have 50% chance of yield greater than 1.0, 3.40, 4.20, 4.45 and 3.84 t ha-1, respectively. The results of climate change impact on maize grain and biomass yield showed that the maize grain yield decreased by -21.8%, -23.2%, -22.3% and -23.8% under RCP 4.5 (2050s), RCP 4.5 (2080s), RCP 8.5 (2050s) and RCP 8.5 (2080s), respectively in 100% organic treatments compared to baseline scenarios. The biomass yield reduction was observed in organic treatment was -15.9%, -16.9%, -16.6, and -17.7% for RCP 4.5 (2050s), RCP 4.5 (2080s), RCP 8.5 (2050s) and RCP 8.5 (2080s), respectively. For the 0% N, under different RCPs, a decrease in maize grain and biomass yield ranged from -16.6% to - 23.9% and -21.5% to -22.5%, respectively, compared to baseline. For the 50% N, the maize grain yield was decreased by -19.1%, -20.8%, -20.3% and -22.2%, while maize biomass yield was reduced by -14.9%, -15.9%, -15.8% and -16.9% under RCP 4.5 (2050s), RCP 4.5 (2080s), RCP 8.5 (2050s) and RCP 8.5 (2080s), respectively, compared to the baseline scenario. Similarly, the decrease in maize grain and biomass yield for 100% N treatment varied between -18.8% to -21.9% and -15.2% to -17.2%, respectively. However, for 150%N, the decline in maize grain and biomass yield was observed to be between -16.6 to -23.9%, and -14.0 to -17.7%, respectively.

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Impact of Irrigation, Nitrogen and Rice Residue Management on Soil Physical Properties under Rice-wheat Cropping System

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Soil physical properties were studied after five years of rice-wheat crop rotation with differential irrigation, nitrogen and rice residue management. The experiment was replicated thrice in split-split plot design in wheat with two irrigation depths in main plots *viz.* 5 cm and 7.5 cm at fixed growth stages. The three levels of nitrogen viz. 120 kg N/ha, 90 kg N/ha and PAU-Leaf colour chart were in subplots. The rice straw management includes the sowing of wheat with different machines and straw management options in sub-sub plots *viz.* T1-conventional tillage + 100% rice straw removal, T2- Roto seeder + 100% rice straw removal, T3- Happy seeder + only loose rice straw removal, T4- Happy seeder +100% rice straw retention, T5-Roto seeder + loose rice straw removal, T6-Roto seeder + 100% rice straw retention and T7- Wheat sowing 21 days after incorporation of rice straw. The soil bulk density was observed to be highest in T1 (1.55 Mg m^{-3}) followed by T2 (1.54 Mg m^{-3}), T3 (1.52 Mg m^{-3}), T5 (1.52 Mg m^{-3}), T4 and T6 (1.51Mg m^{-3}) and lowest in T7 (1.49 Mg m^{-3}). The trend was similar in the lower soil layer (15-30 cm). This shows that residue management option (T7) decreases the soil bulk density by 4% than T1. The soil penetration resistance increased with soil depth. It was highest in T1 (2.75 M Pa) and minimum in T7 (2.46 M Pa) at 0-15 cm depth. The maximum steady state infiltration rate (cm hr^{-1}) was observed in T4, T6 and T7 treatments (1.1 cm hr^{-1}) while, the minimum was recorded in T1 (0.8 cm hr^{-1}). However, the effects of irrigation and nitrogen levels on the soil physical properties were observed to be non-significant. It is thus, concluded that retention of rice residue proves to be promising in improving the physical properties of the soil.

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Effect of Foliar Spray of Salicylic Acid on Physiology and Water Productivity of Summer Mungbean under Different Irrigation Regimes

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Inconsistent rainfall and high evaporative demand in summer consequences in water deficit and yield loss in summer mungbean. Salicylic acid is one of the potential growth regulator which imparts tolerance to abiotic stresses. To evaluate the efficacy of salicylic acid in improving water productivity under different irrigation regimes, a two year field experiment was carried out in 2019-20 and 2020-21 in a split plot design with three irrigation regimes *i.e.*, irrigation water to cumulative pan evaporation ratios of 0.3 ($I_{0.3}$), 0.6 ($I_{0.6}$) and 0.9 ($I_{0.9}$) in main and foliar spray of salicylic acid at four concentrations *i.e.*, 0 (Control), 0.5 ($SA_{0.5}$), 1.0 ($SA_{1.0}$) and 1.5 ($SA_{1.5}$) mM in sub plots. The least irrigated regime affected the plant growth and physiology as depicted by reduced plant height, biomass, leaf area, leaf relative water content, chlorophyll content and NDVI. However, application of salicylic acid improved these traits under all the irrigation regimes. Root mass density was higher in $I_{0.3}$ regime in the lower depths of soil profile as compared to $I_{0.6}$ and $I_{0.9}$, which further increased with foliar application of salicylic acid. Water deficit increased the osmolyte content and salicylic acid application helped to maintain plant water status and compatible solutes to combat irrigation deficit. Highest seed yield was recorded under $I_{0.6}$ regime and $SA_{1.5}$ but it was statistically at par with $SA_{1.0}$. Water productivity was highest in $I_{0.3}$ which was improved by SA. SA@1.0 mM can be considered as the effective treatment for improving seed yield under all irrigation regimes with more pronounced effect in less frequent irrigation regime.

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Simulation of Available Nitrogen and Soil Water Content in Spring Maize Under Variable Nitrogen and Irrigation Regimes with Hydrus 2D Model

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The present study was conducted on the sandy loam soil at Punjab Agricultural University, Ludhiana in spring maize during the year 2019 with split plot design having 125 (N_1), 100 (N_2) and 75 (N_3) kg ha^{-1} nitrogen levels in main plots and sub-surface drip irrigation at 100 (I_1), 80 (I_2), 60 (I_3) percent of ETc and surface drip at 80 percent ETc (I_4) in sub plots to simulate the N and water distribution in soil profile using HYDRUS-2D model. In surface drip higher content of N and water was found at 0-20 cm depth whereas in subsurface drip irrigation high N and water content was observed in 20-40 cm depth. At the time of harvesting observed nitrogen content in 0-20, 20-40 and 40-60 cm depths was significantly higher in N_1 as compared to N_2 and N_3. Observed nitrogen content was also significantly higher in I_4 as compared to I_1, I_2 and I_3 at harvesting in 0-20 cm depth. Hydrus 2-D model satisfactorily predicted water and N distribution in soil with significant values of R^2 (0.92-0.95 for water and 0.94-0.96 for N), RMSE (0.024-0.011 cm^3cm^{-3} for water and 0.025-0.015mg ml^{-1} for N) and NSE (0.88-0.90 for water and 0.92-0.95 for N). The overall RMSE, R^2 and NSE (for all nitrogen and irrigation regimes) for observed and predicted soil moisture content at 10 cm spacing from dripper after 24 hours of irrigation was 0.011-0.024 cm^3cm^{-3}, 0.95 and 0.90 respectively indicating best model performance for estimating volumetric moisture content. Overall mean of seasonal simulated nitrate nitrogen was significantly higher in I_1 (0.27 mg ml^{-1}) and I_4 (0.26 mg ml^{-1}) as compared to I_2 (0.24 mg ml^{-1}) and I_3 (0.23 mg ml^{-1}).

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Soil Organic Carbon Estimation Using Visible-near Infrared Spectroscopy

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Soil organic carbon (SOC) is an important indicator of soil health, and visible and near-infrared (VIS-NIR) spectroscopy combined with multivariate modelling techniques may provide the new possibilities to estimate the SOC. In this study, more than 1200 soil samples were collected from the different soil types of India. The soil samples were grinded and pass through the 2 mm sieve for further use. The reflectance spectra were generated in the laboratory using the ASD spectroradiometer with the spectral range 350-2500 nm with 1 nm resolution. The concentration of SOC was determined through the Walkley-Black chromic acid wet oxidation method. The range of SOC is varied from 0.1 to 2.0 %. Several pretreatments such as derivative, multiple scattering correction, standard normal variate, base correction were applied to enhance the signal to noise ratio of the spectra. The soil and spectra samples were grouped into the calibration and validation sets using the Latin hypercube sampling approach. The three machine learning approaches such as partial least square, random forest and support vector machine were used for chemometric model development. The determination coefficient (R(2)), root mean square error (RMSE), residual prediction deviation (RPD), and the ratio of performance to the interquartile range were used for the model evaluation.

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Effect of Irrigation Scheduling and Residue Management Tillage on Crop Growth and Water Productivity of Wheat

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The present study was conducted at the Punjab Agricultural University, Ludhiana, to study effect of three irrigation scheduling based on IW/PAN-E ratio 0.6 (I_1), 0.8 (I_2) and 1.0 (I_3) and four tillage practices viz mould board ploughing to a depth of 25 cm followed by rotavator (PT_{25}+R), mould board ploughing to a depth of 14 cm followed by rotavator (PT_{14}+R), zero tillage with happy seeder (ZT) and conventional practices of 2 discing + 2 cultivator followed by planking (CT) on crop growth and water productivity of wheat for two consecutive years (2016-17 and 2017-18). During both the years straw and grain yield was significantly higher in I_3 over I_1 and I_2 by 46.05 & 38.5% and 8.72% & 11.30% respectively. Significantly higher water productivity was observed in I_2 over I_1 and I_3. Similarly significantly higher grain and straw yield was observed under PT_{25}+R over PT_{14}+R, ZT and CT respectively. Overall mean of number of tillers, plant height, leaf area index, root length density and root mass density were significantly higher in PT_{25}+R over PT_{14}+R, ZT and CT. Significantly higher water productivity was observed in I_3 and I_2 over I_1 while non significant differences in water productivity were observed among tillage treatments.

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Optical Approach of Post-monsoon Soil Moisture Retrieval at the Farm Scale Offers Greater Applicability over Thermal-optical and Optical-microwave Method in Arid and Semi-arid Regions

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Remote sensing offers a great potential for soil moisture retrieval even though continuous mapping at field scale is impeded by limited availability of high-resolution, all-weather suitable data and model-based complexities. The current study is an attempt to evaluate synergistic use of microwave and optical/thermal-infrared remote sensing approaches for surface soil moisture monitoring over a large semi-arid irrigated agricultural farm. The performance of Water Cloud Model (WCM) with Sentinel-1 & Sentinel-2, Thermal-Optical TRApezoid Model (TOTRAM) and Optical TRApezoid Model (OPTRAM) with Landsat-8 short-wave infrared (SWIR)/thermal infrared sensor (TIRS) data were evaluated for nine dates covering the entire post-monsoon period. Higher prediction accuracy was obtained with OPTRAM + SWIR 1 (R = 0.80, RMSE = 0.064 $m^3 m^{-3}$) closely followed by OPTRAM + SWIR 2 (R = 0.80, RMSE = 0.065 $m^3 m^{-3}$) compared to WCM (R = 0.71, RMSE = 0.068 $m^3 m^{-3}$) and TOTRAM (R = 0.74, RMSE = 0.077 $m^3 m^{-3}$). All the approaches could effectively delineate high and low intensive irrigation zones, although optical and optical-thermal synergy was better towards a dry-moist soil moisture regime. The WCM requires calibration for changing vegetation structure, while TOTRAM needs local calibration owing to sensitivity of land surface temperature to ambient atmospheric condition. The OPTRAM, being simple, low data- and resource-intensive, and surface reflectance-soil moisture relationship independent of local calibration, is advantageous for generating soil moisture maps during post-monsoon period in semi-arid climate with prevailing clear sky condition.

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Estimation of Mean Weight Diameter of Soil Aggregates from Variable Soil Properties in Response to Organic Cropping Systems

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Soil organic carbon (SOC), soil carbon stock (SCS), aggregate associated carbon (AAC), soil pH, soil electrical conductivity (EC), water stable aggregates (WSA), mean weight diameter (MWD) and bulk density (BD) were estimated after *rabi* and *kharif* seasons from five organic cropping systems: Poplar + turmeric (CS_1), Sugarcane + (bottle gourd – broccoli) (CS_2), basmati – wheat (CS_3), sugarcane fodder (CS_4) and maize + summer moong – wheat (CS_5) practiced in cycle at *Bhagat* Puran Singh Natural Agriculture Farm and Research Centre, Amritsar, Punjab. Results showed that CS_1 has significantly higher SOC, SCS, AAC in macro aggregates, WSA and MWD than CS_2, CS_3, CS_4 and CS_5. Percent macro aggregates were significantly higher in CS_1 and percent micro aggregates in CS_3 compared to other cropping systems. Significantly higher soil pH and BD were observed respectively in CS_4 and CS_5 than other cropping systems. Meanwhile CS_3 has significantly lower EC compared to other cropping systems. In the surface layers SOC, SCS, AAC, EC, WSA and MWD were significantly higher than subsurface layers whereas soil pH and BD were significantly lower in surface than subsurface soil. Soil structural stability indicator MWD was significantly correlated positively with clay content (R = 0.729), SOC (R=0.756) and EC (R = 0.488) and negatively with BD (R = -0.64). The regression model developed for estimation of MWD from clay, SOC, EC and BD of the soil was calibrated (R = 0.90, R^2 = 0.81, SE = ±0.0432, n = 80) and validated with root mean square error (RMSE), model efficiency (ME), coefficient of residual mean (CRM), correlation coefficient (R) and coefficient of determination (R^2) values 0.0468, 0.58, -0.054, 0.845 and 0.714 respectively.

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Prediction of Mean Weight Diameter of Soil using Machine Learning Approaches

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Aggregate stability is an indicator of soil structure and mean weight diameter (MWD) is the most widely used index of aggregate stability. Direct measurement of MWD is difficult, time consuming and laborious. Thus, indirect method of predicting MWD from easily measurable soil properties through the development of pedo-transfer functions (PTFs) is very much essential. An attempt was made to predict the of soils using easy to measure parameters in Karnal district of Haryana. Four machine learning approaches such as artificial neural network (ANN), support vector machine (SVM), classification and regression trees (CART) and random forest (RF) were used and their performances were compared with multi linear regression (MLR). Two input datasets were used. First inputs set was sand, silt, clay (%), bulk density (BD), organic carbon (OC) and glomalin content. Second input set was fractal dimension (D), BD, OC and glomalin content. Total 121 data points were used and dataset was divided with 4:1 training and testing dataset. Inclusion of D in MLR did not improve the performance. For both the input sets, ANN with three hidden layers performed better. In ANN, inclusion of D in input set reduced root mean square error (RMSE) by 17% in training dataset whereas, 25.12 % in testing dataset. The MLR and CART showed lower predictive capability than other three approaches. The correlation value was found to be higher in case of SVM (second input set) by 11.11% than SVM model with first input set in training dataset. The SVM modes predicted MWD with more satisfactory performance as compared to the other models owing to their more flexibility and capability to model non-linear relationships.

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Influence of Irrigation Regimes and Wheat Residue Management Practices on Yield, Water Use Efficiency, and Soil Properties of Summer Mungbean (*Vigna radiata* L.)

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To investigate the effect of wheat residue management practices and irrigation regimes on growth, yield, and water use efficiency (WUE) of mungbean (green gram), a field experiment was conducted for 4 years from 2017-20 on sandy loam soil at Punjab Agricultural University Regional Research Station, Bathinda during summer season under semi-arid climatic conditions. The treatments consist of three wheat residue management practices [(Preparatory tillage after removal of wheat residue (WR_0); zero tillage in wheat residue leftover-after making wheat straw by a straw reaper (WR_R); incorporation of leftover wheat residue after making wheat straw along with preparatory tillage (WR_I)] in the main plot and three levels of irrigations *viz*. I_1 - Two irrigations (vegetative growth and flowering Stage), I_2 - Three irrigations (vegetative, flowering, and pod filling stage), and I_3 - Four irrigations (vegetative, flowering, pod filling, and pod formation stage) in the subplots. The experiment was triplicate in a split-plot design with either SML 668 or SML 832 as test cultivar. The pH, electrical conductivity, organic carbon, available phosphorus, available potassium of the experimental soil (0-15cm) was 8.29, 0.245 dSm^{-1}, 2.8 g kg^{-1}, 19.6 kg $ha^{-1,}$ and 383 kg ha^{-1}, respectively. The pooled data of 4 years revealed that the grain yield of mungbean was significantly higher in both residue incorporation (WR_I) and leftover residue zero tillage treatment (WR_R) as compared to no residue addition tillage treatment (WR_0). Both the WR_I and WR_R were also significantly different in terms of grain yield. Irrigation regimes up to I_3 gave significantly higher mungbean yield under all the three-wheat residue management tillage practices. WUE was higher in WR_I tillage treatment followed by WR_R zero tillage and least in the WR_0 treatment. Among the irrigation regimes, the WUE was found to be the highest in I_2. Both the residue incorporation and leftover residue zero tillage treatments increased the soil OC, available N, P, and K content of surface soil.

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Yield and Water Use Efficiency of Bt Cotton (*Gossypium hirsutum* L.) as Influenced by Irrigation Water Quality, Straw Mulching, and Irrigation Regimes

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A field experiment was conducted at Punjab Agricultural University Regional Research Station, Bathinda during *kharif* 2016-20 to evaluate the effect of irrigation water quality, straw mulching, and irrigation levels on growth, yield, and water use efficiency (WUE) of *Bt* cotton under semi-arid climate. The treatments consist of two irrigation water qualities [canal water (CW); poor quality tube well water (TW, residual sodium carbonate, RSC = 1.36 meq L^{-1}, electrical conductivity, EC = 4.2 dSm^{-1})] in the main plot, two levels of mulch (without mulch, M_0 and with rice straw mulch 6 t ha^{-1}, M_1) in the subplot; and three levels of irrigation at IW/CPE ratio 0.3, 0.5 and 0.7 designated as I_1, I_2 and I_3, respectively) in the subplots. The experimental soil was loamy sand in texture with pH 8.25, electrical conductivity 0.240 dSm^{-1}, organic carbon 2.53 g kg^{-1}, available phosphorus 20.8 kg ha^{-1}, and available potassium 331 kg ha^{-1} in the surface layer. The experiment was designed in split-plot with three replications with *Bt* hybrid RCH 773 BG II as a test cultivar. The results of pooled mean showcased that irrigation water quality and rice straw mulching had a significant effect on seed cotton yield. Ancillary plant characteristics like plant height, number of sympods, and bolls per plant were also significantly different in irrigation water quality and mulch treatments. Among different irrigation levels, seed cotton yields were at par when irrigated at IW/CPE ratios of 0.5 and 0.7 which were significantly higher than irrigation at IW/CPE 0.3. Application of rice straw mulch reduced the osmotic stress caused by saline water usage and also improved the physico-chemical characteristics of soil, though marginally. The WUE was found to be the highest in mulch conditions and irrigation regime IW/CPE 0.3 yielded higher WUE.

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Effect of Long-term Tillage and Cropping Systems on Soil Aggregation, Organic Carbon and Crop Productivity in Vertisols

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A long-term field experiment was initiated in 2010 in Vertisols of Central India to ascertain the effect of different tillage [no-tillage (NT) with residue retention and conventional tillage (CT) with residue removal] and cropping systems [CS1: Soybean (*Glycine max* L.*)* - Wheat (*Triticum durum* L.); CS2: Maize (*Zea mays* L.) L. - Wheat (*Triticum durum*) and CS3: Maize-Chickpea (*Cicer arientinum* L.)] on soil properties (aggregation and carbon dynamics) and crop productivity in long run. The present study was undertaken after 9 cropping cycle (2019). The results of the experiments revealed that irrespective of cropping system NT had performed better in improving the physical and chemical properties of the soils over CT. The practice of NT was found to improve soil aggregation/mean weight diameter (MWD, 1.65 mm) and water stable aggregates (WSA, 80.14%) than CT. Among the cropping systems under soybean-wheat system in NT outperformed with respect to available P (13.42 kg ha^{-1}), K (322.8 kg ha^{-1}) and S (12.21 mg kg^{-1}) over the other treatments. The practice of NT was found effective management strategy for carbon (C) storage/improvement especially under semi-arid climate. The maize–gram cropping system recorded highest significant improvement in SOC (0.64%), labile-C (394 mg kg^{-1}) and TOC (1.21%). The distribution of aggregate associated C under NT was higher as compared to CT, which is considered an important process for physical protection and carbon storage. Among the cropping systems, soybean-wheat under NT recorded significantly higher values of LMag-C (1.07%), SMag-C (0.92%); Micro-C (0.90 %) and S+C-C (1.07%) at 0.5 cm soil layer. The results of the present study, reveals that the long-term practice of NT, crop rotation and residue retention is the panacea for sustaining soil health and crop productivity under the prevailing climate change scenario.

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Comparing Three Quantitative Approaches for Evaluation of Soil Quality Under Intensively Cropped Areas with High or Imbalanced Chemical Fertilizer Use

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In intensively cropped areas, effect of high and imbalanced use of chemical fertilizers on soil and water quality is a matter of general concern. A detailed study thus was taken up to quantify the effect of such imbalanced use of chemical fertilizers on soil quality following three different indexing approaches by collecting georeferenced soil and water samples from Udham Singh Nagar district of Uttarakhand at 10×10 km grids. Consumption of chemical fertilizers in the study district is about 545.0 kg per hectare with rice-wheat and sugarcane-wheat as the major cropping systems. Soil samples from 0-15 and 15-30 cm depths were analyzed for key parameters including pH, EC, soil organic carbon, available N, P, K and S, labile carbon and activity of key soil enzymes. Ground water samples were analyzed for NO_3-N content. The content of SOC varied from 0.20 to 1.44% in the 0-15 cm soil depth and about 44% of samples in the surface soil were in the medium range, while, 79% samples were found low in available N content. On the other hand, all the samples were rated high in available P content. About 60% samples were deficient in available S content. The nitrate-N content in the analyzed water samples varied from 5 to 25 mg L^1 with about 66% water samples containing more than the permissible limit of 10 mg L^{-1} of NO_3-N. Soil quality was assessed by computing soil quality index (SQI) using three different quantitative approaches – (1) Indicator selection and weight assigning using principal component analysis (PCA), (2) Indicator selection and weight assigning using PCA and with setting an upper limit of attribute value (3) selection of indicators based on key soil functions and assign of weights based on expert opinion. The SQI values varied from 0.44 to 0.73, 0.46 to 0.77 and 0.52 to 0.82 in the 1st, 2nd and 3rd approaches, respectively. The computed SQI correlated better with rice yield than wheat yield. Among the three approaches, soil function-based approach was better as indicated by higher r^2 value (r^2 = 0.56) and thus is recommended for quantitative evaluation of soil quality in the intensive agricultural regions of Gangetic Plains in North India.

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Evaluating Mini Pan Evaorimeter for On-Farm Irrigation Scheduling of Maize Crop in Eastern India

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In the scenario of water scarcity, it is imperative to utilize available water effectively to improve water productivity. Scientific irrigation scheduling is one of the potential methods to improve water productivity in crop production. Class A pan evaporation has been used extensively for irrigation scheduling. However, it's use in on-farm water management is limited due to non-availability of pan evaporation data in micro scale. Therefore, an attempt was made to develop a small size pan evaporimeter (mini evaporimeter) with less cost and easy to use for large scale adoption for irrigation scheduling by the farmers. Mini pan evaporimeter made up of galvanized iron (GI) and PVC with different diameters (30 cm, 20 cm and 10 cm) and height of 25 cm was designed and tested in Research farm of ICAR-IIWM, Bhubaneswar. It has been observed that GI mini pans of 30 cm and 20 cm diameter and height of 25 cm had closest relationship with USWB Class A pan. Further, a field experiment was undertaken to evaluate the performance of mini pans compared to USWB Class A pan in summer maize. The treatments (T1-Irrigation scheduling based on 30 cm mini pan; T2-Irrigation scheduling based on 20 cm mini pan; T3-Irrigation scheduling based on USWB Class A pan) were laid out in randomized complete block design. Irrigation was applied to experimental fields based on IW/CPE ratio of 1, where IW was 50 mm. The texture of the site was sandy clay loam. All the treatments were irrigated four times. The LAI (2.49 to 2.55), aboveground biomass (6.93 to 7.35 t ha^{-1}) and cob yield (4.06 to 4.08 t ha^{-1}) of maize were not affected significantly under the treatments. The profile soil moisture storage was aslo not significantly different among the treatments. Overall, the maize crop performance under mini pan evaporimeters and USWB Class A pan did not vary significantly. Therefore, the mini evaporimeter of 30 cm diameter made up of GI may be used for irrigation scheduling in maize crop in eastern India.

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Assessment of Ground Water Quality for Irrigation in Tirunelveli District of Tamil Nadu, India

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A study was undertaken to assess the groundwater quality in Tirunelveli district by collecting 130 groundwater samples using GPS and analyzed for pH, EC, anions viz., HCO_3^-, CO_3^-, Cl^-, SO_4^{2-} and cations *viz.*, Ca^{2+}, Mg^{2+}, Na^+ and K^+ by adopting standard procedures and thematic maps were prepared using Arc GIS software 10.1. The investigation revealed that groundwater samples with respect to pH and EC ranged from 6.5 to 8.5 and 0.54 to 44.50 dS m^{-1}. Residual Sodium Carbonate (RSC) varied from nil to19.6 meL^{-1} and Sodium Adsorption Ratio (SAR) ranged from 0.34 to 69.12. According to CSSRI, Karnal water quality classification, 57 per cent of groundwater found under good quality, (18%) Marginally saline, (4%) Saline, (11%) Marginally alkali, (8%) Alkali, (1%) High-SAR saline and (1%) High alkali. The cationic and anionic order of different blocks in Tirunelveli are followed as the $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ and $Cl^- > HCO_3^- > CO_3^{2-} > SO_4^{2-}$, respectively. Among the different blocks investigated, the highest percentage of samples with good quality was found in Kalakkadu and Pappakudi (100%), Ambasamudram (87.5%), Cheranmahadevi and Alangulam (80%) and Nanguneri (70%). Similarly, the poor quality water *viz.,* High SAR saline from Radhapuram block (4%), Saline from Palayamkottai (20%), Marginal saline from Kadayanallur (60%), High alkali from Valliyur (11%), Alkali from Palayamkottai and Keezhapavur (40%), Marginally alkali from Kadayanallur (40%) were recorded. Among the different blocks of Tirunelveli district, Radhapuram (75%) and Valliyur (55.55%) recorded the high level of possible seawater intrusion.

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Temperature Sensitivity of Soil Organic Carbon Mineralization Kinetics as Influenced by Tillage, Residue and Nitrogen Management in Maize-Wheat System

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Temperature sensitivity analysis of SOC mineralization from soil of long term conservation agriculture experiments is essential to understand about C dynamics under CA. Tillage, residue mulch and nutrient management have differential effect on the quality and quantity of SOC, which in turn influence SOC mineralization. Differential SOC mineralization status at different temperature have implications on global C-cycles in the backdrop of climate change and global warming. Keeping this in view, the objective of this study is to study the effect of tillage, residue and nitrogen management on temperature sensitivity of SOC mineralization in maize-wheat system in an ongoing long term field experiments being conducted since 2014 at the research farm of the Indian Agricultural Research Institute, New Delhi. The treatment comprised of two tillage types (conventional tillage (CT) and no tillage (NT)) as main plot factor, two level of mulching (crop residue mulch @ 5t ha^{-1} (R+) and without residue (R0)) as subplot factor and 3 level of nitrogen (50% recommended nitrogen dose (RDN); 100% RDN and 150% RDN) as sub sub plot factor. After fifth year of crop cycle, soil samples were collected from 0-5 and 5-15 cm soil depth and incubated at field capacity moisture content at 35 and 45°C. Soil organic carbon mineralization was continuously monitored in these samples in terms of CO_2 emissions by alkali trap method. It was observed that the cumulative CO_2 emissions increased under NT and crop residue mulching than that of CT and no-mulching but the percentage of total organic carbon mineralized was less under NT and crop residue mulching than that of CT and no-mulching, respectively. The cumulative CO_2 emissions were significantly correlated with total organic carbon, total nitrogen, very labile carbon and non-labile carbon concentration in soil. With the increase in N level cumulative CO_2 emissions increased. There was increase in the rate of carbon mineralization with the increase in temperature. The rate constant of carbon mineralization decreased with depth. The rate of carbon mineralization under NT and crop residue mulching was less than that of CT and no-mulching, respectively at 0-5 cm depth. The rate of carbon mineralization increased with the increase in N level. The mean resident time (MRT) of soil organic carbon was more under NT and crop residue mulching than that of CT and no-mulching, respectively. With the increase in N level, the MRT of soil organic carbon decreased both at 0-5 and 5-15 cm depth. It was observed that Q10 values of CO_2 evolution under NT and crop residue mulching was more than that of CT and no-mulching, respectively. The activation energy (Ea) under NT and crop residue mulching was higher than that of CT and no-mulching, respectively. Therefore NT with crop residue mulching may be adopted for long term carbon sequestration in maize-wheat system in sandy loam soils of Indogangetic plains.

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Crop and Water Productivity of Wheat in Relation to Deep Tillage and Irrigation Regimes

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The rice-wheat cropping system is dominant in the north-west India since decades in which the rice is grown under puddled field conditions. Moreover, majority of soils in the region are from coarse to medium textured therefore puddling over these soils results in the formation of subsurface compact layer (20-25 cm of soil profile). This subsurface compact layer restricts the root penetration of post rice wheat crop thereby hindering the absorption of water and nutrients from the deeper soil layers and ultimately resulting in reduced wheat yield. A research study was carried for two seasons with three tillage practices *viz.* deep tillage before the sowing of wheat crop during both the seasons (DT_2); deep tillage before the sowing of wheat in first season only (DT_1) and conventional tillage (CT) under two irrigation regimes based on irrigation water to pan-evaporation ratio of 1 ($I_{1.0}$) and 0.5($I_{0.5}$). On account of reduced bulk density of 15-30 cm soil layer (1.72 g cm^{-3} to 1.55 g cm^{-3}), the root proliferation was significantly higher in deep tilled plots up to 90 cm soil depth. The wheat yield was significantly higher in DT_1 (5 Mg ha^{-1}) than CT (4.52 Mg ha^{-1}) during 2016-17 and in 2017-18 it was highest in DT_2 (5.19 Mg ha^{-1}) followed by DT_1 (4.96 Mg ha^{-1}) and lowest in CT (4.70 Mg ha^{-1}). Among the irrigation regime, it was 8.5 and 6.25 percent higher in $I_{1.0}$ than $I_{0.5}$ during 2016-17 and 2017-18, respectively. The input water productivity was significantly higher in DT_2 (15.6 kg ha^{-1} mm^{-1}) and DT_1 (15.0 kg ha^{-1} mm^{-1}) plots in comparison to CT plots (14.1 kg ha^{-1} mm^{-1}). Thus deep tillage resulted in higher grain yield and water productivity of wheat crop.

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Technology for Management of Mechanization Induced Soil Compaction in Sugarcane Cultivation

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Recently, farm mechanization has become the order of day in India, due to intense labour scarcity. Sugarcane is a labour intensive crop and shortage of labour and unavailability of labour at reasonable rate are the major concern in sugarcane cultivation. To combat the paucity of labour, mechanized sugarcane cultivation is the only option to carry out all the operations in time. The change from traditional to mechanized cultivation of cane has increased the adverse soil conditions through soil compaction. Soil compaction problems mainly occur in subsoil. The top soil can be loosened every year but compaction of subsoil is greater problem. Compaction may cause persistent reductions in soil productivity. Hence, to develop a suitable management strategy, field experiments were conducted at Sugarcane Research Station, Tamil Nadu Agricultural University, Cuddalore, Tamil Nadu during 2017-20 in a field where mechanized sugarcane cultivation was followed continuously for four years in a non-saline neutral sandy loam (0-20cm) and clay (20-40 & 40-60 cm) texture soil with the sugarcane variety CoC 25 under strip plot design with three replications. The main plot treatments of chisel plough, double disc plough and conventional ploughing in combination with the sub plot treatments of farm yard manure @ 12.5 t ha^{-1}, composted coir pith @ 10.0 t ha^{-1}, press mud @ 25.0 t ha^{-1}, green manure @ 40.0 t ha^{-1} and composted sugarcane trash @ 15.0 t ha^{-1} incorporation. In both the plant and ratoon crops of sugarcane the result revealed that, among the treatment combinations, chisel ploughing with farm yard manure @ 12.5 t ha^{-1} application registered its superiority in reducing the bulk density, particle density and penetrometer resistance and increasing the porosity, HC and IR compared to other treatments and their by recorded significantly higher growth and yield parameters *viz.,* tillers, millable cane, individual cane weight, cane girth, cane length, number of nodes, inter node length and cane yield of 148.9 and 143.3 t ha^{-1} in plant and ratoon crops respectively. The same combination recorded higher values of quality parameters *viz.,* brix, pole, purity, CCS, sugar yield of 18.76 and 17.88 t ha^{-1} in plant and ratoon crops respectively and B: C ratio of 3.23 and 4.22 in plant and ratoon crops respectively.

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Soil Carbon Dynamics under Oxic-anoxic Rice Ecology

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Rice is the principal food of half of the global population and it dominates the food system in south and south-east Asia. Rice cultivation initially requires continuous submergence while maturity and harvesting periods need dry soil. Thus, rice ecology goes through an alternate oxic-anoxic phases and the soil carbon (C) dynamics here is unique. In this study, we tried to identify the C dynamics in rice soils throughout the crop-growing period. Rice plants were grown in pot-culture under controlled environment with three textural variations (sandy clay loam, sandy loam and loamy soil). Standard fertilizer application was done in all the pots (N: P: K @ 100: 50: 50 kg ha^{-1}) while only half of the pots were treated with organic matter (farm yard manure @ 10 t ha^{-1}). Weekly assessment of soil total organic C, water and hot water soluble C fractions and microbial biomass C were done, starting from two weeks prior to rice transplantation up to two weeks after harvesting. Results showed no variation of soil total organic C during the whole crop period. Comparative low presences of labile C pools (water and hot water soluble C) were observed in initial oxic soils followed by a rise during rice transplanting (starting of anoxic conditions). These labile C pools quantitatively declined after that and later maintained equilibrium even after harvesting. Microbial biomass C was found to be relatively higher in initial oxic soils but got curbed with submergence (anoxic conditions). These trends were found similar in all soil textures. UV-Vis spectroscopy analysis indicated increase of aromiticity, hydrophobicity and humification of soil labile C pools in anoxic condition. This study identified decrease in microbial activity and increase in stable characters of soil C in anoxic rice soils, for which lowland rice ecology can be considered as a C store house.

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Impact Assessment of Organic Matter Amendment on Soil Organic Carbon Pools in Tomato Growing Rhizospheric Alluvial Soil of Varanasi

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Soil health deterioration, particularly decline in soil organic carbon (SOC) content, is considered as a one of the major constraints for sustainable agriculture in India. SOC pool is largely divided into two pools viz. active pool and passive pool. For fertility point of view labile pool is important, and for carbon stabilisation, passive pool (resistant/stable) is important. Therefore, an experiment was carried out in net house of IAS, BHU in 2019-20 rabi season to evaluate the impact of organic matter (FYM/ Vermicompost) amendment on buildup of both active and passive pools SOC in rhizospheric soil of tomato crop after harvesting the tomato and consequently its effect on productivity of soil. Soils were amended with absolute FYM at three different levels (FYM @ 4.5 g kg^{-1}, 9.0 g kg^{-1}, 13.5 g kg^{-1} soil); sole vermicompost (VC) at three different levels (VC @ 4.5 g kg^{-1}, 9.0 g kg^{-1}, 13.5 g kg^{-1} soil); three integrated nutrient management systems (½ RDN FYM + ½ RDNF + RDPK, ½ RDN VC + ½ RDNF + RDPK, ¼ RDN FYM + ¼ RDN VC + ½ RDNF + RDPK); one treatment with recommended dose of chemical fertilizer application and control. Organic matter amendment in soil for tomato cultivation, significantly increased the different fractions of active pools (HWSOC, CWSOC, AHOC, RMOC, PDOC and PMOC) as well as passive pool (HA) of soil organic carbon in rhizospheric soil of tomato crop. In most of the cases level of different pools of SOC was higher in VC amended soil than FYM. Polymerization of HA was higher in control and absolute chemical fertilizer applied soil. Soil productivity, in respect of tomato crop in VC and chemical fertilizer amended soil was significantly higher than FYM amended soil, because of lower N, P, K content in FYM. Results indicate that organic matter amendment improve the SOC status in rhizopheric soil and according to the assessment of accumulation of active and passive pools of soil organic carbon in rhizospheric alluvial soil of tomato crop and soil productivity; vermicompost application @ 9.0 g kg^{-1} soil would be suggested for organic tomato production.

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Palygorskite Induced Natural Soil Degradation in Swell Shrink Soils of Semi-arid Central India

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We observed low hydraulic properties in some shrink-swell soils occurring in a similar landscape of Yavatmal district of Maharashtra and investigated the cause of such a phenomena. The present study reports the natural soil degradation due to pedogenic factors and processes related to presence of palygorskite mineral in the shrink-swell SAT Vertisols of Yavatmal district, Maharashtra. The hydraulic properties of some Vertisols of Yavatmal (Typic Haplustert and Sodic Haplustert) are impaired with a saturated hydraulic conductivity (Ks) in the range of 0.1-8 mm hr^{-1}. The exchangeable Ca/Mg ratio of the soils varied from 1.46 to 8.15 in the surface horizons and from 0.73 to 6.23 in sub-surface horizons suggesting increase in Mg^{2+} in the sub-surface layers. The X-ray diffractograms of water dispersible clay indicated the presence of clay size smectite, mica and kaolinite. However, deconvoluted X-ray diffractogram indicates that, instead of any single peak at 1.00 nm, a multiple number of smaller peaks at 1.04, 1.01, and 0.99 nm is visible, which are characteristic peaks of palygorskite mineral. The Mg bearing palygorskite mineral adversely affects the intrinsic soil properties, such as a decrease in Ks (< 10 mm hr^{-1}) and low exchangeable Ca/Mg ratio with pedon depth, and an increase in soil base saturation (> 100%), which were recorded in these soils. We report the presence of palygorskite, which caused decrease in exchangeable Ca/Mg ratio with soil depth and subsequent reduction in Ks which leads to the soil degradation in the SAT environments.We observed low hydraulic properties in some shrink-swell soils occurring in a similar landscape of Yavatmal district of Maharashtra and investigated the cause of such a phenomena. The present study reports the natural soil degradation due to pedogenic factors and processes related to presence of palygorskite mineral in the shrink-swell SAT Vertisols of Yavatmal district, Maharashtra. The hydraulic properties of some Vertisols of Yavatmal (Typic Haplustert and Sodic Haplustert) are impaired with a saturated hydraulic conductivity (Ks) in the range of 0.1-8 mm hr^{-1}. The exchangeable Ca/Mg ratio of the soils varied from 1.46 to 8.15 in the surface horizons and from 0.73 to 6.23 in sub-surface horizons suggesting increase in Mg^{2+} in the sub-surface layers. The X-ray diffractograms of water dispersible clay indicated the presence of clay size smectite, mica and kaolinite. However, deconvoluted X-ray diffractogram indicates that, instead of any single peak at 1.00 nm, a multiple number of smaller peaks at 1.04, 1.01, and 0.99 nm is visible, which are characteristic peaks of palygorskite mineral. The Mg bearing palygorskite mineral adversely affects the intrinsic soil properties, such as a decrease in Ks (< 10 mm hr^{-1}) and low exchangeable Ca/Mg ratio with pedon depth, and an increase in soil base saturation (> 100%), which were recorded in these soils. We report the presence of palygorskite, which caused decrease in exchangeable Ca/Mg ratio with soil depth and subsequent reduction in Ks which leads to the soil degradation in the SAT environments.

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Biochars and Its Liming Potential on Severely Acidic Soils of Western Ghats, India

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Soil acidity reduces soil quality and affects plant growth. Leaching of bases through water leads to increase in soil acidity especially in high rainfall hilly regions. Appropriate corrective measures are followed to raise the pH towards neutrality. Lime or dolomite is applied to ameliorate acid soils. Farmers are applying huge quantity of manures such as Farm Yard Manure (FYM), Poultry Manure (PM), Pig Manure (PiM) etc. Objective of the study was to converting the manures and organic residues as feedstock in to alkaline biochars to neutralize soil acidity so that liming materials need not be applied separately. In Nilgiris of Western Ghats, farmers are using huge quantity of manures (>30 t ha^{-1}) for vegetable crops, mainly FYM and PM. Soil pH of Nilgiris range from 3.6 to 6.5; majority of soil's pH lies between 4.0 to 5.0 and vegetable crops needs pH 5.0 and above. There were seven feedstock namely, PM, FYM, Paddy straw, Sugarcane Bagasse, Coir pith, Mushroom spent waste and Town compost collected and prepared biochar with two pyrolysis temperature *viz.*, 450 and 600°C. These biochars were applied in four doses *viz.*, 8, 12, 16 and 32 t ha^{-1} with two replications along with control and dolomite application. Pot experiment was conducted through incubation. Except Poultry Manure Biochar (PM-BC), other six feedstocks have not raised the soil pH above 5.5. Among PM-BC, both the pyrolysis temperatures were raising pH above 5.50 and the doses 12, 16 and 32 t ha^{-1} raised the soil pH above 5.50. PM-BC contains high quantity of calcium (>12 meq/100g) compared to biochars of other feedstocks that might be the reason for raising pH of severely acidic soils in the Western Ghats, India.

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Incubation Study of Cationic Micronutrient Fractions in Various Tropical Alfisols and Inceptisols as Influenced by Organic Additions and Simulated Moisture Regimes

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Rice cultivation is endangered by the intangible behaviour of micronutrients, which results in irregular availability. The purpose of this research is to see how organic amendments and moisture regimes affect cationic micronutrients including zinc (Zn), copper (Cu), iron (Fe), and manganese (Mn). A controlled scenario incubation study was carried out utilizing a thrice replicated factorial randomized design with three levels of organic amendments, two moisture regimes, and two incubation times. Continuous submergence (CS), 50 g kg^{-1} rice straw and 150 days of incubation (DOI) restored higher soluble and Exchangeable (SE) manganese and iron excepting for SE-Cu, facilitated under alternate wetting and drying (AWD) condition. SE-Zn was higher under AWD, no organic administration and 60 DOI. AWD, 50 g kg^{-1} rice straw and 60 DOI recovered higher Mn, Cu, Fe and Zn in organically bound fractions. CS, 50 g kg^{-1} rice straw and 150 DOI recovered higher Mn, Cu, Fe and Zn in manganese and amorphous iron oxide bound fractions. AWD, no rice straw administration and 60 DOI recovered higher Mn, Cu, Fe and Zn in crystalline iron oxide bound fractions. In the face of rising global water needs, AWD not only saves 30-40% moisture, but also enhances the SE percentage of Cu and Zn, which is amplified by organic matter.

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Macronutrient Status of Soils under Rice Growing Areas of Birbhum District, West Bengal, India

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The present paper deals with the assessment of the status of macronutrients *viz.*, nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) in relation to soil properties in the selected blocks of Birbhum district, West Bengal. A total of 100 soil samples from 5 blocks (twenty from each five blocks *viz.*, Suri II, Rampurhat II, Md Bazar, Nalhati I and Sainthia) of Birbhum district were collected at a depth of 0-15 cm. Twenty representative villages were chosen from the five selected blocks. Collected soil samples were analysed for pH, electrical conductivity (EC), organic carbon (OC) and macronutrients using standard analytical methods. Based on the fertility ratings, collected soil samples varied between strongly acidic to neutral in soil reaction. EC values were low and soils were non-saline in nature. % Organic carbon content of the soil samples varied from 0.37-0.98. Low to medium organic carbon value was observed. Low to medium available nitrogen content were recorded. All the soil samples were found medium in available phosphorus except in the blocks Rampurhat II and Nalhati I which were having high phosphorus content. Medium to high available potassium values were recorded. All the soil samples collected, were found having low sulphur content. Correlation studies showed that soil pH correlated significantly and negatively with available nitrogen, potassium and sulphur, whereas significantly and positively with available phosphorus. Significant and positive correlation was recorded between soil organic carbon content and available macronutrients. EC correlated non-significantly and positively with available nitrogen, phosphorus, potassium and sulphur.

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Influence of Silicon and Water Management under Elevated Level of Phosphorus and Vermicompost on Arsenic Uptake by Boro Rice (*Oriza sativa* L.)

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The soil water plant system is the main source of As entry into human being and has reached a very concerned state specially in Nadia district of West Bengal (W.B). Rice (*Oriza sativa* L.) under flooded anaerobic condition accumulates arsenic (As) in straw and grain. Specially in boro season, contamination of the ground water with As (>0.01 mg l^{-1}) that used for irrigation purpose makes As contamination a serious issue. The present experiment was conducted under greenhouse condition to explore the possibility of mitigation of As contamination in rice through combined application of silica(Si) and water regimes under elevated level of phosphorus (P) and vermicompost (VC) by two rice genotype. As contaminated and uncontaminated soil was collected from Nadia and Hoogly district (W.B.), respectively. Two rice variety (cv. IET-21845 and IET-4786) were chosen and two types of water management were followed 1) fully submerged 2) continuously saturated resembling SRI system. Si was applied in the form of Tabsil (a nanotechnology-based silicon fertilizer)@ 5kg ha^{-1}. A strong negative correlation was observed between Si application and As content in different part of rice. Addition of Si significantly decreased total as content in edible part of rice at harvest. Additional use of P_2O_5 and VC decreased the as uptake by rice under water saturated condition. IET-21845 was observed to accumulate significantly lesser As in leaf, husk, unpolished and polished grain as compared to IET-4786.

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Liming Potential of Low-cost Soil Amendments in Weathered Tropical Soil

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Soil acidity is of the major constraints in weathered tropical soils characterized by low pH, high aluminum (Al) toxicity, and low cation exchange capacity. So, low-cost liming materials (LM) were explored for amending the weathered tropical soil. In this study, low-grade minerals (rock phosphate and silicate minerals) as well as biochar derived from waste biomass were evaluated for their liming potential. The liming potential was evaluated through theoretical calculations, quantified with laboratory titration and incubation with soil. A soil incubation experiment was conducted to quantify more accurate %CCE value using weathered tropical Alfisol (pH 4.5). Rock phosphate (RP), feldspar, and biochar along with agricultural liming material ($CaCO_3$) were added to 100 g of acid soil @ 0.1, 0.5, 1, 5, 10 g kg^{-1} soil, incubated for 90 days at field moisture capacity and analyzed for the change in pH, exchangeable Al and available phosphorus (P) and potassium (K). The %CCE of each liming treatment was determined by using $CaCO_3$ as standard. Soil pH was found to increase while extractable Al was decreased with the increasing doses of liming treatments. Application of RP, feldspar and biochar found less effective as compared to $CaCO_3$ in increasing soil pH. However, RP and biochar found effective in reduction of Al content much bellow the toxic limits. On the other hand, available P and K increased in soil with the application of RP and feldspar, respectively. Biochar also found effective in improving both P and K availability in the soil. As compared to feldspar, RP and biochar exhibited more liming potential and can be used as amendment in acid soils. The results indicate that RP and biochar could be a potential alternate liming agent for low input agricultural system prevailing in tropical environments. Further study on comparing actual %CCE through some model across the variety of soil would be helpful for better understanding.

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Effect of Foliar and Soil Application of Biostimulants extracted from Organic Sources on Growth, Yield and Quality of Different Crops

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The biostimulants (humic acids, fulvic acids and humins) were prepared from composts and organics and were analyzed for total elemental (total carbon, N, P, K, S), functional group and FTIR analysis. The efficacy of the extracted biostimulants were tested to optimize the use of biostimulants based on the total elemental and functional group analysis. The chili, cotton and safed musali were used as test crop to assess the impact of biostimulants on growth, yield, quality and nutrient uptake. Among various treatments, foliar spray of biostimulants recorded higher chlorophyll content of cotton leaves compared to biostimulants applied through drip. The higher chlorophyll cotent was noted with the application of RDF along with foliar spray of biostimulants @1% with concurrent impronvement in the nitrogen balance index (NBI). However, the flavanoid content of cotton leaves were recorded lower in response to foliar application of biostimulants. The application of biostimulants either through foliar or drip did not have any significant change in anthocyanin content cotton leaves. The yield of chilli was increased significantly with the application of 100% RDF + 6 spray of BS @ 1.5%. The chlorophyll content was increased significantly with 100% RDF along with six spray of BS @ 1.5%. The Significantly higher fresh and dry bulb yield of Safed musali were recorded with application of NPS Compost @ 4.5 t ha^{-1} + two spray of BS @ 0.5 % (34.64 and 5.28 q ha^{-1}). The chlorophyll content in leaves of Safed musali were recorded significantly highest with the application of NPS Compost @ 4.5 t ha^{-1} + two foliar spray of BS @ 0.5 % (24.42 (mg g^{-1}). The lowest chlorophyll content in leaf of Safed musali were found in control during all days of planting.

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Effect of Silicon on Plant

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Silicon is the eighth most common element by mass and the second most abundant element in the soil after oxygen. Although silicon has not been considered to be an essential element to plant but it is very difficult to deny the beneficial role of silicon on plant. Recent experimentation has demonstrated that Si exhibits extraordinary effects on plant growth and development unequalled by any other non-essential plant nutrient. Plant absorbs silicon from soil solution in the form of monosilicic acid, also called orthosilicic acid (H_4SiO_4). Silicon is transported from the root to the shoot by means of the transportation stream in the xylem in the plant. Silicon is concentrated in the epidermal tissue as a fine layer of silicon cellulose membrane and is associated with pectin and calcium ions. In this way, a double-cuticular layer can protect and mechanically strengthen plant structures. Silicon may alleviate salt stress in higher plants. There are several hypotheses for this effect. They are (a) improved photosynthetic activity, (b) enhanced K/Na selectivity ratio, (c) increased enzyme activity, and (d) increased concentration of soluble substances in the xylem, resulting in limited sodium adsorption by plants. Si played a key role in plant growth, mechanical strength and resistance to pathogens.

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Quality Parameters of Tomato using Water Soluble Fertilizers Under Fertigation

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Tomato, (*Solanum lycopersicum* L.), is undoubtedly crop of prime importance in the world. The millennial population is moving towards a healthier diet with quality products over unhealthy junk and the tomatoes serve the job. Owing to its richness in minerals, vitamins, especially vitamin 'C', carotenoids, antioxidants, and organic acids, tomatoes are consumed around the globe as fresh and processed products. A pot experiment was conducted during 2020-21 at the Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore to study the effect of nutrient ratios of water soluble fertilizers (WSF) on yield and quality of TNAU Tomato Hybrid CO_3 under fertigation. The experiment was laid out with nine treatments imposed in three replications for the four critical growth stages in Completely Randomized Block Design in 54 pots. The results revealed that the different yield attributes *viz.*, number of fruits per plant (51), fruit volume (45.4 cm^3), fruit weight (42.2 g), fruit length (7.37 cm), fruit girth (15.7 cm) and yield per plant (1.99 kg) and the quality parameters *viz.*, titratable acidity (1.32%), lycopene (5.77 mg 100 g^{-1}) and β carotene (1.49 mg 100 g^{-1}) contents recorded highest values under fertigation with NPK 1:1:1 + Ca + B (100 % RDN) treatment while TSS (5.2 ^{0}Brix) and ascorbic acid (56.6 mg 100 g^{-1}) marked the highest under fertigation with NPK 1:1:1 + B (100% RDN). The lowest yield and quality parameters were observed in the absolute control. This particular study revealed that the conventional methods of fertilization has nothing to do with yield and quality improvement and the application of nitrogen, phosphorus and potassium alone won't result in betterment but, those together with calcium and boron through fertigation may result in the maximum yield in tomato with best quality parameters.

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Potassium Fixation and Adsorption Capacity of Soils in Southern Tamil Nadu

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Potassium (K) is one of the three major plant nutrients and most neglected by the farmer though it is considered as equal as or sometimes more than the nitrogen requirement by the crops in many of the Indian soils. The potassium exist in different forms *viz.* water soluble and exchangeable K as available and non-exchangeable, fixed K and clay lattice K as slowly available to plants. However, the available K constitutes only 1-2% of total K. In order to assess the fixation capacity of southern Tamil Nadu soils, an experiment was conducted in 5 different soils by employing the analytical method developed by Agro Services International, Inc (ASI), 205 E, Michigan Ave., Orange City, Florida, 32763 USA. The fixation study was established by adding 2.5 ml of soil with 2.5 ml of 0, 25, 51, 102, 203 and 407 mg L^{-1} of K solution. The K saturated soil was air dried for 3 days and estimated the concentration of K in the N-N Ammonium acetate extract by using flame photometer. The amount of K required to satisfy the fixation capacity of soil was ranged from 51 to 102 mg kg^{-1}. The data was validated by fitting with freundlich model and confirmed that the fixation capacity of various soils of southern Tamil Nadu was 43 mg kg^{-1}. The 'a' value of the adsorption model ranged from 1.195 to 1.583 and the 'b' value below 0.5 confirmed the normal adsorption of K by the uniform layer of adsorption and concluded that the soil should be fertilized enough in a balanced manner so as to release K for crop utilization.

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Potentiality and Limitation of Inositol Hexaphosphate in Phosphorous Nutrition to Bengal Gram

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Inositol hexaphosphate (IHP) or phytate constitutes a major portion of organic phosphorus (P) compounds in soil. In order to investigate the ease of access of phosphate group of IHP by plants as well as its retention behaviour in soil, a laboratory study and a pot experiment was undertaken. Nutrient free sand and goethite, prepared in the laboratory, were used to study the sorption behaviour of IHP. To test the availability of P in IHP, Bengal gram was grown in pots containing a soil of high P buffering capacity and sand having practically no buffering capacity using various amounts of IHP and /or inorganic soluble sources of P. Results revealed that goethite adsorbed much higher amounts of IHP than did sand. In terms of desorption of the sorbed IHP, goethite exhibited considerable hysteresis thereby representing high buffering capacity. Sand on the other hand had removed insignificant amount of IHP from solution and exhibited practically no hysteresis in absence of binding sites for IHP. The dry-matter weight and P uptake of Bengal gram was noted highest with 100 mg P kg^{-1} applied in inorganic soluble form in the soil. This was followed by addition of P through IHP in sand at the same rate of P application. At lower rates of P (25 mg kg^{-1}), dry matter weight and P uptake were higher in sand than in soil irrespective of the source of P. The findings from the experiment suggested that organic P in the form IHP is an equally good source of P as the inorganic P; performed sometimes better than the inorganic soluble forms. It was concluded that the IHP, that is not strongly adsorbed on to soil particles, could be utilised by plants through hydrolysis by enzymes released by plant roots and microorganisms.

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Exhaustive Cropping with Inadequate Potassium Input Depletes Potassium Fertility of Soils

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A study was conducted to observe the effect of exhaustive cropping with graded doses of potassium (K) fertilizer on K supplying capacity of two alluvial soils. One soil was marginally low in available K (soil 1), whereas, the other soil was high in available K (soil 2). Four successive crops of Sorghum-Sudan grass (hybrid) were grown with varying K doses [0, 10, 20, 30, 50, 100, and 200% of recommended dose of K (RDK)]. In both soils, there was no significant improvement in biomass yield beyond 50% RDK. Negative K balance was observed up to 50% RDK in soil 1, whereas the same was negative in soil 2 irrespective of levels of applied K. For soil 1 at 50% RDK, there was no noticeable decline in K pools, K quantity, and also no substantial increase in K fixation capacity; rather there was large increase in soil solution K activity. Also, negligible negative K balance was observed under 50% RDK. On the other hand, in soil 2, there was a decline in almost all the soil parameters related to availability of K under 50% RDK. Interestingly, in this soil, higher doses of K application *i.e.*, 100% and 200% RDK could not resist the decline in soil K parameters. Hence, it appears that decline in soil K parameters cannot be stopped completely rather depletion of K from non-exchangeable and structural pools should be minimised to the possible extent through adequate K input.

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Sorption of Arsenic on Different Clay-sized Fractions of Soils

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The high concentration of arsenic (As) in soil may pose to potential risk for groundwater contamination and its entry in the food chain. Sorption-desorption of as on different soils especially on clay sized fractions may affect its mobility, toxicity and bioavailability in soil. The interaction of As with soil minerals is greatly influenced by the contents of organic carbon (C) and amorphous Fe-Al-oxides, type of clay minerals as well as soil pH and temperature. Therefore, a laboratory batch experiments were carried out to study the sorption behavior of As on soil and clay sized fractions of two different soil orders namely - Alfisol and Inceptisol at varying pH (5.5 and 7.0) and temperature (298 and 308 K). The clay-organic complex (COC) was separated from soil and subjected to different chemical treatment to sequentially remove the organic C (was considered as clay-oxides) and aluminium (Al) and iron (Fe) oxides (was considered as clay). The Alfisol was dominated with smectite minerals and Inceptisol was dominated with illite minerals. The contents of organic C was lower and free and amorphous Al and Fe-oxides was higher in Alfisol compared to the Inceptisol. The results showed that the adsorption capacity was higher on soil as well as on clay sized fractions in Alfisol compared to the Inceptisol. The adsorption of As on COC was higher at lower pH (5.5) compared to the higher pH in both the soil orders. The thermodynamic results revealed that the sorption reactions were exothermic and favourable at lower temperature (298 K) compared to the higher one (308 K). The adsorption isotherms for both soil orders fitted well to Langmuir and Freundlich models. Among the clay sized fractions, highest adsorption capacity was found for clay-oxides and COC of Alfisol and Inceptisol, respectively and lowest was found for clay in both the soil orders. Therefore, it can be concluded that the contents of organic matter, Al and Fe-oxides and type of clay minerals are the major factors to determine the sorption behavior of As in soil.

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Impact of Conservation Agriculture on Carbon and Nitrogen Dynamics in Soybean-Wheat System in a Vertisol

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A field experiment was initiated during 2015 to study the impact of conservation agriculture practices on carbon and nitrogen dynamics in soybean-wheat system in a Vertisol. The study consists of five different tillage practices treatments (as main plots) with the three nutrient doses (as sub plot) *viz.*, N_1 (75% RDF), N_2 (100% RDF) and N_3 (STCR dose) with three replication. Soil samples were collected at two depths namely 0-10 cm and 10-20 cm at end of *kharif* and *rabi* season after 5 years. Results revealed that greater variation was observed active C fraction during *kharif* and rabi season. Tillage systems recorded significant effect on active carbon in end of *kharif* season only. RT (with 60 cm crop residue height) recorded significantly higher active C (835.7 and 780.7 mg C kg^{-1}) in end of *kharif* and *rabi* season. The effect of tillage on NH_4 – N and NO_3 - N concentration was non-significant in both of the sampling season (end of *kharif* and *rabi).* NH_4 - N (30.10 and 47.29 mg kg^{-1}) and NO_3 - N (113.9 and 135.8 mg kg^{-1}) concentration was found higher under RT (with 60 cm residue height) than CT practices in end of *kharif* and *rabi* season, respectively. Nutrient management practices had a significant effect on active C, NH_4 - N and NO_3 - N concentration at both of the sampling season (end of *kharif* and *rabi*). Among the different nutrient levels, STCR dose was significantly higher active C (824.9 and 782.5 mg C kg^{-1}), NH_4 - N (29.7 and 45.1 mg kg^{-1}) and NO_3 – N (116.2 and 136.4 mg kg^{-1}) content at end of *kharif* and *rabi*. Results demonstrated that NT and RT practices with 60 cm height residue performed better than 30 cm height residue. Thus, CA practices considered as a sustainable management for improving soil carbon and nitrogen status in a Vertisol of central India.

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Evaluation of Potassium Quantity Intensity Relationship under Long Term Conservation Agriculture in Soil of North West India

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Essentiality of Potassium (K) is well known in plant nutrition. However, K fertilization is often neglected leading to imbalanced fertilization. Recently Conservation agriculture (CA) has been quite popular among land practitioners globally. Crop residues are rich source of K and its long term addition may modify the K supplying capacity of soil. With this hypothesis, a field experiment was conducted to assess the effect of CA management practices on K-Quantity/intensity (Q/I) relationship in soil under cereal based systems of North-West India. Different pools of K and Q/I parameters were analyzed after 11 years of an experimental setup having six scenarios *i.e.* Scenario 1 (Sc1) : (CT-CT) conventional till rice-wheat cropping system; Scenario 2 (Sc2) : (CT-ZT-ZT); partial CA based rice wheat-mungbean system; Scenario 3 (Sc3) : (ZT-ZT-ZT); full CA based rice-wheat-mungbean system; Scenario 4 (Sc4) : (ZT-ZT-ZT) CA based maize-wheat-mungbean system; Scenario 5 (Sc5) : (ZT-ZT-ZT) same as scenario 3 with sub surface drip; Scenario 6 (ZT-ZT-ZT) same as scenario 4 with sub surface drip. Soil samples were collected from three depths after harvesting of wheat in 2020. Results revealed that Available K, WSK and Ex-K pools were highest in the uppermost layer of soil (0-5 cm). Available K varied between 111(Sc1) to 191mg kg^{-1} soil (SC5) in 0-5 cm depth and were significantly higher in CA based scenarios (1.5 times) over Sc1. The equilibrium activity ratio of K^+ (AR_e^{0K}) varied between 1.55×10^{-3} in Sc1 to 3.71×10^{-3} (mol L^{-1})$^{1/2}$ in Sc6. Though Sc2 maintained higher labile K and AR_e^{0K}, it had lower PBC^K showing that this practice may be unsustainable over long term. However, all full CA based scenarios maintained higher PBC^K over Sc1 suggesting better sustainability. The study provided useful information regarding K availability and sustainability under CA and could contribute towards better K management.

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Distribution of Different Forms of Zinc Fractions under Long-term Fertilization of Soybean-Safflower Cropping Sequence in Vertisol of Maharashtra

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Field experiment was conducted during *kharif* and *rabi* season of 2019-20 at research farm, AICRP on Long Term Fertilizer Experiment, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to study the distribution of different forms of zinc fractions in long term fertilization of soybean - safflower cropping sequence under Vertisol. All the fractions of zinc *viz*. exchangeable Zinc, carbonated Zinc, organically bound Zinc, manganese oxide bound Zinc, amorphous Fe and Al oxide bound zinc, crystalline Fe and Al oxide bound Zinc, residual Zinc and total Zinc were significantly improved by different treatments of manuring and inorganic fertilizers in long term fertilization. The different forms of fractions Zinc viz. exchangeable Zinc (0.55, 0.44 mg kg^{-1}), carbonated Zinc (2.81, 2.75 mg kg^{-1}), organically bound Zinc (1.20, 1.19 mg kg^{-1}), manganese oxide bound Zinc (6.49,6.06 mg kg^{-1}) , amorphous Fe and Al oxide bound zinc (6.22, 6.06 mg kg^{-1}), crystalline Fe and Al oxide bound Zinc (3.57, 3.4 mg kg^{-1}), residual Zinc (491.00, 449.63 mg kg^{-1}) and total Zinc (505.50, 469.50 mg kg^{-1}) at 0-15 cm and 15-30 cm soil depth, respectively recorded significantly maximum by of 100% NPK + Zinc followed by 100% NPK + FYM @ 5 t ha^{-1} and application of only FYM at harvest of safflower. All the fractions of zinc were decreases with increasing in soil depth.

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Soil to Plant Transfer of Phosphorus through Mycorrhiza in Alluvial Soils of Bihar

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The decreased availability of Phosphorus (P) in Indian soils including the soils of Bihar can be attributed to its affinity to get fixed by the formation of complex compounds in soils with dominant cations like calcium owing to the prevalent alkaline reaction. P nutrition to the crops can be enhanced by the inclusion of microbial inoculants like arbuscular mycorrhizal fungi (AMF). At Bihar Agricultural University, Sabour, we investigated the effects of AM fungi and various P levels on the distribution and availability of P in dominant soils of Bihar. At the same time, five prevalent maize based cropping systems with different tillage practices were tested to evaluate their impact on availability of different fractions of phosphorus in soil and AM infection in the root. Results from the study revealed that the Ca-bound P was the most abundant P fraction in the alkaline soils (65% of the total P) followed by neutral soil (35% of the total P), whereas it was less abundant (<4%) in the acidic soil type. AM fungi leads to the redistribution of P fractions in different soils which helps in improvement of available P in soil. The results of another study on mycorrhiza showed that the cropping system with higher AM infection in roots resisted greater P content in the rhizospheric soil. The highest uptake of P by the grain and straw of rice (13.78 and 11.03 kg ha^{-1}) and wheat (18.74 and 3.04 kg ha^{-1}) was recorded with the combined application of chemical fertilizers with microbial inoculants.

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Plant Growth-Promoting Traits of Thermophilic Bacteria Isolated from Anhoni Hotsprings of Central India and its Effect on Pigeon Pea (*Cajanus cajan*) Seedlings

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In the present investigation, the main aim is to isolate, identify and characterize the efficient stress tolerant plant growth promoting bacterial isolates or consortium for improving the sustainable crop productivity and soil health. Sixty thermophilic bacterial isolates were isolated from Choti and Badi Anhoni Hot springs of Central India. Bacterial cultures were qualitatively tested for cellulolytic, lignolytic, proteolytic, lipolytic, amylase, phosphatase, siderophore and Indole Acetic Acid (IAA) production potential. Based on screening of isolates, six potential bacterial cultures were selected for plant growth promotion potential with pigeon pea (*Cajanus cajan*) (variety ICPH-87) as test crop. Pot culture experiment was performed with 8 treatments (T1: BAM3, T2: BAS11, T3: BAS17, T4: CAM1, T5: CAM-29-3, T6: CAS-5, T7: consortia, T8: control) and 3 replications under CRD design. It was concluded that the isolate CAM1 showed better crop growth followed by BAS11 and CAS5. It was also observed that bacterial culture treatment recorded significant enhancement in the root and shoot growth in comparison with control. Also, the study has demonstrated that the bacterial isolates possessing heat tolerance coupled with PGP properties. Thus, it could serve as efficient biofertilizer candidates for improving plant growth and production of pigeon pea under stress conditions.

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Effect of Phosphorus Levels with Bioinoculants on Phosphorus Use Efficiency and Microbial Count in Soybean on Inceptisol

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A field experiment was conducted to "study the effect of phosphorus levels with bioinoculants on phosphorus use efficiency and microbial count of soybean on Inceptisol" during *kharif* in 2018 at MPKV, Rahuri (MS). The experimental field soil is moderately alkaline in reaction with high $CaCO_3$ content and moderate in organic carbon content. The available N and P content was low and very high K content. Zinc was deficient while Fe was moderate, Manganese content was moderately high and very high content of Copper. The treatments consist three sources of bioinoculants [Phosphorus solubilising bacteria (PSB), Vesicular arbuscular mycorrhiza (VAM), PSB+VAM], four levels of phosphorus (0, 25, 50, 75 kg P_2O_5 ha^{-1}) through Single super phosphate (SSP) and one absolute control (without bioinoculants and phosphorus levels and fertilizer dose). Nitrogen and Potassium applied as per recommended dose of soybean i.e. 50:45 kg ha^{-1} respectively and application FYM 5 t ha^{-1} to all treatments except absolute control. The PSB and VAM population increased with days and maximum at 60 DAS, then decreased their population at 90 DAS of soybean as compared to 60 DAS. Application 50 kg P_2O_5 ha^{-1} and seed inoculation with PSB + VAM and their interaction recorded highest microbial population at 30, 60 and 90 DAS. The results showed that, the highest total N, P and K uptake were recorded in the treatment comprises seed inoculation of PSB and VAM with application of 75 kg ha^{-1} phosphorus. Interaction of phosphorus @ 75 kg ha^{-1} and inoculation of PSB + VAM recorded significantly highest total P uptake. The highest agronomic P use efficiency and apparent P recovery recorded in the interacted treatment with PSB + VAM and 25 kg P_2O_5 ha^{-1}.

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Conservation Agriculture Provides Greater Stimulation to Azotobacter and Phosphorus-Solubilizing Bacteria during Crop Growth upon Application of Pendimethalin Herbicide

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Assessment of soil microorganisms under different management practices helps in developing more productive and sustainable agricultural systems. The conservation agriculture (CA) systems are considered vital for soil health, biodiversity and environmental quality. But the increased and repetitive use of herbicides is inevitable in CA systems. The literature on consequence of herbicides on soil microorganisms is quite controversial, and largely based either on laboratory or short-term field experiments. Therefore, the present investigation was undertaken to assess the impact of pendimethalin on the population of Azotobacter and phosphorus-solubilizing bacteria (PSB) in an alluvial sandy loam soil (Typic Haplustept) under CA system for the last 13 years. The experiment involved three tillage practices: zero tillage with residue retention in both kharif and rabi seasons (ZT-ZT), conventional tillage in kharif and zero tillage with residue retention in rabi (CT-ZT) and conventional tillage in both the seasons (CT-CT), and two cropping systems: mungbean-wheat and sorghum-wheat. Pendimethalin (1.0 kg a.i. ha^{-1}) was applied immediately after sowing. Soil samples collected from different depths and times were assessed for the population of Azotobacter and PSB. In contrast to extensively tillage based conventional system, the CA maintained significantly higher population of Azotobacter and PSB at different soil depths. These microoganisms experienced maximum stimulation at 15 days of herbicide application under different tillage practices and cropping systems in 0-5 and 5-15 cm soil depths. Higher stimulation of Azotobacter (29.8%) as compared to PSB (13.5%) observed in surface 5 cm soil depth under CT-CT accentuated them for being efficient in utilizing molecules which are not adsorbed strongly to soil owing to low organic carbon content. The legume-based mungbean-wheat cropping system was found to promote the growth of these microorganisms better than the cereal-based sorghum-wheat cropping system.

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Evaluation of Native Strains of Raikia Bean Rhizobia under Laboratory and Field Condition in Odisha

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A micro pot experiment was carried out in 500g capacity pots with six treatments including two isolated strains of *Rhizobium*-RBHR-5 and RBHR-21 and soil application of lime @ 0.2 LR. The RBHR-21 strain superseded RBHR-15 significantly with respect to nodulation behaviour and root parameters both at 40 and 60 days after germination. The better photosynthetic activity of the crop in terms of chlorophyll content of the leaves was observed in the crop receiving RBHR-21 seed inoculation than the RBHR-15 strain. The efficiency of the strains improved by 33% when the acid soil was limed @ 0.2 LR. The field experiment to test the efficiency of the isolated strains was conducted in acid *Alfisols* of KVK farm of Kandhamal district under two fertilizer management practices, namely; farmers practice and soil test based recommended dose integrated with liming of soil either alone or together with boron application to soil. Seed inoculation with RBHR-21 strain increased pod yield by 20 percent compared to that with RBHR-15 strain. With adoption of soil test dose of fertilizers integrated with seed inoculation with RBHR-21 alone or associating liming of soil alone or lime and boron application together increased pod yield by 12, 9 and 8.8 per cent over the respective practices with RBHR-15 inoculation. Adoption of soil test based fertilizer application had the advantage of 23.6 per cent higher pod yield over farmer's practice. Liming practice of acid soil improved the pod yield by 17.4 to 20 per cent. Similarly, supplementing the soil with B could enhance the crop productivity by 8.2 to 8.8 per cent over no supplementation. Between two native strains of rhizobia the RBHR-21 was found to be better than RBHR-15. However, both the strains can successfully be used for bio-inoculation of Raikia bean crop.

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Organic Carbon Fractions Show How Rice Cultivation may Impact on Soil Carbon Pools in Baruipur District of West Bengal

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Soil organic carbon represents the primary reservoir of free energy for microorganisms and an equally important store house of nutrients for plantuptake from soil. However, instead of total SOC, certain fractions of SOC are more important in maintaining soil fertility and are, therefore, more sensitive indicators of the effects of management practices. The fractions of SOC may be dependent on their stability or turnover time in soil. In this work, the CENTURY model was used to study effect of cropping in soil system from the point of view of SOC fractions. Rice is the most widely consumed staple food in South Asia. West Bengal produces one of the largest shares of rice in the country. In this work, all the possible rice-centric cropping systems practicing in the experimental farm of University of Calcutta, Baruipur, South 24 Pgs were studied through estimating different SOC pools that varies in environmental stability. The microbial biomass C, water soluble C, carbohydrate C, humas C along with general physico-chemical properties were estimated from the rhizospheric soils of rice-rice, rice-wheat, rice- fallow system. The virgin grassland soils were treated as control. The result shows, the GL soils were possessed with higher amount of carbon as well as higher in all the fractions. The negative impact of rice cropping on carbon pools were also evident. Both the MBC and humus content showed RR system have significantly higher ($P<0.05$) fraction than RF system. Whereas, the RW system could occupy higher share of SOC than RR system in carbohydrate (0.36) and water soluble (0.94) pool. The change in soil pH was also indicative of the effect of rice cropping system. The result primarily represents the practice for rice cropping may enhance the stable SOC pools and precisely it shows RW system of cropping may be the sustainable practice environmentally.

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Effect of Inoculation of Heavy Metal Tolerant Endophytic Fungi on Seedling Growth of Wheat and Maize

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The soil contamination through various means of anthropogenic activities has been continuously increasing due to improper disposal and management of waste coupled with higher speed of generation. In long-run, the accumulation of heavy metals in soil poses a serious threat to soil health. The vegetation growing in waste dumping sites have potential to withstand various heavy metal concentrations due to plant adaptability under such soil. The association of certain microbial flora impart better tolerance to host plant towards heavy metals contaminated sites. The endophytic fungi isolated from the host plants naturally growing in such sites are potential source of promising microbes to be included in the rhizosphere mediated phyto-remediation strategies. In present study, endophytic fungi were isolated from the root of plants growing on waste dumping site of Bhanpur, Bhopal, Madhya Pradesh. The morphologically distinct fungi were screened for heavy metal tolerance in the presence of Pb, Cr, Cd, and Hg. The isolate with maximum tolerance were inoculated to maize and wheat for their effect on plant growth parameters such root, shoot length and dry matter yield. The root growth was enhanced by 8-16% and 7-118% for wheat and maize respectively whereas the shoot growth of increased by 5-20% and 14-28% for wheat and maize with inoculation of endophytic isolates. The result indicated potential of endophytic fungi phytoremediation of heavy metal contaminated soil. The future work should be directed to study precise mechanism of interaction between soil-fungi-plants under heavy metal contaminated medium.

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Role of Soil Physico-chemical and Microbial Parameters towards Suppressiveness against *Rhizoctonia solani*

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Fifty three soil samples were collected based on types of vegetation from various locations of West Bengal and relative suppressiveness of each soil was assessed against the widespread plant pathogen, *R. solani*. Physico-chemical parameters, microbial factors, textural class, moisture holding capacity (MHC) of each soil sample were determined. Effect of different temperatures in combination with soil moisture range on mycelia growth of the pathogen was also evaluated. All the soil samples were broadly categorised into sandy, sandy loam, sandy-clay loam Soil. Sandy clay loam and sandy loam soil promoted highest mycelia growth of *R. solani* at 30°C temperature in conjunction with 65% MHC (Moisture Holding Capacity) followed by 75%MHC. Whereas, in sandy soils (Red sand and white sand), highest mycelia growth observed at 85-100% MHC coupled with 30°C. On the basis of vegetation and crop history soils were classified into arable land soil, forest land soil, fallow land soil, orchard soil and coastal land soil. Of total soil samples assessed, some forest soil and fallow land soil showed strong relative fungistasis with mean inhibition of 37.17±7.16 and lowest fungistasis was exhibited by arable soil with mean average inhibition of 10.04±6.9. Rhizospheric soil of sunflower showed comparatively higher suppressiveness (~30%) than other crop rhizospheric soil followed by soils collected from rhizosphere of sorghum, turmeric and maize (≥20%). Pearson's correlation studies between SI (suppressive Index) and soil biotic factors indicated that among biotic factors, enzymatic activity; Microbial biomass carbon (MBC); population of Pseudomonads sp.; *Trichoderma* sp. and actinomycetes are the most important predictor of soil suppressiveness against *R. solani*.

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Nitrogen Availability in Cotton-wheat System under Conservation Agriculture

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The present study was carried out to study the vertical distribution of available nitrogen fraction at different crop growth stage in cotton (*Gossypium hirsutum* L.) under conservation agricultural based long term experiment (since 2010) during 2019-20. The treatment comprises of two distinct practices *i.e.* conventional tillage (CT) and zero tillage (ZT). Under ZT three crop establishment methods *i.e.* permanent narrow bed without (PNB) and with residue retention of previous crops (PNB+R); permanent broad bed without (PBB) and with residues (PBB+R); flatbed (FB) and FB with residues retention (FB+R). Soil samples were collected (0-15 and 15-30 cm) at pre-flowering, flowering, boll formation and harvest stages. Results revealed that, under CA practises the NH_4-N, NO_3-N and mineral-N fractions of nitrogen at different crop growth stages had more concentration in soil as compared to conventional tillage. Highest NH_4-N, NO_3-N and mineral-N were recorded at flowering and boll formation stage respectively. The effect of crop residue retention and crop establishment methods on available N fractions was prominent up to 15 cm soil depth. Crop residue retained plots recorded significantly higher N fraction compared to respective without residue and CT plots. Residue retained plots of FB, PBB, PNB recorded 50, 25 and 36% higher NO_3-N concentration as compared to respective without residues plots at pre-flowering stage. At flowering stage, maximum NH_4-N was recorded in PBB+R (17.9 mg kg^{-1}) and FB+R plots (17.5 mg kg^{-1}), which was approximately 68 and 16% higher over CT and PNB+R plots. The results revealed that zero tillage together with PBB+R could be a viable option over conventional practice for maintaining nitrogen availability to plants under cotton-wheat cropping system in semiarid climate.

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Soil Microbiological Properties during Wheat Growing Season Under Different Rice Residue Management Practices

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An experiment was conducted at research farm, CCSHAU, KVK, Panipat during the *rabi* season 2018-19 and 2019-20 to study the effect of rice residue management options on soil biological properties at different days during wheat growing season. The treatments applied to wheat consist of four rice residue management practices (R_1: Residue removal, R_2: Residue Burning, R_3: Residue Incorporation and R_4: Residue Retention or direct seeding of wheat with happy seeder into standing rice stubbles) in main plot and different doses of NPK fertilizers (F_1: Control, F_2:100% N + 50% Recommended dose of P&K, F_3:100% N + 75% RD of P&K, F_4: 100% N 75% RDF + Waste decomposer and F_5:100% Recommended dose of NPK fertilizer). The MBC and dehydrogenase activity in soil increased from 0 DAS and attains maximum values at 55 DAS and decreased thereafter for all the treatment during 2018-19 and 2019-20, respectively. Among the observation days activity of alkaline phosphatase and urease increase with increasing days after sowing and maximum values were reported at 55 DAS and decreased thereafter during 2018-19. While in 2019-20 trend was different and after 55 DAS activity decreased at 85 DAS but after that again increased at 115 DAS. Urease and alkaline phosphatase followed same trend however MBC and dehydrogenase followed the different trend during 2019-20. Burning of rice residue decreased the MBC, dehydrogenase and urease activity; however alkaline phosphatase activity increased after burning.

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Deciphering the Role of Microbial Autotrophy in Soil Carbon Fixation

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Ongoing global climate change caused by human induced increases in greenhouse gases represents one of the biggest scientific and political challenges of the 21st century. In this respect, assimilation of atmospheric CO_2 into soil is of utmost importance. Fate of terrestrial carbon (C) cycle depends upon the balance between the autotrophic C fixation and soil respiration which ultimately controls the net effect of climate change on ecosystem carbon budgets. Although, our knowledge of photosynthesis and its response to climate change is well advanced, yet there are considerable gaps in our perception of the potential of microbial autotrophic carbon assimilation in soil C cycle. With this backdrop the present study was under taken to decipher the role of microbial autotrophy in soil C sequestration. For this, soils from natural forest, horticulture and intensive agriculture systems of semi-arid to sub-humid central India, were studied. Undisturbed soil core was collected in triplicate from two depths *i.e.* the 0-15 cm and 15-30 cm soil layers. Simple and most efficient method of sonication is employed for the soil RuBisCO enzyme (ribulose-1,5-bisphosphate carboxylase/oxygenase) extraction, followed by spectrophotometric determination of the enzyme activity. Likewise, *cbbL* gene abundance in respective soil samples were studied by employing targeted metagenomic approach. Result revealed that horticulture system (mango and guava) maintained for long term had RuBisCO enzyme activity in the range of 1.94-2.04 nmol of CO_2 fixed g^{-1} soil min^{-1}) whereas natural forest system (Fig and Palash based system) showed RuBisCO enzyme activity in the range of 0.73-0.84 nmol of CO_2 fixed g^{-1} soil min^{-1} for 0-30 cm depth. Likewise, agriculture system represented by long term fertilizer experiment (LTFE), Raipur and soybean-based system under National Project on Organic Farming (NPOF) showed RuBisCO enzyme activity in the range of 1.04 -1.10 nmol of CO_2 fixed g^{-1} soil min^{-1} and 1.90-2.50 nmol of CO_2 fixed g^{-1} soil $min^{-1,}$ respectively, for 0-30 cm depth. Comparison among these land use systems reflected that agriculture system had more potential of autotrophic microbial assimilation of atmospheric CO_2 in soil carbon followed by horticulture system and forest system in semi-arid to sub-humid central India. However, *cbbL* gene abundance does not commensurate with the trend of RuBisCO enzyme activity. Highest *cbbL* gene abundance has been noticed in horticulture system followed by agriculture system and forest system. These preliminary data offer new insights into the importance of microbial autotrophy in terrestrial C cycling.

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Complementation of Biochemical and Physiological Assays with Functional PGPR Based Assays to Screen Potential Biofertilizer Strains

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The work deals with the biochemical characterization of rhizospheric isolates including IMViC based quantitative biochemical assay, PGPR properties like nitrogen assimilation (in microbes), phosphate solubilization etc. A special aspect of finding the correlation between the biochemical tests and PGPR properties were also studied. Methyl red test and tryptophanase assay (by indole test) were found to be positively and negatively correlated with phosphate solubilization. Vogues Proskeur and citrate utilization tests were negatively correlated with the phosphate solubilization. In future, these biochemical tests can be used as determining factors to identify phosphate solubilizing bacteria. Moreover, a unique group of bacteria was identified by the scatter plot analysis which shows low acid production with high phosphate solubilization.

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Continuous Application of Fertilizers Over 51 Years Alters the Diazotrophic Microbial Community in Rice-Rice Sub-humid Tropical System

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Nitrogen (N) is deprived in most of the world's soil which would directly hamper the sustainability of crop production. More than 50% exogenous applied N-fertilizer is lost in rice field causes negative impacts on soil environment thereby affecting its yield and N-use efficiency. Nitrogen-fixing microbes are one of the possible alternatives of chemical N; however, the structural and functional diversity of these microbes under continuous application of chemical fertilizers especially urea is still unknown particularly under rice-rice cropping systems in sub-humid tropical conditions. Therefore, the present study was an attempt to analyze the diazotrophic microbial community under influence of 51 years old long-term fertilizer experiment (LTFE) paddy soil through cultural, quantification of *nifH* gene through q-RT-PCR and *nifH*-targeted Illumina sequencing. Altogether 214 diazotrophic bacterial isolates were selected from LTFE soils by using selective media and screened for N-fixing ability through universal *nifH* primer. Out of 214, only 40 were found positive for the presence of *nifH* gene. A higher number of *nifH* gene-positive isolates was obtained from absolute control plots (without application of fertilizers) than the chemical fertilizer and organic amended treatments. Based on *nifH* sequences through NCBI, various diazotrophs such as *Sinorhizobium fredii, Ensifer sojae, Paenibacillus antibioticophila, Enterobacter sacchari, Aeromonas enteropelogenes, Thioflavicoccus mobilis, Enterobacter sacchari* were found to be abundant in LTFE. Moreover, *nifH*-targeted metegenome sequence revealed that continuous application of N-alone suppressed *Bradyrhizobium japonicum*, uncultured N-fixing bacteria and many other N-fixing bacteria, while application of FYM with or without NPK encouraged most of N-fixing bacteria. The q-RT-PCR-based quantification study also supports the findings of diazotrophic abundance in LTFE treatments. Overall, the present study concludes that diazotrophic microbial community was altered by continuous application of fertilizers under rice-rice system.

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Assessing Biological Soil Health under Conservation Agriculture-based Rice-Wheat Cropping System in an Inceptisol

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Rice-wheat is the most important cropping system in India covering 24 Mha of land and rice is the most staple food but declining factor productivity and sustainability of this system is the major challenge to all. In this context conservation agriculture (CA) is the one of the best options to sustain productivity by ensuring resource conservation as well as mitigation of adverse climatic impact. To assess biological soil health, soil samples were collected from six treatments viz. (Zero till direct seeded rice (ZTDSR) – zero till wheat (ZTW) (T1), ZTDSR+ wheat residue (WR) - ZTW+ rice residue (RR) (T2), ZTDSR + WR + sesbania brown manuring (SBM) –ZTW + RR (T3), ZTDSR –ZTW – zero till mungbean (ZTMB) (T4), ZTDSR + mungbean residue (MR) –ZTW + RR - ZTMB+ WR (T5), Transplanted rice (TPR)-conventional till wheat (CTW) – conventionally tilled mungbean (CTMB) (T6)) from 0-5 cm soil depth of 10 years old CA based experiment with rice-wheat system situated at ICAR-IARI fram, New Delhi. The soil samples were analysed for different fractions of labile soil organic carbon, soil enzyme activities, microbial population by using standard protocol and molecular based qPCR technique was used to quantify the abundances of different phylogenetic groups and nutrient cycling genes. Inclusion of mungbean residues in T5 and SBM in T3 improve nifH gene abundance over other double and triple ZT treatments. PCA analysis was done to screen out key indicators of biological soil health and â-glucosidase (PC1), *Bacterial amoA* (PC2), *Archaeal* 16S (PC3), *Bacteroidetes* 16S (PC4), *Bacterial* 16S (PC5), mineralizable C (PC6) were selected. The highest biological soil health index (BSHI) was found in ZTDSR + MR– ZTW + RR – ZTMB + WR treatment. Therefore, this practice may be recommended for CA based rice-wheat cropping system in Indo-Gangetic plain.

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Biological Health of Soil under Long-Term Fertilizer Experiments in India

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Long-term fertilizer experiments (LTFEs) in India were initiated in 1970 and have completed fifty years of field experimentation. These LTFEs comprised of imbalanced (control, 100% N, 100% NP) and balanced nutrient options (100% NPK, 150% NPK, 100% NPK+ FYM/ Zn/lime/green manuring) since inception in major soils and crops in different agroecological zones. Data on microbial count, microbial biomass and enzymatic activities clearly demonstrated that application of fertilizer in balanced manner improved count of various microbes *viz.*, bacteria, fungi, actinomycetes as well as microbial biomass and enzymatic activities. Soil organic matter acts as substrate for these organisms and it helps in maintaining microbial activities that led to enhance nutrient supplying capacity and overall soil fertility. Data indicated that imbalance use of nutrients (N alone) had adverse impact on microbial activities particularly in Alfisols. Similarly, ehydrogenase activity (DHA), microbial biomass carbon (MBC) and nitrogen (MBN) are key indicators revealing better biological condition of soil. Data indicated that balanced application of nutrients resulted increase in DHA, MBC and MBN but imbalanced nutrient management has declined these parameters due to less availability of organic matter. However, increase in microbial count with an application of FYM proportionately enhanced the microbial activities which in turn increased overall crop productivity. Thus, balanced use of fertilizer is key for maintaining soil health and sustaining crop productivity.

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Bioremediation of Iron (II) Toxicity in Few Indica Rice Cultivars of Assam: A Laboratory Study

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A greenhouse experiment with ten rice cultivars with four levels of iron (II) @ 0, 500, 1000 and 1500 mg Fe^{+2} L solution were studied to find out iron toxicity mitigation through use of two bacterial isolates *viz.*, PSB_{5w} and PSB_{25w}. Leaf accumulation of Fe^{2+} was profoundly related to leaf bronzing symptom (R square= .616). Differential mechanism of iron toxicity tolerance was observed in the test cultivars. Higher plaque (excluder mechanism) formation was found in *Joymoti* and *Mahsuri* while inclusion/avoidance mechanisms were prominent in *Moniram* (root accumulation) and *Podumoni*, *Prafulla* and *Bahadur* (stem accumulation). Both bacterial strains showed significant influence on agronomic and yield influencing parameters like N, P and K. Both the strain showed significant differences in Fe^{2+} distribution in the plant system. Both isolates were found to be phylogeneticaly related to Burkholderia, showing 96-100% similarity in their 16S-rDNA sequences. The isolates at species level were identified as *Burkholderia tropica*.

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Influence of Zinc Fertilization on Dynamics of Zinc Fractions in Soils and Their Contribution towards Zinc Availability in Soils and Uptake by Tomato-French bean-Cucumber System

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Field experiments were carried out in low (0.88 mg DTPA-extractable Zn kg^{-1}) and high Zn (3.25 mg DTPA-extractable Zn kg^{-1}) soils during 2019-2020 at ICAR-IIHR experimental farm, Bengaluru to study direct and residual effects of different levels of soil applied Zn on Zn fractions in soils and their contribution towards zinc availability in soils and uptake by Tomato (*Lycopersicon esculentum* Miller) - French bean (*Phaseolus vulgaris* L.) - Cucumber (*Cucumis sativus* L.) system in comparison with foliar application. Treatments were one time soil application of 5, 10, 15 and 20 kg Zn ha^{-1} through $ZnSO_4.7H_2O$ as basal dose for tomato; foliar application of 0.5% $ZnSO_4.7H_2O$ (two times for each crop at 45 and 60 days after planting/sowing) and control (no Zn application). Total Zn, DTPA-Zn and Zn fractions in soils were analyzed. Further fruit yield, dry biomass yield, Zn content in plant tissues and Zn uptake by crops were estimated. Correlation and path coefficient analysis were also carried out to assess the contribution of Zn fractions towards yield, Zn availability in soil and Zn uptake by crops. Soil application of Zn had enhanced DTPA-Zn and total Zn in soils. However, there was no significant yield improvement in high Zn soil. In low Zn soil, crop yields were significantly improved from 10 kg ha^{-1} Zn application onwards, but further improvement in yield was not recorded beyond 10 kg ha^{-1} Zn application. Soil application of Zn increased the Zn concentration and uptake by crops in both the soils. Foliar spray of Zn did not show significant change in yield and Zn uptake. Among the Zn fractions, sorbed Zn, Zn associated with reducible-Mn and organic matter bound Zn influenced Zn availability and uptake and crop yield.

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Variation of Soil Nutrients in Oil Palm (*Elaeis guineensis* Jacq.) Plantations in Andhra Pradesh and Telangana States

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Oil palm (*Elaeis guineensis Jacq.*), the highest vegetable oil yielding crop (4-6 t ha^{-1}) in the world, is commercially cultivated to an extent of 3.7 lack hectares in India. Oil palm is a heavy feeder of nutrients. The growth and productivity of oil palm mainly depends on the soil type, climate and nutrient management. Soil fertility in oil palm plantations of different soil types remain poorly documented. The present study was carried out to observe various macro and micro nutrient levels in different soil types such as inceptisol, vertisol, alfisol in Andhra Pradesh and Telangana states. A total of 171 soil samples were collected from the study area and analyzed for various physico-chemical properties using standard protocols. Soil organic carbon (O.C), available phosphorus, potassium, exchangeable calcium, magnesium and DTPA extractable micronutrients (Zn, Mn, Cu, Fe) showed wide variability. Result of the study indicated that the average values of O.C, available P, K, exchangeable Ca, Mg, DTPA extractable Zn, Mn, Cu, Fe and yield were 1.0%, 84.2 kg ha^{-1}, 335.2 kg ha^{-1}, 8.4 meq /100 g, 2.82 meq/100 g, 1.34 mg kg^{-1}, 4.95 mg kg^{-1}, 0.80 mg kg^{-1}, 5.98 mg kg^{-1} and 27 t ha^{-1}, respectively in Andhra Pradesh, whereas it was 1.56%, 83.7 kg ha^{-1}, 331.8 kg ha^{-1}, 11.64 meq/100g, 1.99 meq/ 100g, 0.99 mg kg^{-1}, 7.47 mg kg^{-1}, 0.58 mg kg^{-1}, 12.67 mg kg^{-1} and 32 t ha^{-1}, respectively in soils of Telangana.

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Soil Quality Assessment of Rural and Peri-Urban Areas of Southern Transact of Bengaluru (Principal Component Analysis)

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Environmental degradation is caused by urbanization in developing countries and affects human health. Due to urbanization of the Bengaluru city, the soil and water quality are degrading year by year in the surrounding areas. An experiment was conducted with an objective to evaluate the soil quality of rural and peri-urban areas of southern transect of Bengaluru. The results indicated that soil pH ranges from 5.10 to 8.56 in rural and 4.23 to 8.50 in peri-urban. Among the different regions of southern transect of Bengaluru, soils of rural area recorded significantly higher available nitrogen (323.01 kg ha^{-1}), phosphorus (28.98 kg ha^{-1}), potassium (246.16 kg ha^{-1}), exchangeable Ca [9.67 cmol(p^+)kg^{-1} soil], Mg [7.22 cmol (p^+)kg^{-1} soil], available sulphur (19.32 kg ha^{-1}), Zn (0.73 ppm), B (0.84 ppm) and DHA activity (14.59 µg TPF g^{-1} soil 24 h^{-1}) compared peri-urban. Soils from peri-urban areas were recorded higher Cd (0.041ppm), Cr (0.049 ppm), Pb (0.033 ppm) and Ni (0.043 ppm). To evaluate soil quality index of rural and peri-urban areas principal component analysis approached was followed. Based on rotated factor loadings, the following indicators were used and they are organic carbon, soil pH, sulphur, phosphorus and clay. These selected indicators were converted into scores by linear scoring method and soil quality index was worked out. The rural soil quality index was 0.61 and peri-urban was 0.54. Conclusively, soil quality of southern transact of Bengaluru fall under medium category of soil quality index (0.50-0.75).

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Studies on the Effect of Different Sources and Levels of Boron on Growth, Yield and Quality of Tomato (*Solanum lycopersicum* L.)

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A field experiment was conducted during 2016-2017 in sandy loam soils at Nayanhalli village, Chintamani taluk, Chickaballapura district, Karnataka. The experiment was laid out in a Randomized Complete Block Design with ten treatments which were replicated thrice. Three sources of boron such as borax, boron metalosate and boric acid were used. Borax was applied as soil application, whereas boric acid and boron metalosate were supplied as foliar spray. The experimental results indicated that application of boron significantly influences the plant growth, yield and quality of tomato. There was significantly higher plant height (105.01 and 126.76 cm), number of branches per plant (7.50 and 8.57) and chlorophyll content (39.23 and 33.45) was recorded in treatment received recommended doses of NPK+ FYM + 1.1 kg B ha^{-1} through borax as soil application + 0.05% B through boron metalosate as foliar application at 60 and 90 days after transplanting of tomato. Significant increase in the yield parameters such as number of fruits per plant (40.33), ten fruit weight (865.67 g), fruit yield (3.12 kg $plant^{-1}$) and fruit yield (57.80 t ha^{-1}) was recorded highest in the treatment which received 1.1 kg B ha^{-1} through soil and foliar application of 0.05% boron metalosate along with recommended doses of NPK+FYM. Significant improvement in the quality parameters of tomato such as total soluble solids, titratibale acidity, lycopene and ascorbic acid content with addition of boron as soil and foliar application was recorded.

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Nutrient Use Efficiency and Greenhouse Gas Intensity in Integrated Nutrient Management System in Rice-wheat Sequence in North-Western Indo-Gangetic Plains

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Fertilizer application though increases crop production but there is a tradeoff with emission of greenhouse gases and nutrient use efficiency. This study investigated the effect of different combinations of chemical fertilizers alone and combined with farmyard manure (FYM) on grain yield, nutrient use efficiency, greenhouse gas intensity (GHGI) and C efficiency in rice (basmati)-wheat cropping sequence. Application of chemical fertilizer along with FYM improved nutrient use efficiency and consequently grain yield than recommended fertilizer application (100%NPK) in both rice and wheat crops. Rice and wheat grain yield was higher by 5.98% and 5.3% in 75%NPK+25%FYM than 100%NPK. However, fertilizer application at the rate 50%NPK+50%FYM did not affect grain yield in both rice and wheat. Agronomic efficiency of N, P and K in both the crops significantly improved when chemical fertilizers were added along with FYM. Highest nutrient use efficiency and apparent nutrient recovery were observed in 75%NPK+25%FYM. Application of FYM not only improved grain yield but, also reduced emission of greenhouse gases (GHGs) in both the crops. Emission of GHGs per unit grain production significantly reduced with FYM application, lowest being in 75%NPK+25%FYM. Consequently, application of FYM improved C efficiency in both rice and wheat crops. This study concluded that conjoint application of inorganic and organic amendments in the combination of 75%NPK+25%FYM should be encouraged for agricultural and environmental sustainability.

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Effect of Organic Sources of Plant Nutrients on Yield of Tomato (*Solanum lycopersicum* L.) *vis-a-vis* Status of Soil Fertility

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Sustainable crop production aims at providing healthy food along with promoting soil health. A pot experiment was carried out at the Department of Soil Science and Agricultural Chemistry of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi in the Gangetic alluvial clay loam (Inceptisol) soil during rabi season, 2019-2020 with tomato cv. Kashi Vishesh using farm yard manure (FYM) and rock phosphate enriched vermicompost (VC). The experiment comprised of eleven treatments *viz.* T_1 (control), T_2 (FYM @ 4.5 g kg^{-1} soil), T_3 (FYM @ 9.0 g kg^{-1} soil), T_4 (FYM @ 13.5 g kg^{-1} soil), T_5 (VC @ 4.5 g kg^{-1} soil), T_6 (VC @ 9.0 g kg^{-1} soil), T_7 (VC @ 13.5 g kg^{-1} soil), T_8 (50 per cent N and recommended dose of P & K through fertilizer + 50 per cent N through FYM), T_9 (50 per cent N and recommended dose of P & K through fertilizer + 50 per cent N through VC), T_{10} (50 per cent N and recommended dose of P & K through fertilizer + 25 per cent N through FYM + 25 per cent N through VC) and T_{11} (N, P & K from commercial fertilizer). Urea, diammonium phosphate and muriate of potash were used as commercial fertilizers. Experiment results showed highest tomato yield with T_5 which is 5.28 per cent higher over T_{11}. The per cent increment of N, P, K in organic and integrated nutrient treatments were 8.74-14, 22.7-24.2 and 13.9-16.8, respectively over T_{11}; while, Ca, Mg and S showed 63.71, 63.0 and 100 per cent increment over T_{11}, respectively. The study indicated that the application of FYM and rock phosphate enriched vermicompost resulted in higher tomato yield and found beneficial in improving soil fertility.

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Nitrogen Response in Sesame (*Sesamum indicum* L.) in Coarse-textured Soils

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A field study was carried out on a coarse-textured low nitrogen status soil of CCS HAU, Regional Research Station, Bawal (Haryana) at three different locations from 2015 to 2017 to study the effect of nitrogen fertilization in sesame in terms of yield, total N uptake and N build-up/depletion in soil and economics returns. The experimental soil was loamy sand in texture, alkaline in reaction (pH 8.31 to 8.42), EC (0.18 to 0.21 dS m^{-1}), low in organic carbon (1.9 to 2.0 g kg^{-1}), low in available N (111.00 to 112.90 kg ha^{-1}), medium in available P (10.54 to 11.48 kg ha^{-1}) and medium in available K_2O (169.0-170.2 kg ha^{-1}). The experiment was laid out in randomized block design with thrice replications. There were five graded levels of nitrogen application *viz.,* 0, 30, 37.5, 45 and 60 kg N ha^{-1}. The recommended dose of fertilizers for the crop was applied as per packages practices. Irrigation and plant protection measures were taken as per recommended practices. Crop was harvested at physiological maturity, threshed and plot wise yield was recorded. Seed, straw and soil samples were taken and analyzed for N concentration in seed and stalk and available N in the soil, respectively. The data were statistically analyzed and the economics of the N application was worked out. In coarse-textured low N status soil (mean Av. N 111.0 kg ha^{-1}), sesame seed yield increased significantly with application of N upto 45 kg N ha^{-1}. The increase in mean seed yield was 19.23, 24.52, 39.26 and 41.18 percent and in mean stalk yield was 19.59, 23.81, 30.62 and 34.64 percent due to application of 0, 30, 37.5, 45 and 60 kg N ha^{-1}, respectively over control. The mean N-uptake also increased with N application. The mean N-use efficiency varied from 43.10 to 52.38 percent being maximum (52.38%) with the application of 45 kg N ha^{-1}. The mean post-harvest available N status was 105.43, 107.51, 108.11, 109.15 and 110.23 kg ha^{-1} at 0, 30, 37.5, 45 and 60 N ha^{-1}, respectively. The mean economic data analysis revealed that benefit-cost ratio also increased with nitrogen application and was 0.93, 1.10, 1.15, 1.27 and 1.28 at 0,30, 37.5, 45 and 60 kg N ha^{-1}, respectively. The finding of this study serves to demonstrate that in coarse-textured low nitrogen status soil of Southern Haryana, application of 45 kg N ha^{-1} was found to be optimum for sesame in terms of crop yield, soil N fertility status and economics.

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Incubation Studies on Nutrient Release Pattern of NPK and Enzymatic Activities in Inceptisol of Andhra Pradesh

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Incubation experiment has been conducted with the initial bulk surface soil sample from experimental field to study the nutrient release pattern of soil available N, P, K and soil enzymatic activity (urease, alkaline phosphatase and dehydrogenase activity) under NPK alone, IPNS (NPK+FYM), FYM alone and absolute control. As compared to all other treatments, IPNS recorded relatively higher release of available N, P and K status. In case of NPK alone treatments, the available N showed an increase up to 90 DAI followed by a gradual decline up to 120 DAI. Whereas in case of IPNS treatments, the status has shown an increase up to 120 DAI. Both under NPK alone and IPNS, the available P showed an increase up to 90 DAI and thereafter it has declined gradually up to 120 DAI while soil available K showed a gradual increase up to 120 DAI. Irrespective of different stages of incubation, STCR-IPNS treatments recorded comparatively higher enzymatic activity (urease, alkaline phosphatase and dehydrogenase) than STCR-NPK alone. The findings derived from the incubation experiment brought forth the fact that the release pattern of N, P and K and enzymatic activities under NPK alone, IPNS, FYM alone and absolute control paved way for understanding the beneficial effects of IPNS on crop productivity, efficiency and economy in fertiliser application and soil fertility sustenance throughout the period of crop growth.

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Variation in Soil Physico-Chemical Properties under Different Agriculture Land Use Systems in Inceptisols of Boko Block of Kamrup (Rural), Assam

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The present study was conducted to assess the variation in basic soil physico-chemical properties under four dominant Agriculture Land Use Systems (ALUS) in the soil order Inceptisols of Boko Block of Kamrup (Rural) District of Assam. A total of twenty-four (24) geo-referenced soil samples at a depth of 0-15 cm were collected from across the blocks under each ALUS *viz.*, Rice-Rice, Rice-Fallow, Vegetable-Vegetable and Plantation crops. The observed soil physico-chemical properties differed significantly among the ALUS under study. The soil textural classification ranged from clayey soils to silty clay to silt loam. The clay content was found to be maximum in rice-fallow ALUS as compared to other ALUS under study. Majority of the soil properties viz., pH (4.9 to 5.2), soil organic carbon (0.9 to 1.2%), available nitrogen (175-236 kg ha^{-1}), cation exchange capacity (3.2-9.6 c-mol kg^{-1}) and silt content (31.1-85.6%) did not differ significantly among the ALUS. However, soil properties like available K_2O content (136.9-276.2 kg ha^{-1}), sand (1.8-15.1%), and clay (10.9-59.5%), was found to differ significantly between the ALUS. A significant negative correlation (r = -0.942**) has been observed in between silt and clay content among the ALUS. Based on the survey details, rice equivalent yield (kg ha^{-1}) was calculated and was found in the order Plantation (7425.0) > Rice-Rice (4325.0) **>** Rice-Fallow (3481.3) **>** Vegetable-Vegetable (2100.0). None of the measured parameters were found to be significantly correlated with the yield of crop under the studied ALUS. The study, therefore explores the possibility of soil physico-chemical variation owing to ALUS over long period of time. Based on the observed soil properties, variation in soil properties may occur in a specific region due to agriculture land use practices dominant in the region.

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Soil Test Crop Response Studies under Integrated Plant Nutrition System for Brinjal Oninceptisol of Andhra Pradesh

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Soil test crop response based Integrated plant nutrition system (STCR-IPNS) has got a predominant role in managing demand driven nutrient supply to crops for enhanced yield, FUE and profitability to farmers. With this scope ahead, present study has been undertaken with hybrid brinjal (*Solanum melongena* L.) a member of Solanaceae family, the most common vegetable cultivated in Andhra Pradesh, with a view to establish relationship between soil test values and crop response to applied fertilisers, to develop Soil Test Crop Response based fertiliser prescription equations (FPEs) under Integrated Plant Nutrition System (STCR-IPNS) by targeted yield model, to assess fertiliser input saving within IPNS to develop prediction equations for post-harvest soil test values (PHSTVs) and to validate the prediction equations for FPEs and PHSTVs.Results emanated from the investigation revealed that irrespective of fertility strips, there was a progressive increase in response with increase in the levels of fertiliser N, P_2O_5 and K_2O and FYM and the profound effect of different levels of fertiliser nutrients, FYM and initial soil fertility on fruit yield and uptake of N, P and K by hybrid brinjalhas been elucidated. Making use of the experimental data, the basic parameters *viz.,* NR, Cs, Cf and Cfym towards total uptake by hybrid brinjal and fertiliser prescription equations (FPEs) under NPK alone and IPNS were developed. Nomograms for a range of soil test values under NPK alone and under IPNS for the desired yield target of hybrid brinjal were formulated using the above FPEs. The FPEs were validated at farmers' holding and based on the findings of present investigation,it could be inferred that fruit yield of hybrid brinjal under STCR-IPNS based fertiliser dose for an yield target of 60 t ha^{-1} is found to be ideal in terms of yield (59.91 t ha^{-1}), response ratio (93.12 kg kg^{-1}), benefit cost ratio (3.94), nutrient uptake, quality parameters and sustained soil fertility on Visakahaptnam (Typic Haplustept) soil series of Andhra Pradesh. STCR-IPNS for 60 t ha^{-1} recorded 41.3, 13.3 and 30.7 per cent increased yield over blanket + FYM, blanket and farmer's practice.

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Seasonal Variability of Carbon Labile Pools under Long Term Conservation Agricultural Practices in Acid Alluvial Soils of Eastern Zone of India

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With growing importance of adopting conservation agriculture (CA) to combat sustainability issue and carbon sequestration, present study was conducted in a 9 year long term rice-wheat cropping system to evaluate the effect of tillage, residue and biofertilizers on sensitive pools of carbon *viz.,* total organic carbon (TOC), particulate organic carbon (POC), permanganate oxidizable carbon (AC), microbial biomass carbon (MBC) and hot water extractable carbon (HWEC). Soil samples were collected after the harvest of *kharif* and *rabi* crops from two depths (0-5 and 5-20 cm). The measured pools increased in concentration under conventional tillage (CT) than the zero tillage (ZT) in *kharif* rice where TOC content increased to the tune of 4% and 11% in 0-5 cm and 5-20 cm depths, respectively as compared to ZT, but opposite trend was observed in *rabi* wheat, where the levels of soil C pools were higher in ZT than CT. The impact of ZT on TOC, AC, HWSC and POC was highly synergistic under wheat crop in both depths and increased their level up to 10-20% than CT with more prominent interaction between tillage and residue. Although, except POC, the residue and biofertilizer when applied together under both tillage treatments resulted in increase of all other pools to the tune of 7-20% in both the season in comparison to the plots without residue and biofertilizer among all plots. The amount of pools found higher (35-45%) under 0-5 cm layer than 5-20 cm soil irrespective of tillage and crop. So, findings of the study concluded that adoption of CA practices improves carbon sequestration in the soil, but the degree of carbon accumulation varied from enhanced sequestration in ZT in *rabi* season and in CT during the *kharif* season.

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Influence of Crop Residue Retention and Phosphorus Fertilization on Root Growth Parameters and P Content in Wheat under Maize-Wheat Cropping System in an Inceptisol

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A study was conducted with maize-wheat cropping system to assess the impact of phosphorus fertilization and crop residue retention (CCR) on root growth parameters as well as P content of wheat at ICAR-IARI, New Delhi. For this study, samples were collected and analyzed during the year 2014-15 and 2015-16 using appropriate methods. Different CRR treatments employed in main-plot and in subplots different P fertilizer doses were used in twenty treatments combinations. Results indicated that mean root weight density at 40 and 75 days after sowing (DAS) was significantly increased with 50% crop residue retention (CRR). Similarly CRR significantly affected the root growth rate of wheat over control. Dry root weight density at 75 DAS was significantly improved by the treatment of 50% RDP + PSB & AM. Moreover, 150% RDP treatment showed significant highest root growth rate which was statistically similar to the treatment of 50% RDP + PSB & AM. At different growth stages, significant highest P content in wheat was recorded with combination of 50% CRR along with 50% RDP + PSB & AM treatment. Similar results were also recorded in case of grain P content by these treatments. Thus, combination of 50% RDP + PSB & AM with 50% CR retention was most effective in terms of improving root growth rate, root weight density, growth attributes and P content in wheat at different crop growth stages as well as in grain.

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Enhancement of Rice Yields by STCR Targeted Yield Approach of Mancherial District of Telangana

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Rice is the principal crop extensively cultivated in all the districts of Telangana State both in *Kharif* and *Rabi* seasons. Rice crop accounted for 26.62% of the total cropped area in Telangana during 2014-15 and rice production was increased by more than 20% on a year-on-year basis. Rice is the second largest crop cultivated in the Mancherial district after cotton crop. The average yield of the the district is low against the state average. Fertilizer is the one of the major input which directly affects the yields of the crop and cost of cultivation. Krishi Vigyan Kendra (KVK), Mancherial conducted onfarm trail in two years during *kharif* 2018-19 and 2019-20 in 5 different locations based on Soil test values with targeted yield equation. Substitution of soil test values and target yield in the prescribed equations gives the particular nutrient recommendation which need to be converted in to fertilizer quantity to be applied. The treatments include farmers practice, recommended dose of fertilizers (RDF-120-60-40 NPK kg ha^{-1}) and STCR based fertilizer recommendations with an yield target of 60 q ha^{-1}. The initial soil samples collected and analyzed the nutrient status in the soils are low in available N, high in P and medium in K. The dose of N, P and K fertilizers applied based on targeted yield equation as per initial soil test values. The results showed that, the high yield recorded in STCR (5960 kg ha^{-1}) followed by farmers practice (5200 kg ha^{-1}) and RDF (4845 kg ha^{-1}). The application of fertilizers based on STCR with targeted yield equation increases the yield up to 12% compare to farmers practice. Adaption of STCR based treatments reduced the use of fertilizer doses of Phosphotic fertilizers which saved the cost of inputs with high net returns and B: C ratio.

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Effects of Phosphorus and Zinc Application and their Interaction on Yield and Zinc Nutrition of Rice (*Oryza sativa*)

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A field experiment was conducted in an Inceptisol at Central Research Farm, Bidhan Chandra Krishi Viswavidyalaya, to study the effect of phosphorus (P) and zinc (Zn) application on dry matter yield, P and Zn availability in soil, their concentration and uptake in plant and Zn recovery efficiency of *kharif* rice. The treatments included four doses of each P (0, 40, 60 and 80 kg ha^{-1}) and Zn (0, 5 kg ha^{-1}, 5 kg ha^{-1} + one foliar spray, and 5 kg ha^{-1} + two foliar sprays). The application of P, as well as Zn, significantly increased the dry matter yield of rice. P application up to 80 kg ha^{-1} caused a significant increase in soil P availability, P:Zn ratio and P uptake by the crop with a simultaneous decrease in the availability of applied soil Zn, concentration and uptake of Zn by rice and Zn use efficiency. However, Zn application causes a significant increase in Zn availability in soil, Zn content and uptake by the crop. Phytic acid/Zn molar ratio in grain decreased to the tune of 24.04 and 34.34 % upon Zn application through soil + one foliar and soil + two foliar, respectively, over the control. Zn application further caused an increase in Zn-use efficiency by 1.5 and 2 folds upon soil + one foliar and soil + two foliar applications, respectively than only soil application. Zn application through soil + foliar over basal application could be a useful strategy for Zn enrichment in grain and reduction of phytate/Zn molar ratios, thus enhancing their bioavailability when higher doses of P were applied.

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Fertilizer Prescription for Capsicum (*Capsicum annuum*) based on Targeted Yield Model under Integrated Nutrient Management System in an Inceptisol

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Soil test crop response correlation studies under integrated plant nutrient system were carried out in New Alluvial soil (*Aeric Haplaquept*) during *boro* season (2020-21) with capsicum (*Capsicum annuum*) as a test crop to develop fertilizer prescription equations. A fertility gradient was created with exhaustive fodder crop maize by adopting inductive methodology by dividing experimental field into three equal strips and applying graded dose of fertilizer N, P_2O_5 and K_2O on the strips. In the pre-established fertility gradient field, the test crop experiment was conducted to study the response of capsicum (cv. Indra) to applied combinations of three levels of vermicompost (0, 2.5 and 5 t ha^{-1}) and four levels each of N (0, 80, 100 and 120 kg ha^{-1}), P_2O_5 (0, 60, 75 and 90 kg ha^{-1}) and K_2O (0, 60, 75 and 90 kg ha^{-1}) randomized in three fertility strips, each comprising 21 plots. It was computed that 0.55, 0.07 and 0.44 kg N, P and K, respectively, were required for producing 100 kg of capsicum. Contribution of fertilizer-source to the total NPK uptake in capsicum was far higher than that obtained from organic and soil available sources. Fertilizer prescription equations were generated with the help of basic data. A ready reckoner for fertilizer prescription was prepared on the basis of soil test values for achieving desired target yield.

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Assessment of Integrated Plant Nutrient Supply System (IPNS) in Aman Rice using Different Organic Sources of Plant Nutrients through OFT

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A field experiment was conducted as On Farm Trial (OFT) during *kharif* 2017-18 to 2019-20 at the different Farmers' Fields of Gangarampur Block by the Dakshin Dinajpur Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Majhian, Patiram, Dakshin Dinajpur, West Bengal to assess the integrated plant nutrient supply system (IPNS) in *kharif* rice involving different organic sources of plant nutrients. In OFTs the treatments were kept minimal to avoid multicollinearity effect which would also evoke better understanding of the study by the farming community. The experiment was laid out in a Randomised Block Design consisting of three treatments T_1 = application of NPK @ 55:32:27 kg ha^{-1} as farmers' practice (derived from the Farmer's Participatory survey), T_2 = application of soil test based 75% recommended dose of N through chemical fertilizer + 25% N through Azolla in rice fields and T_3 = application of plant nutrient through soil test based 75% recommended doses of chemical N + 20% recommended doses of N from Vermicompost + 5% recommended doses of N through Azolla in rice fields. Each treatment was replicated by using different farmer's field (having similar soil fertility status and also receiving similar fertiliser application pattern) be fitting the statistical design. The results of the experiment revealed that the Treatment T_3 i.e. application of plant nutrient through soil test based 75% recommended doses of chemical N + 20% recommended doses of N from Vermicompost + 5% recommended doses of N through Azolla in rice fields gave better fertility restoration in respect of increase in N (16.45%), P (48.0%) and K (16.79%) in soil. The highest value of growth attributes *viz* plant height, number of tiller per plant and dry matter accumulation as well as yield attributes *viz* number of panicles m^{-2} (397), 1000 grain weight (22.4 g) and grain yield (5.34 t ha^{-1}) and straw yield (5.87 t ha^{-1}) of *kharif* rice was also noticed the above mentioned treatment which was statistically significant compared to the other treatments.

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Organo Mineral Biochar and Phosphobacteria Application Enhances *Vigna mungo* L. Growth and Yield in Low pH Soils by Augmenting Phosphorous Availability and Utility

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Black gram (*Vigna mungo* L.) production in low pH alfisol is severely hindered by the low availability of soil phosphorous. In low pH soil applied phosphorous get fixed as iron and aluminium phosphate complex, which is insoluble and inaccessible to plant roots. Increasing the availability and utility of applied P is essential to augment black gram yield. Chelation of P using organics widely adopted practice to enhance P availability. Recently biochar is being used as a soil conditioner, which has a great surface area, pores, pore-volume, and multifunctional groups. So, we intended to utilize the multifaceted property of biochar for increasing P nutrition to the black gram. We prepared biochar organo mineral and organo mineral phosphorous fertilizer using maize stalk biochar and Farmyard manure with Rock phosphate and single super phosphate. An experimental trial was laid out during Rabi 2020 in a randomized block design replicated thrice to evaluate the effect of organo- mineral biochar phosphorous fertilizer and Bacillus megaterium var phosphaticum (PB-1) on phosphorous availability, utility, and yield of black gram (VBN8) under irrigated condition. The experimental soil is acidic with sandy loam texture and low in available bray phosphorous (18 kg ha^{-1}). The co-application of superphosphate enriched organo biochar @750 kg ha^{-1} and phosphobacteria 2 kg ha^{-1} recorded the greater soil available P (20.6 kg ha^{-1}) and uptake (16.1kg ha^{-1}) which was 21 and 25 percent higher than superphosphate alone application. The biomass phosphorous, microbial biomass carbon, Acid phosphatase and microbial load also showed a similar trend as that of soil available phosphorous. The same combination registered a maximum seed yield of 973 kg ha^{-1} and boosted the yield 19 percent over superphosphate and gave the highest return of 2.2 rupees per rupee investment.

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Enhancing Groundnut Productivity by Integrated Use of Lime, Organics, Inorganic Fertilizers, and Biofertilizers in Acidic Soil of Tripura

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A field experiment was carried out on acidic soil of Khowai district of Tripura during 2017 and 2018 to study the effect of application of various combinations of lime, farmyard manure (FYM), poultry manure (PM), and rhizobium with the recommended doses of NPK on groundnut (*Arachis hypogaea* L.) productivity. The experiment was conducted in a completely randomized block design with 13 treatments, each of which was replicated thrice. Results indicated that application of the recommended dose of NPK @ 20:60:40 kg ha^{-1} along with lime @ 1/5th Lime Requirement (LR), PM @ 5 t ha^{-1} and seed treatment with *Rhizobium* @ 20 g kg^{-1} of seed significantly increased the seed yield, economic yield, and biological yield of groundnut compared to the recommended dose of NPK alone as well as other treatments combinations. Similarly, the Benefit : Cost ratio (B:C) of the treatment mentioned above was significantly higher than the recommended dose of NPK alone and other treatments combinations. Thus, the integrated use of a recommended dose of NPK @ 20:60:40 kg ha^{-1} in combination with lime @ 1/5th LR, PM @ 5 t ha^{-1}, and seed treatment with *Rhizobium* @ 20 g kg^{-1} of seed may be recommended to the farmers in achieving higher groundnut productivity with better return in acidic soils of Tripura.

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Growth and Yield of Rice (*Oryza sativa* L.) as Influenced by Boron Nutrition in Lateritic Soil of West Bengal

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Boron (B) is an essential micronutrient that plays a vital role in the growth and development of rice. A field experiment was carried out during 2020-21 to investigate the direct effect of different methods and time of boron application on the growth and yield of rice under lateritic soils of West Bengal. The experiment was laid out in a completely randomized block design with 16 treatments, each of which was replicated thrice. Boron was applied as soil (0, 1.5, and 2.0 kg ha^{-1}) and foliar (0.025%) at different growth stages, including transplanting, tillering, booting, and heading stages along with recommended doses of $N:P_2O_5:K_2O$ @ 100:50:50 kg ha^{-1}. The experimental soil was acidic, low in available P, moderate in available N and K_2O, and deficient in hot water soluble B. The pooled data revealed that soil application of B @ 1.0 kg ha^{-1} at 30 DAT + 1.0 kg ha^{-1} at 45 DAT along with the recommended dose of fertilizer produced significantly higher grain and straw yield compared to the control (recommended dose of NPK without B) as well as other treatments combinations. The lowest seed yield was recorded in control (recommended dose of NPK without B). Results also revealed that the split soil application of boron at different growth stages was superior to single soil application. In boron deficient soils, application of boron @ 1 kg ha^{-1} both at tillering and booting stage of rice may be recommended to the farmers for higher yield and return.

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Efficient Microorganisms Isolated from Tea Growing Soils Can Hydrolyze Phytate and Increase Phosphate Availability

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Tea (*Camellia sinensis*) cultivation covers a large portion of area in north-east India including districts of Assam, Tripura and West Bengal. Being a nutrient demanding crop tea requires huge amount of phosphate (P) fertilizers for proper growth of the leaves. However, due to acidic nature of tea growing soil (pH = 4.5-5.5), P fixation is a common phenomenon. On the other hand, a large portion of soil P can be present in the form of organic phosphorus. Out of that inositol-hexakisphosphate (or phytate) may be present up to 50% of the soil organic P pool. But due to its recalcitrant behavior, plants can't uptake phytate. Only a group of soil microorganisms can hydrolyze the phytate through their extra-cellular phytase enzyme and release phosphate for plant uptake. In this work, a total of 28 phytate hydrolyzing microorganisms were isolated from soils of tea gardens. After studying colonies, 13 microbes were selected for further screen process. On modified Pikovskaya's medium they formed halo-zone by hydrolyzing phytate. Depending on that solubilizing efficacy, 8 microbial strains were further studied in broth medium. The result showed, at end of the study all the microbes showed liberation of significantly higher ($F = 480.01$, $p<0.001$) P than non-inoculated broth. Based on that capability four (4) microbial strains were chosen for soil application. The available P dynamics of incubated soil showed there was significant difference ($F = 5.535$, $p<0.001$) among the microbes. Highest P value was obtained from the bacterial strain PpSM#25 (11.31 ± 0.43 mg kg^{-1}) followed by the fungal strain PpSM#4 (10.07 ± 1.82 mg kg^{-1}). The results of several screening process suggest these two microbes may have the potential to be applied in soils for higher P availability to plants for better growth and yields.

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Phosphorus Use Efficiency and Phosphorus Balance as Affected by Olsen-P Levels under Long-term Maize-Wheat Cropping Sequence

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Long-term phosphorus (P) fertilization in maize-wheat cropping system in northwest India have led to considerable build-up of Olsen-P concentrations in many fields that exceed the P required for optimal crop growth. This study aimed at finding the impact of fertilizer P applications on crop yield, P uptake, P use efficiency and P balance (P input minus P output) from a long-term (10 years) study on maize-wheat sequence having contrastingly different Olsen-P levels. No response to both maize and wheat to P application rates beyond 13 kg ha^{-1} in 'high' P (HP) (22.5- 50.0 kg ha^{-1}) soils and 26 kg ha^{-1} in 'medium' P (MP) (12.5-22.5 kg ha^{-1}) and 'low' P (LP) (<12.5 kg ha^{-1}) soils. P fertilization, significantly enhanced average maize P uptake by 8% and 26% and wheat P uptake by 5% and 18% in HP soils relative to MP and LP soils. For producing 1000 kg of grain in HP, MP and LP soils, crops needed 5.40, 5.48 and 5.64 kg P ha^{-1} for maize and 6.42, 6.56 and 6.72 kg P ha^{-1} for wheat. Improved agronomic and recovery P efficiencies were obtained in HP soils by reducing fertilizer P to 50% of the recommended fertilizer P (26 kg P ha^{-1}). Without P application, the average Olsen-P declined at the rate of 3.43 kg P $ha^{-1}year^{-1}$ in HP soils leading to highest negative P surplus in these soils. P fertilization rates of 26 kg P ha^{-1} or above caused soil P build-up in loamy sand soils irrespective of Olsen-P status, thereby increases soil P surplus ranging from 13.4 to 67 kg P ha^{-1}. Therefore, for attaining optimum yields and P use efficiency under intensively cultivated maize-wheat cropping sequence, long-term P balance, P availability in different Olsen-P soils should be undertaken while formulating P recommendations.

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Kharif Rice as Affected by Integrated Nutrient Management under Rice-Urdbean-Rice Cropping Sequence in Lateritic Soil of West Bengal

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Field experiments conducted to evaluate the effect of integrated nutrient management (INM) on kharif rice under rice-urdbean-rice cropping sequence during 2015 and 2016 at the Research Farm of Institute of Agriculture, Visva-Bharati, India**.** The experiment was laid out in a randomized block design with three replications and fifteen INM treatments in Lateritic soil of West Bengal. Results revealed that INM has a significant influence on yield, uptake and soil quality under rice-urdbean-rice cropping sequence. Application of 2.2 kg B ha^{-1}, 4.2 kg Zn ha^{-1}, 0.26 kg Mo ha^{-1}, 20 kg S ha^{-1}, RDF along with 2.5 t Vermicompost ha^{-1} and 6 kg *Azospirillum* ha^{-1} (T_{13}) resulted highest grain yield (6.21 t ha^{-1}) of kharif rice followed 6.05 t ha^{-1} in T_{12} (NPKZnMoSVCAzoto) and T_{11}(NPKBZnMoSVC). The present study indicate that application of vermicompost and boifertilizers (*Azotobacter/ Azospirillum*) along with inorganic fertilizers (N, P, K, S, Zn, B, and Mo) in soils resulted higher rice yield, quality produce and improved soil quality under rice-urdbean-rice cropping sequence in lateritic soils.

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Estimation of Soil Organic Carbon Stock in Eastern Ghats of Karnataka, India. A Case Study

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A Detailed soil survey was undertaken to assess the soil resources in the selected villages of Eastern Ghats of Karnataka, India, since, very little information is available on the spatial variability of SOC stock at farm level in under diversified land use system. The Study was aimed to estimate Soil organic carbon stock at larger scale. It is useful in predicting the need based techniques in different land use system and having wide variation in landforms. Soil samples were collected at 250 m grid interval to a depth of 0-30cm (surface layer) in the study area. Interpolated values of SOC stock in the surface layer were obtained by kriging based on a spherical model; it ranged between 0.19 and 10.92 kg m^{-2}. Data showed that 27.5% (583.48 ha) area in SOC stock (3-4 kg m^{-2}) followed by 25.7% (546.56ha) area had 4-5 kg m^{-2}. Least SOC stock was observed in 51.86 ha representing 2.4% of the study area. A total of 88885.12 t SOC stocks was estimated on an area of 2123.35 ha surface soils representing all land physiography and land-use systems. The major contribution SOC stock (>40%) coming from plantation crops and scrub cum forest soils. Mapping and monitoring SOC stock variation in large scale (farm level) will helpful sustainable management of soils.

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Evaluation of Sardar Amin Granules and Bentonite Sulphur on the Productivity of Maize based Cropping System and Soil Health

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An efficient cropping system leads to improvement of soil fertility status and rhizosphere modification by different crops. This provides an opportunity to achieve higher productivity for water and nutrients. To analyze such possibilities, a field experiment was conducted to determine the effects of amin granule and bentonite sulphur application on the productivity of Maize based cropping system and on soil health. The experiment was carried out in split-plot design with three cropping systems as main plots *viz.* maize-wheat, maize-potato-onion, maize-potato-summer moong and eight treatments in subplot. Subplot treatments were T_1: Control; T_2: SAG @8 kg ha^{-1}; T_3: SAG @8 kg ha^{-1} + Bentonite Sulphur; T_4: 100% Recommended dose of fertilizers (RDF); T5: 75% RDF + SAG @8 kg ha^{-1}; T_6: 75% RDF + SAG @8 kg ha^{-1} + Bentonite Sulphur; T_7: 100% RDF +SAG @8 kg ha^{-1}; T_8:100% RDF + SAG @8 kg ha^{-1} + Bentonite Sulphur. Results showed that the application of amin granule and bentonite sulphur substantially affected the system yield and productivity. Significantly higher maize equivalent yield (14.9 tha^{-1}) was obtained under maize-potato-onion sequence followed by maize-potato-summer moong system (12.0 tha^{-1}). System productivity was also highest under maize-potato-onion system (43.5 kg ha^{-1} day^{-1}) followed by maize-potato-summer moong (33.2 kg $ha^{-1}day^{-1}$). No significant influence of different treatment combinations was observed on pH, EC & OC content of the soil. However, there was a significant increase in the content of soil N & P as compared to the content in the treatments where Amin granule and Bentonite sulphur were added alone or in combination.

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Effect of Nutrient Mobilizer on Soil Properties and Yield of Cabbage Crop under Inceptisol

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A field experiment was conducted during the year 2017-18 at AICRP on IWM, M.P.K.V., Rahuri, in RBD with three replications and eight treatments. The treatments comprised of T1: 100% RDF + 2.5 L ha^{-1} nutrient mobilizer, T2 : 100% RDF + 5 L ha^{-1} nutrient mobilizer, T3: 75% RDF + 2.5 L ha^{-1} nutrient mobilizer, T4: 75% RDF + 5 L ha^{-1} nutrient mobilizer, T5: 2.5 L ha^{-1} nutrient mobilizer, T6: 5 L ha^{-1} nutrient mobilizer, T7: 100% RDF and T8: Absolute control. Farm yard manure was applied @ 20 t ha^{-1} and nutrient mobilizer was given by fertigation 21 Days after transplanting except for treatment T8.The polar circumference of cabbage at 50 DAT and at harvest was found significantly increased in treatment 100 % RDF and 5 L ha^{-1} nutrient mobilizer and also for equatorial circumference. Plant spread of cabbage the same treatment was increased in 2145 cm^2 $plant^{-1}$ at 50 DAT and 2971 cm^2 $plant^{-1}$ harvest.The cabbage yield per plot and yield per hectare was significantly influenced by application RDF and nutrient mobilizer, and found significantly highest in the treatment 100% RDF + 5 L ha^{-1} nutrient mobilizer but it was at par with treatment (T1) 100% RDF + 2.5 lit ha^{-1} nutrient mobilizer. The available N, P and K status of soil at harvest were found to be significantly affected due to application of 100% RDF along with 5 L ha^{-1} nutrient mobilizer. Total uptake of nitrogen, phosphorus and potassium by cabbage crop was found significantly increased due to application of 100% RDF along with 5 L ha^{-1} nutrient mobilizer. Total uptake of micronutrients Fe, Zn, Mn and Cu found significantly increased due to application of 75% RDF + 2.5 L ha^{-1} nutrient mobilizer over the rest treatments.The soil nutrient movement of NPK was found significantly higher in the treatment 100% RDF + 5 L ha^{-1} nutrient mobilizer. The movement of P was less as compared to N and K. The nutrient balance in respect of N and P in all the treatments was positive while K was in negative balance in treatment 100% RDF + 2.5 L ha^{-1} nutrient mobilizer and 100% RDF + 5 L ha^{-1} nutrient mobilizer. The treatment 100 % RDF has showed highest nutrient balance of N, P and K.The highest fertilizer use efficiency 185.04 kg kg^{-1} was recorded in treatment 75% RDF + 5 L ha^{-1} nutrient mobilizer which was followed by treatment 100% RDF + 5 L ha^{-1} nutrient mobilizer.The highest nutrient use efficiency of N,P,K was recorded in treatment 100% RDF + 5 lit ha^{-1} nutrient mobilizer followed by treatment 100% RDF + 2.5 lit ha^{-1} nutrient mobilizer. It is concluded that, the application of RDF through fertigation in 12 splits with 2.5 litres or 5 litres per hectare nutrient mobilizer for cabbage crop has produced highest plant growth parameters, yield, fertilizer use efficiency, nutrient movement and maintained the soil health. The fertilizers applied to the crop as well as the initial nutrients get mobilized due to nutrient mobilizer thereby increasing the yield of the crop.

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Change in Productivity of Soybean-Wheat Cropping System by the Long-term Application of Fertilizer and Manure

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This experiment was commenced from 1972 to assess the effect of continuous fertilizer application on productivity of soybean-wheat cropping system in Vertisol. The optimal dose of fertilizer for soybean and wheat was 20:80:20 and 120:80:40 respectively. The experiment laid out in combination of optimal N, NP, NPK, NPK without S and NPK with FYM etc. The data on grain yield of crops revealed that increasing trend was recorded with the successive application of fertilizer over control and continuous cropping without supplementing with fertilizers invariably reduced the crop yield. The results indicated that continuous application of N alone caused a declining trend with time due to imbalanced use of nutrients. Further, the supplementation of P with N (100% NP) remarkably enhanced the yield while, application of K along with NP *i.e.* 100% NPK further increased the yield. These findings indicate that integrated use of optimal dose of fertilizer and organic manure was superior thus, the balanced use of fertilizer in combination with organic manure is necessary for sustaining productivity of crops. On the other hand, the deficiency of S with DAP addition manifested through yield reduction in comparison to SSP application.

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Rapid Prediction of Soil Available Sulphur using Visible Near-Infrared Reflectance Spectroscopy

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Rapid and accurate prediction of soil available S, an important secondary nutrient, is crucial for its site-specific management in a cultivated region. Although traditional chemical analysis of any nutrient is an accurate method, but often costly, time-consuming and destructive in nature. Recently visible near-infrared (VIS-NIR) reflectance spectroscopic technique has gained its popularity for rapid, non-destructive and cost-effective assessment of soil nutrients. Hence, a study has been conducted in an intensively cultivated region of Katol block of Nagpur district, Maharashtra, India in the years of 2018-20 for rapid prediction of soil available S using spectroscopic technique. Both spectroscopic and chemical analysis were carried out using 132 georeferenced surface soil samples (0-15 cm depth). The descriptive statistical analysis showed that the available S content varied from 1.09 to 47.88 mg kg^{-1}. Multivariate models namely partial least square regression (PLSR) and random forest (RF) were applied to develop spectral models for S prediction from spectral dataset. Several statistical diagnostics like coefficient of determination (R^2), root mean square error (RMSE), ratio of performance deviation (RPD) and ratio of performance to interquartile distance (RPIQ) were used to evaluate the performances of two models. The best prediction of S was achieved from nonlinear RF model (R^2 = 0.71, RMSE = 8.86, RPD =1.18, RPIQ = 1.69) as compared to linear PLSR model (R^2 = 0.53, RMSE = 9.04, RPD = 1.16, RPIQ = 1.66). Therefore, the result suggested to apply non-linear multivariate model (RF) for obtaining best predictability for S from spectroscopic technique.

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Fertilizer Prescription for Targeted Yield of Sesame (*Sesamum indicum* L.) as per Soil Test Crop Response Study

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Sesame (*Sesamum indicum* L.) is an important oil seed crop which is being cultivated in tropics and sub-tropics for past 3000 years is also called as "queen of oilseeds". But the productivity of sesame in India is low main;ly because of its cultivation in marginal and submarginal lands under poor management and input starved rainfed conditions. So, in order to get targeted yield of TKG-21 variety of sesame, soil test based crop response field study was undertaken during *kharif* 2017 to develop fertilizer prescription of macro nutrients in an Inceptisol. For this, quantitative estimations of basic parameters *viz.* nutrient requirement (NR), percentage contribution of nutrients from soil (C_S); from fertilizer (C_F); from farm yard manure (C_{FYM}) were done. The essential information obtained from soil and crop testing was used for development of fertilizer prescription equations for different nutrient management practices using organic (FYM) and inorganic chemical fertilizer alone or in combinations. The mean nutrient requirement for the production of 100 kg of sesame grain was 7.03, 1.61 and 3.82 kg of nitrogen (N), phosphorus (P) and potassium (K), respectively. The C_S, C_F and C_{FYM} values were 21.41, 53.27 and 7.77 for N; 42.85, 22.95 and 2.47 for P; 12.32, 60.23 and 5.66 for K, respectively. For Those parameters were used for preparation of ready reckoners of fertilizer prescription for range of soil test values of N, P and K to get targeted yield (±5 to ±10% of potential yield of variety) of 9 q ha^{-1} for sesame grain using FYM and inorganic chemical fertilizer alone or in combinations. The amount of applied fertilizer could be reduced by a significant amount if FYM is used in integration with chemical fertilizer.

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Soil Physico-chemical Properties under Different Traditional Agroforestry Systems in Chhattisgarh Plain Agro-climatic Region, Madhya Pradesh

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Chhattisgarh Plain agro-climatic region covers whole Balaghat district (9,229 sq.km.) of Madhya Pradesh. Region has red and yellow (medium) soil and received 1200 to 1600 mm annual rainfall. In respect to the total geographic area of region, 53.44% covered by forest area. Farming communities of the area kept some multipurpose tree species on the bunds of their farm. The study was carried out in 2019-20 to know the soil physico-chemical properties (0-30 cm depth) under different traditional agroforestry systems identified from the region. Agri-silviculture, silvo-pasture, agri-silvi-pasture, agri-horticulture, agri-horti-silviculture, agri-silvi-horticulture and homegarden traditional agroforestry systems were identified from the region. Soil pH was slightly lower (5.5-6.5) in all agroforestry systems as compared to the control (sole cropping system). Electrical conductivity (0.32 to 0.38) and bulk density (1.33 to 1.37) were lower down in agroforestry systems compared to control. Organic carbon was higher under silo-pasture (1.79%) as compared to control and other agroforestry systems also. Available NPK values under different agroforestry systems were higher as compared to control. Soil health/quality was improved under different traditional agroforestry systems with comparison to the control. Thus silvo-pasture system superior over other agroforestry systems.

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Impact of Conjoint Application of Inorganic Fertilizers and Organic Manure on Rice Productivity in a Vertisols

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Rice (*Oriza sativa*) is one of most important kharif cereal crop of the Balaghat district of Madhya Pradesh. The availability of nutrients in the soil for plant utilization is known to be affected not only by the inherent soil characteristics but also by the fertilizer use and management practices followed for crop production. Therefore, a study on the response of integrated application of inorganic fertilizers and organic manure (vermicompost) on rice productivity at farmer field was performed at Balaghat district of Madhya Pradesh. In between the technology intervention human recourse development components were also included to excel the farmers understanding and skill about the demonstrated technology on nutrient management aspects. The front line demonstration conducted at different farmer's field of village's viz. Koppe, Chiloud and Lendejhari on rice (variety JRB-1) during kharif season 2019-20 under Indian Council of Agricultural Research funded Project on Farmer FIRST at College of Agriculture, Balaghat (M.P.). The based on the basic soil properties of farmer's field, the present experiment included four treatments *viz.*, T_1 - 100% NPK + 2 t Vermicompost ha^{-1}, T_2 - 100% NPK, T_3 - 100% NPK (– S) and T_4 – Farmer's practice. The result indicated that the treatment T_1- 100% NPK+ Vermicompost produced the highest average yield of rice. The lowest yield was recorded in T_4-Farmer's practice. The highest increase in yield (47%) was observed with 100% NPK + Vermicompost over Farmer's practice.

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Effect of In-situ Residue Recycling under Cotton based Intercropping Systems on Carbon Pools and Productivity of Cotton in Vertisol

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In view of enhancing soil health and productivity of cotton based intercropping system, the present investigation with long-term objectives was carried out at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during year 2017-18 to 2020-21 in split plot design with three replications to assess the carbon dynamics in Vertisol, by adopting integrated nutrient management with 75% RDF + compensation through NPS compost and organic with 100 % NPK dose through NPS compost in main plot and different cotton based intercropping systems *viz.* cotton + dhaincha (1:1), cotton + sunhump (1:1), cotton + greengram (1:1), cotton + blackgram (1:1) and sole cotton in sub plot. Results of the present investigation indicated that integrated use of chemical fertilizers along with nitrophosphosulpho compost (75% RDF + NPS) improved the soil physical, chemical and biological properties. Built up of the total organic carbon, soil carbon pools and carbon pool indices viz. Lability of SOC, Lability Index, Carbon Pool Index and Carbon Management Index was recorded with the adoption of INM (75% RDF + NPS compost) and Organic (100% NPK - NPS compost) with intercropping of cotton + dhaincha (1:1) which was at par with cotton + sunhump (1:1) followed by cotton + greengram (1:1) and cotton + blackgram (1:1) as compared with sole cotton. The magnitude of various carbon pools in respect of the treatments were in order as non labile > very labile > less labile > labile, indicating dominance of non labile portion of carbon pools in Vertisols. Percent contribution of active pools recorded more under cotton + dhaincha (1:1), followed by cotton + sunhump, grain legume intercropping systems as compared with sole cotton. Adoption of integrated nutrient management system involving 75% RDF + NPS compost and 100 % RDF through NPS compost along with green manuring of dhaincha, sunhump, green gram and black gram found useful for enhancing seed cotton yield and cotton stalk yield.

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Evaluating the Sulphur Use Efficiency in Small Onion (*Allium cepa* var. *aggregatum*) using the Radio-tracer Technique

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A radiotracer experiment was conducted using ^{35}S to evaluate the Sulphur use efficiency in small onion grown in sulphur deficient (available sulphur:7 mgkg^{-1}) and sufficient soils (available sulphur:20 mg kg^{-1}) with the sources ammonium sulphate and SSP at 20 and 40 kg S ha^{-1}. In sulphur deficient soil, % Sdff was significantly higher in AS @ 40 kg S ha^{-1} + RDF ± VAM which was on par with SSP @ 40 kg S ha^{-1} + RDF ± VAM both in bulbs and leaves. Whereas, % Sdfs was significantly higher in SSP @ 20 kg S ha^{-1} + RDF ± VAM which was at par with AS @ 20 kg S ha^{-1} + RDF ± VAM both in bulbs and leaves. In sulphur sufficient soil, the application of AS and SSP both at 40 and 20 kg S ha^{-1} + RDF ± VAM recorded a non-significant increase with % Sdff and %Sdfs both in bulbs and leaves. Among the two soils, relatively higher % Sdff was observed in the sulphur deficient soil and relatively higher % Sdfs was observed in the sulphur sufficient soil both in bulbs and leaves irrespective of the sources and levels of sulphur. With regards to SUE% in bulbs, in both the soils, the values were significantly higher in AS @ 20 kg S ha^{-1} + RDF ± VAM (sulphur deficient soil:+VAM:26.34%;-VAM:26.16%; sulphur sufficient soil: + VAM:18.27%; -VAM:17.64%) followed by SSP @ 20 kg S ha^{-1} ± VAM and relatively higher SUE% was observed in the sulphur deficient soil both in bulbs and leaves irrespective of the sources and levels of sulphur. Thus, for sulphur deficient soils, AS or SSP @ 40 kg S ha^{-1} + RDF and for sulphur sufficient soils, AS or SSP @ 20 kg S ha^{-1} + RDF could be the best sulphur recommendation.

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Effect of Sulphur and Boron Application on Yield of Lentil (*Lens culinaris* M.) and Status of Soil Fertility in Alfisol of Vindhyan Region, Uttar Pradesh

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Sulphur and boron deficiency is a widespread problem in acidic soil for field crop production where large losses of yield occur. A pot experiment was conducted consecutively in the year 2018-19 and 2019-20 in alfisol of Vindhyan region, the eastern part of Uttar Pradesh with crop lentil cv HUL-57 to evaluate the effect of levels of sulphur (S) and boron (B) application. The treatments comprised of four levels of S (0, 15, 30 and 45 kg ha^{-1}) and four levels of B (0, 1, 2 and 3 kg ha^{-1}) with a recommended dose of N, P and K fertilizers. Gypsum, borax, urea, diammonium phosphate and muriate of potash were used as fertilizers. The pooled data of experiment results showed that application of S and B, either alone or in combination, increased significantly the yield of lentil and soil fertility status over the application of a recommended dose of NPK alone. When sulphur and boron were applied alone, S resulted in a high yield (1.97 g $plant^{-1}$) at the application of 45 kg ha^{-1} sulphur, while boron produced maximum yield (1.37 g $plant^{-1}$) at the application of 2 kg ha^{-1} boron. Interestingly, the yield improvement was recorded with combined application of S @ 45 kg ha^{-1} and B @ 2 kg ha^{-1} along with RDF (2.29 g $plant^{-1}$) over RDF (1.23 g $plant^{-1}$), which shows S and B synergistic effect on lentil performance. Similarly, nitrogen, phosphorus and potassium increased 5.93, 29.32 and 1.42 per cent over RDF. An increasing level of sulphur gave a better result but a higher dose of boron may show some antagonistic effect in the yield of lentil and available nutrients of post-harvest soil.

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Soil Organic Carbon Fractions under Integrated Management Systems in a Wetland Paddy Soil (Ultisol)

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Labile soil organic carbon fractions are important indicators of soil C dynamics, which is affected by different management practices. However, few studies have reported the short-term effect of a wide range of organic materials on the distribution of soil total organic C (TOC) and its labile C pools. Hence, a field experiment was undertaken to quantify these in a rice –rice cropping system receiving four organic amendments (farm yard manure, jack tree (*Artocarpus* sp.) leaves, daincha (*Sesbania aculeata*) and rice husk biochar). All the organic sources were applied along with fertilizer nitrogen, urea at four levels *viz.*, 0, 35, 70 and 105 kg ha^{-1}. Soil samples were taken from 0-15 cm and 15-30 cm soil depths and analysed for soil total organic carbon (TOC), microbial biomass C (MBC), coarse and fine particulate organic C (cPOC and fPOC) and light and heavy fraction organic carbon (LFOC and HFOC). Carbon stock was also calculated. Results showed that rice husk biochar had the most profound effect on soil TOC and labile organic C fractions. The RHB without NPK resulted in the highest level of TOC (3.76 %) and carbon stock (46.14 Mg ha^{-1}). Among the carbon pools, the cPOC and LFOC concentrations in the RHB treated soil were 5 times and 6 times higher in comparison to control at the 0-15 cm depth. The effect on fPOC and HFOC to different treatments is less pronounced in both depths. The soil MBC content was almost in the stable range of 450 to 455 mg kg^{-1} with RHB and produced an average rice grain yield (3.8 t ha^{-1}). Overall, the integrated use of RHB and NPK fertilizers is the most efficient management practice in improving carbon sequestration. A long-term assessment is needed to confirm the most effective and sustainable management practice for improving soil quality.

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Effect of Precision Nitrogen Management Strategies on Soil Properties and Crop Productivity in Maize-wheat System under Permanent Raised Bed Planting

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Unsound management practices of the past have led to the twin challenges of depletion of resources and deceleration of productivity of cereal crops. However, maize based systems are recommended as an alternate to rice-based systems to address the issues of degradation of natural resources in north-western India. A 2-year (2013-2015) field experiment was conducted to evaluate the effects of residue management (no residue-R and residue retained+R) in main plots and combinations of two rates (90 kg N ha^{-1}- N_{90} and 120 kg Nha^{-1}, N_{120}) and three methods of N fertilizer application (drilled on beds-DB, drilled in furrows-DF and uniformly broadcasted on beds and furrows-B) plus no N control (N_0) treatment in subplots on the soil properties and crop productivity in permanent raised bed (PB) maize-wheat (MW) system. Residue retained on surface significantly increased grain yields by 7.7% and 4.3% in maize and wheat compared to no residue, respectively. Results showed that similar maize and wheat yields can be achieved with 90 kg N ha^{-1} using deep placement on beds (DB) as compared to uniformly broadcast method (B) with 120 kg N ha^{-1} thereby saving 30 kg N ha^{-1}. The crop residues application significantly increased the soil organic carbon (SOC) under +R by 3.88% over the -R at the 0-7.5 cm soil depth after two years. Residue retained on surface significantly increased ammonical nitrogen and nitrate nitrogen by 6.25% and 7.64% in 0-7.5 cm soil depth at the end of the experiment compared to no residue, respectively. Significantly higher NH_4^+-N and NO_3-N was recorded at different soil depths under the N_{120}-DB as compared to control, N_{120}-B and N_{120}-DF. Residue retention on soil surface also significantly increased the soil P and K content by 5.31% and 8.87% as compared to -R in the 0-7.5 cm soil depth after two years, respectively.

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Polyhalites/Polysulphates: A Best Soil Ameliorant for Cassava (*Manihot esculenta* Crantz) in the Ultisols of Kerala

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Among the tropical tuber crops, cassava is important due to its higher biological efficiency, larger area under cultivation both for edible and industrial uses, ability to withstand biotic and abiotic stresses, quality starch in the preparation of many value added products including ethanol and biodegradable plastics. In India, cassava is cultivated mainly in Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra and North Eastern States In Kerala, it is grown as an edible crop and more than 90% of the soils under cassava are acidic (Ultisols), deficient in nutrients like K, Ca, Mg and B. Polysulphate, a natural mineral product containing 18.5% S, 13.5% K2O, 5.5% MgO and 16.5% CaO was tried in the agro-ecological unit (AEU) 3 and AEU 9 for two seasons in five farmers' fields and one at on station since June 2018 to explore its possibility as a good soil amendment by studying its effect on tuber yield, tuber quality and soil physico-chemical properties. Polysulphate application can be done either as half lime and half dolomite as per lime requirement along with 1-2 t ha^{-1} polysulphate which gave a tuber yield of 53.33 t ha^{-1} on par with full dolomite along with polysulphate (50.32 t ha^{-1}) and polysulphate alone (49.24 t ha^{-1}). The yield increase with polysulphate application over PoP, and lime together with dolomite was to the tune of 17.10, and 15.55% respectively. Bulking of tubers in good form with better quality in terms of cooking, improvement of starch and lowering of bitterness was the best observation. Though there is no substantial improvement in soil pH, the exchangeable K, Ca, Mg and S showed an increase of 80.93, 91, 2.54 and 59.84% over initial compared to 17.84, 90, -11, -0.66% under PoP and 42.39, 82, 18.95 and -3.28% under lime along with dolomite respectively for these nutrients.

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Nutrient Dynamics and Rooting behavior under Rice-Wheat Cropping Sequence in Vertisol

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The experiment was conducted to assess the effect of long term manuring and fertilization on nitrogen and potassium dyanmics and rooting behaviour under rice-wheat cropping sequence in Vertisol during 2014-15 (*kharif* and *rabi*) at Raipur. The experiment comprises various fertilizers and manure treatments laid out in randomized block design with four replications. The results of the present experiment revealed that, the various N fractions viz: inorganic-N (NO_3-N and NH_4-N), Organic –N (hydrolysable NH_4-N, amino acid –N, amino sugar-N and hydrolysable unknown N) and total N were significantly influenced with the application of 100% NPK + FYM and 150% NPK. The total hydrolysable N (organic N) was contributed 70-74% to total N followed by non hydrolysable N (20-25%) and inorganic N (5 to 7%). All the K fractions were significantly improved with the combined application of 100% NPK + FYM and 150% NPK. The application of 50% NPK along with green manure also found beneficial in maintaining relatively higher amount of water soluble, exchangeable and non exchangeable K. The root length, root volume, root diameter and root surface area was increased with the application of 100% NPK + FYM. Continuous rice-wheat cropping without P and K fertilizers adversely affected root length, root volume, root diameter and root surface area as compared to 100% NPK and 100% NPK + FYM. The root CEC was increased with increasing levels of nitrogenous fertilizers along with P and K. The higher value of CEC, however noted under 100% NP in rice (20.49 meq 100^{-1} g DW) and wheat (18.96 meq 100^{-1} g DW). Thus it can be concluded that, combined use of organic and inorganic fertilizer found beneficial in improving nitrogen and potassium dynamics and rooting behavior with sustainable yield of rice and wheat in Vertisol.

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Preparation of Enriched Phosphocompost using Rock Phosphate and Various Crop Residues

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The enriched phosphocompost was prepared by using crop residues. The experiment was laid in RBD with six treatments replicated four times at Dr. PDKV, Akola. The results revealed that, the chemical properties of phosphorus enriched compost such as EC, total N, Nitrate-N, total P, citrate and water soluble P, total potassium and sulphur content significantly slightly increased as the decomposition progressed. The pH, total carbon, NH_4^+-N: NO_3^-–N ratio, CO_2 respirations and C: N ratio decreased with increase in decomposition of phosphorus enriched compost. Among the crop residues used for preparation of phosphorus enriched compost, mixed weed (MW) + 10% gliricidia leaves (GL) + 12% rock phosphate (RP) were found equally beneficial in improving the content of phosphorus enriched compost. The phosphorus enriched compost prepared from MW + 10% GL + 12% RP was found beneficial in increasing the total N, P, K, S, ammonical-N, Nitrate-N, citrate soluble P, water soluble P, Zn and Fe during decomposition of crop residues. The lowest C: N ratio was found in (T_6) MW + 10% GL + 12% RP. The compost prepared from shredded cotton stock (SCS) + 10% GL + 12% RP recorded the lowest NH_4^+-N: NO_3^-–N ratio (0.44) at the end 120 days of decomposition of enriched phosphocompost. While, the highest NH_4^+-N: NO_3^-–N ratio (0.59) was recorded with shredded pigeonpea stalk (SPS) + 10% GL + 12% RP. It can be concluded that, phosphorus enriched compost prepared from wheat straw, cotton stalk, soybean straw, paddy straw, pigeon pea stalk and mixed weed along with 10% gliricidia leaves, 12% rock phosphate, PDKV decomposer, PSB, urea solution and cow dung slurry was found beneficial to increase the concentration of total N, P, K, S, nitrate nitrogen, citrate soluble P, water soluble P and micronutrients (Zn, Fe, Mn and Cu).

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Effect of Different Trash Management Practices on Sugarcane Yield and Different Yield Parameters

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Sugarcane (*Saccharum officinarum*) is a widely grown commercial crop in the world and is cultivated in more than 105 countries. Traditionally, sugarcane residues are burnt after harvest. Usually, farmers burn sugarcane residues due to scarcity of labor to remove trash out of the field and lack of knowledge regarding the potential use of trash as a source of organic carbon and nutrients. Keeping all these points in mind a field experiment on trash management practices was carried out at Regional Research Station, CCS Haryana Agricultural University, Karnal, Haryana during 2019-20 and 2020-21 for consecutive two years. The experiment had eight treatments laid out in Randomized Block Design. The eight treatments were the T1 (Removal of Trash), T2 (Trash mulch in continuous rows), T3 (Trash mulch in alternate rows), T4 (Trash mulch in continuous rows + waste decomposer), T5 (Trash mulch in alternate rows + waste decomposer), T6 (Chopped trash mulch in continuous), T7 (Chopped trash mulch in alternate rows) and T8 (Trash burning). In both the years highest cane yield 98.75 and 94.59 t ha^{-1} respectively was recorded with T5 which was 18.60 and 18.71 % higher than the control (T1), respectively. Likewise, in both the years maximum cane length was recorded by T5 which was 2.71 m in the first year and 2.50 m in the second year. Highest cane weight (1.068 kg) was registered by T5 in the first year. However, in the second year, no significant difference between the cane weights was observed among different treatments. In the first year no significant difference was observed in the cane girth of different treatments. But in second year T1, T3 and T8 recorded same cane girth which was recorded to be 2.61cm. Cane girth observed by T2, T6 and T7 was at par. Lowest cane girth (2.47 cm) was recorded in treatments T5 and T4. It is evident from the results that application of trash in alternate rows enriched with waste decomposer positively affects yield and yield attributes.

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Influence of Foliar Application of Titanium Dioxide Nanoparticles in French Bean (*Phaseolus vulgaris* L.) on Nutrient Availabilities and Biological Activities in Rhizospheric Soil

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Nanotechnological intervention in agriculture is one of the modern tool for the improvement of productivity of land maintaining sustainability. The soil, which is a natural matrix, is the final environmental sink of all the nanoparticles used in crop cultivation. The present investigation has been carried out with the objectives to assess the impact of nano-titanium dioxide (TiO_2-NPs) polymorphs (*viz*. anatase and rutile) suspension spraying (0.00, 0.01. 0.02, 0.03, 0.04 and 0.05%) in French bean on plant nutrient availabilities (N, P, K and S) and biological activities (FDA and protease enzyme activity) in rhizospheric soil. The water suspensions of n-TiO_2 (both anatase and rutile) were sprayed during vegetative stage (30 days after sowing) and reproductive stage (60 days after sowing) of French bean with application of N, P and K fertilizers at the recommended doses. The availability of N and K at 60 days after sowing and the P and S at 45 days after sowing in the rhizospheric soil were enhanced by the falling droplets of TiO_2-NPs. The fluorescein diacetate hydrolytic activity (23.1-78.6%) and proteases enzyme activity (90.5-177.9%) in soil were positively influenced by TiO_2-NPs spraying droplets. Thus, foliar application of nano-titanium dioxide for crop production and quality improvement programme of French bean have no environment risk.

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Evaluation of Various Extractants in Assessing K Supplying Capacity in Northwest India

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Despite considerable removal of potassium (K) through plant uptake, response to applied K continues to lack even when soils test 'low' with respect to most commonly used 1M neutral ammonium acetate. In the light of this, major soil test K methods need to be evaluated comparatively. Accordingly, the field and pot experiments were conducted to evaluate the critical soil test potassium levels of different soil K extractants for potato. In the pot experiment, 30 bulk soil samples were used and K was applied @ 0 and 60 kg K_2O ha^{-1}, Data splitting models involving statistical Cate-Nelson (CN) model, and non-linear segmented linear-plateau (LP) and quadratic-plateau (QP) models were used to compute critical K levels by relating relative yield with soil test K (using five different methods: 1M Ammonium acetate (AAK), 1M Ammonium bicarbonate-0.005M Diethylenetriaminepentaacetic acid (AB-DTPA), Mehlich-3, sodium tetraphenylboron (STPB) and boiling 1M nitric acid). Based upon field validation (field experiment was carried out on four sites, using six K levels 0, 15, 30, 45, 60, and 90 kg K_2O ha^{-1}), the CN model was the best predictor for soil K tests (AA K = 65.5 mg kg^{-1}, AB-DTPA K = 80 mg kg^{-1} and HNO_3 K = 404 mg kg^{-1}) whereas LP and QP were best-fitted models for STPB K. Both Mehlich 3-K and AB-DTPA were highly correlated with potato yield (r = 0.78**, 0.75**) while AA K was poorly correlated with the yield (r = 0.15). STPB K showed strongest correlation with plant K uptake (r = 0.76**) followed by Mehlich 3-K (r = 0.72**), AB-DTPA K (0.64**) and HNO_3 (0.44*), respectively. The study revealed that 1M Ammonium acetate method is not a reliable index of K and Mehlich-3 or AB-DTPA methods can be considered as suitable substitutes.

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Long-term Effect of Fertilization and Manuring on Different Fractions of Calcium and Magnesium in Isothermic Kandic Paleustalfs of Eastern Dry Zone of Karnataka under Finger

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The long term field experiment has been in progress since 1986 at Zonal Agricultural Research Station, GKVK, Bengaluru located in Eastern Dry Zone of Karnataka with finger millet – hybrid maize cropping sequence. The experiment consists of eleven treatments with four replications in RCBD having individual plot size of 16 m x 9 m. The treatments include different levels of nutrients (control, 50% NPK, 100% NPK, 150% NPK, 100% N and 100% NP, 100% NPK with S free) in combination with FYM and lime application. The soil samples collected after 31 cropping cycles (2017) were studied for different fractions of calcium and magnesium and available nutrient status. The results revealed that, the different fractions of Ca and Mg were in the order of mineral > acid soluble > exchangeable > organic complexed form. All forms of Ca and Mg were significantly higher in the treatments receiving 100 % NPK + FYM + lime (T_{10}) and significantly lower in the treatments receiving imbalanced nutrients (100% NP and 100% N) and control plot. The correlation study revealed that pH, EC, OC, nitrogen content are the important parameters in influencing the status of Ca and Mg fractions. There was a positive correlation between grain yields (finger millet and maize) and fractions of Ca and Mg.

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Effect of Boron and Sulphur Application on Growth and Yield of Rice (*Oryza sativa* L.) in Lateritic Soil of West Bengal

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The present investigation was carried out in the experimental field of Palli siksha Bhavana, Visva-Bharati, West Bengal, during 2020-2021 to know the combined effect of different levels of sulphur (S) and boron (B) on yield and yield contributing characters of rice and to find out the suitable combination of sulphur (S) and boron (B) for yield maximization of rice. There were 16 treatment combinations comprising four levels each of S (S0= 0, S1=20, S2= 30 and S3= 40 kg S ha^{-1}) and B (B0= 0, B1= 1, B2= 1.5 and B3= 2 kg B ha^{-1}) as soil application along with RDF at the time of transplanting. The study indicated that plant growth and yield of rice were significantly influenced by boron and sulphur application. Results showed that the combination of S and B (30 kg S ha^{-1} and 2 kg B ha^{-1}) contributed positively for better performance of yield contributing characters of rice compared to single application of S and B. The lowest seed yield was found in control (S0B0) combination. Therefore, the combination of S and B (30 kg S ha^{-1} and 2 kg B ha^{-1}) might be suitable dose for cultivation of rice in lateritic soils of West Bengal.

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Optimisation of Fertigation Schedule for Brinjal

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Brinjal (*Solanum melongena* L.) is one of the most common vegetables grown throughout the country for its purple, green or white pendulous fruit. is a hardy crop and is cultivated under a wide range of soils. Fertigation is an agricultural technology that combines irrigation and fertilization. Fertigation technology uses a pressure system to combine soluble solid or liquid fertilizers with irrigation water, according to the soil nutrient content and the nutritional needs of the crop. Fertigation can be used to avoid problems such as volatilization losses, slow dissolution, and slow fertilizer activation that arise from applying fertilizer onto dryer surface soils. Field investigation was attempted during *Kharif* 2020 and *summer* 2021 to evaluate the effect of fertigation in brinjal at Agricultural College and Research Institute under ICAR-AICRP on IWM. The soil of the experimental site was low in available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in randomized block design with ten treatments. The experiment was conducted in sandy clay loam soil with pH of 7.5, EC 0.92 dSm^{-1} and soil is medium in available nitrogen (285 kg ha^{-1}) and high in available P (30 kg ha^{-1}) & K (319 kg ha^{-1}). Simran hybrid was used as test crop. The fertigation was given upto 20 weeks in 20 splits at a frequency of 7 days. The treatment comprises of combination of water soluble fertilizers with conventional fertilizers and application methods as detailed below. RDF for brinjal is 100:150: 100 kg NPK ha^{-1}. 100%RDF N, NPK, N and K through fertigation and 25% as basal, 75% of P & K as basal, 75% P as basal and 75% NPK through fertigation with no basal application. 25% NPK as basal and remaining through fertigation. Absolute control is maintained for comparison. The objective of the investigation is to optimize the fertigation schedule for brinjal. The results of the experiment showed 75% NPK applied through fertigation without any basal application recorded highest fruit yield of 50.15 t ha^{-1}, gross income of 7.52 lakhs ha^{-1} with a net income of 5.75 lakhs ha^{-1}. Benefit cost ratio was 4.25.

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Effect of Different Sources and Levels of Sulphur on Soil Available Nutrients and Yield of Jasmine in Madurai District of Tamil Nadu

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Sulphur deficiencies in Indian soils vary from 5 to 83% with an overall mean of 41%. The nutrient database generated clearly established that only 5 percent of the cultivable area of Madurai district has sufficient sulphur status. Due to this drastic decline in the availability of sulphur, there is a possibility for reduction in the productivity of jasmine flowers, its quality and concrete content. A field experiment was conducted to study the effect of different sources and levels of sulphur on jasmine growing soils of Thiruparangundram block of Madurai district of Tamilnadu during 2017-19 with the objective of enhancing the yield and quality of jasmine. The treatments comprised three levels of sulphur (20, 40 and 60 g sulphur/plant/year) from pressmud, gypsum and sulphate of potash, T_1 control (no fertilizer source) and T_2 farmers fertilizer practice (70 : 110 : 100 g of NPK / plant / year) . The recommended dose of fertilisers (RDF) for jasmine @ 60:120:120 g of N: P_2O_5: K_2O/plant/ year was applied as suphala, urea, single super phosphate and muriate of potash to the treatments T_3, T_4, T_5, T_6, T_7 and T_8.The soil samples were collected at current season, shoot initiation, bud forming, peak flowering and post flowering stages and analysed for soil available N,P,K and S. The highest available nitrogen was recorded in the treatment that received RDF along with gypsum @ 60 g sulphur/plant/year followed by treatment that received RDF along with pressmud @ 60 g sulphur/plant/year. The higher mean available sulphur status of 9.2 mg kg^{-1} and mean water soluble sulphur content of 7.9 mg kg^{-1} were recorded in the treatment that received gypsum as sulphur source @ 60 g sulphur/plant/year along with RDF (T_8) which also recorded the highest flower yield $plant^{-1}$ of 2406 g.

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Evaluating the Soil Quality Indicators in Various Yield Zones of Pulses in Tamil Nadu

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Developing region-specific soil quality indicators and proper nutrient management practices based on soil analysis are the key areas to be focused for improving the soil quality and thus the productivity in predominant pulse growing regions of Tamil Nadu. A systematic soil quality assessment survey was taken up in the major pulse growing regions of Virudhunagar district of TamilNadu during 2016-2018 which was classified into three categories *viz.*, low yielding (< 400 kg ha^{-1}), medium (400 to 700 kg ha^{-1}) and high yielding (>700 kg ha^{-1}) categoriesbased on past ten years yield data of pulses. About 50 surface samples (0-15 cm) for each zone @ 50 samples per block in two replications were collected from three blocks amounting to 300 samples representing the variability of soils. Principal components with eigen values $e^{-1}1$ and those that explain at least 5% of the variation in the data were examined by SPSS software The positive effects of soil quality was established through the yield data of the high yielding zone which ranged from 769 to 989 kg ha^{-1} with an average yield of 880 kg ha^{-1}. This may be attributed to more favourable soil physical environment of soil texture (sandy clay loam), higher mean percentage of water stable aggregates (51%) and a favourable pH of 7.52.These parameters coupled with lower bulk density (1.23 M gm^{-3}), optimum infiltration rate (1.76 cm hr^{-1}) and maximum mean organic carbon status (1.38 mg kg^{-1}) contributed to higher range of soil cation exchange capacity (28.7 to 47.2 cmol $p^{+}kg^{-1}$).Adoption ofTNAU recommended dose of fertilizers *viz.*,12.5:25:12.5:10 kg N,P_2O_5,K_2O and S per hectare or soil test based application of nutrients along with regular and integrated application of enriched farmyard manure at 750 kg ha^{-1},Azospirillum at 2 kg ha^{-1} and TNAU Pulse wonder at 5 kg ha^{-1} contributed towards better soil quality for obtaining higher yield in pulses.

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Nitrogen Release Pattern as Influenced by Natural Zeolite under Cotton Grown on Salt Affected Soils of Purna Valley

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Nutrient imbalance and reduced availability of nitrogen in sodic soil of Purna valley is a serious concern. Accordingly, reducing the heavy use of nitrogen fertilizer and improving in sodic soil of Purna valley. The present study was conducted at shed net house department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola. The experiment laid out in completely randomized design with eleven treatments consisting of 75% RDF (90:45:45 NPK kg ha^{-1}) and 100% RDF (120:60:60 kg ha^{-1}) for bt cotton in separate treatment combinations with FYM, gypsum and three zeolite levels with three replications. The results indicated that, the available nitrogen fraction in soil showed a steady state of release with various zeolite levels. The most significant impact on rate of change and steady mineralization of ammonical and nitrate nitrogen in soil were obtained with soil application 100% RDF + zeolite @ 450 kg ha^{-1} which was found at par with 100 % RDF + Zeolite @150 kg ha^{-1} and 75 % RDF + Zeolite @ 300 kg ha^{-1}. The application of various levels of zeolite were found significantly beneficial in availing the nitrogen in soil for uptake by cotton with improving the release of both nitrogen fractions (NH4-N and NO3-N) in soil and minimizing their leaching losses.

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Assessment of Impact of Nitrogen Sources on Productivity of Rice-Wheat Cropping System in Calcareous Soil

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Nutrient Expert (NE), a new freely accessible nutrient decision support system based on principles of site specific nutrient management (SSNM), offers solutions for providing field specific fertilizer recommendations to improve yield and economics of rice-wheat growing farmers in the region. During the season 2016-19, an experiment was conducted at Experimental Farm of RPCAU, Pusa in hybrid rice-wheat cropping system to evaluate the efficiency of N sources. Nine treatment combinations *viz.* T_1 – 100%N through prilled urea (PU), T_2 – 100% N through neem-coated urea (NCU), T_3 – basal N through ammonium sulphate and rest N top dressed with NCU, T_4 – basal N through Calcium Nitrate and rest N top dressed with NCU, T_5 – basal N through Di-ammonium phosphate and rest N top dressed with NCU, T_6 – 100% N through S- coated prilled urea, T_7 – 100% N through S-coated neem coated urea, T_8 – control (without N), T_9 – unfertilized (without NPK) were taken with three replications in randomized block design. The nutrient recommendation both in hybrid rice and wheat was made with the help of Nutrient Expert. The mean rice equivalent varied from (three years) grain yield of rice (Arize-6444) varied from 4.7 to 11.5 t ha^{-1} under unfertilized and S-coated prilled urea (S-PU) plot, respectively. The rice equivalent yield (REY) increased significantly in the entire treated plot with different N sources over control and N omitted plot but it was non-significant between prilled urea and neem-coated urea. Based on REY, if neem coated urea is used as a source of N then about 9 kg urea ha^{-1} could be saved. The changes in available N in post harvest soil were non-significant.

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Soil Health Card App: A Holistic Spatial Decision Support System Integrated Android Solution for Managing Soil Health Information System-based Crop Recommendation in India

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Development of an android based mobile GIS application on Soil Health Card generation and its report based crop suitability cum fertilized recommendation is a testimony towards inventorying land resources for the betterment of the farming community. GIS technique is precise, time efficient and cost effective to develop Soil Health Cards (SHCs) and fertilizer recommendations for large number of farmers. The information could also be stored and retrieved for monitoring soil health in future. It involves collection of soil samples one each in 10 and 2.5 hectare area for rainfed and irrigated, respectively, sample processing and laboratory analysis for macro and micro-nutrients. Development of database in GIS and generation of soil nutrient status map using area specific interpolation technique, is the subsequent step. The linking of cadastral/plot no. database with soil nutrient information and soil-site suitability assessment based crop cum fertilizer recommendation on the backdrop of google imagery is the novelty of this application. The App is capable of visualizing, disseminating and sharing of the soil health information in an auto generated card based format in a digital manner. It derives information from the Bhoomi Geoportal (http://nbsslup.in bhoomi). The app is programmed for automatic soil-site based crop suitability assessment and it also act as a spatial fertilizer calculator based on the crop choises. The Soil Health Card app has information on: Administrative layers (State Boundary, Panchayat Boundary, Cadastral boundary); soil nutrient status as well as absolute interpolated values, self operated crop choices options for the farmers based on scientific suitability as well as market demand. Moreover, the need based crop linked fertilizer requirement calculation including macro and micro nutrients along with FYM and bio-fertilizer dose is also present in an auto-generated mode inside the soil health card. This App will benefit the farmers of the country, state govt. planners and executors. This is capable of being the part of Digital India platform and an effort towards the Honorable Prime Minister's vision on Soil Health Card programme.

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Short-term Impact of Conservation Agriculture-based Sustainable Intensification (CASI) on Soil Organic Carbon Fractions and C-mineralization Kinetics in Entisol and Inceptisol

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Conservation agriculture-based sustainable intensification (CASI) provides more crop residue which is a source to increase soil organic carbon (SOC). However, depth-wise information on fate of different C fractions under CA at different soil types, is not sufficient. We assessed the performance of CASI on SOC dynamics from two short-term (4-year) field experiments (Entisol in Coochbehar and Inceptisol in Malda, West Bengal, India) in rice-wheat (RW) and rice-maize (RM) rotations under zero tillage (ZT). We found that SOC, hot water extractable C (HWEC), particulate organic C (POC), and mineral associated C (MAOC) were significantly ($p<0.05$) higher in RM than RW under ZT greater in Inceptisol than Entisol because of high residue biomass inputs and higher clay content in the former. The ZT had higher SOC and SOC fractions by 16.8 and 9.8 % over conventional tillage (CT) at 0-5 and 5-10 cm respectively; but reverse was the case at 10-20 cm because of residue incorporation in CT. Thus, Inceptisol containing more clay content could accumulate more C as compared to Entisol with sandy loam texture since there was a positive relationship between SOC and clay content. Further, we examined the relative decomposition of crop residues (rice and maize) when applied either on the surface (as in ZT) or incorporation (as in CT) in Entisol and Inceptisol in a laboratory experiment and the C loss from the residue followed the exponential decay: $C = C0 \times e\text{-}kt$. The rate of maximum potential mineralizable (C0k) residue C was maximum under CT but there were relatively similar amounts of C mineralized over time from both residues under ZT. In conclusion, residues when incorporated into the soil under puddled condition significantly enhances the C loss; but leaving on the surface reduces the same, which helps in achieving sustainability from an environmental perspective.

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Influence of Foliar Spray of NPK and Micronutrients on Yield and Quality of Sugarcane

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A field experiment was conducted for two consecutive years to find out the influence of foliar application of NPK and micronutrient on cane yield, yield parameters and quality of sugarcane in clay loam soils during 2019 and 2020. The present study was carried out at Research Farm of Regional Research Station, CCS Haryana Agricultural University, Karnal, Haryana. The experiment was laid out in randomized block design and consisted of eight treatments with three replications. The variety used was CoH 160. The treatments were: T1- RDF + Foliar spray of 0.5% $ZnSO_4$ + 1% $FeSO_4$+2.5% Urea; T2- RDF + Foliar spray of 0.5% $ZnSO_4$ +2.5% Urea; T3- RDF + Foliar spray of 1% $FeSO_4$+2.5 % Urea; T4- RDF+ 2.5% Urea; T5- RDF+ 2% NPK; T6- RDF + 2% NPK +Foliar spray of 0.5% $ZnSO_4$ + 1% $FeSO_4$; T7: Foliar spray of 0.5% $ZnSO_4$ + 1% $FeSO_4$+ lime 0.5%; T8- RDF alone. RDF for plant crop was 150-50-50 NPK kg ha^{-1}. Research revealed that all yield and yield parameters *i.e.*, cane length, cane weight and number of internodes were significantly affected with the foliar spray of NPK and micronutrient but non-significant effect was observed on cane girth. With respect to qualitative parameters *viz.,* Commercial Cane Sugar (CCS), Pol % and sugar yield, significant improvement was noticed with foliar spray of NPK and micronutrient. The highest cane yield was recorded with the fertigation of 2% NPK (19:19:19) + 0.5% $ZnSO_4$ +1% $FeSO_4$ (96.23 t ha^{-1}) followed by the foliar spray of 0.5% $ZnSO_4$ + 1% $FeSO_4$+ lime 0.5% which recorded 93.63 t ha^{-1} cane yield. The lowest cane yield was reported with the application of RDF alone (71.93 t ha^{-1}). The highest CCS (12.32%) and Pol % (17.36%) was reported by the treatment 2% NPK (19:19:19) + 0.5% $ZnSO_4$ + 1% $FeSO_4$. Thus, fertigation with NPK and micronutrient could significantly improve the yield and quality of sugarcane crop.

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Long Term Monitoring of Fertility Status of Soil in Sugarcane-Sugarcane Cropping System in Clay Loam Soils

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A long-term field experiment was planned in 2001 to monitor the changes in the fertility status of soil in sugarcane-sugarcane cropping system in clay loam soils. The experiment was initiated at the research farm of Regional Research Station, CCS Haryana Agricultural University, Karnal. The initial soil sample from 0-15cm, 15-30 cm, 30-45 cm, 45-60 cm, and 60-90 cm were collected for a thorough soil profile study. Sugarcane was grown with Recommended Doses of Fertilizer (RDF) as mentioned in Package and Practices by CCS Haryana Agricultural University, Hisar. The topsoil of experimental site exhibited pH- 8.5; EC- 0.19 dS m^{-1}; organic carbon- 0.46%. Available N, P_2O_5 and K_2O content of the soil was medium in the range i.e. 140.3, 32 and 257.2 kg ha^{-1} respectively. The results revealed that after 15 years of experimentation the cane yield decreased @ 2.16 q ha^{-1} yr^{-1} in sugarcane-sugarcane mono-cropping system. Due to a continuous decline in the cane yield, the experiment was modified and the field was divided into two halves in 2017-18. In half of the field, only RDF (T1) was applied to the crop. In the remaining half (T2) field was kept fallow. Meanwhile, in the fallow plot green manuring with *Sesbania aculeate* was done and a sub-soiler was used to break the hardpan of the soil. In 2018-19 in T2 FYM@12.5 t ha^{-1} was applied and incorporated in the soil. As a result, there was a tremendous increase in the cane yield by 24.5% and 28.9% in T2 as compared to T1 during 2019-20 and 2020-21 cropping season, respectively. Hence, it can be concluded that the sugarcane-sugarcane cropping system is not a sustainable system for the long term.

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Ecofriendly Management of Cane Trash through Rapid *in situ* Decomposition

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A field experiment was conducted during 2018-19 and 2019-20 in plant ratoon sequence at RARS, Anakapalle to evaluate the effect of *in-situ* recycling of sugarcane trash with different substrates like molasses, jaggery and dung slurry along with microbial consortium. Results revealed that, highest cane (80.20 t ha^{-1}) and sugar yields (11.05 t ha^{-1}) were recorded with application of Molasses 0.2 % + Dung slurry @ 5 % + Decomposing culture @ 2 kg per acre along with cane trash obtained immediately after harvesting of previous sugarcane crop under insitu conditions and it was on par with Jaggery 0.1% + Dung slurry @ 5% + Decomposing culture @ 2 kg per acre. C/N ratio of cane trash was significantly decreased to 20.22 from its initial value of 67.50 with in a period of 60 days under *insitu* decomposed conditions. Soil C/N ratio was slightly increased to 30-45 days after incorporations and later achieved more or less equal to initial values. Soil available macro and micronutrients were slightly increased from its initial values, however available potassium was significantly increased from its initial status over a period of two years.

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Distribution of Soil Properties and Phosphorus Fractions Influenced by Land Use and Nutrient Management Practices at Farmer's Field in Arable Lands of Arid Environment

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In the recent past, the agricultural production scenario of the Indian arid zone is changed substantially which needs intensive nutrient and water management for sustainable agricultural production. Soils are getting a continuous accumulation of phosphorus (P) due to poor recovery of applied P, high P fixation, and meager loss of soluble P in the arid environment. We have assessed the arable lands of Jhunjhunu district having intensive cultivation history (>200% cropping intensity) for soil properties and P fractions. Based on land and nutrient management during the last more than five years, the soils were grouped as irrigated (IRRI), rainfed (RF), inorganic (INORG), and integrated nutrient management (INM). The soils were deep to very deep, single-grained fine to medium-weak sub-angular blocky in structure, and generally fine sand to sandy loam in texture which is mapped as *Typic Torripsamments*, *Typic Haplocambids,* and *Typic Torriflents* sub-groups. The soils were alkaline in reaction (pH; 7.60 to 9.44) having normal EC (0.054 to 0.442 dS m^{-1}), and low in organic carbon (0.015 to 0.285%), available phosphorus (2 to 69 kg ha^{-1} P) and potassium (67 to 1080 kg ha^{-1} K). Wide variation was observed in dehydrogenase (10.7-83.9 µg TPF g^{-1} day^{-1}), acid (8.18-95.11 µg p NP g^{-1} $h)^{-1}$, and alkaline phosphatases (21-178 µg p NP g^{-1} h^{-1}) with highest activities in irrigated and INM samples. The soil phosphorus comprises of inorganic P (70.6 to 88.1%) and organic P (11.9 to 29.4%). Generally, the Pi fractions were recovered in the order of HA-P>Al-P>OC-P>Occl-P>DC-P>Fe-P>Sol-P under irrigated and inorganic management. However, this sequence of Pi fractions was altered for only OC-P, Occl-P, and DC-P under RF and INM practices and recovered in the order of OC-P>DC-P>Occl-P and DC-P>OC-P>Occl-P, respectively. Generally, about 2% of the total soil P was recovered as available (Olsen) P and up to 82% organic P as phytate P. Hence, the residual soil P comprises of mineral P (10 to 55%) followed by sorbed P (4 to 36%) and soluble P (0.5 to 6%) pools. The land use and nutrient management practices significantly affected the availability of P and potassium and activities of phosphatases enzymes in these soils of arid environment.

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Effect of Land Use Systems on Depth Variation of Different Soil Organic Carbon Pools in the Hilly Ecosystem of Manipur

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A Comprehensive study of soil organic carbon pools/fractions under different land use systems is necessary for estimating the potential of its soil quality and C sequestration. The present study was undertaken to study the long term effect of five different land uses (>10 years) on SOC pools at four soil depths (0-20, 20-40, 40-60 and 60-80 cm) in the hilly ecosystem (for land use) of Manipur, India. Different pools of SOC viz. C_{frac1} (Very Labile), C_{frac2} (Labile), C_{frac3} (Less Labile), and C_{frac4} (Non Labile) were studied. Under all the studied sites the non-labile C_{frac4} constituted the largest percentage of total organic carbon (TOC) for all the depth (0-80 cm). Higher percentage of the labile C_{frac1} was observed under surface soil and was significantly decrease with increasing depth. Overall mean evaluation of different C fractions (in percent) out of total oxidizable organic C and TOC (0-80cm) of different land uses revealed that, C_{frac1} constituted highest (51.41%) percent of oxidizable organic carbon whereas C_{fract4} (55.56%) for TOC. Considering all the land use systems in study altogether it has been recorded that the overall mean percentage of different fractions out of TOC of soil were in the trend of $C_{frac4}>C_{frac1}>C_{frac3}>C_{frac2}$, constituting about 54.56%, 23.36%, 11.89% and 10.20% respectively. Therefore, for reclamation and restoration of soil health in degraded soils of Manipur, particularly in north-eastern hilly regions of India, land use change of forest to other systems should be avoided. Any land use change of these forest cover can leads to more efflux of CO_2 making more vulnerable to global warming and climate change.

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Effect Of Biogas Slurry Based Organic Fertilizers on Growth and Yield of Wheat (*Rabi*) and Maize (*Kharif*) under Middle Gujarat Condition

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A field experiment on testing the effect of application of gobargas plant spent slurry based SuDhan organic products (supplied by the NDDB) on growth and yield of wheat (*rabi*-2019-20) and maize (*kharif*-2020) was conducted at Anand Agricultural University, Anand. The soil of the experimental field is sandy loam in texture having medium fertility status and low organic carbon content. The treatments of SuDhan products included PROM (Phosphorus Rich Organic Manure), Root Enhancer (Root Guard) and Micronutrients Rich Liquid (MRL: SuDhan Grade III). The treatments were imposed with 75 per cent of recommended NPK dose in various combinations of SuDhan products in comparison to the application of Recommended Dose of Fertilizers (RDF) *i.e.* 120-60-00 kg NPK ha^{-1} as Control. The experimental was conducted under Randomized Block Design (RBD) keeping four replications. The PROM was applied as basal, RootGuard liquid was applied after establishment of the plants through drenching in root rhizosphere area; while SuDhan Grade III was applied as foliar application at the rate of 1% twice during the crop growth period *i.e.* first spray at 30 DAS and second spray at 45 DAS. The different observations related to crop growth, yield of grain and straw were recorded; and plant samples were taken for analysis of nutrients. The results on wheat (*rabi*-2019-20) and maize (*kharif*-2020) indicated that different SuDhan products and their combinations were found beneficial in enhancing the growth of the both the crops as well as grain and straw yield. The treatment T5: 75% RDF + SuDhan PROM + SuDhan Root Enhancer increased maximum wheat and maize grain yield by about 24 and 32 per cent over 100% RDF, respectively. The quality of wheat and maize grain was found superior over control as there was an enhancement in nutrient content and their uptake especially in case of Zn, Mn, Cu (in wheat grain) and Fe, Zn (in maize grain) besides increase in protein content. Similarly, the application of SuDhan products was also found beneficial in increasing the microbial count over control. The soil chemical properties remained more or less unaltered (except increase in DTPA-Zn after maize over control) due to application of SuDhan products. The application of SuDhan products saved the 25% of chemical fertilizers and improved the soil health as well.

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Evaluation of Nitrogen-enriched Zeolite Forms for Increased Nitrogen Use Efficiency under Protected Conditions

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Nano-forms of zeolite was synthesized using high energy ball milling at 500 rpm for 6 hours and size reduced to 200-500 nm and its surface was modified, fortified N, and characterized using nanotechnology. The surface area measured were 41 and 110 m^2g^{-1} for micro and nano-zeolite, respectively. The XRD determined the crystalline nature reduced 60-70% and the amorphous phase of nanoforms. Raman Spectroscopy and FT-IR confirmed the functional groups. SEM and EDAX explained the surface morphology and elemental composition. TEM images indicated typical hexagons. The theoretical Freundlich adsorption isotherm equations predicted adsorption of N as 35.0, 48.5 mg g^{-1} (NH_4^+), and 17.5, 28.2, mg g^{-1} (NO_3^-) for micro and nano zeolite, respectively. The N content of the fabricated fertilizers using, micro and nanozeolite, were 18.5, and 28.5%, respectively. Percolation reactor study revealed that N release from zeourea, nanozeourea, and urea were detected till 34, 48, and 3 days, respectively. The grain N content of nanozeourea on Inceptisol (0.26, 0.32%) and Alfisols (0.48, 0.76%) of control and treated respectively. The response was more pronounced in Alfisol than Inceptisol. The fate of ^{15}N nanozeourea and recovery of labeled N in maize on alfisols had significant results with nitrogen use efficiency (NUE) (48.7%), recovery, and retention (22.5%) in soil. Relatively low recovery of N was observed in grain (16.97%), leaf (7.95%), cobsheath (2.65%), and stover (21.13%) with 100% of nanozeourea. The ^{15}N study revealed that the increased NUE of zeolite-based nano N fertilizer. The biosafety data have shown that nano-formulation is safer for beneficial soil microorganisms and seed germination. These formulations are capable of releasing N slowly and steadily for a period of 40 days that eventually improved the NUE. Zeolite forms were found to be efficient in improving NUE without associated environmental hazards, however, more field tests may be conducted prior to commercialization.

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Impact of Soil Amendments on Yield and Yield Attributes of *Zea Mays* L. (Maize) under Fluoride Stress Condition

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A field trial was conducted during Rabi season 2020-2021 at Muthiyarpatti village, Kundadam block, Tiruppur district, Tamil Nadu, India to study the effect of applied soil amendments on maize yield and yield attributes in fluoride contaminated soil. The field experiment was layout in randomized complete block design having three replication four treatments were implemented and compared with fertilized plot and unfertilized plot (Control). The treatments consisted of Soil amendments like FYM (12.5 t ha^{-1}), Vermicompost (5 t ha^{-1}) lime (2 t ha^{-1}) and Gypsum (2 t ha^{-1} were used All plots were fertilized with RDF except continue plot. Applied soil amendments showed on effect on yield and yield attributes. Plots supplied with FYM produce maximum yield (8405 kg ha^{-1}), Straw yield (9981 kg ha^{-1}) and 100 grain weight (31.0 g). However, this was closely followed by vermicompost applied plot. This may be due to fluoride remediation by the use of FYM and vermicompost it can be reduce the fluoride toxicity by amelioration of enzyme activity and lower the fluoride uptake by plants and also higher microbial population present in organic source (FYM + Vermicompost) Can helps in better uptake of nutrients from soil, accumulation of soluble sugars, maintain the peroxidase and catalase activity decrease the fluoride concentration and stimulate the maize crop production. It was concluded from the experiments the plots treated with FYM at the rate of 12.5 t ha^{-1} improved maize production and also reduces the fluoride toxicity in plants and also it can be recommended for general agriculture practices in agro climatic Zone of kundadam block of Tiruppur district.

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Zinc Application Improves Grain Zinc Accumulation, Use Efficiencies and Yield of Basmati Rice in Zn Deficient Soil

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Zinc (Zn) deficient soils have poor nutritional quality and there is a need to improve the use efficiency of applied and native zinc in the soil. Zinc fertilisation is a cost-effective approach to increase crop productivity with Zn-enriched grain. A field experiment was conducted with five Zn levels for two consecutive years to assess the response of Zn fertilisation on productivity, Zn content and its accumulation in basmati rice. The grain and straw yield in basmati rice was maximum with Zn application of 40 kg ha^{-1} and was statistically at par with treatment having 10 & 20 kg ha^{-1} Zn application. Average yield of basmati rice increase varied from 14.8-27.7% in grain and 20.0-33.5% in straw with Zn application treatments. The Zn content and its accumulation in basmati rice grains were highest with Zn application of 40 kg ha^{-1}, which was at par with Zn application of 10 & 20 kg ha^{-1}, respectively. Agronomic efficiency varied from 21 to 88 kg kg^{-1}, physiological efficiency from 6927 to 7391 kg kg^{-1}, grain physiological efficiency from 14915 to 15214 kg kg^{-1} and apparent recovery efficiency from 0.97 to 4.19 % and utilisation efficiency varied from 6700 to 31000 kg kg^{-1}, respectively. All the use efficiencies were higher at lower Zn levels. The net return and benefit-cost ratio was observed highest with the application of Zn at the rate of 10 kg ha^{-1}. Thus, the study concluded that treatment 10 kg ha^{-1} of Zn application was best for higher productivity, the net return, benefit-cost ratio and Zn accumulation of Basmati rice in Zn deficient soil.

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Soil Nutrient Status and its Impact on Yield of Major Mango Growing Soils under Southern Karnataka

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Efficient nutrient management of soil needs proper understanding of spatial variability of phyto-available nutrients and factors that impact on its availability. Mango is one of the most important horticultural crops in southern Karnataka which has huge impact on socio economic status, so proper management of soil nutrients of mango plantations is needed to be focused to obtain sustainability of crop yield. The present study conducted on 108 mango orchards under different agroclimatic zones around the southern Karnataka. The whole study area comes under acidic and non-saline in nature where organic carbon status varied from medium to high for most of the cases. Overall nitrogen deficiency can be found along with medium to high content of phosphorus and potassium. Nutrient index for nitrogen is low while for phosphorus and potassium is low to medium during study. Calcium and magnesium content varied with different agroclimatic zones where sulphur was sufficient for whole study areas. Micronutrient status is found to be sufficient except copper, zinc and boron for most of the study areas. Proper nitrogen fertilization along with FYM and boron through out the growing cycle is recommended for better yield and quality.

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Soil Carbon Dynamics as Affected by Ramie based Cropping System

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Soil organic carbon plays an important role in soil fertility, productivity and quality. The soil organic matter not only affects the sustainability of systems, but also extremely important in maintaining overall quality of environment. Soil organic matter preservation can be considered as one of the most significant sinks for atmospheric carbon. Ramie being perennial crop can have a positive impact on soil organic matter concentration, thus improving the long-term sustainability of cropping systems. Therefore, impact of ramie based cropping systems on soil organic carbon concentration as well as the long-term sustainability of the cropping systems was evaluated. The present study showed that ramie based cropping systems influenced the soil organic carbon and its labile pools. Soil organic carbon, labile carbon, microbial biomass were significantly improved under long term ramie cultivation (15 years). Soil organic carbon decreased with soil depth, but sole ramie 15 years was significantly higher than fallow at 0-20 and 20-40 cm soil profiles. Soil very labile carbon concentration in the different land uses ranged 0.34 to 0.57% along the soil profile up to 100 cm depth. Soil labile carbon and less labile carbon contents of different land uses varied in a range of 0.24-0.31% and 0.11-0.19% respectively. The very labile carbon fraction constituted a higher proportion of total organic carbon with an average of 42.7% ranging from 33.5 to 42.7% in the different land use types. Results showed that long-term ramie cultivation is very important for maintaining soil quality as well as positive impact on the environment.

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Evaluation of Extractants and Instrumental Methods for Determination of Sodium in Soils of South Gujarat

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An experiment was conducted at Department of Soil Science and Agricultural Chemistry, Navsari Agricultural University during the year 2018- 19, with the objectives of (i) to find out suitable extractant and instrument for the determination of sodium from soil and (ii) to establish the relationship of various soil properties with sodium availability. For evaluation of methods of sodium, each Taluka wise one sample; total 46 samples from south Gujarat (Bharuch, Dang, Narmada, Navsari, Surat, Tapi and Valsad) were collected from 0-15 cm depth. Soil physico-chemical properties *viz.,* pH, EC, CEC, organic C, $CaCO_3$ content and soil texture were determined from these sample soils. These soils were used to evaluate six methods of sodium. The methods of sodium was (i) Extracted through NH_4OAc and determined with FPM (Na_1), (ii) Extracted through NH_4OAc and determined with MP-AES (Na_2), (iii) Extracted through AB-DTPA and determined with FPM (Na_3), (iv) Extracted through AB-DTPA and determined with MP-AES (Na_4), (v) Extracted through Neubauer and determined with FPM (Na_5) and (vi) Extracted through Neubauer and determined with MP-AES (Na_6).The methods of sodium were evaluated through method validation parameters like linearity, sensitivity of instruments, precision and predictability. The available sodium determined from the sample soils were correlated with soil physico-chemical properties. The linear dynamic range of NH_4OAc-FPM (Na_1), AB-DTPA-FPM (Na_3) and Neubauer FPM (Na_5) extractants was between 25 to 100 ppm having Co-efficient of determination (R^2) 0.982, 0.988 and 0.994, respectively. The NH_4OAc-MP-AES (Na_2), AB-DTPA-MP-AES (Na_4) and Neubauer-MP-AES (Na_6) had linear dynamic range between 1.0 to 10 ppm with Co-efficient of determination (R^2) 0.985, 0.945 and 0.991, respectively. The sensitivity of instruments was identified by measuring limit of detection (LOD) and limit of quantification (LOQ) of FPM and MP-AES for NH_4OAc, AB-DTPA and Di-acid extractant. The LOD of FPM for NH_4OAc, AB-DTPA and Diacid extractants were 0.578, 0.382 and 0.614 ppm, respectively. The corresponding LOQ of FPM for NH_4OAc, AB-DTPA and Di-acid extractants were 1.925, 1.272 and 2.045 ppm, respectively. The LOD of MP-AES for NH_4OAc, AB-DTPA and Di-acid extractants were 1.663, 3.542 and 0.643 ppm, respectively. The corresponding LOQ of MP-AES for NH_4OAc, AB-DTPA and Di-acid extractants were 5.537, 11.79 and 2.142 ppm, respectively. Amongst the chemical methods the measured values were observed in increasing order of Na_2 (685.7 kg ha^{-1}) > Na_1 (673.8 kg ha^{-1}) > Na_4 (365.1 kg ha^{-1}) > Na_3 (255.8 kg ha^{-1}). NH_4OAc-FPM (Na_1) extractant of Na determination is accepted extractant. Sodium determined by this extractant was highly positive and significantly correlated with uptake-FPM (r = 0.663**) and uptake MP-AES (r = 0.674**). In extractant AB-DTPA-FPM (Na_3), highly positive and significantly correlated with uptake-FPM (r = 0.630**) and uptake MP-AES (r = 0.642**). Na extracted with AB-DTPA MP-AES (Na_4) was highly positive and significantly correlated with uptake FPM (r = 0.645**) and uptake MP-AES (r = 0.667**). In sodium determination NH_4OAc-FPM has highly positive and significantly correlation with nutrient uptake by wheat on MP-AES instruments.

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Fertility Status of Soils of West Tripura District

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The present study was conducted in West Tripura district comprising of medium & low tilla land, with an aim to assess the fertility status of soils of West Tripura District. Soil samples were taken from depth 0-15 and 15-30 cm and collected from different parts of the district. The soil samples were analyzed for various parameters in the laboratory. The results of the study indicated that the soil pH varied from 4.06-5.95 and in more than 90% soils, pH was below 5.7. On an average 53.3% of the soils were found to be medium, 24.5% low and 23.4% high in organic carbon content. Nitrogen was found low, medium, high in 55, 32 and 14 percent cases, while P_2O_5 was low, medium and high in 45, 38 and 15 percent cases, respectively. K_2O was found low in 20, medium in 53 high in 27 percent cases. Appraisal of the data suggests that N-index values ranged from 1.95 to 2.07, P-index values ranged from 1.35 to 1.58 and K-index values varied from 1.29 to 1.43. Perusal of the results indicates that within the profile organic carbon (%), total N (%), available P_2O_5 and available K_2O decreases with the depth.

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Effect of Zinc and Boron on Yield and Quality of Broccoli (*Brassica oleracea* var. *italica*) with Different Application Methods in Alfisols

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Broccoli (*Brassica oleracea* var *italica*) is an important vegetable crop with high nutritional and good commercial value (Yoldas *et al.*, 2008). It mostly contains sulforaphane that checks the growth of tumors and reduces the risk of cancer. Zinc may represent a co-factor of the myrosinase in broccoli and favours the formation of sulforaphane at the initial reaction. Boron plays a vital role in pollen enlargement, fertilization and flowering processes of plants. This study was designed to find out the suitable dose and method of Zn and Boron application for broccoli production with zinc sulphate and borax as source in *rabi* season of 2019-20 in the months of November to January in the Agriculture farm of Palli Sikhsha Bhavana (Institute of Agriculutre), Visva Bharati. The treatments included different methods of zinc application with different doses against control plot viz. T1 (control), T2 (zinc foliar @0.5%), T3 (zinc soil @ 25 kg ha^{-1}), T4 (boron foliar @ 0.5%), T5 (boron foliar @ 0.5% and zinc foliar @0.5%), T6 (boron foliar@ 0.5% and zinc soil @ 25 kg ha^{-1}), T7 (boron soil @ 2 kg ha^{-1}), T8 (boron soil @ 2 kg ha^{-1} and zinc foliar @0.5%), T9 (boron soil @ 2 kg ha^{-1} and zinc soil @ 25 kg ha^{-1}) in randomized block design replicated thrice. Yield attributes responded favourably to zinc foliar application mostly in combination with boron foliar. Maximum head weight per plot (495.94 gm) was recorded for zinc soil application @ 25 kg ha^{-1} whereas maximum broccoli yield (21.03 ton ha^{-1}) was found for zinc foliar application @ 0.5%. Stem girth, head length, head width did not respond significantly but maximum was recorded for combined effect of boron foliar @ 0.5% and zinc foliar @0.5%. Quality parameters responded significantly to combined application of boron and zinc except reducing sugar. Vitamin C content in broccoli responded significantly for combined application of boron foliar@ 0.5% and zinc soil @ 25 kg ha^{-1}. Total sugar was maximum recorded for boron foliar@ 0.5%. Maximum content of Chlorophyll A, Chlorophyll B and Total Chlorophyll was registered for combined application of boron foliar@ 0.5% and zinc soil @ 25 kg ha^{-1}. Thus, results reveal that broccoli responded positively to combined application of boron and zinc in red and lateritic soils of West Bengal.

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Comparative Assessment of Manganese Nano Fertilizers with Respect to their Release Pattern under Laboratory Incubation Experiment

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Manganese (Mn) deficiency is appearing as potential global challenge in front of crop production and productivity. High yielding cereal-cereal cropping system due to nutrient mining and forgetfulness of Mn fertilizer applications accelerates Mn deficiency. Conventional Mn fertilizer ($MnSO_4.H_2O$) reported to have very low manganese use efficiency of applied Mn (1-3%). Nano particles and slow-release nutrient fertilizers are getting widespread appreciations over the world. Nano enabled Mn fertilizers can be safer and more nutrient efficient alternatives for conventional Mn fertilizers. However, studies about nano Mn fertilizer behaviour in soil system are rare. In this study two novel nano Mn fertilizers *i.e.,* nano MnO_2 and manganese nano clay polymer composites (Mn-NCPC) were investigated for their release pattern and their interaction behaviour with other cationic micronutrients in laboratory incubation experiment for 60 days. Study included four Mn sources as control (no Mn), $MnSO_4.H_2O$, nano MnO_2 and Mn-NCPC. Under laboratory incubation experiment maximum DTPA-Mn (6.77 mg kg^{-1}) was determined at 30 days after incubation in Mn-NCPC while it was minimum for control treatment. Mn-NCPC was found to be most efficient Mn fertilizer in terms of controlled release pattern at the end of incubation compared to $MnSO_4.H_2O$ followed by MnO_2. Mn-NCPC and nano MnO_2 maintained significantly higher DTPA-Mn status into soils even upto 45 days after incubation. Both the nano fertilizers had no significant effect on DTPA-Fe status of soil. Availability of Zn and Cu in soil was improved under Mn-NCPC treatment due to alteration of soil reaction during degradation of polymer composite. However, Mn-NCPC and nano MnO_2 need to be critically investigated under long-term crop experiments in field conditions, soil types and cropping system for evaluating their effect on root microbiological climate and acquisition of macro or micro nutrients by crops.

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Evaluation of Soil Physical Properties under Different Agroforestry System in Haryana

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Assessment of physical properties of soil was carried out under different agroforestry systems in Haryana at the Research Farm, Department of Forestry, CCS Haryana Agricultural University, Hisar during 2018-19. Soil samples from different tree based system (Poplar + wheat, *Eucalyptus* + barley, *Melia* + wheat, Shisham + mustard) and sole cropping system (wheat, barley and mustard) were analysed for bulk density, infiltration rate, texture and saturated hydraulic conductivity at four depths 0-15, 15-30, 30-60 and 60-90 cm. The design was randomized block design with four replications. Soil bulk density was significantly influenced by tree based system and soil depth but depicted non-significant relationship with their interaction. Bulk density attained under Poplar + wheat agroforestry system was lowest and at par with rest of the agroforestry systems. Minimum bulk density was acquired at 0-15 cm soil depth which differed significantly with all the soil depths. Non-significant effect was observed in case of soil texture among different agroforestry system. Upto 30 cm soil depth, sandy loam soil texture was recorded. But, with the increase in soil depth, clay content in soil increased leading to sandy clay loam texture in lower soil profile. At 0-15 cm depth, Poplar + wheat recorded maximum infiltration rate and saturated hydraulic conductivity which was at par with *Eucalyptus* + barley based agroforestry system. Enhancement in physical properties was observed under different agroforestry system as compared to sole cropping, thus enabling better crop environment and paving a way towards agricultural sustainability.

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Impact of Different N Levels on Crop Productivity and Soil Nutrient Status in Cereal-pulse based Cropping System

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AICRPDA and AICRP on Agroforestry, under rainfed and irrigated conditions, respectively. Split plot design was used which consist of three levels of nitrogen *viz.*, high (100% Recommended dose RD), medium (50% RD) and low (no application of nitrogen) as subplot and type of crop grown as finger millet, field bean and maize were grown as main plot under both irrigated and rainfed conditions. Apart from nitrogen, other cultural practices were followed as per the package of practices. The increase in nitrogen (N) level leads to increase in grain and straw yield. Under irrigated condition, maize showed 19% hike while field bean and finger millet showed approximately 22% and 9% increase in grain yield in relation to hike in N level. Similar trend was observed under rainfed situation and percent hikes were 16%, 35% and 9% recorded for maize, field bean and finger millet crops. Available nitrogen in soil was found 285.07 kg ha^{-1} at high level of nitrogen as compared to 186.01 at low level of nitrogen under maize cultivation in irrigated situation. Field bean and finger millet showed approximately 28% and 61% higher soil available N at high level of N. Similar trend followed in rainfed situation with 54, 48 and 80% hike in available N at High level of N. The status of available phosphorus (approximately 19%, 36% in irrigated condition, under maize and field bean, respectively) and potassium (approximately 55%, 45% and 49% in rainfed condition, under maize, finger millet and field bean, respectively) was contradictory and declining content was observed with increasing the levels of nitrogen. Thus, it was concluded that higher nitrogen level increased the crop yield as well as maintained the soil nutrient status in the soil as compared to low level.

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Effect of Liquid Biofertilisers in Combination with Inorganic Fertilizers on Nutrient Status of Soil under Direct Sown Rice (*Oryza sativa*)

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A field experiment entitled "soil nutrient transformations and performance of direct sown rice (*Oryza sativa*) as influenced by liquid biofertilizers" was conducted during *kharif,* 2019 at Agricultural College Farm, Bapatla, Andhra Pradesh. The experimental soil was sandy clay in texture and slightly alkaline in reaction. The soil was medium in organic carbon, low in available nitrogen, medium in available phosphorus, high in available potassium and sufficient in all available divalent cationic micronutrients (Zn, Fe. Mn and Cu). The experiment was laid out in RBD with eleven treatments replicated thrice. The treatments comprised of T_1-Control , T_2 -100% Recommended Dose of Fertilizer (RDF), T_3 - 100% RDF + *Azospirillum* , T_4 - 100% RDF + *Azospirillum* +Phosphorus Solubilising Bacteria (PSB), T_5 - 100% RDF + *Azospirillum* + Potassium releasing bacteria (KRB), T_6 -100% RDF + *Azospirillum* +Phosphorus Solubilising Bacteria (PSB) + Potassium releasing bacteria (KRB), T_7 – 75% RDF + *Azospirillum*, T_8 -75% RDF + *Azospirillum* + PSB, T_9 -75% RDF + *Azospirillum* + KRB, T_{10} -75% RDF + *Azospirillum* + PSB + KRB, T_{11} - *Azospirillum* + PSB + KRB. The results of the experiment indicated that application of different levels of fertilizers along with liquid biofertilizers significantly increased N, P and K status of the soil while their effect on soil organic carbon was non significant. The highest available nitrogen contents (299 kg ha^{-1}, 290 kg ha^{-1} and 278 kg ha^{-1}) at maximum tillering, panicle initiation and harvest stages respectively were recorded in the treatment T_6 (100% RDF+*Azospirillum*+PSB+ KRB) followed by T_4 (100% RDF +*Azospirillum* + PSB) and T_5 (100% RDF + *Azospirillum* + KRB) and these were on par with each other. The highest available phosphorus content (66.33 kg ha^{-1}, 62.42 kg ha^{-1} and 60.97 kg ha^{-1}) at maximum tillering, panicle initiation and harvest stages respectively was recorded in the treatment T_6 (100% RDF+*Azospirillum*+PSB+ KRB) followed by T_4 (100% RDF +*Azospirillum* + PSB) and T_5 (100% RDF + *Azospirillum* + KRB)) and these were on par with each other. Similar trend was noticed in the content of available potassium also. The highest organic carbon values (0.59, 0.58 and 0.56 %) at maximum tillering, panicle initiation and harvest stages respectively was observed in T_6 (100% RDF + *Azospirillum* + PSB+ KRB. The lowest available nitrogen, phosphorus and potassium contents were recorded in the treatment T_1 (Control) at all stages.

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Distribution of Total Organic Carbon in Different Size Soil Aggregates under the Influence of Levels of Nitrogen in Rainfed Condition

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Two experiments were conducted in 2018-19, at AICRPDA and AICRP on Agroforestry, GKVK, Bengaluru under rainfed and irrigated conditions, respectively. Treatments were imposed in split plot design in which three types of crops, finger millet, field bean and maize were grown as main plot and levels of nitrogen *viz*., high (100% Recommended dose RD), medium (50% RD) and low (no application of nitrogen) were taken as subplot under both irrigated and rainfed conditions. Apart from nitrogen, other cultural practices were followed as per the package of practices. Soil samples were separated in to two size aggregates, macro (>250 μm) and micro (< 250 μm) using wet sieving method. Total organic carbon (TOC) was analysed using TOC analyser in each group of soil and it was found that increased level of nitrogenous fertilizer enhanced the total organic carbon (approximately 25%, 37%, 16% respectively in soil under field bean, finger millet and maize under irrigated situation) in all the crops and the impact was more pronounced under maize (7.98 g kg^{-1}). Macro aggregates showed higher accumulation of TOC as compared to micro aggregates. The extent of increase of TOC in macro aggregates was about 12.01%, 12.01%, 9.61% in soil under field bean, finger millet and maize cultivation in rainfed condition. The higher accumulation in macro aggregates might be due to the immense role of organic carbon as a binding agent for soil particles and thus contributed higher amount in macro aggregates.

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Evaluation of Different N Management Practices for Higher Wheat Productivity and Nitrogen Use Efficiency

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A field experiment was conducted at research farm, department of soil science, CCS HAU Hisar, to evaluate different nitrogen management practices for higher wheat productivity and N use efficiency during rabi 2020-21. Different N management practices i.e., T1:Control; T2: Recommended dose of Nitrogen (Blanket recommendation of 150 kg N /ha in two equal split at basal and at first irrigation); T3: Soil test based nitrogen management; T4: STCR based nitrogen management; T5: LCC based nitrogen management (137.5 kg/ ha DAP at the time of wheat sowing +100 kg/ ha urea at the time of first irrigation + LCC based nitrogen application at the time of second irrigation (50-55 DAS); T6: LCC based nitrogen management (137.5 kg/ ha DAP at the time of sowing + LCC based nitrogen application at first irrigation (21 to 28 days) and second irrigation (50-55 DAS) were studied in randomized block design with three replications. Recommended dose of p and K was applied as basal dose in all the treatments except T1. On comparing the different approaches adopted in the present experiment, the highest grain (40.3 q/ha) and straw yield (52.4 q/ha) was obtained under leaf color chart (LCC) based nitrogen management which was statistically at par (38.7 q/ha) with that of STCR based N management (T4), however, the higher nitrogen was is required in STCR as compared to LCC. The percent increase in the yield through LCC usage over the RDF is 14.14 % while under STCR 9.63 % increase was observed as compared to RDF. The application of nitrogen based on soil testing provides yield at par with RDN (Recommended dose of Nitrogen) practices. The agronomic efficiency (14.7%) and apparent recovery efficiency (48.60 %) was found higher in T5; however, the physiological efficiency (96.7 %) was found higher in the T2 treatment. So, overall, the highest yield obtained with the use of LCC for nitrogen management but additional urea application at first irrigation seems to be crucial.

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Validation of Soil Test and Yield Target based Fertilizer Prescription Model Developed for Onion (Suksagar) in Gangetic Alluvial Soils

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Field verification trials are important because the calibration of results obtained in a research farm have to be tested for their validity under farmers' field condition. The objectives of these trials were to verify the validity of fertilizer prescription equations developed for onion before recommending them for adoption by extension agencies and to convince the farmers about greater profitability and efficiency of the soil test based fertilizer recommendation than general recommended dose. Using the prescription equations fertilizer doses were calculated for 25 t ha^{-1} and 28 t ha^{-1} of onion and were compared with recommended dose of fertilizers (RDF). Results of the trials showed that application of soil test-targeted yield (ST-TY) based inorganic fertilizer with and without FYM achieved the target yield of 25 t ha^{-1} onion bulb with (-) 0.6 and (+) 4.08% yield deviation respectively. The corresponding values for 28 t ha^{-1} target yield were (-) 2.82 and (+) 1.71% yield deviation respectively. Net monetary returns was higher in treatments where fertilizer were applied based on soil test target yield approach as compared to general recommended dose of fertilizer treatments. The net return was further increased when FYM was included in the fertilizer prescription. Among the different treatments evaluated in the field verification trial, IPNS and ST-TY based fertilizer application (28 t ha^{-1}) treatment recorded highest B:C ratio over all treatments including RDF and control.

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Effect of Different Rates and Frequency of Zinc Fertilization in Maize-wheat Cropping System: A 6- Year Study in Typic Ustochrepts Soil of Gujarat, India

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Zinc (Zn) play a vital role and an essential element for higher plants and its importance in agriculture is increasingly being recognized. Although many techniques of Zn application to crop has tested, still suitable and proper application methods of Zn fertilizer are still unclear which must to known the use efficiency in soil. Therefore, the present study was planned to optimize the fietilizer dose and its frequency of allocation in maize (*Zea maize* L.) - wheat (*Triticum aestivum* L.) cropping system grown *Typic Ustochrepts* soil. Field experiments were conducted during 2012-18 at Anand Agricultural University, Anand Gujarat, India. The study was comprised with three frequency level, i.e. Zn application of first year only (F_1), alternate year (F_2) and every year (F_3) and four different rates of Zn, i.e. 2.5, 5.0, 7.5, and 10.0 kg Zn ha^{-1} per year in maize – wheat cropping system in each *kharif* seasons for six year. There was one Zn control plot which applied recommended dose of fertilizer (NPK) only. Zn was applied through zinc sulphate (ZnSo4.7H2O). In F1 the crop was fertilized with Zn only to maize crop at the initiation of the experiment in the year 2012. In F2, Zn fertilization was given to every alternate year i.e. 1st, 5th and 9th crop of maize. Whereas in F3, Zn was applied every year i.e., 1st, 3rd, 5th, 7th, 9th and 11th crop of maize at the rate of 2.5, 5.0, 7.5, and 10.0 kg Zn ha^{-1}. The experimental was designed in randomized block design (RBD) with three replications at the same plot of experiment for six year. The result state that, Zn applications to maize at 7.5 and 10 kg ha1 of alternate year and 5.0 to 10 kg ha1 of every year had the highest maize equivalent yield as compared to no-Zn treatment. These results emphasize the importance of Zn retention capacity in response to different rates and frequencies of Zn application.

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Dynamics of Boron in Soil under Long Term Fertilization of Boron in Groundnut-Cabbage Cropping System

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Boron fertilization is essential for increasing crop productivity, thus its dynamics and suitable soil application method for B fertilization is required. To estimate the depth-wise distribution of boron fractions, soil samples from different depths (0-15, 15-30, 30-45, 45-60, 60-75 cm depth) were collected from each plot of long term field experiment. The treatments comprised of different combinations of three frequencies (in the first year, alternate year and every year B application) in four rates (0.5, 1.0, 1.5 and 2.0 kg B ha^{-1}) and the treatments comprised of total 13 combination including one control with repeated four times. The B was applied to the soil as borax to groundnut crop only. A sequential extraction method was adopted for different boron fractions i.e. readily soluble boron (RsB), specifically adsorbed boron (SaB), oxide bound boron (OxB) , organically bound boron (OrB), residual boron (ReB) and total boron (TB). The effect long-term boron application on boron fractions i.e. readily soluble B, specifically adsorbed B, oxide bound B, organically bound B, residual B and total B found significant under different soil depths (0-15, 15-30, 30-45, 45-60, 60-75 cm) of soil. Amount of boron fractions was increased with increase in level of boron application. Generally the contribution of different fractions to the total boron was in the order of readily soluble (0.43-0.55%) < specifically adsorbed (0.74-0.98%) < oxide bound (1.26-3.11%) > organically bound (0.70-1.55%) < residual boron (93-96.8%). Therefore, from present study, it concluded that B application at 2.0 kg ha^{-1} every year showed the maximum amount of B fractions in different depth of soil.

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Zinc Amelioration of Low Land Rice with Appropriate Doses, Method and Time of Application

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To alleviate Zn-deficiency of rice or its hidden hunger zinc fertilization with right dose, method and time of application is very essential to sustain the production as well as to get the value added product, but information in this regard is meagre. With this view a field experiment was undertaken to evaluate the right dose, method and time of application of Zn using 4- Zn levels (0,2.5,5,10 kg ha^{-1}) as soil application and foliar application of $ZnSO_4.7\ H_2O$ and Zn-EDTA (@0.5%) at different growth stages in low land rice (IET-4786) in the university experimental farm (Central research farm at Gayeshpur, WB). Among all the twelve treatments, soil application of Zn @10 kg ha^{-1} along with foliar application of Zn-EDTA @0.5% at Maximum tillering stage is superior to the others in all the aspects such as grain yield, Zn content and uptake by rice root, shoot and grain. Results revealed the highest B:C ratio (1.54) obtained from soil application of Zn @ 5 kg ha^{-1} along with foliar application $ZnSO_4.7H_2O$ @ 0.5% at max tillering stage is highly suitable for sustaining the rice production and it might be recommended to the farmers not only for sustainable production but also for getting the value added product. Results also showed that a very little amount of applied Zn (<1%) is utilised by rice and its magnitude is high when it is applied at lower level. Zn translocation factor from root to shoot and shoot to grain, agronomic efficiency (AE) and apparent recovery efficiency (ARE) were also higher at lower level of Zn applications than the higher from which it might be opined that lower level of Zn application would be effective to sustain the rice production with high B:C ratio without affecting the soil environment.

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Organic Carbon Dynamics after Thirty Seven Years of Long Term Integrated Nutrient Management in Rice-Wheat Cropping System

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A long term experiment was initiated in 1983 by taking rice and wheat as test crops with fourteen treatments replicated thrice, designed in a completely randomized block design. The treatments comprised of different levels of chemical fertilizers and their combination with FYM, crop residues and green manuring with a objective to develop suitable integrated nutrient supply system for rice-wheat cropping sequence involving more efficient use of fertilizer in conjunction with a judicious combination of organic manures by effective recycling techniques, without detriment to long term fertility and improving crop productivity. The experimental soil was found to be alkaline in reaction with pH value of 7.6, EC 0.22 dSm^{-1}, and organic carbon 0.31%. The experimental results revealed that the highest value of organic carbon 0.595% was obtained where 50% N was supplemented through FYM along with RDF, followed by 0.58% where 25% N was supplied through FYM along with 75% recommended NPK and followed by 0.57%, where 50% N was substituted through green manuring along with 50% recommended NPK. The organic carbon was 0.55%, where 50% N was substituted through green manure, followed by 0.51%, where 50% N was substituted through wheat cut straw and lower OC was found in RDF (0.48%) and control plots (0.45%). The % increase in organic carbon was 31.8% over the initial value where 50 percent N was supplemented through FYM along with RDF. On the other hand, 91.3% percent increase was observed in treatments, where 50 percent N was supplemented through FYM compared to initial value, 83.3% with green manure and 50% through NPK to rice and 100% NPK was applied to wheat crop. Out of all the treatments, 50% FYM and 50% NPK treated plot was considered the best treatment in improving the soil health in terms of organic farming.

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Effect of Soil and Foliar Application of Potassium on Raya under High Available Potassium Status Soil

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A field study was conducted to find out the response of raya crop to soil and foliar application of potassium under high K status soils. This study was carried out at research farm of department of Soil Science, CCS HAU, Hisar in a randomized block design with three replications. The study included seven treatments *viz*. T_1: Control; T_2: 20 kg K_2O ha^{-1}; T_3: 40 kg K_2O ha^{-1}; T_4: foliar spray of KNO_3 @ 1% at flower initiation stage; T_5: foliar spray of KCl @1% at flower initiation stage; T_6: foliar spray of KNO_3 @2% at flower initiation stage; T_7: foliar spray of KCl @2% at flower initiation stage. The newly released raya variety RH 725 was raised with recommended dose of N and P in all treatments including control and dose of K was applied according to designed treatments. The soil application of potassium did not affect seed and stover yield of raya significantly. However, foliar application of potassium in the form of KNO_3 @ 1% had significantly improved the yield. About 16 and 19% higher seed yield of raya was observed with the foliar application of KNO_3 @ 1% and 2% respectively. Foliar application of KCl in the form of murate of potash fertilizer did not significantly improve the yield. The seed K content was found highest in T_3 treatment and it was increased 2.77% and 5.55% when foliar spray of @ 1% and 2% KNO_3 was applied over control.

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N Assimilation in Partitioned Plant Parts at Successive Stages of Bt Cotton as Influenced by Irrigation Water Quality and N Fertigation

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The effect of different qualities of irrigation water viz. canal water (CW), alternate CW and saline water (CW-SW) and CW irrigation up to germination and subsequent irrigation with SW (CW_g-SW) along with three N fertigation levels [100% (N_{100}), 80% (N_{80}) and 60% (N_{60}) of recommended dose of N (RDN)] on N content of *Bt* cotton at successive stages of growth [60, 90, 120 days after sowing (DAS) and at harvesting stage] after 3 cycles of cotton-summer squash cropping system under surface drip system during *kharif* 2019 at PAU Regional Research Station, Bathinda. The field experiment was laid out in split design with four replications in paired row geometry (50-85-50 cm) with drip lateral placed in the middle of paired rows having in-line emitter spacing of 30 cm and discharge rate 2.4 L hr^{-1}. The residual sodium carbonate and electrical conductivity of the tubewell water (SW) ranged from 1.2 to 1.4 meq L^{-1} and 3.8- 4.2 dS m^{-1}, respectively. The corresponding values for canal water (CW) were 0.2 to 0.3 meq L^{-1} and 0.258-0.301 dSm^{-1}, respectively. The results showed that the N content of leaves, stems and roots decreased with the advancement in the age of crop, irrespective of water quality and fertigation levels. Increase in salinity in irrigation water reduced N content as well as respective uptake in all plant parts. Maximum N was translocated into leaves at 60 DAS and 90 DAS whereas at 120 DAS reproductive portion accounted for most of the total N absorbed, regardless of IWQ and N fertigation. The increasing rates of N addition resulted in an increase of N content and its uptake in different plant parts at all the growth stages under all the IWQ. Within partitioned plant parts cotton seed had highest N concentration at 120 DAS and at harvesting stage. In addition, cyclic use of good quality CW and SW of EC up to 4.0 dS m^{-1} (CW-SW) are statistically at par with CW in terms of N content and its uptake in partitioned plant parts at different stages of cotton development on a sandy loam soil in semi-arid environment under surface drip.

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Interactive Effects of Phosphorus Application and Salinity on Yield and Quality of Tomato Fruits

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The tomato plants were grown upto maturity in pots filled with sandy soil which contained 72 and 90 meq/l of chloride and sulphate dominant salts in its saturation extract, to which 0, 12.5, 25 and 50 ppm P was added. The fruit yield decreased 54% and 42% under chloride and sulphate salinities than non saline conditions. The results indicated that tomato fruit yield increased significantly by 50 ppm of added P both under non-saline and chloride dominated conditions but 25 ppm added P was optimum under sulphate dominated conditions. The increase in TSS was reported as 32% and 53% under chloride and sulphate dominated conditions compared to non saline control but it decreased significantly with added P. The firmness of tomato fruits increased 45% and 66% in chloride and sulphate environments respectively and mean values of firmness increased 27%, 19% and 13% from 0 to 50 ppm added P under non saline, Cl^- and SO_4^{2-} dominated conditions, respectively. Salinity stress increased the Ascorbic acid content and titrable acidity of tomato fruits significantly, but upon addition of 0 to 50 ppm P, ascorbic acid content decreased 30%, 28% and 21% and titrable acidity decreased 19.6%, 18.7% and 18% under non saline, Cl^- and SO_4^{2-} dominated conditions, respectively.

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Interactive Effects of Phosphorus Application and Salinity on Physiological Parameters and Nutrient Content of Tomato Plant

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In a screen house study, the tomato plants were grown upto maturity in pots filled with sandy soil which contained 72 and 90 meq l^{-1} of chloride and sulphate dominant salts in its saturation extract, to which 0, 12.5, 25 and 50 ppm P was added. The number of days taken for 50% flowering was reduced under salinity stress and flowering days increased and approached to normal days as the P level increased. The chlorophyll content of leaves and quantum yield of photosystem II was increased by added P as compared to control. The data revealed that while the salinity induced decrease in both types of chlorophylls are similar but the increase in chl 'a' content upon P addition is higher than chl 'b'. The plant N, P and K content increased with added P under either type of salinity and this indicated the role of P in plants to overcome salt stress. The Cl^- content of plants was significantly decreased and SO_4^{2-} was increased with the increase in the P content of soil. A synergistic relation between the SO_4^{2-} and P and antagonistic relation between the chloride and P content of tomato plants was observed.

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Nutrients Dynamics under Long Term Block Plantations of Different Tree Species

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The physico-chemical properties viz. texture, soil pH, EC, OC, $CaCO_3$, available nitrogen, phosphorus, potassium and DTPA-extractable micronutrients (Mn, Fe, Cu and Zn) of soil have been analyzed under block plantations of different tree species *viz. Pongamia pinnata*, *Prosopis cineraria* and *Ailanthus excelsa* in Regional Research Station, Bawal, Rewari (Haryana). For this, soil samples from 0-15, 15-30, 30-60, 60-90, 90-120, 120-150 and 150-180 cm soil depths under tree canopies including sites without plantations of these tree species (control) have been collected. Leaves samples of different tree species were also collected to analyze plant nutrient status. The soil was found in loamy sand. In general, soil pH and EC decreased significantly under plantations as compared to control and increased with soil depth along with profile under tree plantations as well as under control. The highest reduction in pH was recorded under *Prosopis cineraria* followed by *Pongamia pinnata* and *Ailanthus excelsa*. $CaCO_3$ content decreased under tree plantations as compared to control and increased with soil profile. Available NPK and micronutrient content increased under tree plantations as compared to control. A maximum increase in nutrient content was recorded under *Prosopis cineraria* followed by *Ailanthus excelsa* and *Pongamia pinnata*. However, nutrient status decreased with increasing soil depth. The organic carbon content increased significantly under different tree species as compared to control and decreased with soil depth. It was recorded that percent N, P and K content was highest in leaves of *Prosopis cineraria* followed by *Ailanthus excelsa* and *Pongamia pinnata*. Micronutrients viz. Mn, Fe, Zn and Cu content were also found highest in leaves of *Prosopis cineraria* followed by *Ailanthus excelsa* and *Pongamia pinnata*. It was concluded that tree plantations helped in the overall improvement of soil nutrient status and maintained its fertility.

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Effect of INM and Organic on Soil Biological Properties and Nutrient Uptake by Bt Cotton

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Cotton is the most capital intensive cash crop grown predominantly in Maharashtra mostly on black cotton soils, the typical swell-shrink. The economy of agricultural community of Vidarbha is mostly dependent on the cotton. The fertility of soil is highly related with soil organic matter. Organic matter is an important soil constituent influencing a number of constraints linked with crop productivity. The integrated use of organic along with chemical fertilizers and also only use of organic is a promising approach in preserving soil biological activities, which will ultimately show positive impacts on different soil physicochemical properties and nutrient uptake by cotton crop. In this regard the, the present investigation was conducted at Research Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, during year 2017-18 and 2018-19. The experiment was laid out in split plot design with three replications. The main plot treatments comprised of nutrient management *viz.*, INM (75% RDF + compensation through NPS compost) and Organic (100% NPK dose through NPS compost). Sub plot treatments consisted of cotton based intercropping systems *viz.*, Cotton + dhaincha (1:1), Cotton + sunhemp (1:1), Cotton + greengram (1:1), Cotton + blackgram (1:1) and Sole cotton. Results revealed that, the use of 75% RDF + compensation through NPS compost enhanced the soil biological properties (SMBC, DHA, Urease activity and CO_2 evolution). 100% use of NPS compost, under cotton + dhaincha (1:1) also found beneficial in improving biological properties which was found on par with cotton + sunhump (1:1) based intercropping systems. Integrated nutrient management involving use of organics viz. NPS compost and green manuring with dhaincha, sunhump, greengram and blackgram in conjunction with chemical fertilizers and 100% RDF through NPS compost was found to be improve nutrient content and uptake of major and micro nutrients by cotton.

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Potential of Resource Conservation Practices for Productivity and Sustainability in a Rainfed Cotton-Soybean Rotation on Vertisols in Central India

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A field investigation was conducted to evaluate the various resource conservation practices for sustainability under cotton-soybean rotation on Vertisols at Dr. PDKV, Akola during 2011-12 to 2016-17. The experiment was carried out in RBD with nine treatments replicated thrice. The treatments imposed on cotton comprised of 100% RDF through only chemical fertilizers, 25% N (through various organic sources *viz.*, sesbania lopping, composted cotton stalk, wheat straw and sorghum stubbles), 50% N through FYM & leucaena loppings and 100% N through FYM with RDF compensation applied to cotton. While, treatments imposed on soybean comprised of 100% RDF through chemical fertilizers and 100% N through FYM. The pooled results revealed that the application of 100 or 50% N through FYM or 25% N through dhaincha loppings recorded significantly higher soil organic carbon, residual soil fertility status and soil biological properties along with improvement in soil quality index over rest of the treatments.. The application of neem cake and green manuring for substitution of 25 per cent nitrogen along with remaining nutrients of RDF through chemical fertilizer to cotton and RDF of soybean through chemical fertilizers or 100% recommended N of cotton and soybean through FYM along with phosphorus compensation through phosphocompost to cotton was found beneficial in respect of seed cotton yield and grain yield of soybean. The highest soil organic carbon stock was recorded under 100% recommended N of cotton and soybean through FYM along with phosphorus compensation through phosphocompost. Hence, it can be concluded that application of dhaincha loppings for substitution of 25% nitrogen along with remaining nutrients of RDF through chemical fertilizers to cotton and 100% N through FYM to soybean was found beneficial in respect of improvement in cotton-soybean productivity and soil quality in Vertisols of central India.

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Soil Organic Carbon Stock of 6-Year-Old Semal (*Bombax ceiba* L.) based Agroforestry System with Varying Tree Densities

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A field experiment was conducted to estimate the soil organic carbon (SOC) content and soil organic carbon stock potential of 6-year-old *Bombax ceiba* L. plantations by four different tree densities (5.2m, 5.3m, 5.4m and 5.5m) in Calciorthent of North-West Alluvial plain of Bihar. Soil samples from two depths (0-15 and 15-30 cm) were collected from each density plantation to estimate the soil carbon in the laboratory. Different spacings along with the open showed significantly highest buildup of SOC (%) and soil active carbon (mg kg^{-1}) in 5?2m spacing (0.541% and 183.524 mg kg^{-1}) followed by 5.3, 5.4, 5.5m and open irrespective of the soil depths. The surface soil also showed significant buildup of SOC (0.542%) and soil active carbon (184.034 mg kg^{-1}) when compared to subsurface irrespective of the tree densities and control. Interaction effect between soil depths and spacings showed significant effect in enhancing the SOC status and soil active carbon content. Soil organic carbon stock in 0-30 cm were also estimated and found that in higher densities of the plantations, SOC stocks were higher and varied from 13.384 Mg ha^{-1}in open to 22.999 Mg ha^{-1} in 5.2m. Irrespective of soil depths, soil bulk density varied between 1.420 Mg m^{-3} in 5.2m spacing to 1.521 Mg m^{-3} in open condition. The surface soil (1.435 Mg m^{-3}) showed significantly lower bulk density compared to subsurface soil and control. In the surface soil, with the higher tree density there was increase in SOC, SOC stock and soil active carbon was observed. Whereas reverse trend was observed with soil bulk density. Thus the above study indicates that different spacings of *B. ceiba* plantations sequester good quantity soil carbon to help in mitigating climate change.

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Effect of Sludge Application on Status of Metals in Soils and their Uptake by Mustard

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A green-house pot experiment was conducted in the Division of Soil Science and Agricultural Chemistry, IARI, New Delhi during 2018-19 to study the effect of sludge application on the status of metals in soils and their uptake by mustard grown on acid and alkaline soils with different levels of sludge. The treatments were: recommended dose of NPK, $N_{75\%}$PK + sludge @ 2.5, 5, 10, 20, 40, 80 g kg^{-1} of soil. Result revealed that content of metals in mustard seed varied from 40.0 to 129 for Fe, 8.87 to 28.8 for Mn, 12.4 to 40.9 for Zn, 6.98 to 10.1 for Cu, 0.09 to 0.69 for Ni, 0.07 to 0.16 for Cd, 0.06 to 0.21 for Pb and 0.11 to 0.55 mg kg^{-1} for Cr. Relative order of translocation factor ($TF_{root/soil}$) for transfer of metals from soil to root grown on sludge amended soil was Cd > Zn > Cu > Cr > Pb > Ni > Mn > Fe. There was a significant increase in available N, P and K content in both the soils after the harvest of mustard. DTPA extractable Fe, Mn, Zn, Cu, Pb, Ni, Cd and Cr content ranged from 14.9 to 38.7, 22.7 to 39.6, 2.03 to 21.8,1.33 to 9.83, 2.46 to 4.14 mg kg^{-1}, 288 to 1419, 31.4 to 86.8 and 3.18 to 11.8 µg kg^{-1}, respectively. In the face of escalating price of chemical fertilizers as well as abysmally low organic carbon content of most of the Indian soil, use of sludge in agriculture may be considered as a lucrative option for improving soil fertility provided food chain contamination with pollutant elements would be within safe limits.

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Can Pressmud Application Mediated the Saline-Sodic Soil Properties

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Increasing population pressure on limited natural resources may lead to environment pollution and poor soil health. Increasing crop yield potential in problematic soils can be a rational way to enhance food grain production by adding organic matter. Land degradation caused by salinity poses a global danger to the environmental and food production. Soil organic carbon (SOC) is critical for sustaining soil resilience, which has an impact on ecosystem services and climate change. Irrigation with bicarbonate-rich subterranean water not only increases Na-saturation in clay complexes, but it also causes clay particle dispersion, impedes soil aeration, and reduces permeability, lowering crop productivity. Continuous irrigation with low-quality water generated a substantial quantity of salt in the rhizosphere, limiting the crop's nutrient uptake ability. The physico-chemical and biological properties of soils are affected by these salt ions. In this context, an incubation experiment was carried out to monitor the dynamics of plant nutrients in soil solution. During the experiment, the soil moisture and temperature were kept constant. Plant nutrient dynamics were studied using periodic sampling. The use of pressmud and FYM increased the concentration of essential plant nutrients as well as the biological properties of the soil. Higher pressmud application rates (over 10 t ha^{-1}) increased nitrogen, phosphorus, and sulphur availability. Carbon mineralization rate was also enhanced with increasing the incubation period. Soil biological properties are also mediated by the press mud application with higher doses. Pressmud having huge scope for its use in agricultural crop system and also reduce the storage problems in major sugarcane industries. This concept may be useful for enhancing the soil organic matter for reducing the saline ion toxicity for sustainable crop production.

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Study on Foliar Supplementation of Nano Potassium on Yield and Yield Attributing Characters of Rice in Acid Soil of Odisha

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A field experiment was conducted in the research field of Odisha University of Agriculture and Technology during 2019-20 to study the effect of foliar application of nano potassium on yield and yield attributes of rice. The experimental design was randomized block design with 3 replications and 7 treatments. These treatments were T_1:Control (No potassium); T_2:100% of Soil Test based Dose (STD) for K ; T_3:100% of STD for K + Once foliar spray (FS) of water at 14 Days after transplanting (DAT); T_4:100% of STD for K + Once FS of Nano K at 14 DAT; T_5:100% of STD for K + Twice FS of Nano K at 14 and 28 DAT; T_6: 75% of STD for K + Twice FS of Nano K at 14 and 28 DAT; T_7: 50% of STD for K + Twice FS of Nano K at 14 and 28 DAT. The result indicated that highest number of panicles/hill and spikelet/panicle, filled grains/panicle and 1000 seed weight recorded with T_5. Significantly highest rice grain yield of 2569.6 kg ha^{-1} was recorded with T_5 where as lowest value of 1724.6 kg ha^{-1} was recorded with T_1. The grain yield of 2420.6 kg ha^{-1} was recorded due to T_6 which was not significantly decreased than that of the value (2493.9 kg ha^{-1}) recorded with T_2 (100% of STD for K). From the result it was revealed that amount of potassium can be reduced in the tune of 25% of STD which can be compensated by twice foliar application of Nano-K at 14 & 28 DAT without sacrificing the grain yield.

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Long-term Fertilization Influenced the Crop Productivity and Soil Health under Diverse Sources of Nutrients in Maize-Chickpea Cropping System in Vertisols

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The integrated nutrient management (INM) practices under long term fertilizer experiment for maize-chickpea system in vertisols improved system productivity, sustainable yield index (SYI) and soil properties. The average grain yield of maize and chickpea and system productivity was considerably higher with STCR based 75% NPK along with FYM at 5 Mg ha^{-1} followed by STCR based 75%NPK + poultry manure (PM) at 1 Mg ha^{-1} as compared to recommended dose of NPK (GRD) and 100% STCR based NPK. Whereas, application of organic modules (the integration urban compost (UC), maize residue (MR) and *Gliricidia loppings*) did not influence the maize yields. The application of 5 Mg ha^{-1} FYM to chickpea and residual fertility of 20 Mg ha^{-1} FYM (every season) increased the chickpea yields. Increase in chickpea yield might be due to residual fertility effect of long term use of organic manures. The application of organic modules maintained the soil properties but could not achieve the targeted yield of maize. Furthermore, result indicated that the application of higher quantity of FYM @ 25 t ha^{-1} in each season improved the Walkley Black carbon (WBC) level and increase in WBC was 79.6, 77.9% and 52.1%, 43.7% with application of FYM at 20 t ha^{-1} as compared to control and GRD, respectively in both the soil layers (0-15 and 15-30 cm). The INM modules enhanced the soil organic carbon contents and the highest total organic carbon (TOC) (13.90 and 10.01 g kg^{-1}) was registered with the application of large amount of organic manures (FYM 20 t ha^{-1}) in both soil layers. Next to it, application of STCR based 75% NPK along with 5 t ha-1 FYM improved the TOC values and followed 75% NPK along with 5 t ha^{-1} FYM once in four years. The bulk density was significantly decreased with the application of organic manures and balanced fertilization over the chemically mediated and control plots. The lowest bulk density was observed with higher amount of FYM @ 20 t ha^{-1} was supplied in both crops. The integration of diverse source of organic nutrients (FYM, PM, UC, GL and MR) also significantly reduced the bulk density in both layers as compared to control, GRD and STCR based fertilizers in both soil layers.

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Effect of FYM and Fertilizer Nitrogen on Productivity and Fertility of Soil after 50 Years of Experimentation

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A field experiment was initiated in 1967 at Research Farm Department of Soil Science CCS Haryana Agricultural Hisar to study the effect of long term application of FYM and fertilizer N on productivity and fertility of soil under pearl millet- wheat cropping system. Three levels of FYM @ 5,10 & 15 t ha^{-1} (15, 30 & 45 t ha^{-1} up to 2007-08) was applied in rabi, kharif and both seasons, A FYM control treatment was also kept under split plot design and three levels of N i.e. 0, 60 & 120 kg ha^{-1} was kept as sub plot treatment. All the treatments (ten main and three sub plot) were replicated four times in the permanent plots. After fifty years of experimentation, it was observed that increase in pearl millet grain yield was about, 58, 66 and 73% and that of wheat grain was 18, 39 and 55% upon application of FYM @ 5, 10 and 15 t ha^{-1} over the control, respectively. The mean increase in pearl millet and wheat grain yield was 42 and 23, 26 and 34, and 26 and 41% over control with the application of 15 t FYM ha^{-1} in *kharif, rabi* and both the seasons, respectively. Soil pH decreased from initial value with the application of FYM. However, increase in EC was observed with the application of FYM. Organic carbon (@0.016 to 0.028% $year^{-1}$), available N (@ 0.64 to 1.36 kg ha^{-1} $year^{-1}$), P (@0.81 to 2.04 kg ha^{-1} $year^{-1}$) & K (@3.21 to 21.64 kg ha^{-1}) in soil was increased over the initial values with the application of FYM alone or in combination with fertilizer N.

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Impact of Forty Eight Years of Cropping and Fertilization on Carbon Management Index in an Acidic Alfisol

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Labile organic carbon serves as a sensitive indicator of changes in soil health in response to different land management practices. The labile fractions have a much shorter turnover time and a higher turnover rate than the more stable organic carbon in soils. Potassium permanganate oxidizable carbon is more sensitive to management induced changes compared to total soil carbon and therefore it is considered as a useful index of labile carbon. Determination of carbon management index (CMI) is of considerable importance while describing soil quality. CMI compares the efficacy of different management practices to evaluate the long term effectiveness of nutrient supply, productivity and soil carbon pools. A higher value of CMI indicates better and sustained management system. A study was undertaken in an ongoing long term fertilizer experiment which is in operation since 1972 at Birsa Agricultural University (BAU), Kanke, Ranchi, Jharkhand, India, with the objective to study the impact of forty eight years of continuous cultivation, fertilization and liming on the carbon management index (CMI) in a sub-tropical Alfisol under soybean-wheat cropping system. There were ten treatments with three replications; 50% NPK+Weedicide(W), 100% NPK+W, 150% NPK+W, 100% NPK+Handweeding (HW), 100% NPK+Lime+W, 100% NP+W, 100% N+W, 100% NPK+FYM 100% N(S) PK and control. The source of P fertilizer was diammonium phosphate (DAP) in all the treatments except in 100% N(S)PK where it was single superphosphate (SSP). The source of nitrogen was urea and potassium was muriate of potash (MOP). In 100% N(S)PK treatment, initially the source of N was ammonium sulphate which was changed to urea during the year 2010. Surface soil samples were collected after the harvest of wheat during 2018-19 for determination of soil organic carbon (SOC), permanganate oxidizable soil carbon (POSC) and carbon management index (CMI). Results indicated that 100%NPK+FYM treatment had maximum accumulation of soil organic carbon which was 22.9% and 43.9% greater than 100% NPK+W and unfertilized control plots, respectively. Permanganate oxidizable soil carbon (POSC) content was highest in 100% NPK+FYM treatment followed by 100% NPK+lime +W treatment followed by 100%NPK+W. 100% N treatment recorded lowest value of SOC as well as POSC. All the treatments except 100% N showed improvement in CMI value over control (which was taken as reference in calculation of CMI). Balanced application of NPK fertilizer recorded 50%, 26.6% and 72.5% increase in CMI value over control, 100%NP and 100% N, respectively. Highest value of CMI was recorded in 100% NPK+FYM+W treatment followed by 100% NPK+Lime+W treatment. Inclusion of FYM and lime in addition to inorganic fertilizer recorded increase of 71.5% and 64.3% in CMI value over control while 100% N resulted in 12.85% decrease over control. The study indicated that though the balanced application of NPK fertilizer improved the CMI as compared to imbalanced fertilization and no application of fertilizer but further improvement can be achieved through application of lime or FYM along with inorganics for better management of carbon under long term intensive cultivation in acid soils.

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The Interaction Effect Between Zinc and Iron in Low Land Rice

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Rice is the main staple food in India grown in submerged condition leading to a wide spread deficiency of Zn in both soil and plant. Recent days human-beings are suffering from micronutrient deficiencies due to inadequate intake of Zn and Fe in daily diet. So, It have to be clear about Zn & Fe interaction in soil and plant for avoiding malnutrition and better heath of human being, but the information regarding this is very meagre. With this background an incubation study accompanied by a greenhouse experiment had been conducted growing rice in rabi season on the new alluvial soils of West Bengal by applying both elements in three different levels *i.e.* 0, 5, 10 kg ha^{-1}. Results showed highest decrease in Zn content at 100 days of incubation for T3 treatment at 16.31% higher than control, because of higher dose Fe application @10Kg ha^{-1}. Due to submergence there was an increasing trend on availability of Fe and highest was for T3 at 18.35% with no application of Zn. Green house result was similar with incubation, highest decrease in available Zn was for T3 with 13.43%. Available Fe was increased upon submergence and highest for T3 with 27.94%. So, Zn availability was decreased when Fe was added in soil and the magnitude of decrease was higher with adding higher dose of Fe. At harvesting Zn concentration in root, straw and grain are highest for T7 due to higher dose of Zn application @ 10 kg ha^{-1}, also showed that Fe addition cause decrease of Zn concentration in rice. Results from the correlation study also revealed that Fe content in rice grain have negative significant correlation with zinc content of the plant (root, straw & grain) was recorded. Therefore over all findings of Zn & Fe study showed antagonistic effect.

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Characterization and K Release Kinetics of Indian Glauconitic Shale in Two Contrasting Soils of India

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Potassium is essential to all forms of plant and animal life. It is the seventh most abundant element in the lithosphere. For attaining and maintaining the self-sufficiency in food grain production, potash fertilizers has played important role in Indian agriculture. However the entire K fertilizers are imported causing huge loss of foreign exchange for Government of India. No or less than recommended application of K is causing mining of K from soil. Considering this a study was conducted to evaluate the feasibility of Indian Glauconitic Shale as source of potassium in agriculture. The glauconite mineral was collected from Singrauli District of Madhya Pradesh. The total K_2O content in glauconite samples ranges from 7.1 to 12.6%. The pH and EC of different glauconite varies from 7.97-8.85 and 0.09-0.26 dSm^{-1}. The total elemental composition of whole rock reveals that it contains 5 to 9.6% of K, 1 to 2.2% of Fe, 0.4 to 4.4% of Ca, 0.6 to 0.3% of Mg, 0.3 to 0.6% of B, 0.02 to 0.13% of Na. The concentration of Mn, S, Zn, Ni, Cr, Co and As are less than 0.001%. The XRD pattern of the air dried gluaconite sample exhibits a (001) reflection at 10.05 Å, a (002) reflection at 4.5 Å and a strong reflection at 3.3 Å. The gluaconite is well ordered and having 5% expandable layers. The peaks are unmoved after glycol treatment and heating at 110°C, 300°C and 500°C indicating minimal inter-stratification between expandable and non-expandable layers. Over all from mineralogical studies, it can be inferred that the present material is composed of 55% of glauconite, 33% mica and around 11% of quartz, feldspars, illite, chasmosite, goethite are part of glauconite. The incubation experiments were also performed to study the potassium release behaviour from glauconite after application in black soil (Vertisol, Wanirambhapur soil series) and red soil (Alfisol, Vijaypura, soil series). The effect of glauconite application alone or in combination with FYM and microbial inoculation with *Bacillus cereus* was studied. The results of the experiment suggested that the heat treatment (calcined glauconite), acidulation of glauconite and use of FYM@0.5% showed pronounced influence on K release from glauconite in both the soils. The application of microbial culture of *Bacillus cereus* did not show any significant improvement in K availability. Among the different treatments application of acidulated calcined glauconite along with FYM and microbial inoculation with *Bacillus cereus* showed the highest release of potassium throughout the incubation period. The zero-order, first-order and parabolic equations fit the data much better than the Elovich, power function as evidenced by the higher correlation coefficients, the smaller standard errors of estimate, and the values of parameter estimate for NH_4OAc-K and WSK under different treatments.

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Response of Tillage and Nitrogen Sources on Crop Yield, Enzyme Activity, MBC, MBN, Total C and Total Soil N under Maize in a Maize-Rice System

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A field experiment was conducted for two years: 2017-18 and 2018-19 at research farm of UBKV, Pundibari, Cooch Behar, West Bengal, India with maize in a maize-rice cropping system. The experiment was in a split-plot design with three tillage practices *viz*. zero tillage (ZT), conventional tillage (CT) and alternate tillage (AT, maize under ZT and rice under CT) in main plots and five nitrogen (N) treatments consisted of NS_0 –with no nitrogen (control), NS_1 – sole application of fertilizer N (160 kg ha^{-1}), NS_2 –NS_1 plus crop residue@ 6 Mg ha^{-1}, NS_3 – 75% of NS_1 (120 kg ha^{-1}) and 25% N (40 kg ha^{-1}) as FYM and NS_4 – 75% of NS_1 and 25% N as vermicompost in the sub-plots and each replicated thrice. A uniform dose of P (50 kg P ha^{-1}) and K (100 kg K ha^{-1}) was applied to all treatment plots in maize crop. AT was superior to other tillage methods producing 8.26 Mg ha^{-1} average grain yield, the lowest being with ZT (7.91 Mg ha^{-1}). Among N treatments, NS_4 produced the highest mean yield (10.01 Mg ha^{-1}) irrespective of tillage practices. Dehydrogenase (DHA) and urease (Uase) at 0-10 cm soil depth attained their maximum values (27.52 mg TPF $kg^{-1}day^{-1}$ and 32.37 mg NH_4-N kg^{-1} hr^{-1} respectively) due to NS_4, while the highest average acid phosphatase (APase) was obtained due to NS_2. MBC content in post-maize soil was maximum (543.93 mg kg^{-1}) at 0-10 cm depth under ZT and varied significantly from both CT and AT. Total soil carbon was higher in AT over ZT. Maximum MBN (25.19 mg kg^{-1}) was noted under AT practice. Practically no change in total soil N was seen. Combined application of organic-based N sources under AT resulted to produce higher maize yield, enzyme activities, MBC, MBN and total C in post-maize soil.

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Influence of Land Configuration Techniques and Weed Management on Biological Properties of Soil and Productivity of Soybean in Inceptisols

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An investigation on "Influence of land configuration techniques and weed management on biological properties of soil and productivity of soybean in Inceptisols" was conducted at Research Farm of All India Coordinated Research Project on Weed Management, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2019-20. The five weed control practices were superimposed in four strips of different tillage practices. The experiment was laid out in strip plot design with three replications. The soil of the experimental plot was alkaline in reaction and low to medium in organic carbon. The available nitrogen and phosphorus was low and potassium was high to very high. Soil biological properties were assessed after eight and thirty days of spraying of weedicide. The individual and interaction effect of tillage and weedicide were assessed on physical and biological properties of soil. Similarly, the yield of soybean was also recorded. The results reveal that the bulk density of soil was significantly influenced due to tillage and weed management practices. The highest bulk density was noted with zero tillage (1.46 Mg m^{-3}). The highest bulk density (1.46 Mg m^{-3}) was registered in weedy check. The highest MWD (0.75 mm) was enumerated with minimum tillage and hand weeding management practice (0.75 mm). The interaction of tillage and weed management practices showed non-significant results in respect of soil physical properties. In respect of biological properties , the highest count of fungi (13.65 cfux 10^4 g^{-1} soil), bacteria (37.10 cfu x 10^7 g^{-1} soil), actinomycetes (18.26 cfu x 10^6 g^{-1} soil), urease (68.43mg NH_4 kg^{-1} 24 hr^{-1}) and alkaline phosphatase (131.93 µ p-nitrophenol g^{-1} 24 hr^{-1}) were recorded in minimum tillage. The significant change in fungi (16.21cfux 10^4 g^{-1} soil), bacteria (37.62cfu x 10^7 g^{-1} soil), actinomycetes (17.70 cfu x 10^6 g^{-1} soil), urease (69.60 mg NH_4 kg^{-1} 24 hr^{-1}) and alkaline phosphatase (139.34 µ p-nitrophenol g^{-1} 24 hr^{-1}) were registered in weedy check treatment. However, the highest grain yield (22.96 q ha^{-1}) of soybean was observed with conventional tillage. The minimum disturbance to soil through various tillage practices and adoption of hand weeding has evolved promising findings towards long term sustainability of soil.

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Studies on Sulphur Fractions and their Correlation with Soil Properties in Calcareous Soils of Bihar

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With the introduction of high yielding varieties, more irrigation facilities and use of high analysis sulphur free fertilizers, depletion of sulphur in soil has been observed in various parts of the country. The studies are important to know the level of sulphur, their fraction and corelations with soil properties in calcareous soils of Bihar. Altogether, thirty surface soil samples, ten samples from each upland, midland and lowland topography were collected before onset of monsoon 2019 from Dholi Kothi Farm of Tirhut College of Agriculture, Dholi. The soil samples were analysed for important physico-chemical properties as well as different sulphur fractions using the standard procedure. The values of correlation coefficient between soil properties and forms of sulphur without considering topography shows that sand content was significantly and negatively correlated with all the forms of sulphur while it showed significance at only 5 percent level of significance with water soluble sulphur. Silt showed significantly positive correlation with all the forms of sulphur except non-sulphate sulphur. Clay was found positively correlated with all the forms of sulphur except non-sulpahte sulphur. pH and EC showed negative correlation with all the forms of sulphur except non-sulphate sulphur. Organic carbon, $CaCO_3$, CEC, total nitrogen, dehydrogenase and arylsulfatase showed positive correlation with all the forms of sulphur except non-sulphate sulphur. In the study, organic carbon of the surface soil exhibited positive and significant correlation with all forms of sulphur except water soluble and sulphate sulphur, indicates towards urgent changeover in management practices for organic carbon build up in calcareous soils of Bihar.

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Effect of Technology Demonstration of Field Pea on Productivity, Profitability and Soil Health under Lateritic Soil of West Bengal

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Cluster Front Line Demonstration (CFLD) on Field Pea were conducted during 2015-16 to 2018-19 at Birbhum district by Rathindra Krishi Vigyan Kendra, Palli Siksha Bhavana, Visva-Bharati, Sriniketan under lateritic soil with pH of 5.5-6.2. The improved variety Rachna of field pea was demonstrated against the local check variety (Gheso Motor). Beside that the post emergence herbicide Fenoxaprop-P-ethyl and foliar spray of micro nutrient Boron-20 were applied against the farmers' practice (no herbicide & no micronutrient). From the four years' average data, it is observed that demonstration of the technologies increased the number of branches per square metre (528), number of nodules per square metre (4455), and average yield (1.06 t ha^{-1}) of field pea in Birbhum district. The Benefit : Cost (B:C) ratio of demonstration has been gradually increased up to 4.0. More over technology demonstration on field pea increased available nitrogen content in soil and added average 101.5 kg N ha^{-1} $year^{-1}$ in the soil and thus maintained the soil health.

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Depth-wise Distribution of Different Fractions of Zn and Fe under Long-term Fertilization and Manuring in Pearl Millet-Wheat Cropping System

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In the present scenario of degrading soil health and produce quality due to intensive agricultural practices, the proposed hypotheses are aimed at integrated nutrient managements. Under a long-term fertilizer investigation including organic and inorganic nutrient applications, the soil profile was studied for the dynamics of zinc (Zn) and iron (Fe). The experiment included the seasonal application of different levels of FYM (0, 5, 10 and 15 Mg ha^{-1}) and nitrogen (0, 60 and 120 kg ha^{-1}) laid out in split plot design. In view of the objective of determining the sequential extraction of different fractions of Zn and Fe, the residual fraction was found maximum for both Zn (170.50, 130.70 and 88.00 mg kg^{-1}) and Fe (1.37, 0.90 and 0.63 %) under the application of FYM @ 15 Mg ha^{-1} along with nitrogen @ 120 kg ha^{-1} in 0-15, 15-30 and 30-45 cm soil depths respectively showing a declining trend with increasing depths. The various fractions of Zn and Fe increased with the increasing levels of FYM and nitrogen in both single as well as dual season applications as compared to control. In addition, among the different fractions, the residual fraction of both Zn and Fe contributed maximum to the total Zn and Fe content respectively while the most labile pool including both water soluble plus exchangeable and specifically adsorbed fractions showed minimum contribution. The present study came up with the conclusion that the long term application of FYM and nitrogen significantly increased the total Zn and Fe content in the soil.

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Impact of Organic Manures and Biofertilizers on Soil Properties and Productivity of Mustard

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In order to assess the impacts of organic manures and bio-fertilizers on soil properties and productivity of mustard, a field experiment was conducted at Deendayal Upadhyay Centre of Excellence for Organic Farming (DDUCE-OF), CCSHAU, Hisar during 2020-21. The experiment was laid out in Randomized Block Design (RBD) replicated thrice with eight treatments viz. 100% RDN through Farm Yard Manure (FYM), Vermicompost (VC), Poultry Manure (PM) alone and along with biofertilizer (BF) and Cow based Bio-Formulation. The results showed that treatment 100% RDN through PM+BF produced significantly higher seed and stover yield of mustard, total NPK content and their uptake in seed and stover of mustard which was at par with treatment 100% RDN through VC+BF and 100% RDN through FYM+BF. Maximum seed and stover yield (29.84 q ha^{-1} and 74.75 q ha^{-1}) were obtained under treatment 100% RDN through PM+BF. However, minimum seed and stover yields (23.41 q ha^{-1} & 64.09 q ha^{-1}) were obtained from the control, where there was no application of organic manure. Similarly, highest total N, total P and total K uptake (116.2 kg ha^{-1}, 19.9 kg ha^{-1} and 83.5 kg ha^{-1}) were recorded in the treatment 100% RDN through PM+BF. The highest soil restorative effect *i.e.* soil organic carbon (0.67%), available N (162 kg ha^{-1}), available P (13.7 kg ha^{-1}) and available K (280 kg ha^{-1}) were observed under treatment 100% RDN through PM+BF. The regular addition of organic materials to the soil is the only way to maintain and increase the level of carbon that can be absorbed by the soil and this is the basis of organic farming. In order for farming to help mitigate the potential for devastating environmental effects, we need to move to modern organic methods.

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Effect of Organic Manures and Biofertilizers on Soil Properties and Productivity of Desi Wheat

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Since the last couple of years, the agricultural paradigm has been shifting from inorganic to organic practices because of growing awareness about soil health, environment, ecosystem and human health concerns among the farmers. In order to assess the effect of organic manures and biofertilizers on soil properties and productivity of desi wheat, a field experiment was conducted at DDUCE-OF, CCSHAU, Hisar during 2020-21. The experiment was laid out in RBD replicated thrice with eight treatments *viz.* 100% RDN through FYM, Vermicompost (VC), Poultry Manure (PM) alone and along with Biofertilizer (BF) and Cow based Bio-Formulation. The results revealed that organic treatments had significant influence on plant physiological parameters, grain and straw yield of wheat as compared to control. Maximum grain and straw yield (31.33 q ha^{-1} and 47.92 q ha^{-1}) of wheat were obtained under treatment 100% RDN through PM+BF. However, minimum grain and straw yields (24.58 & 41.08 q ha^{-1}) were obtained in the control. Among various organic treatments, 100% RDN through PM+BF produced significantly higher N, P and K content and their uptake in wheat grain and straw which was at par with treatment 100% RDN through VC+BF and 100% RDN through FYM+BF. Highest total N, P and K uptake (91.70 kg ha^{-1} for Total N, 15.63 kg ha^{-1} for Total P and 82.23 kg ha^{-1} for Total K) were recorded under treatment 100% RDN through PM+BF. The highest SOC (0.68%), available N (157 kg ha^{-1}), available P (12.7 kg ha^{-1}) and available K (272 kg ha^{-1}) were observed under treatment 100% RDN through PM+BF. The findings of the trial suggested that soil properties and crop productivity may be improved significantly by the application of various organic manures alone and along with biofertilizers for longer time and could be more effective and sustainable for environment and agriculture.

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Effect of Integrated Nutrient Management on Soil Health of Pomegranate (*Punica granatum* L.) Orchard

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The present investigation entitled "Studies on Effect of Integrated Nutrient Management on Soil Health, Disease Resistance and Nutrition of Pomegranate (*Punica granatum* L.) Orchards" was carried out during the year 2017-18 and 2018-19 on the research farm of College of Agriculture, Golegaon, Vasantrao Naik Marathwada Krushi Vidyapeeth, Parbhani. The experiment was planned in randomized block design with seven treatments *i.e.* T_1- Absolute Control, T_2- Farmer's Practices (½ RDF), T_3- RDF (625:250:250 g N, P_2O_5, K_2O $tree^{-1}$), T_4- INM (15 kg FYM + 8 ml *Azotobactor*, 8 ml PSB, 100 g *Trichoderma* + RDF), T_5- RDF + Antibiotics (Streptocycline @ 250 ppm), T_6- T_4 + Antibiotics, T_7- T_4 + Umber (*Ficus racemosa)* Rhizosphere Hybridised Soil (URHS @ 25 kg per tree) and four replications.The result revealed that organic carbon was improved significantly due to application of FYM @ 15 kg, *Azotobacter* @ 8 ml per tree, PSB@ 8 ml per tree and *Trichoderma* @ 100 g per tree, 625:250:250 g N, P_2O_5 and K_2O per tree and 25 kg URHS (T_7). Soil pH, EC and calcium carbonate content were not reached to the significance level. The highest organic carbon content was recorded in surface and subsurface soil, due to application of treatment T_7 at flowering. Also the same treatment registered maximum available nitrogen, phosphorus and potassium at flowering and harvesting at 0-22.5 and 22.5-45 cm depth, which was superior over all the treatments.

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A Comparison of Four Extractants for Soil Zinc in Rice Soils of West Bengal

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30 soil samples collected from different agro-climatic zones of West Bengal covering 30 blocks were compared for assessing the suitability of extractant for determination of available zinc (Zn) in rice growing soils of West Bengal. Rice was grown in pots and also analysed for Zn which was later co related with the soil available values. The greenhouse experiment was conducted at the Central Research Farm of Bidhan Chandra Krishi Viswavidyalaya at Gayeshpur, Nadia in 2015 during Kharif. Soil was treated with two Zn doses *viz.*, 0 and 5.0 kg Zn ha^{-1} through $ZnSO_4.7H_20$. Diethylene triamine penta acetic acid (DTPA), ammonium bicarbonate- diethylene triamine penta acetic acid (AB-DTPA), 0.05M HCl and Mehlich-3 were the extractants used. Efficiency of the extractants tested was in the order: Mehlich-3 > 0.05M HCl > AB-DTPA > DTPA in context to extractability. Zn in soil extracted with AB-DTPA gave the best correlation with the zinc content and yield attributes of the crop.

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Effect of Different Residue Management Practices and Fertilizers Level on Soil Properties after Rice Harvest under Rice-Wheat Cropping System

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An experiment on residue management was conducted during *Rabi,* 2018-19 and 2019-20 at Research Farm KVK, Panipat, CCS Haryana Agricultural University to study the effect of residue management options and fertilizer levels on soil properties and crop productivity under rice wheat cropping system. The experiment was laid out in spilt plot design consisted 4 residue management practices (R_1: Residue removal, R_2: Residue Burning, R_3: Residue Incorporation and R_4: Residue Retention ,Direct seeding of wheat with happy seeder into rice stubbles) in main plot and with five fertilizers level (F_1: Control, F_2:100% N + 50% RD of P&K, F_3: 100% N + 75% RD of P&K and F_4:100% N+75% RD of P&K+ Waste decomposer and F_5:100% of RDF) in sub-plot.The post-harvest available N.P and K content in soil varied from 115 to 129 and 113 to 134, 24.6 to 44.2 and 25.2 to 48.2 and 175 to 193 and 176 to 196 kg ha^{-1}, respectively among different treatment combination during 2019 and 2020, respectively. Result showed that available nutrient status in soil followed the order retention> incorporation> burning> removal under residue management and 100% RDF>100% N+75% RD of P&K> 100% N + 75% RD of P&K>100% N + 50% RD of P&K> control in case of fertilizer levelduring both years. Higher value of SOC (0.680 and 0.694 %) was reported with the retention treatment while mean value of DOC (418 and 540 mg/kg) recorded higher under incorporation during both the year.

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Soil Organic Carbon Fractions Influenced by Rice Residue Management Options under Rice-Wheat Cropping System

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A field experiment was conducted at research farm, KVK, Panipat, CCS Haryana Agricultural University, Hisar during the 2018-19 and 2019-20 with the objective to study the impact of rice residue management options and fertilizer doses on soil organic carbon and its fraction after harvesting of rice during both the years. Treatment consist of four rice residue management practices (R_1: Residue removal, R_2: Residue Burning, R_3: Residue Incorporation and R_4:Residue Retentionand direct seeding of wheat with happy seeder into standing rice stubbles) in main plot and different doses of NPK fertilizers (F_1: Control, F_2:100% N + 50% Recommended dose of P&K, F_3:100% N + 75% RD of P&K, F_4:100% N 75% RDF+ Waste decomposer and F_5:100% Recommended dose of NPK fertilizer) in sub main plot. The highest value of TOC (0.800 and 0.814%) and SOC (0.680 and 0.694%) was reported with residue retention followed by incorporation, burning and removal during 2019 and 2020, respectively. Fertilizer level showed significant difference on TOC and SOC and higher value reported with 100% RDF fertilizer level. Result also revealed that less labile, very labile and recalcitrant carbon fraction was significantly affected by residue management during both the year while labile carbon significantly affected by residue management during first year. Similarly fertilizer treatments significantly influenced all fractions during first year where as very labile and recalcitrant during second year.

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Improved Crop Establishment Methods and Nutrient Management Improves Productivity and Income of Rice Cultivation under Salt-affected Soils of West Coast Region of India

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The extent of the salt-affected soils in the coastal region of India is 2.50 million hectares (mha), of which 1.82 mha is saline and 0.67 mha) is sodic (Mandal *et al.*, 2018). In the salt-affected soils of west coast region, rice is the most prevalent crop on these soils and its productivity is poor (1.0-1.5 t ha^{-1}). Management of the salinity is a herculean task as the source of salinity is the ingression of the saline water from sea and estuaries and shallow saline groundwater table. Thus, management practices suitable for salt-tolerant rice varieties were needed to improve rice productivity and income. A package of practice on the crop establishment methods (broadcasting and transplanting) and integrated nutrient management for improving the productivity and income through the cultivation of the salt-tolerant rice varieties (Goa Dhan 1, Goa Dhan 2 and Goa Dhan 3) on salt-affected soils of the west coast region was standardized and developed. The package of practice comprised of a method of seed treatment of the of seeds of salt-tolerant rice varieties with Goa Bio - 1 (a talc-based & salt-tolerant bioformulation of *Bacillus methylotrophicus* STC-4) at 40 g kg^{-1} seed, nursery treatment of the seedling at 50 g/m^2 and transplanting of 35-days old seedlings, application of revised and modified fertilizer recommendations of 120:30:0:4:2 N:P_2O_5:K_2O:Zn:B kg ha^{-1} (omission of K to reduce the cost of fertilizer) and its split application and other plant production practices. The package of practice on effect nutrient management strategy, crop establishment methods and variety were significant on the grain yield, straw yield, net income and benefit to cost ratio over the farmer's practice of cultivation. Significantly higher grain (2.87 t ha^{-1}), straw yield (4.52 t ha^{-1}), net income (Rs. 33427 ha^{-1}) and benefit to cost ratio (2.04) was achieved with the transplanting 35-days old Goa Bio-1 nursery treated seedling than the broadcasting (2.44 t ha^{-1}, 3.11 t ha^{-1}, Rs. 27679 ha^{-1} and 1.98). The variety, Goa Dhan 3, outperformed Goa Dhan 1 and Goa Dhan 2 with the highest grain yield (3.51 t ha^{-1}), net income (Rs. 48727 ha^{-1}) and benefit to cost ratio (2.56). The performance with respect to the net income and benefit to cost ratio the order was observed as Goa Dhan 3 > Goa Dhan 2 > Goa Dhan 1. A package of the practice of transplanting of 35-days old Goa Bio 1 nursery treated seedling of an improved salt-tolerant rice variety with soil test-based fertilizer recommendation or modified blanket fertilizer application has been identified to improve the productivity and income for paddy cultivation under salt-affected soils of the coastal region. Further, a package of practice was demonstrated over 29 ha area for two consecutive years and it generated a total income of Rs. 13.12 Lakhs using the improved method of cultivation as against the farmer method with Rs. 9.53 Lakhs. The net income from the farmers' practice was Rs. 32,862/ha whereas the improved practice yielded a net income of Rs. 45,275 ha^{-1}, which amounted to an additional income Rs. 12,413 ha^{-1}, 38% higher than the farmers' practice.

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Fertilizer Calculator - New! An android Mobile Phone App: An Innovative Tool for Soil Test-based Fertilizer Recommendations to Different Crops

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Multi-nutrient deficiency in soils is one of the major constraints to crop production in India and other countries of the world. The imbalanced use of the fertilizer nutrients coupled with multi-nutrient deficiency warrants the need for a decision-making tool on the soil test-based fertilizer recommendations to different crops to improve the productivity and income of the farmers. A 'Fertilizer calculator – New!' was developed to enable farmers' decision-making on the soil test-based fertilizer application to different crops of the coastal region. It is a completely offline app for which can be used to calculate the amounts of the desired fertilizers based on with or without soil testing values. The recommendations can be obtained by feeding inputs such as area (ha, acre, etc.) or a number of trees, recommended doses of fertilizer nutrients for a given crop, soil testing report values (optional) and desired fertilizer grades. It calculates the amounts of both macro and micronutrients recommendation. The app has a feature to share the final results in a form of advisory and recommendations which can be shared with the farmers through messaging and social media apps. The tool enables the use of the right amount, right source and right time and method of application of the fertilizer nutrients. The results would help to use the fertilizer in an appropriate amount and in a balanced way. The link to download the app is https://play.google.com/store/apps/details?id=in.res.ccari.fertcalc&hl=en_IN. The number of downloads and installs of the apps since uploading the app is 2410 in just 6 months (December 2020) from launching. The rating of the app is 4.5 out of 5.0. The technology reduces the fertilizer cost from 2.0-13.0% with 24.0-37.50% increase in paddy and coconut yield through balanced use of fertilizers inputs.

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Potassium Nutrition Affecting the Growth and Yield Parameters of Summer rice (*Oryza sativa*)

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An experiment was conducted at the agricultural farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar during the years 2018 and 2019 to determine the effects of Potassium on growth and yield parameters of Summer rice. The experiment was carried out with eight treatment combinations [T_1: Farmer's practice ($N:P_2O_5:K_2O$ as 120: 60: 60 kg ha^{-1}); T_2: RD (Recommended dose) of $N:P_2O_5:K_2O$ (140: 70: 70 kg ha^{-1}); T_3: NP(RD) + K0 (Control); T_4: NP (RD) + 125% of the RD of K; T_5: NP (RD) + 150% of the RD of K; T_6: NP (RD) + 55% of the RD of K was replaced by Vermicompost; T_7: NP (RD)+ 110% of the RD of K replaced by crop residue (rice straw); T_8: Nutrient expert software-based Potassium recommendation ($N:P_2O_5:K_2O$ as 141: 44: 80 kg ha^{-1})]. The growth and yield parameters of the crop such as number of tiller/m^2, number of panicle/m^2, number of grains/panicle and harvest index were significantly affected by the added potassium fertilizer. It was observed that, maximum grain yield (6.34 t ha^{-1}) was obtained by 150% of the RD of potassium fertilization (T_5) with constant levels of nitrogen and phosphorus which was statistically at par with the treatments T_4 and T_8. The highest straw yield (11.77 t ha^{-1}) was achieved by 150% of the RD of potassium fertilization (T_5) with constant levels of nitrogen and phosphorus which was enhanced with higher level of potassium. Hence, the potassium for rice should be included at proper doses to achieve the target yield of rice and to maintain the K^+ balance in soil.

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Effect of Conservation Tillage and Organics on Productivity of Cotton and Soil Properties under Vulnerable Climatic Conditions of Vidarbha

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An investigation on "Effect of conservation tillage and organics on productivity of cotton and soil properties under vulnerable climatic conditions of Vidarbha" during the year 2017-18"at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was framed with object to assess the influence of conservation and conventional tillage on properties of soil and seed cotton yield by adopting low external inputs techniques.The experiment having the history of six years comprises two sets i.e. conservation tillage (one harrowing and two weeding) and conventional tillage (one ploughing and one harrowing, two hoeing and two hand weeding) were laid out with eight sub plot treatments consisting of control, 100 per cent RDF and use of chemical fertilizer along with organic source of nutrient in which 50 per cent N applied through organic sources (*viz*. FYM, Wheat straw, Green leaf manuring, Cotton stalk, Vermicompost and Phosphocompost). An application of FYM, Gliricidia leaf manuring, Vermicompost and Phosphocomopst in conjunction with chemical fertilizers recorded significant changes in soil properties as compared to the sole use of chemical fertilizers and control under conservation tillage. The chemical properties like soil organic carbon, available macro and secondary nutrients were enhanced under conservation tillage. The Highest seed cotton yield was recorded under conservation tillage using phosphocompost and vermicompost in conjunction with chemical fertilizers. The reduced tillage (Conservation agriculture practice) showed promising results in respect of soil properties and yield of Cotton. Therefore, it can be concluded that combined and consistent use of organic inputs (FYM, Green leaf manuring, Phophocompost) along with 50% recommended dose of inorganic fertilizers under conservation tillage is the advisable way to maintain the biological sustainability of soil. Equally, it exclusively help to minimize the use of external inputs for enhancing productivity of crops under changing climatic scenario.

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Identification of Key Soil Health Indicators and Establishment of their Critical Limits in Upper Indo-Gangetic Plains

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Soil degradation both in irrigated and rain-fed agro-ecosystems is a major threat to agricultural sustainability and environmental quality in India. It is mainly due to intensive cultivation and overuse of chemical fertilizers and agrochemicals. Therefore, assessment of soil health and identification of key indicators with their critical limits are very important for taking necessary rehabilitation measures. The present investigation was undertaken to develop soil health indices and to identify sensitive soil health indicators with their critical limits using data collected from farmers' fields growing different long-term rice and vegetable based cropping systems in Modipuram district of Uttar Pradesh. Soil samples were collected after harvesting of wet season crops and analysed for 21 physical, chemical and biological attributes of soil. Principal component analysis (PCA) was used to create minimum data set of physical, chemical and biological indicators which were encompassed to develop unified soil health index (SHI) under different cropping systems. The key indicators selected were soil organic carbon (SOC), available Cu, available Mn, bulk density, alkaline phosphatase, dehydrogenase and urease activity of soil. The value of SHI developed was varied from 0.48 to 0.83. The critical limits for key indicators under various sites were determined using regression equation between relative yields with different indicator values. The critical limit equivalent to 80% and 40% of relative yield are the optimum and threshold values of selected key indicators. The critical limits established for key soil health indicators as well soil health index could periodically be judged for maintaining/enhancing soil health and yield sustainability through the employment of optimum management practices in upper IGP.

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Impact of Microbial Intervention and Liming on Transformations of Phosphorus in Relation to its Availability to Soybean (*Glycine max*) in an Ultisol

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Phosphorus deficiency is quite common in agricultural soils throughout the world. Although most of the soils contain appreciable amount of total P, but the concentration of P in available form is usually very low. Therefore, water soluble phosphatic fertilizers are used in intensive agriculture to meet the crop demand, which results in a huge build-up of P in soil in fixed or unavailable form as the use efficiency of applied P fertilizers seldom exceeds 20%. Utilization of this fixed P in soil is an urgent need as the reserves of rock phosphate, the raw material of phosphatic fertilizer production are declining rapidly. Laboratory incubation as well as green-house experiments were conducted in a bulk surface of Assam (order- Ultisol, pH = 4.23) having low available P status (8.59 kg ha^{-1}) to solubilize the fixed P in soil using lime ($CaCO_3$) and phosphate solubilizing microorganisms (PSMs). Pure cultures of phosphate solubilizing bactria (PSB), *Enterobacter* sp. and phosphate solubilizing fungi (PSF), *Aspergillus niger* were used. Based on the results of incubation study, treatments were selected for green-house experiment. In green-house experiment, different levels of P, lime and PSF were applied and soybean was grown in pots. Sequential P fractionation was done in the post-harvest soil. Positive growth response of soybean crop was obtained due to the application of P, lime and PSF. Application of P increased almost all the inorganic P fractions in soil. Liming as well as PSF application individually increased soluble and loosely bound P and decreased aluminium and iron bound P fractions in soil. Soluble and loosely bound, iron bound, occluded, calcium bound and residual P contributed positively towards dry matter yield of soybean.

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Silicon-rich Agro-wastes Facilitates Phosphorus (P) Availability in a Tropical Alfisol

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The need of the hour is to find out alternative sources of Si for application in farmlands for utilization of native P reserves in soils; and such sources should simultaneously be cost-effective, environment-friendly and sustainable. Sugarcane bagasse ash (SBA), rice husk ash (RHA) and corn cob ash (CCA) are the examples of such Si-rich wastes, produced in large quantities in developing countries like India. An incubation study was carried out in an Alfisol of Ranchi, Jharkhand to assess the release kinetics of native soil P as affected by these wastes for 90 days at 35°C maintaining field capacity soil moisture. A pot culture experiment was also conducted using these wastes along with seed treatment by phosphate solubilizing bacteria (PSB) and wheat (*Triticum aestivum*) was grown as a test crop. In case of incubation study, a significant increase was observed in cumulative P release due to the application of the Si-rich wastes over control. Cumulative P release under SBA, RHA, and CCA were ~ 1.37, 1.48, and 1.55 times greater than control, correspondingly during 90 days of incubation. However, rate of P solubilization under SBA, CCA, RHA was ~1.04, 1.34, and 1.13 times higher as compared to control. Moreover, potentially available P for those treatments were ~ 15.9, 25.4, 22.8% higher than the control, respectively. The total biomass yield (grain + straw) increased by 43%, 54%, and 59%, over control upon application of SBA, RHA and CCA, respectively. Hence, Si-rich agro-wastes could be utilized to exploit the service of native P in sustainable crop production.

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Effect of Conservation Agriculture Practices on Temperature Sensitivity of Aggregate Associated Soil Organic Carbon Mineralization

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Conservation agriculture (CA) offers an excellent crop residue (CR) management strategy, wherein CR serves as a resource for C sequestration and better soil aggregation. Nevertheless, CR load needs to be standardised under CA. The decomposition rate of SOC largely depends on temperature, hence it is interesting to study the influence of raised temperature on SOC associated with various soil aggregate size fractions. In the present study, post wheat harvest soil samples were collected from an on-going field experiment on CA having three levels of CR retention, under maize-wheat-mungbean cropping system. Results indicated significant improvement in total SOC and its' pools of varying oxidizability consequent to increment in CR load. Treatment CR_4 (CR retention @ 4 t ha^{-1}) had the highest macro-aggregate percentage followed by CR_2 (CR retention @ 2 t ha^{-1}) and CR_0 (no CR retention), whereas an opposite trend was recorded for soil micro-aggregate percentage, implying accumulation C-rich macro-aggregates under CR retained plots, with a subsequent depletion of micro-aggregates. Both macro-aggregate and micro-aggregate associated C followed the trend $CR_4 > CR_2 > CR_0$. Micro-aggregates had higher percentage of total SOC mineralized, decay rate (Kc) and temperature sensitivity (Q_{10}) compared with bulk soil and macro-aggregates. The CR_4 had lower percentage of total SOC mineralized and Kc compared with that under CR_0 treatment for both aggregate fractions. Treatment CR_4 registered lesser Q_{10} for macro-aggregate associated SOC, compared with CR_0 in 0-5 cm soil layer. Decay rate of SOC mineralization was drastically reduced by increments in CR loads, indicating higher C stability by means of greater physical protection through soil aggregates. The C stabilized in residue-retained plots of CA was found to be physically protected, especially inside macro-aggregates, and more importantly temperature insensitive. Therefore, in the present global warming scenario, CA holds the key for effective C capture from the environment.

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Effect of Phosphorus Biofertilizers on Fractions of Soil P Under Maize (*Zea mays* L.)

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A field experiment entitled "Effect of phosphorus biofertilizers on dynamics and fractions of soil P and performance of maize (*Zea mays* L.)" was conducted at Agricultural College Farm, Bapatla during *kharif*, 2019. The experimental soil was clay in texture, slightly alkaline in nature, non-saline, medium in organic carbon, medium in available nitrogen, high in available phosphorus, high in potassium and sufficient in all micro nutrients (Zn, Fe, Mn and Cu). The experiment was laid out in RBD with nine treatments replicated thrice. The treatments comprised of T_1- Control (without P), T_2 - 100% Recommended Dose of Phosphorus (RDP), T_3 - 100% RDP + PSB @ 1 L ha^{-1}, T_4 - 100% RDP + VAM @ 12.5 kg ha^{-1}, T_5 - 75% RDP + PSB @ 1 L ha^{-1}, T_6 -75% RDP + VAM @ 12.5 kg ha^{-1}, T_7 – PSB @ 1 L ha^{-1}, T_8 - VAM @ 12.5 kg ha^{-1}, T_9 - PSB @ 1 L ha^{-1} + VAM @ 12.5 kg ha^{-1}. The P fractions (saloid-P, Al-P, Fe-P, Ca-P and total-P) were significantly influenced by application of 100% RDP. Available P and Saloid-P were higher in surface soil (0-15cm) than sub surface soil (15-30cm) and were significantly influenced by application of 100% RDP along with biofertilizers. The highest saloid phosphorus (17.6,19.4 and 21.1 mg kg^{-1}) was recorded in the treatment 100% RDP + VAM @ 12.5 kg ha^{-1} (T_4) and followed by 100%RDP + PSB @ 1 L ha^{-1} (T_3) (15.1, 16.7 and 17.8 mg kg^{-1}) at knee high, tasseling and harvest.The highest Al-P (87.7, 92.3 and 94.8 mg kg^{-1}), Fe-P (79.6, 82.8 and 86.9 mg kg^{-1}) Ca-P (242.3, 245.1 and 247.7 mg kg^{-1}) were recorded in treatment 100% Recommended Dose of Phosphorus (RDP) (T_2) at knee high, tasseling and harvest stages respectively.. The highest total-P (644, 663 and 694 mg kg^{-1}) was also recorded in treatment 100% Recommended Dose of Phosphorus (RDP) (T_2) at knee high, tasseling and harvest stages respectively. The lowest Al-P, Fe-P and Ca-P recorded in T_9 (PSB@ 1 L ha^{-1} + VAM@ 12.5 kg ha^{-1}) might be due to organic acid production in soil by P-solubilizing microorganisms which leads to release of phosphorus from different pools either by lowering the pH, or by enhancing chelation of the cations bound to P or by competing with P for adsorption sites on the soil or by forming soluble complexes with metal ions associated with insoluble P (Ca, Al, Fe) and thus P is released.

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Effect of Phosphorus Biofertilizers on Nutrient Uptake in Maize (*Zea mays* L.)

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A field experiment entitled "Effect of phosphorus biofertilizers on dynamics and fractions of soil P and performance of maize (*Zea mays* L.)" was conducted at Agricultural College Farm, Bapatla during *kharif*, 2019. The experimental soil was clay in texture, slightly alkaline in nature, non-saline, medium in organic carbon, medium in available nitrogen, high in available phosphorus, high in potassium and sufficient in all micro nutrients (Zn, Fe, Mn and Cu). The experiment was laid out in RBD with nine treatments replicated thrice. The treatments comprised of T_1- Control (without P), T_2 - 100% Recommended Dose of Phosphorus (RDP), T_3 - 100% RDP + PSB @ 1 L ha^{-1}, T_4 - 100% RDP + VAM @ 12.5 kg ha^{-1}, T_5 - 75% RDP + PSB @ 1 L ha^{-1}, T_6 -75% RDP + VAM @ 12.5 kg ha^{-1}, T_7 – PSB @ 1 L ha^{-1}, T_8 - VAM @ 12.5 kg ha^{-1}, T_9 - PSB @ 1 L ha^{-1} + VAM @ 12.5 kg ha^{-1}. At knee high, tasseling and at harvest stage(kernel and stover) respectively, the highest nitrogen uptake (44.60, 91.44, 81.80 and 42.03 kg ha^{-1}), phosphorus uptake (6.89, 12.35, 11.58 and 4.68 kg ha^{-1}), potassium uptake (49.94, 92.62, 91.51 and 18.89 kg ha^{-1}) and sulphur uptake (4.39, 8.71, 15.89 and 5.63 kg ha^{-1}) were recorded with application of 100% RDP + VAM @ 12.5 kg ha^{-1} (T_4) which was on par with 100% RDP + PSB @ 1 L ha^{-1} (T_3) and 100% Recommended Dose of Phosphorus (RDP) (T_2). The lowest nutrient uptake was recorded in Control (without P) (T_1). The highest zinc uptake (61.45, 127.59, 105.69 and 168.19 g ha^{-1}), iron uptake (199.98, 345.00, 165.39 and 347.70 g ha^{-1}), manganese uptake (86.32, 166.30, 85.00 and 174.99 g ha^{-1}) and copper uptake (36.64, 72.85, 32.07 and 60.38 g ha^{-1}) at knee high, tasseling, kernel and stover at harvest, respectively were also recorded with application of 100% RDP + VAM @ 12.5 kg ha^{-1} (T_4).

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Split Application of Slag-based Gypsum on Yield of Groundnut and Soil Properties in Acid Soils

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Slag based gypsum (SBG) is a value added product of iron and steel industry. Application of gypsum as source of calcium and sulphur for groundnut cultivation is common practice and mainly applied during peg initiation stage of groundnut. However, its effect is mainly influenced by the type of soil and dissolution of gypsum, which influences the yield and quality of groundnut. Hence, field experiments were conducted to know the effect of application of SBG as basal and basal + split on soil properties, yield and quality of groundnut in acidic soil. Study conducts of seven treatments which includes recommended dose of fertilizer (RDF) with three levels of SBG (375, 500 and 625 kg ha^{-1}) applied as basal and basal + split and 500 kg commercial gypsum ha^{-1} applied as basal dose according to package of practice (POP) of University of Agricultural Sciences, Bangalore by using randomly complete block design at Agricultural Research Station, Balajigapade during *kharif* - 2018 and 2019. The pooled data of two field experiments on groundnut revealed that application of RDF + 625 kg SBG ha^{-1} as 50% at sowing + 50% at 30 days after sowing (DAS) recorded higher pod (2.80 t ha^{-1}), haulm (5.45 t ha^{-1}) and oil (885.37 kg ha^{-1}) yield when compared to other treatments. There was increase in pod, haulm and oil yield of groundnut by 12.02, 13.94 and 24.06%, respectively with the application of 625 kg SBG ha^{-1} (50% at sowing + 50% at 30 DAS) over POP. Application of SBG significantly increased the availability of nutrients in post harvest soils than commercial gypsum. Higher benefit cost ratio (3:1) was noticed in the treatment which received RDF + 625 kg SBG ha^{-1} as 50% at sowing + 50% at 30 DAS when compared with POP (2.70:1) applied treatments.

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Impact of Bio-enriched Farm Yard Manure on Soil Available Major Nutrients at Different Growth Stages of Finger Millet (*Eleusine coracana* (L.) Gaertn) under Dryland Condition

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Biofertilizers play a very significant role in improving soil fertility by increasing nutrient availability to plants. Application of enriched organic manure with biofertilizer can improve physico-chemical and biological conditions of soil. In this view, field experiment was under taken to study the "Impact of bio-enriched farmyard manure on productivity and soil properties of finger millet" at AICRP for Dryland Agriculture, GKVK, Bengaluru during *kharif* 2019. The experiment was laid out in a Randomized complete block design with factors consisting of four biofertilizer strains *i.e.,* B_1: N fixers + PGPR, B_2: P solubilizers + PGPR, B_3: K solubilizers + PGPR, B_4: Microbial consortia with two levels of fertilizers *i.e.,* L_1: 60 *per cent* RDF, L_2: 80 *per cent* RDF in three replications. The results revealed that among different bio-enriched FYM, enrichment with microbial consortia recorded significantly higher available nitrogen (186.95, 169.76 and 152.95 kg ha^{-1}), phosphorous (130.83, 124.13 and 118.80 kg ha^{-1}) and potassium (135.05, 124.58 and 116.13 kg ha^{-1}) at 60, 90 DAS and at harvest, respectively. Similarly, there was significant build-up of available nitrogen (181.64, 167.15 and 148.95 kg ha^{-1}), phosphorus (125.61, 120.68 and 120.68 kg ha^{-1}) and potassium (131.23, 123.12 and 113.81 kg ha^{-1}) with application of higher level of fertilizer *i.e.,* 80 per cent RDF at 60, 90 DAS and at harvest, respectively. But at 30 DAS, application of different bio-enriched FYM and levels of fertilizers showed no significant affect. Over all conjugative use of microbial consortia along with 80 per cent RDF recorded significantly higher available major nutrient concentration at different growth stages of crop, which improved uptake of these major nutrients and it was very much reflected in terms of higher yield.

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Major Nutrient Uptake by Finger Millet at Different Growth Stages as Influenced by Different Bio-enriched FYM and Levels of Fertilizers under Dryland Condition

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Dry land soils need addition of organic matter along with chemical fertilizer to maintain productivity and soil health, but crop suffers from the slow release of nutrients from organic manures at initial stages, which can be overcome by enrichment of organic manures with beneficial microbial culture and judicious combination of inorganic fertilizers with such enriched organic manures. In this view, field experiment was conducted during *kharif* 2019 at AICRP for Dryland Agriculture, GKVK, Bengaluru to study the effect of bio-enriched FYM *viz.*, nitrogen fixers, phosphorous solubilizers, potassium solubilizers, PGPR and microbial consortia with two levels of RDF *viz.*, 60 and 80 per cent on major nutrient uptake by finger millet at different growth stages, comprising of ten treatments replicated thrice in RCBD. The results revealed that combined use of microbial consortia bio-enriched FYM + 80% RDF proved to be the best treatment in term of higher uptake of nitrogen (6.33, 21.68 and 45.39 kg ha^{-1}), phosphorous (0.87, 3.95 and 9.85 kg ha^{-1}) and potassium (4.28, 18.58 and 41.98 kg ha^{-1}) at 30, 60 and 90 DAS, respectively. Similar was the trend at harvest with significantly higher uptake of nitrogen (41.27 and 29.31 kg ha^{-1}), phosphorus (11.33 and 10.07 kg ha^{-1}) and potassium (17.70 and 42.14 kg ha^{-1}) in grain and straw, respectively with application of higher level of fertilizer *i.e.,* 80 per cent RDF with microbial consortia enriched FYM. Over all conjugative use of microbial consortia enriched organic manure along with 80 per cent RDF was found to be suitable nutrient management strategy not only to enhance the yield but also improved nutrient uptake under dry land condition.

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Are All Three Pillars of Conservation Agriculture required for Resource-efficient Rice-based System?

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To overcome the adverse impact of puddling and mono-cropping of rice in conventional practices, conservation agriculture (CA) is introduced to bring sustainability to the rice-based cropping system in eastern India. The aim of the experiment is to study the impact of different components of conservation (minimum soil disturbance/reduce tillage (T), permanent soil covers through crop residues or cover crops (R), and crop rotations (D)) alone and in combination. The experiment was initiated in 2017 at a research plot of ICAR-National Bureau of Plant Genetic Resources farm NBPGR farm of NRRI, where treatments imposed were control, R, T, D, RT, TD, RD and RTD replicated thrice in randomized block design (RBD). Mainly a short duration (about 100 days) rice variety (sahabhagidhan) was grown along with green gram (IPM 2-3, duration about 80-90 days) during rabi season and rice variety Pooja was grown during *kharif* season. The highest yield of rice (pooja) was recorded in RD which is at par with TD and RTD. When Moong is grown in the diversification component in the succeeding season, the rice equivalent yield (REY) was lower than the rice as a sole crop. On system basis, higher energy productivity and energy ratio was recorded in the TD which is the most energy-efficient system. During the cropping period weed biomass in 20, 40 and 60 days after sowing were collected. Treatments RT and T showed higher weed biomass i.e, more than 45 gm^{-2} (dry weight) throughout all the three sampling periods (20, 40 & 60 days DAS). In soil analysis it was observed that an increase in organic carbon (OC), readily mineralizable carbon (RMC) and microbial biomass carbon (MBC) were recorded in RD, TD, RTD treatments compared to other treatments. Among the different stages of rice, higher RMC and MBC were found in the PI stage. Among the different stages of rice, higher enzymatic activities were observed in the PI stage. Among the different components of conservation agriculture, the effect of diversification is more prominent during the initial stages.

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Application of Boron and Silicon Enhance the Rice Yield under High Temperature Stress

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Rice is the staple food for more than 100 million households in developing countries in Asia, Africa and Latin America and its cultivation is the main source of income for them. There are already many challenges to achieving higher productivity of rice. In the future, the new challenges will include climate change and its consequences. It is reported that high temperatures would cause a marked decrease in world rice production. In tropical regions, high temperatures are a constraint to rice production and would cause reductions in grain weight and quality. Proper plant nutrition is one the good strategies to alleviate the temperature stress in crops. This study on use of silicon, potassium and boron to alleviate high temperature stress in rice was conducted during dry season under field condition with three dates of sowing in main plots; two rice cultivars Naveen (high temperature susceptible) and Lalat (high temperature tolerant) in sub plots; and seven nutrient management treatments in sub-sub plots. The results revealed that high temperature stress reduced grain yield of rice cultivars mainly because of low pollen viability and spikelet fertility. The effects of high temperature on the spikelet fertility and grain filling varied among cultivars and the growth stages of plant when exposed to the high temperature stress. Under high temperature stress, the tolerant cultivar displays higher cell membrane stability, less accumulation of osmolytes, more antioxidant enzyme activities, and higher pollen viability and spikelet fertility than the susceptible cultivars. Combination of B (@ 1 kg ha^{-1}) + Si (@ 200 kg ha^{-1}) + K (@ 50 kg ha^{-1}) resulted in higher grain yield which was at par with the B (@ 1 kg ha^{-1}) + Si (@ 200 kg ha^{-1}) and significantly higher than other treatments and help in alleviating the high temperature stress due to late sowing.

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Physico-chemical Analysis of Soil Under Miscellaneous Forest Plantation at Guru Ghasidas Vishwavidyalaya Campus, Bilaspur, Chhattisgarh

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Soil quality and fertility have been identified as the key to sustain the good environment surround us. We know that soil nutrient availability and soil quality management are essential factors for controlling and maintaining an area's productivity. Some nutrients, such as Nitrogen, Phosphorous, and Potassium, are very important nutrients required for the growth of plants and increasing yield. Soil fertility is determined by the availability of nutrients like NPK and organic matter content in the soil. This study was conducted to investigate the influence of miscellaneous forest plantation on soil properties. The data were collected from the four different sampling sites in around 10-acre miscellaneous forest plantations in the GGV campus. The soil samples were analyzed for the observation of various Physico-chemical properties such as pH, EC (Electrical Conductivity), soil color, SOC (Soil Organic Carbon), NPK (Nitrogen, Phosphorus, Potassium), S (Sulphur), Fe (Iron), Zn (Zinc), B (Boron), Mn (Manganese) and Cu (Copper). The analysis found that the soil differs in Physico-chemical parameters as compared to the control soil. The soil quality Index of the soil parameter was assessed by comparing the value of soil properties of the present study with the permissible limit to know the fertility status of the soil. This study provides the baseline information for forest plantation management.

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Impact of Conservation Agriculture on Quality and Yield of Broccoli

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Broccoli is one of the commercially important and nutritious cole crops under the family *Brassicaceae.* Broccoli is mainly cultivated for its high economic returns and commercial value. Broccoli is rich in sulphoraphane, highly nutritious and have anti carcinogenic properties. Due to recent concerns over environmental degradation, there is a need for optimization of a sustainable production technology for broccoli. To accomplish this we have conducted an experiment on to study "the effect of different conservation agricultural practices on yield and quality of broccoli" at Balindi research complex under the project "CAAST on conservation agriculture". The experiment was laid out in randomized complete block design with twelve different combination of organics (*viz.* vermicompost and straw mulch) and inorganic fertilizers in alluvial soils of west Bengal. Among the different treatment combinations, combination of inorganic fertilizer along with vermicompost and straw mulch (VSF1, VSF2 and VSF3) recorded significantly higher curd weight (av. 368.62 g) and curd yield (16.59 t ha^{-1}). Such combination also recorded higher nutrient concentration of N (7.16%), P (0.61%) and K (2.31%) in curds of broccoli. From this study we could conclude, that the practice involving all the straw mulch and vermicompost along with inorganic fertilizers performed better with respect to the growth and yield attributes for sustainable production of broccoli in alluvial soils of west Bengal.

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Comparison of Multinutrient Extractant AB-DTPA with Ammonium Acetate in Extraction of Soil Available Potassium

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A study was initiated to evaluate the performance of multinutrient extractant AB-DTPA in comparison with conventional extractant (ammonium acetate) for estimation of soil available potassium in 30 selected soils with varying native potassium status. The amount of available potassium extracted by the neutral normal ammonium acetate method (standard method) was extended from 82 to 692 kg K_2O ha^{-1} with mean of 295 kg K_2O ha^{-1} whereas with AB-DTPA it varied from 67 to 689 kg K_2O ha^{-1} with an average value of 278 kg K_2O ha^{-1}. The correlation coefficient between the two extractants was found to be 0.73* in low potassium status soils, 0.84** in medium potassium group soils while in high potassium status soils it was 0.92**. In overall soils also the two extractants are significantly and positively correlated with each other with correlation co-efficient value (r) 0.97**.

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Influence of Organic Manure and Urea on Nitrogen Availability, its Uptake and Yield of Paddy

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A field experiment was conducted to study the effect of organic manures of different sources (vermicompost, poultry manure and FYM) and urea application on nitrogen availability, its uptake and yield of paddyvar. CAU-R1 (*Tamphaphou*) in an acid soil of Manipur. Organic manures were applied @100% RDN (recommended dose of nitrogen), combination of the organic manures @ 75% and 50% with urea @ 25% and 50% RDN, 100% RDN as urea and no nitrogen source represented different treatments. Results revealed that amount of inorganic N ($NH_4^+$and NO_3^-) and total N in soil were higher at the start of the growing season and decreased with crop growth. Higher values of $NH_4^+$and NO_3^- in soil were observed in plots which received both organic manures and urea compared to their individual application. At the end of the experiment, significantly higher amount of exchangeable NH_4^+ was accumulated in soil treated with 50% RDN vermicompost + 50% RDN urea. Irrespective of different treatments, total N uptake reached its peak at 75 DAT (days after transplanting) and decreased gradually upto the harvest. Addition of organic manures and urea either singly or in combination significantly improved its uptake and rice yield over control. Moreover, rice yield was more in integrated treatments over their individual addition. The highest grain yield (5.55 t ha^{-1}) and straw yield (7.23 t ha^{-1}) were recorded in treatment combination of 50% RDN vermicompost + 50% RDN urea which was at par with the combined application of 50% RDN poultry manure + 50% RDN urea and single application of 100% RDN urea but superior to rest of the treatments. Application of urea-N in combination with organic manures could be considered more effective measure in rice production for reducing N-losses, conserving-N and increasing the efficiency of applied nitrogen.

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Effect of Different Organic Treatments on Soil Fertility Status of Sugarcane Crop

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To elucidate the advantages of organic farming over inorganic farming in sustainable agriculture, a field experiment was conducted during three Consecutive years (2018-2020) at research farm of Regional Research Station, CCS Haryana Agricultural University, Karnal. The soil of the experimental site having clay loamy texture was neutral to alkaline in reaction (pH-8), non-saline in nature (1.25 dS m^{-1}), low in organic carbon content (0.30%), Nitrogen (115 kg ha^{-1}), Phosphorus (10 kg ha^{-1}) and Potassium (384 kg ha^{-1}). The treatments applied were different for both plant as well as ratoon sugarcane crop and the experiment was laid out at Randomized block design (RBD). For plant crop, treatments were: FYM @10, 20 and 30 t ha^{-1} along with biofertilizers (BF), Green manuring (GM) and integrated pest management practice (IPM); Seed treatment with organic formulation 1 + three sprays of organic formulation 2 (Zero Budget Technique); Recommended dose of fertilizer (RDF) (187.5-62.5-62.5 kg ha^{-1} for CoH 160 and 150-50-50 kg ha^{-1} for CoH 167) + control of insect pests and diseases through chemical practices. For ratoon crop, treatments were: FYM @20, 25 and 30 t ha^{-1} + BF + GM+ IPM; Zero Budget Technique; RDF (187.5-62.5-62.5 kg ha^{-1} for variety CoH 160 and 225-50-50 kg ha^{-1} for variety CoH 167) + control of insect pests and diseases through chemical practices. The results revealed that in both plant and ratoon crop, various organic treatments had significantly influenced the status of soil organic carbon (SOC), available nitrogen, phosphorus and potassium during three years of experiment. In contrast, soil pH and EC was not altered significantly with organic applications. In plant crop, there was found 7-11% increase in organic carbon content with the application of FYM @10, 20 and 30 t ha^{-1} + BF + GM + IPM over RDF. The application of FYM 30 t ha^{-1} + BF + GM + IPM recorded highest available nitrogen (142.50 kg ha^{-1}), phosphorus (18.55 kg ha^{-1}) and potassium (402.8 kg ha^{-1}) in the soil which was found at par with FYM 20 t ha^{-1} + BF + GM + IPM (138.50, 18.05 and 399.80 kg ha^{-1}) and RDF (139.33,18.05 and 402.05 kg ha^{-1}). Similarly, for ratoon crop, highest available Nitrogen (142.17 kg ha^{-1}), Phosphorus (18.78 kg ha^{-1}) and Potassium (267.78 kg ha^{-1}) were recorded in treatment FYM 30 t ha^{-1} + BF + TM + IPM, which was at par with FYM @25 t ha^{-1} + BF + GM + IPM (139.0, 18.58 and 264.11 kg ha^{-1}) and RDF. So, to achieve equivalent yield to RDF, application of FYM 20 t ha^{-1} + BF + GM + IPM for plant crop and FYM 25 t ha^{-1} + BF + GM + IPM for ratoon crop was preferred and recommended for organic cultivation of sugarcane crop.

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Effect of Long-term Application of Fertilizers and Organic Manures on Soil Fertility and Productivity of Rice-Wheat Cropping System in Typic Ustochrept of Punjab, India

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The long-term nutrient management experiment on rice-wheat cropping system has been in progress since 1999 at Research Farm, Department of Soil Science, PAU, Ludhiana. The experiment aimed to study the long-term changes in soil fertility and crop productivity under combination of chemical fertilizers and organic manures. The experiment was conducted in a randomized block design (RBD) with 12 treatments, replicated three times. After 20 cropping cycles, surface soil samples were collected for examining the changes in soil fertility and crop productivity. The positive effect of fertilizer application on grain yield of rice and wheat was observed compared to no fertilizer application (control). Application of organic manures like green manure, straw incorporation and farmyard manure in addition to recommended fertilizers further improved grain yield of rice and wheat. The grain yield of rice and wheat in 100%NPK+FYM treatment was 20% and 15% higher than 100% NPK treatment, respectively. The intensive cultivation of rice-wheat system under balanced fertilization with FYM significantly improved the organic carbon content from 0.24% at the start of the experiment to 0.58% in 2019. On the other hand, continuous application of fertilizers resulted in a decline in soil pH. The continuous application of inorganic fertilizers conjunctively with FYM significantly enhanced available N, P, and K status. The study indicates that long-term application of balanced fertilizer and organic manure improved soil fertility and productivity of rice-wheat system.

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Soil Phosphorus Dynamics under Conservation Agriculture in An Inceptisol

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Keeping in view the low phosphorus (P) use efficiency and scarcity of data on P dynamics under conservation agriculture, the present study on soil P dynamics under CA based maize-mustard system is very much pertinent especially in the soils of upper Indo-Gangetic plains of Inceptisol which are slightly alkaline in nature with medium organic C and available P. The objective of the present study was to study the impact of conservation agriculture on soil phosphorous fractions under maize-mustard cropping system. For this, soil samples were collected from the on-going conservation field experiment at ICAR-IARI, Pusa, New Delhi with randomized block design, comprising of four double cropping zero-till and two triple cropping zero-till systems with or without crops residue retention along with two conventional till systems [T1: ZTMZ-ZTM; T2: ZTMZ+BM-ZTM; T3: ZTMZ(+R)- ZTM(+R); T4: ZTMZ(+R)+BM-ZTM(+R); T5: ZTMZ-ZTM-ZTSMB; T6: ZTMZ(+R)- ZTM(+R)-ZTSMB(+R); T7: CTMZ-ZTM; T8: CTMZ-CTM]. Results showed that highest and lowest value of soil available P in the surface soil layer were observed in T6 treatment [ZTMZ(+R)-ZTM(+R)-ZTSMB(+R)] and T8 treatment (CTMZ-CTM) respectively. Fractionation study was done according to modified Hedley sequential fractionation scheme which revealed that highest fraction was contributed by Ca-bound fraction followed by residual fraction. The zero tillage with residue retention practices significantly increased the water soluble P (WSP), NaHCO3 extractable fraction (labile P) in both 0-5 cm and 5-15 cm soil layer whereas it didn't significantly affect NaOH extractable fraction as well as HCl extractable fraction. Total P as well as MBP was observed to be maximum in T6 treatment whereas lowest values were recorded in T8 treatment. The findings from this study may be a way forward towards sustainable and balanced nutrient management strategy under conservation agriculture.

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Status and Forms of Sulphur, Zinc and Boron in Paddy Growing Soils of Kalghatagi Taluk in Dharwad District and Response of Paddy to their Application

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The study was carried out in the Department of Soil Science and Sgricultural Chemistry, college of agriculture, Dharwad to know the "Status and forms of sulphur, zinc and boron in paddy growing soils of Kalghatagi taluk in Dharwad district and response of paddy to their application" during 2017 and 2018. From 15 villages, 225 surface soil samples were coolected from the farmers' fields. The results revaledthat soils were sandy loam, silty loam and clay, acidic to alkaline in reaction, low in total soluble salts, low to medium in organic carbon, low to medium in available N and P and medium to high in available K, 42.2, 50.7 and 66.7 per cent of the soil were defiecient in available sulphur, zinc and boron. The distribution of soil sulphur forms followed the order: water soluble-S < sulphate-S < organically bound-S < total-S. Similarly, the different forms of zinc in soil followed the order as water soluble plus exchangeable-Zn < organically bound-Zn < amorphous sesquioxide-Zn < crystalline bound-Zn < total-Zn. The different forms of boron in the soil samples followed the order: readily soluble-B < specifically absorbed-B < total-B. Soil application of $ZnSO_4$ @ 25 kg ha^{-1} and borax @ 3 kg ha^{-1} along with their foliar sprays each at 0.50 per cent at 50 DAS recorded significantly higher grain (65.9 q ha^{-1}) and straw (77.6 q ha^{-1}) yields and grain protein (7.31%) because of higher plant height, more number of effective tillers, total dry matter production, higher panicle length, and more number of filled grains per panicle and higher thousand grain weight, uptake of N, K and S and micronutrients *viz.*, Cu, Fe, Mn Zn and B. This treatment also recorded the higher gross (Rs. 82, 817 ha^{-1}) and net (Rs. 47, 998 ha^{-1}) returns and B : C ratio (2.38). This treatment was on par with the treatment with soil application of gypsum @ 89 kg ha^{-1} along with $ZnSO_4$ and borax foliar sprays each at 0.5 per cent at 50 DAS. The treatment with gypsum, $ZnSO_4$ and borax improved the status of available sulphur, zinc and boron in soil. Soil application of zinc sulphate and borax @ 25 and 3 kg ha^{-1}, respectively along with their foliar sprays each @ 0.5 per cent concentration at 50 DAS helps in increasing the yield of direct seeded paddy along with maintain the soil fertility.

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Growth and Productivity of Rabi Groundnut after Thirteen Crop Cycles under Organic Nutrient Management

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A field experiment was carried out at College of Agriculture, Rajendranagar, Hyderabad during two consecutive *rabi* seasons of 2016-17 and 2017-18 to evaluate six different nutrient management practices in randomized block design with four replications. The experimental soil was non-saline, neutral in reaction with sandy loam texture. Prior to conduct of this experiment, the field was under a long term study which was conducted to know the effect of organic, inorganic and integrated nutrient management practices on maize-onion cropping system since *kharif*, 2003-04 to 2014-15. Results revealed that significantly higher plant height, dry matter production at vegetative, flowering and harvest stages along with higher pod (3053 kg ha^{-1}) and haulm yield (5228 kg ha^{-1}) was recorded with application of 50% N through farm yard manure + 50% N through chemical fertilizers. Application of 100% nitrogen through organics like farm yard manure, neem cake and vermicompost along with biofertilizers like rhizobium and PSB and application of 100% recommended NPK through chemical fertilizers also recorded comparable yield and drymatter. Significantly lower plant height (18.80 cm), dry matter production (6243 kg ha^{-1}) at harvest stage along with lower pod yield (2230 kg ha^{-1}) and haulm yield (4228 kg ha^{-1}) was recorded in the treatment which received 50% N through FYM + Bio-fertilizers for N, Rock phosphate for P and PSB at vegetative (1000 kg ha^{-1}), flowering (2712 kg ha^{-1}) and harvest (6243 kg ha^{-1}) stages than the rest of the treatment.No significant differences in the harvest index of the crop were recorded with different nutrient management practices.

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Predicted and Observed Soil Test Values for Rice-Rice Cropping Sequence in UT of Puducherry

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The gradient crop (Rice var. Kulla Ponni) and the test crops (Rice var. White Ponni) and (Rice var. ADT 45) experiments were conducted at farmer's field in Karikalampakkam village, U.T of Puducherry, The soil of the experimental field belongs to Bahour series, taxonomically *Typic Ustropept*; sandy clay loam in texture, pH- 8.40, EC- 0.778 dSm^{-1}, CEC-32.5 cmol (p^+) kg^{-1}, $KMnO_4$-N-170.8 kg ha^{-1}, Olsen-P-65.4 kg ha^{-1} and NH_4OAc-K- 236 kg ha^{-1}. The study was based on the inductive methodology developed by Ramamoorthy *el al*. (1967) as followed in All India Coordinated Research Project on Soil Test Crop Response correlation (AICRP - STCR). In the present investigation, the soil test values for $KMnO_4$-N, Olsen-P and NH_4OAc-K were predicted and compared with observed values (actually tested). The mean observed value of $KMnO_4$-N was 199.3 kg ha^{-1} while the mean predicted value based on grain yield and uptake were 200.7 kg ha^{-1} and 199.0 kg ha^{-1} respectively. The mean variation, between observed and predicted value was 1.4 with yield and 0.3 with uptake. The observed mean value of Olsen-P was 47.6 kg ha^{-1} and the predicted mean value based on grain yield and uptake was 48.6 kg ha^{-1} and 47.1 kg ha^{-1} respectively. The mean variation, between observed and predicted Olsen-P was 1.0 with yield and 0.5 with uptake. In the case of NH_4OAc-K, the observed mean value was 233.2 kg ha^{-1} and the predicted mean value based on grain yield and uptake was 233.6 kg ha^{-1} and 232.7 kg ha^{-1} respectively. The mean variation between observed and predicted NH_4OAc-K was 0.4 with yield and 0.5 with uptake. The difference between the predicted and observed soil test values for the treated plots was found to be very negligible and found to agree very closely. Similar analysis for Olsen-P and NH_4OAc-K indicated highly significant relationship with high R^2 values fall in the category of good fit in the present study, taking a value of R^2 above 0.65 as the criterion for good fit. The R^2 values suggested that the prediction equations could be used with confidence for the prediction of available N, P and K after rice for making the soil test based fertilizer recommendations for the crop after rice. Accordingly in the present investigation, the soil test values for $KMnO_4$-N, Olsen-P and NH_4OAc-K were predicted and compared with the observed values. The results revealed that the comparison between observed and predicted soil test values of available N, P and K after rice using 1:1 regression line wherein all the points stayed close to the line and the values were in good agreement with the fitted equations agrees with observed points in both yield and uptake for N, P and K respectively. From the results obtained for rice, both observed and predicted soil test values were in good agreement proving the validity of the post-harvest soil test values prediction equations which was also exhibited in the 1:1 regression line with highly significant 'r' values.

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Soil Moisture Estimation by Minimizing the Roughness and Vegetation Properties using Sentinel-1 C Band

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Soil moisture studies play a crucial role as a prerequisite input for many applications. Soil moisture comprise a very small proportion of the global water resources but possess a key indicator of assessing drought or flood events. Remote sensing methods specifically the microwave region of electromagnetic spectrum is considered as the optimum tool for monitoring the soil moisture due to unique property of microwave sensitivity towards water contained. There is various method available to estimate the soil moisture such as backscatter models, change detection, interferometry approaches. Ground collection of soil parameters using random sampling approach were done over the region where soil moisture ranges from 1.70 to 31.9 vol. % and surface roughness ranges from 0.465 cm to 1.438 cm and average of 0.95cm surface roughness was used in the simulation. Semi empirical model such as modified Dubois model and traditional Dubois model were used for the calibration of the model. The backscatter coefficient values simulated from modified Dubois model by Baghdadi *et al.*, 2016 and Sentinel has showed Pearson correlation coefficient of 0.45 and RMSE of 2.08 which is improved one compared to the Dubois model 1995 in which RMSE of 3.867 dB is found. Simulated backscatter coefficients obtained from the models were then compared with Sentinel1A backscatter coefficients values. Further, model optimization was performed in order to minimise the error and finally Dielectric mixing model such as Topps model was used to convert the dielectric constant into soil moisture values. The sensor parameters such as incidence angle average (31-41°C), ks=0.67 cm (assume) and wavelength = 5.5 cm were used in the Dubois model for IARI farm whereas averaged incidence angle of 27.9-39.3°C, ks=0.802 cm and wavelength of 5.5 cm used as an input for central state farm Hisar.

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Exploring the Potentiality of Acidulated Manures in Reclamation of Sodic Soil

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Organic manures are used for sodic soils reclamation. The reclamation potentialities of manures are low and it depend on the amount of Ca^{2+} and acidity present in manure to neutralize free carbonates in soils. Acidity of manure mobilizes calcite to release Ca^{2+}. Acidified manures (AM) are recommended for improving the reclamation potential of sodicity. This experiment was conducted to improve sodicity reclamation potentiality of manures by increasing the production of titratable acidity (TA) through rapid acidulation using elemental sulfur (S^0) and S^0–oxidizers. City waste compost (CWC) and farmyard manure (F) were incubated separately with and without S^0 20 kg per ton manure at field capacity for 30 days. Further, sodic soil (ESP 72.2%) was incubated with separate Gyp, S^0,CWC @ 10 t ha^{-1}, CWC + S^0, F,F + S^0 for one month. Leaching was performed with deionized water at 30 and 45 days after incubation. Acidulation (S^0) decreased and increased pH and TA of F and CWC compared to non-acidulated F and CWC. The decrement of pH and production of TA was greater for F + S^0 than CWC + S^0. Incubation of sodic soil with Gyp neutralized carbonates and reduced leachates pH followed by CWC + S^0 ≤ F + S^0=S^0= CWC <F < control. S^0 oxidation produces SO_4^{2-}.SO_4^{2-} upon solubilization supplies mineral acids. The dissociation of acids reduced pH and increased TA of AM. The solubilization of Gyp produces soluble Ca^{2+} which neutralizes alkalinity and performs exchange reaction. The presence of TA in AM neutralizes the alkalinity and lower down pH of sodic soil. TA helps in mobilization of native calcite and supply Ca^{2+}_{sol} for performing the exchange reaction between Na^{+}_{ex} and Ca^{2+}_{sol}.Acidulation of city waste compost and manure is an option for neutralization of soil alkalinity and reclamation of sodicity.

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Land Use and Management-induced Soil Degradation in Coastal Light Soils of South Eastern India

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Land use types strongly influence the ecosystem functions and services rendered to the human well-being. Annihilation or diminution of ecosystem functions like carbon storage causes soil degradation. Objectives of the study were: (1) to assess the effect of different land uses on soil carbon pools, and their stocks, (2) to evaluate the soil quality under different land use types through parameters like CMI and SR. Six typical land uses were selected in West Godavari district of Andhra Pradesh: Sugarcane (SC), Fallow - Tobacco (F-T), Paddy- Maize- Fallow (P-M-F), Eucalyptus + Bamboo (E+B), Oil Palm (OP) and natural forest (NF). The samples were collected from four soil depths (D0: 0-5cm, D1: 5-15 cm, D2: 15-30, D3: 30-45 cm). Land use types showed wide variability in Total Organic Carbon (TOC), C pools, SOC (Soil Organic Carbon) stocks, stratification ratio (SR) of carbon and carbon management index (CMI). NF showed 53.7, 69.4, 62.2, 51.4, and 46.8 per cent higher TOC than F-T, P-M-F, E+B, OP, respectively. A significantly higher labile carbon (0.743 g kg^{-1}) was recorded in NF at D_1 which was 2.25, 2.67, 2.41, 1.94 and 1.68 times higher over SC, F-T, P-M-F, E+B and OP systems, respectively. The SOC stocks ranged from 25.75 Mg ha^{-1} (F-T) to 59.30 Mg ha^{-1} (NF) in the soil depth of 0-45 cm. CMI for all land uses were below 100 when compared with NF systems (Reference). NF system followed by OP system showed higher SR of SOC (>2.0) depicting greater soil quality and sustainability.TOC, labile C pools, SRs and CMI values were lower in F- T and P - M- F indicating poor soil quality and its deterioration. Enhancing soil organic carbon content under such land use types is inevitable to improve productivity and to stop further deterioration in soil carbon stocks thereby soil health.

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Long-term Manure and Compost Management on Soil Organic C Stabilization in Rice (basmati)-Wheat System of North-West India

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Nature of carbon input to soil, its transformation to soil organic matter (SOM), and the degree of protection from decomposition are important for long-term persistence of SOM. The effect of exogenous addition of organic matter on SOM build-up is well known; however, changes in quality vis-a-vis composition of added organic matter have been less investigated. Changes in composition of SOM were studied by fractionating the soil into coarse (cPOC; >250 mm) and fine particulate organic C (fPOC; 53-250 mm) and mineral-associated organic C (MinOC; <53 mm) and measuring the acid non-hydrolyzable C (NHC) following applications of farmyard manure (FYM), rice straw compost (RSC) and vermicompost (VC) in a rice (basmati)–wheat system. Addition of organic amendments for 10 years significantly increased soil organic C (SOC) stocks and the increase was greatest with RSC followed by FYM, and lowest with VC, compared with solitary application of NPK. Carbon accumulation in separated pools was influenced by the chemical composition of the organic source. Compost applications accumulated C preferentially in the MinOC pool, whereas the FYM accumulated a greater proportion of C as fPOC. The differences were attributed to the lower C/N ratio and higher lignin content of RSC than FYM. The RSC application increased NHC stocks to a greater extent than FYM and VC, indicating recalcitrance of the accumulated C. The results showed that addition of compost, besides leading to C build-up, improved C stabilization by imparting recalcitrance to SOC.

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Prospective Double Cropped Rice Ecology to Conserve Energy, Carbon and Greenhouse Gases in Lowland Coastal Ecosystem

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Inappropriate farm practices can increase greenhouse gas (GHG) emissions and reduce soil organic carbon (SOC) sequestration, thereby increasing carbon footprints (CFs), jeopardizing ecosystem services (ES) and affecting climate change. To assess the contributions of rice based cropping system in low land coastal ecosystem on climate change, along with energy budget, carbon footprints (CF) and ES values of climate regulation, the net ecosystem exchange of CO_2, exchange of non-CO_2 carbon, CH_4 and N_2O fluxes were continuously monitored at day and night on annual basis using static chamber-gas chromatography methods and biometric observation under conservation tillage practices. The design of experiment was split-split plot with cropping system (rice-rice (RR) and rice-cotton (RC)) as main plot treatments and tillage type such as zero tillage (ZT), reduced tillage (RT), and conventional tillage (CT) as sub plot treatments and residue (R) and no residue (NR) under sub-sub plot treatments. Operation wise energy used was calculated and treatment under reduced tillage condition was most efficient in utilizing energy. Rice based cropping system under low land condition significantly increased SOC with the rate of 0.22 to 0.69 and 0.09 to 0.45 Mg ha^{-1} yr^{-1} in case of rice-rice and rice-cotton system whereas the treatment RC-ZTNR depleted SOC with the rate of -0.11 Mg ha^{-1} yr^{-1}. The evaluation of net ecosystem carbon budget (NECB: considering net ecosystem CO_2 exchange and non-CO_2 C exchange by crop harvest, CH_4-C, C inputs to soils and C loss through runoff) and GHG budget (GHGB: adding CH_4 and N_2O fluxes and emission from Inputs used to the NECB based on CO_2 equivalent) showed that the rice based cropping system persistently functioned as an intensive carbon sink (NECB: 1523 and 944 kg C ha^{-1} yr^{-1} in rice-rice and rice-cotton system) but GHG source except under treatment RTR which still behaved as an important GHG sink (-68 to -228 kg $CO_{2\text{-eq}}$ ha^{-1} yr^{-1}). The treatment RTR also recorded least CF, and highest ecosystem service values of climate regulation among all tillage practices.

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Underwater Soil and Farming

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Underwater farming has always been practiced in the form of seaweed as early as 1670 in Japan. It soon spread to neighboring coastal countries such as China, Indonesia, Korea etc. But with the increase in demand for food, soil degradation and sea level rise led scientists to take interest in underwater farming as an alternative for terrestrial agriculture for offshore sites in sustainable manner. For that underwater soil were needed to be studied for coastal ecosystem management, aquaculture and restoration. Upper boundary of soil was considered as air or shallow water. Soil which was permanently submerged in water was regarded as sediments. George Demas who was working for the US Department of Agriculture started wondering why underwater soil was not considered as soil. They show pedogenesis and can also support rooted plants and thus the definition of soil had to be changed to include subaqueous soil which is permanently submerged in water upto 2.5 m deep. After more than a decade, it was classified under soil orders Entisols and Histosols with suborders Wassents and Wassists. Its properties is different than subaerial soil due to different environment of formation. They are effected by bathymetry, flow regime, water column and catastrophic events and thus Jenny's equation for factors of soil formation does not apply here. It is one of the greatest carbon sinks compared to its terrestrial counterparts and thus have a great potential for blue carbon sequestration. Currently there are two underwater farming projects undergoing improvements and showing promising results. First is the 3D ocean farming in USA where both aquatic animals and plants are cultivated at different water depth without the use of fertilizers, pesticides and fresh water. Second is the Nemo's garden in Italy where underwater transparent biosphere has been able to produce crops and herbs using hydroponic techniques.

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Assessment and Mapping of Spatial Variability for Soil Carbon Concentration and Stocks

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Soil carbon is a major indicator for sustainability of agricultural production and also plays crucial role in context of climate change. Soil carbon concentration, density and stock at farm of ICAR-Indian Agricultural Research Institute (IARI), New Delhi were estimated using geo-statistical techniques. Soil samples from the farm were collected using grid sampling technique and excavation of 10 representative soil profiles under each soil mapping unit. Laboratory analysis of collected soil samples were carried out, followed by statistical and geo-statistical analysis to map top soil carbon concentration using ordinary kriging interpolation technique. Average concentration of surface soil (0-15 cm) carbon was observed to be 5.1 g kg^{-1} with a range from 0.72 to 14.5 g kg^{-1}. Spatial range or zone of influence for soil organic carbon and total carbon concentration in the farm was 180 m and 83 m respectively. Ordinary kriging technique reliably predicted and generated spatial distribution map of soil surface carbon content. Among ten soil mapping units within soil subgroup of Calcic/Typic/Fluventic Haplustepts from piedmont plain *i.e.* Pusa A, B, C, D, E, F soils and old alluvial plain *i.e.* Pusa G, H, I and J soils; surface soil organic carbon density (0-30 cm soil depth) ranged from 9.36 Mg ha^{-1} to 31.54 Mg ha^{-1}. Pusa G soils had no inorganic carbon content throughout the soil profile and Pusa A soils had highest deep soil inorganic carbon density (30-150 cm soil depth) value *i.e.* 361.38 Mg ha^{-1} within of the farm. Surface SOC density was higher than surface SIC density in all Pusa soils except Calcic Haplustepts. Deep SIC density was higher than deep SOC density for piedmont soils except Pusa C soils while it was lesser in case of old alluvial soils except Pusa I soils. Total carbon stock within 0-150 cm soil depth of the farm (293.1 ha) was 27.98 Gg, of which proportion of SIC stock (51.0 %) was higher than SOC stock (49.0%).

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Influence of Soil Moisture Regimes, Amendments and Ageing on Lead (Pb) Availability in Soils

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Heavy metal (HM) contamination of the soil can occur either due to toxic metals from groundwater or through various anthropogenic activities. Heavy metals such as manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn) are essential for plants, animals and microorganisms, while cadmium (Cd), lead (Pb), nickel (Ni), chromium (Cr) and mercury (Hg) have no known biological or physiological functions but are toxic to soil-plant-animal-human continuum (Bolan *et al.* 2014, Alloway B J 2012). Lead is one of the most widespread heavy metal contaminants of soil and plants. In a range of lead (Pb) spiked soils the effects of soil moisture regimes, amendments and ageing were estimated on Pb availability. The soil was spiked with Pb @ 0, 25 and 50 mg kg^{-1} soil through its nitrate solution. Lime, FYM and Zn were added @ 5%, 20 t ha^{-1} and 25 mg kg^{-1}, respectively. The so treated soil samples were incubated at 35°C for 1, 45 and 90 days at field capacity and submerged soil moisture regimes. Available Pb was extracted with 0.005 M DTPA which was determined on ICP-AES. The results revealed that there was a temporal decrease in the available Pb with ageing and it was in the order of 90 days>45 days>1days. The magnitude of decrease in Pb availability was higher with the addition of amendments in the order of lime > FYM > Zn > unamended soil. The decrease in available Pb was further pronounced under submerged moisture regime than under field capacity. The mean per cent recovery of DTPA-Pb in the 25 mg kg^{-1} Pb spiked treatments decreased from 80.3 after one day of incubation to 43.7 and 41.3 per cent, respectively after 45 and 90 days of incubation whereas in the 50 mg kg^{-1} Pb spiking it decreased from 70.2 after one day of incubation to 39.1 and 36.0%, respectively after 45 and 90 days of incubation. An overall reduction in the mean per cent recovery of DTPA-Pb was observed under submergence as compared to field capacity moisture regime in all lime, FYM, Zn amended soils and unamended soil. The results enable us to understand the effect of ageing coupled with different amendments under various soil moisture regimes on Pb availability and provide useful information to work out the capacity of the soil to serve as a sink for lead.

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Interactive Effects of Soil Lead and Cadmium on Dry Metal Yield and Metal Content of Spinach (*Spinacia oleracea*)

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In a screen house, interactive effects of soil cadmium (Cd) (0, 10, 25, 50 and 100 mg kg^{-1}) and lead (Pb) (0, 25, 50, 100 and 200 mg kg^{-1}) were studied on dry matter yield (DMY) and content of Cd and Pb in Spinach (Spinacia oleracea) grown for 60 days in a loamy sand soil. The dry matter yield (DMY) was recorded and plants were analysed for total Cd and Pb contents. Soil was analysed for DTPA-extractable Cd and Pb. Results showed that the mean DTPA-Cd and DTPA- Pb in equilibrated soils increased significantly with increase in spiking of Cd and Pb, respectively. The content of DTPA-Cd increased significantly where different combinations of Cd and Pb were applied whereas, DTPA-Pb significantly decreased when Pb was applied in combination with Cd. The mean shoot Cd content of Spinach increased by 8.65% with application of Cd+200 mg Pb kg^{-1} soil while the mean Pb content decreased by 12.73% with application of Pb+100 mg Cd kg^{-1} soil as compared to their respective single treatments. At Cd+200 mg Pb kg^{-1} soil and Pb+100 mg Cd kg^{-1} soil, the mean shoot DMY of Spinach decreased by 45.09 and 42.30%, respectively as compared to control. The postharvest soil DTPA-Cd and Pb decreased as compared to their pre sowing contents but considerable residual contents still remained in soil. An additive adverse effect of the metals upon the studied parameters of the crop was observed.

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Machine Learning-based Prediction Models Based on Field Data Can Explain Deficit Irrigation and Organic Amendments-role in Reducing Dietary Arsenic Risk

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Dietary rice consumption can play a very important role in terms of the significant pathway of the carcinogenic arsenic (As) in the human system. A field experiment with rice (cv. IET-4786) was done for two years in geogenically arsenic-contaminated areas (West Bengal, India) in quest of a suitable mitigation approach. The goal of the study was to see how effective organic amendments (vermicompost, farmyard manure, and mustard cake) and irrigation management (saturation and alternate soaking and drying) were at decreasing as load in the entire soil-plant system. The As content in the soil, plant parts, and associated soil physicochemical parameters were determined using a three-fold replicated strip plot design. The results showed that vermicompost amendment combined with alternate wetting and drying (0.318 mg kg^{-1}) resulted in the least amount of as buildup in edible grains when compared to the farmer's technique of continuous submergence with no manure (0.895 mg kg^{-1}). Intriguingly, a 25 percent rise in grain yield was also seen. A target cancer risk (TCR) and severity adjusted margin of exposure (SAMOE) mediated risk thermometer was used to estimate the risk of dietary exposure to as from rice. To ensure a higher quality of health, the adopted method made all risk factors harmless. Random Forest outperformed k-Nearest Neighbour and Generalized Regression Model in forecasting grain as concentration, according to the Machine Learning algorithm. As a result, if calibrated and validated appropriately, the former can be a useful instrument for estimating grain as content in rice.

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Influence of Different Rainfed Land Use Systems on Soil Properties in Lower Shiwalik of Punjab

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Land use changes alter the soil properties and functioning of rhizosphere due to changes in soil microbial biodiversity, SOC storage and nutrient turnover in soils. In present study, a total of 48 soil samples were collected from four rainfed land use systems (agri-horticulture, agroforestry, cultivated, and barren land) from. Garhshankar block of district Hoshiarpur. The soils were loamy sand to sandy loam in texture with neutral to slightly alkaline in soil reaction. The EC ranged from 0.18 to 0.23 dS m^{-1}. Soil organic carbon content ranged from 2.18 to 5.83 g kg^{-1}, being highest under dek at Garhshankar. The soil microbial biomass carbon ranged from 48.1 to 170.0 µg g^{-1}, respectively. In soil enzymes, the soil dehydrogenase activity varied from12.1 to 37.1 µg TPF g^{-1} hr^{-1}, fluorescein diacetate activity from 0.65 to 2.49 µg fluorescein g^{-1}, acid phosphatase from 14.7 to 22.2 µg PNP g^{-1} hr^{-1}, alkaline phosphatase activity from 17.1 to 44.3 µg PNP g^{-1} hr^{-1}, and urease activity from 4.67 to 6.62 µg NH_4-N g^{-1} hr^{-1} in land use systems, respectively. The soil physico-chemical, biological properties, soil microbial quotient and metabolic potential were higher under agroforestry and agri-horticulture systems and least under barren system. The labile carbon fractions and carbon management index had higher values for agroforestry and agri-horticulture systems. Principal component analysis and soil quality index showed that, agroforestry system followed by agri-horticulture systems had higher values of soil enzymes, MBC, SOC and carbon fractions. Among soil properties, SOC, available P, DTPA-Zn, MWD, DHA, and urease activity were the most reliable sensitive indicator for assessing soil quality under rainfed land use system in sub montane Punjab.

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Distribution of Organic Carbon Pools in Soil Aggregates as Affected by Long-term Fertilization and Liming

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To understand the effect of long term (60 years) fertilization, manuring, alone or in combination on an acidic Alfisol, distribution of soil organic pools in different soil aggregates was studied under maize (*Zea mays* L.) wheat (*Triticum aestivum* L.) cropping system. There were eight treatments laid in randomized block design, having three replications each. Farmyard manure (FYM) was applied on equivalent N basis to both crops and P and K doses were adjusted based on P and K contents in applied FYM (FYM + P'K) over the years. Other treatments included FYM + P'K treatment in combination with lime (FYM + P'K' + L), N, N+L, NPK, NPK+L, FYM and control. Results indicate that FYM + P'K' + L plots had significantly more large macroaggregates than NPK and NPK + L plots. Among all treatments, FYM + P'K' plots contained highest SOC inside large macroaggregates, which was 92 and 33% higher than unfertilized control and NPK plots, respectively. But, the FYM + P'K' + L plots contained highest amount of micoraggregate-associated C, which was 48 and 18% higher than unfertilized control and NPK plots, respectively. In soil surface, large macroaggregates of FYM + P'K' plots contained 32, 40 and 11% larger labile C than unfertilized control, NPK and FYM and plots, respectively. Small macroaggregates of FYM + P'K' plots contained 80, 90, 41 and 12% higher labile C than the small macroaggregates of unfertilized control, NPK, FYM and FYM + P'K' + L plots, respectively. Inside the microaggregates, labile C was maximum in FYM + P'K' plots, whereas recalcitrant C was maximum in plots treated with NPK + L. Higher recalcitrant C in plots treated with FYM + P'K' + L in small macroaggregates was due to additional effect of liming on better binding and protection of SOC inside small macroaggregates which makes it important management practice that can be adopted.

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Appraisal of Environmental and Ecological Risk Due to Heavy Metals in a Three Decade Old Sewage and Solid Waste Contaminated Landfill Area of West Bengal

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The present investigation was conducted at Dhapa, a well known city waste dumpsite of Kolkata metropoliton which has been subjected to sewage and municipal solid waste deposition through landfill for over 34 years. GPS based soil sampling was carried out at 36 sites covering the entire area. Soils were analyzed for important physico-chemical properties and available heavy metal contents (Cd, Pb, Ni and Cr). The assessment of soil pollution, ecological and environmental risk due to the heavy metal load in this area was calculated based on the indices like geo-accumulation (Igeo), contamination factor (Cf), degree of contamination (CD), pollution load index (PLI), ecological risk factor (Er) and global ecological risk (RI). Results revealed a significant load of Cd (0.72-3.76 mg kg^{-1}), Pb (28.59-87.29 mg kg^{-1}), Ni (3.11-8.73 mg kg^{-1}), and Cr (2.23-8.43 mg kg^{-1}) in surface soil samples. Igeo for Cd ranges from 0.35-1.84, Pb from 0.22-0.69, Ni from 0.20-0.56 and Cr from 0.33-1.25 indicating that the sampling sites are mostly uncontaminated to moderately contaminated for Pb and Ni, while for Cd and Cr some areas are moderately contaminated. Cf ranges from 1.76-9.17 for Cd, 1.12-3.41 for Pb, 1.00-2.80 for Ni and 1.65-3.22 for Cr indicating moderate contamination for Ni, moderate to considerable contamination for Pb, Cr and moderate to very high contamination for Cd. Er exhibits that ecological risk is low for Pb, Cr and Ni, but moderate to high for Cd. Among the combined pollution indices, CD ranges from 6.22-19.47, PLI ranges from 1.46-4.35 and RI ranges from 67.95-314.36, suggesting low to considerable contamination and global ecological risk respectively. As "Garbage farming" is encouraged in the study area, these findings can help to delineate the status and enforce policy decisions for solving this precarious conundrum of managing waste on one hand and saving human lives on the other.

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Phosphorus Thresholds for Assessing Environmental Risk in Two Acidic Soils of West Bengal

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It is imperative to find out a practical indicator to assess the potential for phosphorus (P) movement from a given site to surface waters causing environmental pollution. The present study was undertaken with two acidic soils from cultivated land of terai and red & lateritic zone of West Bengal to estimate their P threshold values and to establish a simple model from the soil test data. The mean P adsorption maximum (P_{max}) and P-buffering capacity was higher in red and lateritic soils than the terai soils. P-threshold values calculated from incubated soils with the addition of various levels of P based on different P_{max} saturation for 20 days revealed that the change point values for the soils of terai zone ranged from 32 to 68 mg kg^{-1} by Bray-1, and from 28 to 63 mg kg^{-1} by Mehlich-1 extractant. The same for the soils of red and lateritic zone were from 47 to 90 mg kg^{-1} and from 44 to 89 mg kg^{-1} assessed by Bray-1 and Mehlich-1, respectively. For safety reasons, the application of phosphatic fertilizers should not be allowed beyond 75 % of the change-point value considering as its threshold value to avoid the risk of soil becoming a source of P pollution for surface water bodies. Since, the change point values assessed by Bray-1 (R^2 = 0.94* & 0.87*) and Mehlich-1 (R^2 = 0.96** & 0.88**) were significantly correlated for terai and red & lateritic soils, respectively with clay content; thus, it should be included in assessment of P-threshold value of soil. The simplified model of P-threshold (mg kg^{-1}) assessed by either extractant for terai soil was '4.75 clay content (%) – 30' and for red and lateritic soil was '6.00 clay content (%) – 75'.

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Short-term Impact of Weathered Fly Ash Amendment on P Adsorption, Release Kinetics and Enzymatic Activities in Two Taxonomically Different Soils of India

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Safe disposal of huge quantity of fly ash is compulsory to avoid environmental problems, and contents of significant amount of plant nutrients, particularly phosphorus (P), make it a potential amendment in agriculture. Though fly ash is utilized in different construction sectors, but impacts of fly ash on soil properties, nutrient dynamics is relatively less studied till date. A comparative assessment of P adsorption, release kinetics and enzymatic activities of weathered fly ash amended texturally different soils is yet to be explored. This investigation explores the influence of fly ash with or without FYM on P adsorption parameters and indices, release kinetics, P activity coefficient (PAC) and enzymatic activities in Inceptisol and Vertisol with the treatments comprising graded doses of weathered fly ash and FYM. Results revealed that increased fly ash doses amplified the P adsorption in soils, which further increased with FYM application. Data obtained in adsorption well fitted to Langmuir and Redlich-Patterson isotherm. Binding energy, adsorption maxima and P sorption index also augmented by increased doses of fly ash. Gibb's free energy of adsorption indicated that P adsorption was due to chemisorption. However, rate of P release was 6-10 times higher at initial stages and increased concentration of P through fly ash and FYM quantified higher P diffusion rate. PAC was negatively influenced by higher quantity of fly ash, but FYM positively influences PAC. Enzymatic activities (acid phosphomonoesterase, alkaline phosphomonoesterase and fluorescence diacetate) decreased in Inceptisol beyond 200 t ha^{-1} fly ash; however, 50 t ha^{-1} FYM nullifies the negative impact of fly ash and increased enzymatic activities in both the soils. Increased maximum P buffering capacity, PAC, enzymatic activities and liming effects on acidic soils suggested better management options of fly ash as slow-release P source in crop production along with FYM.

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Efficacy of Yellow Gypsum on Mitigating Arsenic Bioavailability in Arsenic Contaminated Groundnut and Boro-Rice Soil

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A series of pot experiments were conducted to study the efficacy of Yellow Gypsum application on bioavailability of arsenic to groundnut and *Boro*-rice under contaminated soil during the period 2019-2021. Pots were filled with five kg of soil spiked with seventeen different levels of arsenic using arsenic salt of sodium (sodium arsenite $NaAsO_2$) and allowed to equilibrate for one month. The present investigation started with *kharif* Groundnut (TG-51) followed by *Boro*-Rice (Shatabdi: IET-4786) for two consecutive years. Seventeen levels of arsenic and three levels (0, 30, and 60 kg ha^{-1}) of yellow gypsum were laid out in a two factor Factorial Complete Randomized Design with three replications. Recommended dose of chemical fertilisers (RDF) was also applied to the crops. The results showed that application of yellow gypsum at 60 kg ha^{-1} recorded lowest arsenic content 1(6.89, 13.54 $mgkg^{-1}$ and 15.07, 11.59 mg kg^{-1}) in groundnut and *Boro*-rice. The soil extractable arsenic decreased significantly with increasing dosage of yellow gypsum in arsenic treatments. The mean soil extractable arsenic (mg kg^{-1}) averaged over the three yellow gypsum levels decreased from its initial values at harvest of groundnut and rice crop. In both the cropping cycles, irrespective of treatments, with respect to control (Y_0), highest percentage decline in soil extractable arsenic was observed in Y_{60} (5.90, 19.05 and 12.61, 27.64%) followed by Y_{30} (1.96, 6.60 and 4.30, 9.60%) in both groundnut and rice crops respectively.

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Innovative Approach for Bio-waste Recycling in Sukhet Model for Monetization and Self-reliant

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Efficient utilization of bio-waste either from rural or cities improve productivity, soil health, biodiversity, livelihood security, employment generation and environmental quality. In Bihar, there is no proper mechanism for the disposal of agro waste as well as household waste and animal dung which is mainly used as cake for domestic fuel. With *Ujjwala* programme, it was expected that the cow dung cake will be replaced by LPG providing smokeless domestic cooking. But refilling of cylinders is less than 50% due to poor economic conditions. Thus, a unique solution of sustainable nature was conceptualized with four objectives-(i) Rural sanitation by collecting household waste and agricultural waste; (ii) Improvement in soil health; (iii) Monetizing cow dung to pay for LPG refilling, and (iv) Creating employment opportunities at village itself. With this concept, a vermicompost unit was developed in the village Sukhet of Madhubani district of Bihar, named as '*Sukhet Model'*. For vermicomposting, shredded biowaste is mixed with cow dung slurry (65:35; waste:cow dung, w/w), at suitable moisture and temperature (50-65% and 35-40°C), the epigeic earthworm species (*Eisenia fetida, Peryonix excavates* and *Eudrilus eugenii*) was spiked @ 2 kg per tonne of bio waste mixture. The compost quality and maturity parameters *i.e.,* C/N ratio, CEC/TOC ratio, Total N,P, K, and micronutrients has been assessed and compared with standard compost quality parameters. It has been envisaged that about 250 tonnes of vermicompost will be prepared every year giving gross revenue of Rs. 15.0 lakhs per annum. With 5 laboures being paid 5 lakhs per annum and Rs 50000/- as contingent expenditure the total annual expenditure will be 11 lakhs and a total profit of 4 lakhs per annum. Thus, the system which is being called "*SUKHET MODEL*" will be self-sustaining economically, will provide employment to five person and achieve all four objectives.

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Impact of Heat Stress on Source-sink Relationships and Physiological Aspects in Lentils

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Crops such as lentil (*Lens culinaris Medikus*) is now a days facing temperature stresses as a result of climate change due to global warming. Increasing the yield and sustainability of yield under such stressful conditions has long been a major target of lentil breeding. Exposure of lentil plants in their reproductive or grain-filling stage to high temperature, affects the development of flowers, disrupts the structure of pollen tubes, shortens the duration and rate of grain filling, and hence has a negative impact on lentil productivity. Therefore, understanding source-sink relationships at the reproductive and grain-filling stages is critical for the selection of germplasm that can maintain high yields under heat stress. To ameliorate the detrimental effect of high temperature, it is necessary to concentrate on the effects of heat stress on source-sink relationships in a wide range of lentil genotypes and highlight the current metabolomic approaches that are used to investigate high temperature responses in lentil.

The experiment was conducted with 8 genotypes of lentil during 2020-2021. The field experiment was laid in random block design with 3 replications. The laboratory analysis of the samples collected from the field experiment was carried out at the Department of Soil Science & Ag. Chemistry, Visva-Bharati, West Bengal, India.

In the present study it was observed that high stress [temperature >30°C/25°C (day/night)] hampered reproductive growth, seed filling and pod development. Our investigation also reveals that there is a negative impact on the chlorophyll content, yields and biomass in some of the late sown variety. Out of 8 lentil genotypes IPL 220 and HUL 57 genotypes showed poor performance with respect to photosynthetic activity and yield attributes and some were able to escape the effect of heat when exposed to higher air temperature like L-4717 and BM 7. To overcome this situation, new strategies should be developed to improve heat stress tolerance of lentil.

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Carbon Dioxide Emission from the Soils Under Various Land Uses in the Nilgiris of Temperate Ecosystem in Parts of Western Ghats, Southern India

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Carbon dioxide (CO_2) is an important greenhouse gas accounting for 76 per cent of the total greenhouse effect. It is well known that vegetation and soils are major storage sinks of atmospheric CO_2. Therefore, CO_2 emission was measured soil CO_2 analyzer with canopy assimilation chamber (EGM-5; PP Systems) from various land uses such as agriculture, tea plantation, forests (Shola, wattle, Eucalyptus, mixed, pine forests) and grasslands in ICAR- *Indian Institute of Soil and Water Conservation* research farm (11°23'15" to 11°24'6" N and 76°40'3.96 to 76° 40'7.29 E; 2218 m above MSL) at Udhagamandalam using. Results indicate that CO_2 emission was more in the soils of agricultural land (41.37 tonnes/ha/year) followed by grassland (38.81 tonnes/ha/year) and *shola* forest (37.87 tonnes/ha/year). The lowest amount of CO_2 emission was observed in Pine forest soils (26.41 tonnes/ha/year). However, our eddy covariance data indicates that the temperate ecosystem especially forest and grassland act as a sink to atmospheric CO_2 with an average net primary productivity of -2575.28, -3212.21 and -2518.03 kg ha^{-1} $month^{-1}$ in monsoon, winter and summer respectively. Also, our study on various grass varieties indicate that besides forests, grasslands behave as a net sink to the atmospheric CO_2 and the average net carbon assimilation potential grassland comes to 33.41 tonnes/ha/year. Our study concludes that conversion of forest and grasslands agricultural activities should be avoided to sustain the carbon sequestration potential in soils. Enactment and strict enforcement of forest policy act prohibiting conversion of forest and grassland into agricultural land should be implemented.

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Impact of Sludge Application on Yield and Metal Uptake in Baby Corn and Spinach

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A field experiment was carried out to evaluate the long-term sludge (SS) application on metal uptake by plants under baby corn-spinach crops. The experiment was laid out with eight different treatment combinations comprising of different levels of sludge and fertilizer as follows: T1 = control (no sludge and NPK fertilizer), T2 = 100% recommended dose of NPK (NPK), T3 = $N_{25\%}$(SS) + $N_{75\%}$ + PK, T4 = $N_{50\%}$(SS) + $N_{50\%}$ + PK, T5 = $N_{100\%}$(SS) + PK, T6 = $N_{200\%}$(SS) + PK, T7 = $N_{300\%}$(SS) + PK and T8 = 100% RDF + 2.5 t sludge/ha. Impact of sludge application on grain yield of baby corn showed that maximum yield was recorded with 100% RDF plus 2.5 t sludge/ha, which is equivalent to the yield obtained with 25% N substituted by sludge plus NPK i.e. 5 t sludge/ha. A similar trend of spinach leaf yield was also recorded at all levels of treatments, where the residual effect of sludge depicted that up to 50% substitution of N fertilizer can be possible to achieve the similar yield of spinach as obtained with 100% RDF plus 2.5 t sludge/ha. Risk assessment of sludge amended soils was carried out and hazard quotient was computed using the formula of USEPA. Both baby corn grain and spinach are not likely to induce any health hazard to consumers as the value of HQ for Ni, Pb, and Cd were far less than 1. It can also be observed that there was an increase in the values of HQ as a result of the addition of sludge at all levels and maximum HQ was recorded at T7 where the highest rate of sludge was applied in the soil.

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No-till is More of Sustaining the Soil than a Climate Change Mitigation Option: A Meta-analysis

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No-till (NT) is referred to as an option to mitigate the climate change, possibly with a stronger conviction than as a practice to manage soil organic C (SOC) content. We conducted global meta- and mixed model analyses to evaluate the effect of NT in major crop rotations on SOC concentration (SOC_c, g C kg^{-1} soil) and the stock (SOC_s, kg C ha^{-1} land) with an aim to appraise the priority-setting, and the relative abundance of major SOC pools. No-till increased 25-33% SOC_c only in surface soil layer of 10 cm with a substantial increase of 38% in 0-5 cm and 6% increase in the 5-10 cm layer. SOC_c remained unchanged in soil layer below 10 cm and reduced with depth (10-16% increase in 0-20 or 0-30 cm layers; and only 5-9% increase for 0-50 or 0-100 cm profile). Temperate climate was the most conducive for NT. Soil texture had no influence, but inclusion of legumes in crop rotation facilitated greater SOC_c in deeper layers. Duration of NT had a cumulative impact, and a minimum period of 11-15 yrs could be necessary for the largest accumulation in the 0-30 cm profile. The microbial biomass-C was the most abundant pool with 61% and 23% increases in 0-5 and 5-10 cm layers, respectively. The top 0-5 cm layer was also characterized by large differences in aggregate-associated C, attributed to residues addition and physical protection by the NT. Particulate organic matter-C recorded no-change. Benefits of NT are restricted to the top layer only, which is potentially exposed and therefore could be short-lived. Nevertheless, change in the top layer has fundamental importance to soil quality and to cultivation, but have little relevance to C-sequestration potential. No-tillage should be promoted primarily as a sustainable agricultural management option, and not as a potential climate change mitigation option.

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Nutrient Management Drives the Direction and Magnitude of Nitrous Oxide Flux from Crop Residue Returned Soil under Different Soil Moisture

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Crop residue return is an integral part of sustainable agricultural management. The benefits of returning crop residues to improve crop yield and soil ecosystem services have been recognized globally. To test the response of soil nitrous oxide emission, soil organic carbon, and N mineralization to crop residue return with various C:N ratios at different soil moisture and how these responses are modulated by nutrient management, we used a laboratory based soil incubation approach. In this study, we incorporated crop residues with different C:N ratio (wheat, rice, soybean, and maize) with two contrasting soil moisture contents (80% FC and 60% FC) at seven nutrient levels: N0P0K0 (no nutrients), N0PK, N100PK, N150PK, N100PK+manure@ 5 Mg ha^{-1}, N100PK + biochar@ 5 Mg ha^{-1}, N150PK+ biochar@ 5 Mg ha^{-1}. The surface soil (0-15 cm) was collected after the harvest of wheat in the year 2020 from a 12 years old conservation tillage experiment in soybean-wheat cropping system under reduced tillage with 30% residue return plus 100%NPK. The results demonstrated that there were significant ($p<0.01$) differences in the responses of soil N_2O emissions to residue type, nutrient addition, and soil moisture. However, only the interaction effect of residue x nutrient and nutrient x moisture was found significant ($p<0.05$). Residue effects were negatively correlated with C:N ratio (not significant) and a strong positive correlation ($p<0.01$) was obtained between N_2O emission and CO_2 fluxes, labile carbon, ammonical N, nitrate nitrogen, nitrite N, dehydrogenase activity. The addition of residues with nutrients (N100PK, and N150PK, N100PK+manure) decreased the cumulative fluxes of N_2O from fertilizer N by 4 to 18 percent. The cumulative N_2O fluxes decreased significantly ($p<0.05$) by 16 to 62% with a reduction in incubation soil moisture from 80% FC to 60% FC in control and residue amended soil, across nutrient management. The effect of soybean and maize residue was relatively higher on wheat and rice residue on cumulative emissions of N_2O from fertilizer N in all nutrient plus treatments compared with control without residue. The effect of N fertilization on the magnitude and direction of SOC and residue C mineralization was dependent on residue type and soil moisture. For example, N fertilization significantly reduced the mineralization in maize amended soil, at both moisture contents and had no effect in control and other residue types at 80% FC. The results of this study suggested that the integrated application of crop residues with nutrients at specified soil moisture could be useful in mitigating N_2O emissions from Vertisols.

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A Laboratory Study on Degradation pattern of Herbicides in Acid Soils of Assam as Influenced by Moisture Content, Farm Yard Manure and Nitrogen Content

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Herbicides are the chemicals have capacity to move in the environment away from the target area, and to cause damage to non-target plants and animals. Herbicides vary in their potential to dissipate in the environment indicating the extent of contamination of the ecosystem including food chain. The persistence of herbicides in soils is influenced by adsorption, water content, temperature and soil composition. In the present study, effect of water content, organic and inorganic manure on the persistence of three herbicides *viz*. metribuzin, pretilachlor and pendimethal in soil was investigated in laboratory with soil textures, sandy loam and silty clay loam during 2019 in Assam Agricultural University, Jorhat, Assam. To study persistence and degradation, 2 kg of soil samples were incubated with 0, 50, and 100 mg kg-1 soil with the herbicides in glass bottles separately. Three soil moisture regimes viz., air dried 0, 50, and100 % of water retention capacity were maintained on the basis of the initial soil analysis. The herbicide residues were monitored in GC – 1000 using electron capture detector. Again, effect of farm yard manure (FYM) and nitrogen application at 30 and 80% moisture content at 0, 2.5, 5 g kg^{-1} FYM and 0, 100 and 200 mg kg^{-1} of nitrogen (as urea) separately repeated thrice and CRD as the design on experiments. The process of degradation followed first order kinetics. The rate of degradation increased with increase in moisture content and amount of farm yard manure or nitrogen and decreased with increasing herbicide concentration. The degradation processes of herbicides are faster in sandy loam than silty clay soil. The results suggest that contamination of the three herbicides in soils may be greatly diminished if soils are amended with manure and kept at higher moisture content for a certain period of time.

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Influence of the Mangrove Plantation on Stock and Stability of Carbon in Saline Soils of Sundarban, West Bengal, India

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Mangrove forests play a significant role in cycling and storing carbon in coastal saline soil. Whereas, saline soil mostly indicates low carbon contents because of poor plant growth. However, the influence of mangrove forests on carbon pools and stock of saline soil is yet to estimate. The Sundarban of India and Bangladesh put together to form the single largest block of mangroves in the world. Considering these, the current investigation was conducted on mangrove and saline soils of Sundarbans, 24 Parganas, district of West Bengal to evaluate the influence of mangrove forests (mangroves) on carbon stock and stability of carbon in saline soils of Sundarban with natural vegetation (fallow). Soil samples were collected from three depths (0-20 cm, 20-40 cm. 40-60 cm) from fourteen different places of mangrove and fallow soils of the Sundarban region. Soil carbon stock and different carbon pools were quantified. From the experimental result, it was found that although the pH of the mangrove and fallow was almost 7.0 ± 0.5 but the EC value was observed high (5±0.13) dS m^{-1} in the mangrove. Considering three depths, total carbon (TC) content was found higher in the mangroves than in the fallow. The TC decreased along with depth. In 0-20 cm depth, soil organic carbon (SOC) is found in the order of mangroves < fallow. On the other hand, recalcitrant carbon (RC) content in mangrove soils was higher as compared to fallow. Lower microbial biomass carbon (MBC) in mangroves supported the higher RC value in mangrove than fallow soil. Higher percent contribution (~ 40%) of RC to TOC under mangrove ecology implied build-up of stable C under mangrove ecology over fallow. This indicated the efficacy of mangrove ecology on the stability of carbon in saline soil.

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Assessment of Soil Quality Indicators as Influenced by Inorganic and Organic Fertilization in Different Rice-based Cropping Systems of Sub-humid Tropical Inceptisols

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Cropping system diversification under integrated nutrient management is an important tool for sustaining crop productivity as well as maintaining soil quality. A field experiment was conducted for the seven consecutive years (2013-14 to 2019-20) with three rice-based cropping systems (rice-mustard-jute; rice-wheat-maize+greengram; rice-lentil-sesame) and four nutrient management practices (NPK fertilizers and biogas slurry or BGS in various combinations) in a sub-humid tropical Inceptisols under the new alluvial zone of West Bengal to evaluate the influence of inorganic-organic fertilization on soil quality and system productivity. The experiment was laid out in strip-plot design and replicated thrice. Soil samples were analysed for physical, chemical and biological indicators after seven crop cycles and the soil quality index (SQI) was calculated by nonlinear scoring functions following the methodology of principal component analysis and multiple regression analysis-based minimum data set (MDS) selection. Results revealed that irrespective of the cropping systems, system rice equivalent yield (SREY) varied from 5.87 t ha^{-1} in the plots treated with 100% N through BGS to 7.78 t ha^{-1} under 100% NPK fertilizers. However, higher sustainable yield index (SYI) values were observed with the treatments receiving sub-optimal doses of NPK fertilizers along with BGS over that with the 100% NPK fertilizers. The best attainment of SQI was found in the rice-lentil-sesame system (3.32), followed by the rice-wheat-maize+greengram system (3.27) with integrated nutrient sources. A greater value of SQI in the integrated treatments suggested that partial substitution of chemical fertilizers with BGS has an edge over sole fertilizer treatments. Among all the indicators under study, available N, B and S as well as dehydrogenase activity were screened as key indicators which contributed 26, 25, 24, 25%, respectively to the SQI in integrated chemical fertilizer and biogas slurry treatment.

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Long Term Impact of Fertilization on Yield Sustainability and Climate Change Indices in a 20 Year Rice-wheat Rotation in Vertisols of Chhattisgarh Plain zone

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Rice-wheat cropping system (RWCS) is one of the prominent life-line for majority of the population of South-East Asia is under stress, due to indiscriminate and imbalance use of fertilizers. Thus, the present work was undertaken to assess the long-term impact of nutrient management options on sustainability of rice-wheat yields and climate change indices. The treatments used for assessing the sustainable yield index (SYI), partial factor productivity (PFP), global warming potential (GWP), green house gas intensity (GHGI) and carbon equivalent emission (CEE) includes (unfertilized control, 100% N, 100% NP, 50% NPK, 100% NPK, 150% NPK, 100% NPK+ZnSO 4 and 100% NPK+FYM respectively). The SYI improved with integration of manures with inorganic fertilizers and it was higher in rice over wheat. The SYI of the rice-wheat system varied from 0.59 (control) to 0.64 under 100% NPK+FYM. The SYI of the rice-wheat system clearly depicts the importance of balanced nutrition. The PFP improved for the rice-wheat system on integration of P and K with N. The PFP improved a lot if nutrients contribution from FYM was not considered. The GWP in rice-wheat rotation increased remarkably with super-optimal doses of NPK 30.78 over integrated nutrient combinations 23.14. The GHGI and CEE were also found to be higher with 150% NPK. Thus, the balanced and INM i.e., 100% NPK+FYM served as the most important nutrient management strategy for achieving better sustainability indices and lower GHG emissions under rice-wheat crops.

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Suitable Extractants for Predicting Bioavailable Cadmium Concentration in Soil and its Phytotoxicity Limit for Major Soil Orders of India

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Critical limits for metals contaminating the terrestrial environment are often required and the risk associated has to be assessed by comparing current concentrations against concentrations above which adverse effects are considered likely to occur. Pot culture experiments were conducted to derive phytotoxicity limits of Cadmium for Major soil Orders (Alfisol, Vertisol and Inceptisol) of India. Also incubation study was conducted to evaluate the suitable extractants for predicting bioavailable cadmium concentration in soil. The results showed that cadmium application had significant yield reduction over control. The dry weight of above biomass of spinach at highest level (40 mg kg^{-1}) of cadmium application was 49.7, 39.7 and 38.5% as compared to control in alluvial, lateritic and black soil, respectively. Phytotoxicity limit of cadmium for spinach biomass was more in alluvial soil of Kanpur as compared to black soil of Indore. Plant accumulation of cadmium increased with increasing levels of cadmium in all the 3 soil types. At their corresponding levels, cadmium accumulation in spinach biomass leaf was more in lateritic soil followed by alluvial and black soil. At the highest level (40 mg kg^{-1}) of cadmium application, the leaf Cd concentration was 151.23, 78.15 and 64.85 mg kg^{-1} of biomass in lateritic, alluvial and black soil, respectively. Indicating that the transfer coefficient value for cadmium was significantly high in lateritic soil (4.87) followed by alluvial (3.22) and black soil (2.32). Also different extractants (0.01 *M* $CaCl_2$, 1 *M* $CaCl_2$, DTPA and 0.43 *M* HNO_3) were evaluated to predict the bioavailable concentration of Cd in soil. Among the different extractants, the magnitudes of bioavailable fraction were highest in 0.43MHNO_3 followed by 1*M* $CaCl_2$, DTPA and 0.01 *M* $CaCl_2$ extractant. Among the soil types, the bioavailable concentration was significantly higher in lateritic soil followed by alluvial and black soil in all the extractants used. Significant linear relationship were observed in all the soil types between the extractable fraction by 1 *M* $CaCl_2$ extractant and total Cd content in soil with R^2 value of 0.985, 0.982 and 0.962 in lateritic, alluvial and black soil.

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Effect of Crop Residue Management and Conservation Agricultural Practices on Properties of Soil and Productivity of Soybean in Inceptisols

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An investigation on "Effect of crop residue management and conservation agricultural practices on properties of soil and productivity of soybean in Inceptisols" was conducted on farmers field at three villages of Barshi takali block, Akola district during 2019-20. The ten farmers have been selected in each village. Each farmer has been practicing conservation agricultural practices since last many years except one farmer who has been practicing conventional agriculture practices regularly. In the present study, highly variable trend in respect of soil biological properties *viz.,* soil microbial population, SMBC and CO_2 evolution were observed where conservation agriculture practice was followed since last 15 years and the lowest was observed in the field where regular ploughing was practiced each year. The soil physical properties like- BD, MWD, HC and soil moisture were significantly improved where conservation agriculture management practices were followed since last 15 years. The yield of soybean as influenced by conservation agriculture management practices was significant. Highest grain yield (24.50 q ha^{-1}) was obtained under T4 where conventional agricultural practices was followed each year followed by T10 (23.67 q ha^{-1}), and T9 (23.37 q ha^{-1}), where conservation management practices was adopted one and two years back respectively Hence, it is concluded that the consistent adoption of conservation agricultural practices supported well to enhance the soil health parameters and also noted significant change in yield of soybean. Therefore, adoption of crop residue management under conservation agriculture practices is advisable for long term sustainability of soil in rainfed agriculture.

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Evaluation of Microbial Inoculants for Acceleration of Composting Process of Municipal Solid Wastes

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Increasing population leads to the generation of more amount of municipal solid wastes (MSW) in developing countries. To reuse, reduce and recycle the MSW, proper and rapid solid waste management technique is more important. Composting is the times of yore practice in solid waste management, however shortening the duration of composting assumes much significance. A lab incubation study followed by field experiment were conducted to reduce the time period of composting from 60-75 days to 30-45 days. MSW collected from the Thoothukudi micro-composting centre were inoculated with TNAU Biomineralizer, Effective Microorganisms (EM) solution, PUSA decomposer, Regional Centre for Organic Farming (RCOF) waste decomposer, and TNAU Microbial Consortia. A perusal of the results showed that compost prepared from the inoculation of PUSA decomposer and Effective Microorganisms (EM) solution were on par in shortening the duration of compost to 35 days and 37 days respectively. The CO_2 evolution rate for above treatments were 7.56 mg CO_2-C and 6 mg CO_2-C per g of compost respectively indicating that they showed higher degradation efficiency compared to other treatments. The quality parameters of compost viz., colour (dark brown), odour (earthy odour), moisture content (68%), C:N ratio (13:1), Total N (3.37%), Total P (0.14%) and Total K (0.65%) were the best in those prepared with PUSA decomposer followed by EM solutions and TNAU microbial consortia. Hence, inoculation of PUSA decomposer @ 4 capsules per tonnes of waste facilitates 35 days of composting of MSW and produces compost with better quality parameters.

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An Integrated Approach for Arresting Transfer of Arsenic from Soil to Rice Plant

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Food-chain arsenic (As)-poisoning is a lethal problem in the rice-growing areas of Bengal Delta Plain. In view of a practically feasible solution to this problem, the present investigation was carried out. The efficacy of integrated use of chemical amendments and suitable rice cultivars for arresting transfer of As from soil to rice plant was assessed. For this purpose, a pot experiment was conducted to assess the effect of applied sodium metasilicate (@ 0, 250 and 500 mg kg^{-1}) on As uptake ability of four rice cultivars *viz*. IR-36, Khitish, Satabdi and Badshabhog, using an As-polluted soil, collected from West Bengal. Results indicated that relative ability to accumulate As in rice grain was minimum in the case of Badshabhog (0.12 mg kg^{-1}) as compared to Khitish (0.28 mg kg^{-1}), IR-36 (0.36 mg kg^{-1}) and Satabdi (0.40 mg kg^{-1}) under control. On the basis of the permissible limit of grain-As content (0.2 mg of As kg^{-1} of grain), Khitish, IR-36 and Satabdi were deemed unfit for human consumption when grown unamended on polluted soil. On an average, translocation factors of As from shoot to husk were 0.47, 0.18, 0.17 and 0.11 for Badshabhog, IR-36, Satabdi and Khitish, respectively, with the corresponding values for husk to brown rice were 0.09, 0.55, 0.71 and 0.39. On average, there was a significant reduction in As content in brown rice to the tune of 14.3 and 28.6% where sodium metasilicate was added @ 250 and 500 mg kg^{-1}, respectively. The cultivar Khitish was made suitable for human consumption when applied with 500 mg kg^{-1} sodium metasilicate. Integrated use of low-As-accumulating rice cultivars and silicate at a practically feasible low dose can be a promising strategy to arrest the transfer of As from soil to the grain of rice.

85th Annual Convention: November 16-19, 2021
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Understanding the Impact of Tillage and Potassium Management for Optimizing the Micro-environment for Rainfed Lentil (*Lens culinaris* Medik) Production under Moisture Stressed Rice-fallow

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Uncertainty of rainfall intensity and distribution, fast depletion of soil moisture contents affect timely sowing, seed germination and establishment of lentil in rice-fallows. Mid-season and terminal droughts retard growth and development of rainfed lentil by affecting its critical growth stages. A two-years field experiment was conducted in split-plot design with tillage (ZT-zero tillage and CT-conventional tillage) in main-plots and strategic K application methods (K0-no potassium, Kb-basal application, Kf-foliar application and K(b+f)-basal-foliar application) in sub-plots using rainfed lentil (*var.* B-77) as test crop in rice-fallow system. We assessed the yield, physiological and biochemical changes of lentil and soil biological properties under the given treatments. ZT showed ~15 and 23.5% higher yield than CT in 2015 and 2016, respectively. Under both tillage practices, Kf and K(b+f) increased lentil yield along with soil microbial biomass carbon (MBC) and dehydrogenase activity (DHA). Kf under ZT retained highest relative leaf water content (RLWC) and leaf area index (LAI); whereas K(b+f) showed similar results in CT. Irrespective of tillage and growth stages, K(b+f) correspondingly increased the chlorophyll and carbohydrate content by ~24.3 and 41.5%. In addition, enhanced concentration of phenol, free amino acids and proline in lentil showed a clear indication of moisture stress in K0 under both the tillage practices over the years. We can conclude that practicing zero tillage with foliar potassium can be an efficient way to escape soil moisture stress sustaining lentil productivity by regulating the biochemical properties of the plant at initial, subsequently improving crop physiological features under rice-fallow system.

85th Annual Convention: November 16-19, 2021
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Thermal Sensitivity of Soil Organic Carbon Decomposition Under Different Land Uses of Ranchi, India

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This study was undertaken to assess the impacts of different native land uses of Ranchi, India on thermal sensitivity of organic carbon decomposition (Q_{10}) in bulk soils and in aggregates. The samples were taken from six different land uses *viz*. native forest (NF), agri-horticulture (AH), native grass land (NG), rice-wheat (RW), rice- vegetable (RV) and maize-wheat (MW) from two soil depths (0-15 and 15-30 cm). Samples were incubated at 27, 32 and 37 °C, following standard procedures for assessing organic C mineralization. Initially (within 4 days after incubation) soils under NF showed lowest cumulative C value (Ct) whereas, after 32 days of incubation, bulk soils under NF had 18 and 17% higher Ct than AH and RV, respectively. In case of macroaggregates also, the NF showed increasing Ct values with increasing temperature. The microaggregates showed less Ct values than macroaggregates. But SOC in microaggregates were more thermally sensitive compared with SOC in macroaggregates. Soils under NG in the 0-15 cm layer had highest Q_{10} value that was 78 and 89% higher compared with AH and MW, respectively. The soils under RV had highest Q_{10} value in macroaggregates in both soil layers and in microaggregates in the surface layer. Thus, land use had significant effect on temperature sensitivity of C decomposition in both surface and sub-surface layers in Ranchi, India.

85th Annual Convention: November 16-19, 2021
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Appraisal of Heavy Metals Contamination in the Soil and Water in Peri-urban Region of Delhi for Sustainable Land Management

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Soil and water contamination in the peri-urban regions due to heavy metals is genuine concern. Thus, an intensive study was carried out for assessment of eight heavy metals [cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn)] concentration level in water and soil samples of peri-urban region of Delhi. Water sample was collected from different sources like drains, Yamuna River and groundwater, and soil samples were collected from cultivated field of peri-urban regions during 2019-2020, and metal concentration in soil and water was determined using AAS. Analytical results revealed that significant amount of metal concentration were found in irrigation water, out of which concentrations of Cu, Fe, Cr, Mn, Zn and Cd in drain water were almost beyond the permissible limit of FAO. Cu and Pb concentration in surface soils of majority of sites were recorded beyond the permissible limit of FAO. The overall mean metal concentration in soil found in the sequence Zn>Cu>Fe>Mn>Cr>Ni>Pb>Cd. It reveals that increasing trend of heavy metals concentration in water used for irrigation results in metal accumulation in soil, and their consequent accrual in the crops and soil ecosystem. Thus, continuous monitoring of heavy metal concentration in soil and water ensures better soil quality and management of natural resources of the region for its sustainable agriculture.

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Assessment of Soil Quality in Some Tea Growing Areas of Assam

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A study was conducted to assess the pedogenic processes of tea garden soils of Assam region. Seven representative soil profiles from seven sections of three different tea gardens namely Kakadonga tea estate (P1, P2), Mahema tea estate (P3, P4, P5) and Jamaguri tea estate (P6, P7) from Jorhat and Golaghat districts of Assam were collected of which Jamaguri tea estate followed organic cultivation method. The decreasing productivity of tea gardens of Assam has been driven by soil quality decline due to long term cultivation with inorganic inputs as well as use of high amount of pesticide/herbicides. It is therefore important to identify the sensitive soil quality indicators used for assessing agricultural sustainability of tea grown in these area. Soil quality can be determined by from management induced changes in key physical, chemical, biological attributes. 98 soil samples were collected from two depths *i.e.* 0-15 and 15-30 cm, in seven sections with three replications from two inorganically and one organically grown tea gardens. It was found that all the physical, chemical, biological parameters were improved in organically tea growing soils compared to inorganically grown tea soils. Conceptual framework and principal component analysis was used as a tool to create minimum data set for soil quality index in 0-15 cm and 15-30 cm soil depth under productivity management goal. PCA could screen out most sensitive indicators for SQI under productivity management goal. Linear scoring function performed well to express the variability under management goal. In 0-15 cm depth MWD, EC, CEC, available K and at 15-30 cm depth, MWD, EC, available Cu was found to be the key indicators for soil quality assessment. SQI values showed that organically grown tea gardens had better soil quality compared to the inorganically grown ones. It was also observed that with the increase in age of tea gardens, soil quality also decreased. From the present study it was concluded that Clay illuviation leading to Argillic sub-surface horizon was found to be the major pedogenic process involved in genesis of the tea garden soils leading to formation of Ultisols with low base saturation. It was also found that combined application of compost and vermicompost can reduce input costs of fertilizer and pesticides and will help to improve the soil quality of the tea growing soils of Assam. The high premium of the organically grown tea can compensate its low productivity as well as help to maintain soil quality of the tea gardens by improving soil microbial parameters, aggregate formation and reducing bulk density in the long run. As the association between CF-based and PCA-based SQI assessment was in good agreement, PCA based approach could be used as a powerful tool to screen the sensitive soil quality indicators and development of SQI in tea garden soils of Assam.

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Comparison Between Geostatistical and Deterministic Approach for the Spatial Mapping of Soil Organic Carbon: A Case Study of Agartala

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Soil Organic Carbon (SOC) of surface soil is one of the key factors for the assessment of soil fertility and land degradation. Geographic Information System (GIS) is a computer system which may help in determining the value at sampled location as well as helps in obtaining an accurate Digital Soil Mapping (DSM) of SOC. Deterministic method and geostatistical method are the two broadly classified interpolation methods available in GIS platform for obtaining a spatial distributed map. In this paper a comparison between few popular geostatistics and deterministic methods has been shown along with some discussion about the strength and short coming of both the methods. The results depict that despite of superiority associated with geostatistical method in some cases deterministic based method may give better output than geostatistics based approach. The RMSE and ME value for the best model are 0.59, (-)0.01. Grass and agricultural land has the highest SOC content in the final SOC map. This work shows the robustness of the deterministic based prediction method over the geostatistical techniques. This study will help the policymakers in adopting sustainable land use management.