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Abstracts

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Digital Soil Mapping of Key Global Soil Map Properties of India - A Case Study from Northern Karnataka Plateau

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Accurate and quantitative information of soil properties is essential for site specific sustainable management. Indian Soil Grids project aimed to map several key soil properties onto a three-dimensional grid at fine spatial resolution (~100 m) with local uncertainty estimates. A case study was conducted to predict the different key soil properties of Northern Karnataka, using the Quantile Random Forest Model (QRFM). High resolution satellite imagery (Sentinal-2-13 bands, Cartosat-2), terrain attributes such as elevation, slope, aspect, topographic wetness index, topographic position index, plan and profile curvature, Multi-resolution index of valley bottom flatness and Multi-resolution ridge top flatness, Vegetation factors like NDVI and EVI are used as covariates. The coefficient of determination (R^2), Mean error (ME) and root mean square error (RMSE) were calculated in order to assess model performance. Prediction interval coverage percentage (PICP) was calculated to evaluate the uncertainty of prediction. Soil properties like pH, OC, CEC, content of clay, sand and silt, field capacity and permanent wilting point were predicted in this study by this model. The predicted soil properties are reliable with observed properties with minimum errors and the QRF model can capture maximum variability in the top soil than the sub surface soil layers.

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Mapping of Soil Properties and Delineation of Management Zones in Konkan Region of India

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Land degradation in coastal region creates multi-nutrient deficiency and threatening future land use sustainability. Soils of Konkan region are highly vulnerable. Spatial mapping of soil properties is the key for management of these soils. Study was conducted in South Goa district located in Konkan region of western coastal India. Objectives of the study were to assess the spatial variability in soil properties, find the correlation amongst them and develop spatial maps of soil properties as well as delineate the soil management zones. A total of 258 geo-referenced soil samples were collected from the study area and analyzed for various physico-chemical properties using standard methods. Soil pH, EC, SOC, available N, P, K and DTPA extractable Zn, Cu, Fe and Mn showed wide variability. The average values of soil pH, EC, SOC available N, P, K and DTPA extractable Zn, Cu, Fe and Mn were 4.92, 0.08 dS m^{-1}, 1.67%, 211.2 kg ha^{-1}, 8.4 kg ha^{-1}, 202.3 kg ha^{-1}, 0.22 mg kg^{-1}, 0.44 mg kg^{-1}, 7.78 mg kg^{-1} and 7.86 mg kg^{-1}, respectively. SOC significantly correlated with N (0.33), P (-0.23), K (0.20) and Zn (0.17). Geo-statistical analysis revealed J-bessel best fit semivariogram model for pH, available P and K; rational quadratic for EC, SOC, Zn and Mn; hole effect for available N; stable for Cu and K bessel for Fe for spatial mapping. The spatial distribution of soil properties are useful for site-specific nutrient management for various crops grown in the region. The first four principal components showed >1.0 eigenvalue and cumulative variability of 59.38%. Three soil management zones were delineated by using the Fuzme and Arc GIS software for better soils management. Mapping of these zones holds potential for prioritization of management options.

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Mapping and Characterization of Salt affected Soils in Uttar Pradesh using Remote Sensing and GIS

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IRS LISS III Resource SAT data was used to delineate salt affected soils in eight districts (31717 km^2) Uttar Pradesh. Image analysis revealed large scale distribution of salt affected soils in the middle- and lower-Gangetic plains. High reflectance from salt encrustation in barren waste land indicated the presence of strong sodicity in large areas of the Ganga-Yamuna *doab*. Waterlogged sodic soils are also observed in the irrigated areas of Sarda, Upper- and Lower Ganga canals. The primary processes are transportation and deposition of salts in the catchment areas of the Gangetic plain. A large number of drains, canals and streams also favoured the redistribution of salts in the agricultural areas. Finer soil texture, nodular and concretionary calcium carbonate and petro-calcic horizon at shallow (<50 cm) depths rendered salt movement. Dominant calcium and carbonate salts in calcareousness soil restricted root growth and natural drainage. Sodium carbonate and bicarbonate salts are key issues for soil alkalinity and sodium saturation in exchange complex caused high exchangeable sodium percentage (ESP). Mixed spectral signatures was noted due to the intricate association of salt, higher moisture content and partial crop covers in moderate and slightly sodic soils. Sodic soils were commonly located in arable cropped areas under rice and wheat, horticultural crops such as mango orchards, mixed forest/plantation, grasslands, along the canal, river beds and drains and also used for brick kiln and industrial purposes. Soil analysis data indicated three categories of sodic soils viz. slight moderate and strong. Slightly sodic covered 85% of the reported soil samples followed by moderate and strongly sodic soils.

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Fertility Status of the Soils of Meerut District near Ganga Canal Command Area

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The present study was conducted in Meerut district along the west side of Ganga canal, with an aim to assess the properties of soils. Soil samples were taken from depth 0-15 and 15-30 cm and collected from 5 different locations of Meerut district. The soil samples from every location were taken up to 5000 meters from the Ganga canal for every 1000 meters. The soil samples were analyzed for various parameters in the laboratory. The results of the study indicated that the soil were be neutral to slightly alkaline in reaction in surface while slightly to moderately alkaline in subsurface. The EC of the soil samples were found as normal in salinity at surface and subsurface. The soil samples are poor in available nitrogen, medium to low in organic carbon at surface and subsurface. Most of the soils of the study area are characterized as low-high-medium categories in fertility index for N, P and K at surface, while at subsurface characterized as low-medium-medium. Total N content was found to be high at surface while low to medium at subsurface. Available P content was found to be medium to high at surface while low to medium at subsurface. Available K content samples are found to be medium at surface while low to medium at subsurface. The surface soils are sufficient in available micronutrients while they are marginal at subsurface.

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Estimation of Salinity of Coastal Salt-affected Soils using Mid-infrared Spectroscopy

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Assessing levels of salinity of salt-affected soils is very important for its sustainable utilization. Presently, it is achieved through routine soil chemical and physical laboratory analysis which is often time-consuming and expensive. In this regard, the reflectance spectroscopy is a modern and alternative technique which overcomes the limitations of conventional techniques. The study aims to estimate salinity of the salt-affected soils of the coastal region using mid-infrared (2500-15000 nm) reflectance spectroscopy (MIRS). The spectral reflectance of processed soil samples (2 mm sieved, n = 402) was recorded using Fourier Transform Infrared Spectrometer (Shimadzu IRTracer-100). A 10 nm averaged raw (RS10nm) and Savitzky-Golay standard normal variate processed spectral reflectance (SG-SNV10nm) were used for analysis. The data was divided into two sets, one as train data (70% of total) to develop the calibration model and other as test data (30% of total) to evaluate the performance of the calibrated model. Partial least-squares regression (PLSR) and principal component regression (PCR) were applied to construct calibration models, which were independently validated for soil salinity prediction (electrical conductivity, EC) from the soil spectral data. Prediction accuracy of the model improved when SG-SNV10nm was compared to RS10nm and and found that PLSR performed better than PCR. A 'very good' prediction accuracy was achieved using PLSR with SGSNV10nm pre-processing (R2=0.79, r=0.89, RMSE=2.21 dS m^{-1}, ratio of performance to deviation=2.15). Thus, it may be concluded that the mid-infrared spectroscopy data could be employed for monitoring the soil salinity of the salt-affected soils as it is rapid, repeatable, reliable and cost-effective.

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Mapping of Organic Carbon through Digital Soil Mapping Techniques

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Soil organic carbon is the most important indicator of soil quality and agricultural productivity and in turn environmental sustainability. The conventional method of soil organic carbon estimation is highly laborious and time consuming. Advancement in remote sensing, geocomputation and geostatistics has paved way to the concept of predictive soil mapping. Predictive soil mapping is a numerical or statistical model for establishing a relationship between environmental variables and soil properties. The present study concentrated on digital soil mapping of soil organic carbon in Coimbatore district of Tamil Nadu. The legacy soil data, profile information and soil maps were used as an input for soil mapping along with limited survey. A total of 440 soil profile informations were collected both from legacy data and actual profile observations. The ground truth soil data used as a dependent variable and remote sensing, terrain analysis and environmental data as independent variables to extract knowledge base for predictive soil mapping. The data mining technique used in the present study is decision tree model and see5 algorithms. Out of 440 points, 348 and 92 points were used as training and testing data, respectively. There were 16 useful co-variants of which physiography was the most influencing factor followed by green band and geomorphology. The predicted map produced an overall accuracy of 89.13 per cent and the kappa co-efficient of 0.81 indicating high accuracy in mapping. Thus, the digital soil mapping is reliable, time saving and produced a high resolution soil organic carbon map.

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Soil Health Card of Babhalgaon Village of Latur District Maharashtra for Sustainable Land Use

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The soils of Babhalgaon village are shallow to very deep, black (10 YR 2.5/1) to light gray (10YR 7/2) in colour, granular to angular blocky in structure, sandy to clay in texture, non-sticky non-plastic to very sticky very plastic in nature and the bulk density, saturated hydraulic conductivity and PAWC of soils varied from 1.42 to 1.79 Mg m^{-3}, 2.40 to 29.25 cm h^{-1} and 76.09 to 480.40 per cent respectively. The soils are slightly to strongly alkaline in nature and electrical conductivity is < 1.0 dSm^{-1}. The organic carbon content of the soils was low to moderate and calcium carbonate content varied from 6.4 to 16.6 per cent which indicates that the soils were calcareous in nature. The cation exchange capacity is low to high (32.92 to 68.04 cmol (p^+) kg^{-1}). The base saturation varied from 78.18 to 99.83 per cent. Taxonomically these soils are classified as Typic Ustorthents, Typic Haplustepts and Typic Haplusterts. The quality of ground water indicated medium salinity-low sodicity (C2S1) to high salinity-low sodicity (C3S1). Residual sodium carbonate in well and tube well water had less than 1.25 $mmol^{-1}$. This suggests that this water is safe for irrigation. The fertility status of surface soil sample (0-30 cm) and microbial properties does not vary with soil type. The physical properties *viz*. texture, structure, soil depth, coarse fragments and PAWC varied with soil type. Hence, it is concluded that the soil type and soil quality parameters viz. soil depth, texture, structure, coarse fragments and PAWC should include in the present existing twelve parameters of soil health card in order to suggest soil site suitability with site specific soil management practices for sustainable land use and doubling farmer income.

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Evaluation of Flouride Contamination in Soil Water and Plant Continuum of Reddiyarchatram Block of Dindigul District, Tamil Nadu

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Fluoride is potent halogen which causes major health ailments to humans when it exceeds the permissible limit of consumption. Presently 200 million people are at the risk of sever fluorosis in all over the world, where the India alone 65 million people are suffering with oesteofluorosis and dental mottling. Present study was conducted in Reddiyarchatram block of Dindigul district to assess the fluoride endemicity by collecting 47 soil, water, and plant samples from 23 villages. Result showed that seven villages (30% of block) were severely contaminated with fluoride in every part of ecosystem where water shown upto 2.30 mg L^{-1} (1.5 mg L^{-1} is permissible), soil of 3.22 ppm and accumulated upto 5 ppm in plants.

A field experiment was carried out to test the efficiency of fertilisers, manures and amendments in fluoride stress area of Reddiyarchatram to reduce the accumulation in plants and the water-soluble F availability in soil where onion (*Allium cepa* L. var *aggregatum*) is grown as a crop. The plant growth T3 (RD dose of NPK + FYM) was showed maximum values in parameters which was on par with another treatment of T4 (RD dose of NPK + Vermicompost) showing slight difference with one another. High bulb yield was recorded in treatments of T3 (RD dose of NPK + FYM) with the 16.4 t ha^{-1} followed by T4 (RD of NPK + Vermicompost). Organic amendments provide resistance to plants and endure the F stress where control plot having a reduction in physiological, biochemical and yield parameters showed fluoride having deleterious effects on plants. With regard to fluoride content in the soil, T6 (NPK + Gypsum) forms complexes most of the water-soluble fluoride, converts them into total form and reduces the plant available fluoride.

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Spatial Distribution of Nutrients in Soils of Krishi Vigyan Kendra, Panchkula, Haryana, Northwest India

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Mapping the spatial variability of soil fertility by applying GIS technique provides an elicit information for current and future use. Sixteen surface soil samples from Krishi Vigyan Kendra (KVK) Panchkula (Haryana) were collected and analysed to evaluate the spatial distribution of nutrients. The soils of the study area were loam to clay loam in texture, neutral to slightly alkaline (7.20-7.80) in reaction and non saline in nature. Organic carbon was low to medium and varied from 0.20-0.60 percent. Available nitrogen (N) and potassium (K) were low and varied from 76.00-147.00 kg ha^{-1} and 62.00-93.00 kg ha^{-1}, respectively. Available phosphorous was medium to high and varied from 10.00-37.00 kg ha^{-1}. Among the micronutrients, zinc, iron, copper and manganese varied from 1.20-3.20, 14.60-24.20, 0.84-1.88 and 10.84-18.80 mg kg^{-1}, respectively. Available N, P and K showed high variation as indicated by CV values (631.27, 56.30 and 69.33, respectively). Organic carbon (0.01), zinc (0.42), iron (8.34), copper (0.11) and manganese (7.77) showed small variation as indicated by low variance. Organic carbon was significantly correlated with N and P suggesting synergistic effect. All the soils were low in available nitrogen and potassium, therefore, the application of nitrogenous and potassic fertilizers are necessary to ameliorate nutrient deficiency and enhance crop production. The spatial variability maps of nutrients provide an insight of fertility status of the area and will help in easy monitoring of precision fertilizer management.

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Development of Land Resource Inventory based Soil Organic Carbon Restorative Land Use Plan for Terai Region of West Bengal

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To understand the sub-soil contribution in selecting crops and cropping intensity, a study was carried out in Maynaguri block, Jalpaiguri district, West Bengal (AESR15.3). Soil resource mapping showed seven land management units (LMU) having three land uses viz. field crops, forest and tea plantation. Horizon wise soils samples have been collected from fifteen model soils profiles upto a depth of 150 cm. Results showed that the SOC chemical pools of very labile (P1), labile (P2), less labile (P3) and non-labile (P4) in different LMUs varies from 24-34,14-20,19-24 and 26-38% of total soil organic carbon, respectively in the above root zone depth (ARZD) while it varies from 24-31, 12-22, 20-22 and 26-34% of total soil organic carbon, respectively in the below root zone depth (BRZD) following the order of P4>P1>P3>P2. The labile pool was highest (14.69 g kg^{-1}) in LMU1 having forest land use and lowest (1.61 g kg^{-1}) in LMU3 in single cropping in the ARZD and the same trend followed at BRZD. The recalcitrant pool is also the highest (14.13 g kg^{-1}) in LMU1 and lowest (2.05 g kg^{-1}) in LMU3 but the same trend did not follow in BRZD. Relationship among the soil particles with different C polls showed significant positive correlation with clay, fine silt, fine silt + clay and their ratios but not significant with silt fraction. It has been observed that the CEC/clay+fine silt ratios (illite dominant in clay fraction; mica and feldspars in fine silt fraction) showed asymptotic relationship with labile (L) and recalcitrant (R) pools. The recalcitrant pool in BRZD, SOC pools maxima and its derived priority class will guide selection of root zone depth based crop suitability, cropping intensity and input management practices with the restoration of SOC in soil profile under suggested land use plan.

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Mapping of Diara Land of Sabour block of Bhagalpur district, Bihar using RS and GIS Techniques

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Diara land, an enormous biodiversity and typical geomorphic feature is found in adjoining of river Ganges from Buxar to Pirpainti in Bihar. It is formed due to meandering and course changing behavior subsequently year after year. In *rabi* season, wheat and maize are generally grown in irrigated area where as pulses *viz.*, gram, pea, mustard and lentil have been advocated in non-irrigated areas. Among vegetables crops, tomato, potato, bottle gourd, pointed gourd and brinjal are taken by famers. In these framework, the present study have been conducted on groundwork of digital map towards availability of *Diara* land in various panchayats of Sabour block by employing satellite image of Lansat 8 (2019). *Diara* land was perceived as light tone (whitish) in contrast to water bodies and Tal land in False Colour Composite (FCC) image. Developed map is constructed by digital image processing techniques under RS and GIS domain, where NDVI was used as significant findings for crop land. The visual interpretation of the satellite imageries and physiographic configuration of the landscape, various patches of *Diara* lands were digitized in polygons (shape file). Out of fourteen panchayats of Sabour block having total geographical area of 114.95 km^2, only five panchayats viz. Rajandipur, Barari, Shankarpur, Fatehpur and Sabour were identified as *Diara* land consisting 38.59 km^2. As per USDA taxonomy classification, sabour and its adjoining areas fall under *fine-loamy, mixed, hyperthermic Typic Ustifluvents and justify the Diara land.* From fertility point of view, most of the samples of selected pedons were inadequate in available nitrogen and phosphorus and medium in available potassium. Overall, it can be concluded that, maximum exposure of *Diara* land was traced in Northern part of Sabour block which is helpful to assess the agricultural land, and to demorcate the area affected by flood.

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Characterization and Classification of Salt affected Soils of Reoti Block of Ballia District in Uttar Pradesh

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Three soil pedons were studied in three villages *viz.* Kuapipar, Dhirachhapra and Bishunpura of Revati Vikashkhand of of Ballia District, U.P. Soil samples were collected from 0-15, 15-30, 30-45, 45-60, 60-90, 90-120 and 120-150 cm depths and analysed for pH, EC, bulk density, pH, EC, water holding capacity, organic carbon, texture, $CaCO_3$, available N P K and S, Ca^{2+} and Mg^{2+}. Soil pH of all profile1 was 9.8 at 0-15 cm and there after increased with depth up to 9.79 at 120-150 cm. Profile 2 showed 7.70 pH at 0-15 cm to 8.06 at 120-150 cm and profile 3 showed 9.75 pH at 0-15 cm to 9.85 at 120-150 cm. EC of soil water extract was below 1.010 dS m^{-1}. The greater amount of organic carbon in surface soil of all profiles was due to accumulation of organic materials. The calcium carbonate ranged from 3.10 to 1.47, 3.5 to 0.7, 1.75 to 1.32 in pedons 1, 2 and 3 respectively. Greater amount of available N was found in surface soil (0-15 cm) and after that decreased with increasing soil depth in all profiles. Amount of available P content was decrease with horizons depth. It was slight higher in pedon 2, and medium in pedon 1 and 3 and decreased with soil depth upto 120-150 cm. The highest available K content was found in surface horizons (0-15 cm) and decreased with increasing depth in all profiles. Available S was 12.25 mg kg^{-1} in 0-15 cm depth and after that it decreased with depth in all pedond. Natural vegetation along with duration of waterlogging lead to the accumulation of organic matter and other plant nutrients in soil and influence on soil properties and land use system.

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Study of Physico-Chemical Properties of Light Textured Soils under Different Rice-based Cropping Systems

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A study was carried out at BEDF (APEDA) farm, SVPUAT Campus, Meerut during 2017-18 to determine the physico-chemical properties of light textured soils under different rice based cropping systems. APEDA farm is mainly used for production of basmati rice seed. Different pulses based cropping systems like rice-wheat-mung bean, rice-mustard-mung bean, rice-lentil-mung bean, rice-white chick pea-mung bean and rice-black chick pea-mung bean are cultivated to minimize the chemical uses and improve the soil health. Soil samples were collected from each cropping systems after harvesting of rice during 2017 and analyzed for physical and chemical properties. Results revealed that pH was alkaline in range (8.15-8.37), EC (0.169-0.194 dSm^{-1}), OC (0.15-0.93%), available N (184.39-278.47 kg ha^{-1}), P (20.60-50.67 kg ha^{-1}), K (209.49-254.24 kg ha^{-1}), Zn (0.60-1.45 ppm) and Fe (27.31-38.87 ppm), soil texture (sandy clay loam), bulk density (1.35-1.58 Mg m^{-3}), particle density (2.52-2.59 Mg m^{-3}), porosity(39-48%), aggregate stability (33-75%) and hydraulic conductivity (1.02-1.58 mm/h). Inclusion of pulses in cropping systems improve the physiochemical properties of soils which yielded maximum system land use efficiency, system productivity and system rice equivalent yield (87.43%, 0.31 kg ha^{-1} day^{-1} and 112.71 q ha^{-1} respectively) under rice-lentil-mung bean cropping system. Although inclusion of pulses did not affect soil texture, pH, EC, bulk density, particle density and porosity significantly as compared to wheat or mustard based cropping systems but aggregate stability, hydraulic conductivity, availability of phosphorus, zinc, iron and organic carbon (%) influenced significantly. Wheat and mustard being deep rooted crops remove more nutrients from subsoil and hence subsoil of rice-wheat/mustard-mung bean cropping system found poor than cereals-pulses-pulses cropping system. Study also indicates that continuous adoption of cereals-pulses cropping system may have added excess amount of available P, Zn and Fe in soil especially when phosphatic fertilizers applied regularly.

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Assessment of Crop Suitability of Padavaramarahalli Microwatershed, Chamarajanagar District, Karnataka using GIS Tools

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Land resource inventory of a Padavaramarahalli micro-watershed under Sujala–III project was carried out at site specific cadastral level to assess the crops suitability and land capability classes. The total geographical area of the micro-watershed is 708.00 ha, out of which 377.20 ha land is cultivated and 30.40 ha of land is severely eroded. The topography in the entire cultivated land is gentle sloping with slight erosion (348.30 ha), thus nearly 321.70 ha land belongs to Class II with soil limitations. Soil depth in the micro watershed in major area is 150 cm and soils are non gravelly. In the area, sandy clay textured soils are predominant followed by sandy loam soils and neutral to moderately alkaline in reaction is observed in the micro-watershed. The organic carbon and available nitrogen content are low in 364.6 ha and 372.30 ha, respectively. Available phosphorus is medium in 377.20 ha. whereas, available potassium is high in 332.80 ha. Among micro nutrients, copper and manganese found to be sufficient in 377.20 ha. The iron and zinc content is deficient in 375.40 ha and 73.90 ha, respectively. Using GIS platform, the analytical data was interpreted and thematic maps were prepared to show the extent of different categories of soil parameters and crops suitability to each parcel of the land for the micro watershed. The crop suitability indicates that 304.90 ha area is highly suitable for sorghum, red gram, tomato, chilli, amla and custard apple followed by mulberry, mango, sapota, coconut, banana and lime. However, guava and cashew crops are moderately suitable for the majority of the area. The soil properties and crop suitability information is of greater help in managing the resources and to obtain higher crop yields.

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Assessmetn of Soil Resources of Saintala block in Bolangir district of Odisha for Formulating Agricultural Land Use Plan

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The Saintala block of Bolangir district, Odisha was selected to develop block level Land Resource Information System (LRIS) in GIS environment. The area covers 59704 ha occurring in the hot moist subhumid agroecological subregion (AESR 12.1) and is developed on Eastern Ghat Super Group of rocks consisting of Khondalites, Charnokites and Gneissic rocks/Magmatites along with quaternary alluvium deposits Visual interpretation of IRS LISS-IV data followed by digital terrain analysis lead to delineation of five major landforms in the block viz., hills, upland, pediments, valley and active alluvial plains. The land use data of the block shows that forest lands occupied 27.7% of TGA of the study area while agricultural lands under single cropped lands occupy 23.3% of TGA and double crops were only confined to 7.0% of TGA in the block. Forty five 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, thirteen soil series have been identified and are classified under loamy- skeletal, coarse loamy, fine loamy and fine textural classes under Ustorthents, Haplustepts, 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 29% of TGA while soils having sandy loam texture and low organic carbon content (<0.5%) is observed in 56% and 85% of TGA respectively. About 62.2% of TGA are having moderate to severe erosion constraints while soils with shallow depth occur in about 26% of TGA. The major constraints are soil acidity, low organic matter, coarse texture which along with erratic rainfall and undulating topography adversely affects the crop growth and productivity.

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Characterization and Classification of Soils in Semiarid Region of Tatrakallu Village of Anantapuramu District in Andhra Pradesh

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Twenty two typical pedons representing major landforms in semi-arid ecosystem of Tatrakallu village, Anantapuramu district of Andhra Pradesh viz., plains and uplands originated from granite-gneiss and limestone parent materials were studied for their morphological, physical and chemical properties, soil genesis, taxonomy and nutrient status. The soils were slightly acidic to strongly alkaline (6.5 to 9.0) in reaction, non-saline (0.01 to 1.90 dS m^{-1}) shallow, deep and very deep in depth and had isohyperthermic temperature and ustic soil moisture regimes. The texture, organic carbon (OC), cation exchange capacity (CEC) and base saturation were ranged from loamy sand to clay, 1.0 to 6.7 g kg^{-1}, 6.4 to 50.6 cmol(p^+)kg^{-1} and 55 to 99 per cent, respectively. Pedons 1, 2, 3, 5, 8, 9, 10, 11, 21 and 22 were placed under Entisols due to absence of sub-surface diagnostic horizon and were classified as Lithic Ustorthents and Typic Ustifluvents whereas pedons 4, 7, 13 and 14 were grouped under Inceptisols due to presence of cambic (Bw) sub-surface diagnostic horizon and classified as Lithic Haplustepts, Typic Haplustepts and Fluventic Haplustepts. However, Pedons 6, 12 and 15 were classified under Alfisols due to presence of argillic horizon (Bt) and classified as Typic Haplustalfs and Lithic Haplustalfs. The remaining pedons were placed under Vertsiols due to presence of more than 30% clay in all the horizons and presence of slickensides and wedge shaped aggregates in sub-surface horizons and cracks in surface horizons and were classified as Sodic Calciusterts, Sodic Haplusterts, Typic Haplusterts and Leptic Haplusterts.

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Response of Vegetable Crops to the Varying Levels of Added Fluoride Concentration in Controlled Condition

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Fluoride, a ubiquitous toxin became a severe ecological problem and more than 200 million people is at the risk of fluorosis globally due to wide release in natural Environment. Major source of fluoride in the environment is weathering of fluoride containing rocks and anthropogenic activities such as haphazard disposal of industrial effluents and use of fertilizers. As a result, it is highly reactive, easily combine with other element and widely dispersible in plant, soil and water continuum. Ingestion of fluoride above permissible limit (1.5 ppm) can cause Dental fluorosis, Oeste fluorosis and several other health problems for both humans and livestock and toxic to plants. Translocation of fluoride to plants from air, water and soils depends upon the characteristics of soil, plant type and variety, quantity of fluoride present in air or type of water used for irrigation. A laboratory experiment was conducted to study the effect of different concentrations of natural fluoride present in water on five vegetables crops (Ladies finger, brinjal, chilli, onion, tomato) grown in a paper medium with concentration of 0.5, 1.0, 1.5. 2.30 mg L^{-1}. Water required for experiment is collected from different regions of Reddiyarchatram, Dindigul, India, known for fluoride endemicity. At the end of the experiment (14 days-21 days) the seedlings were analysed for physiological parameters (chlorophyll a and b content, Catalase activity), fluoride content, vigour index along with plant biomass, root length and shoot length were measured. Results showed that all four vegetable crops rendered gradual dwindle in root and shoot length, vigour index, and germination percentage with increase in concentration of fluoride. Onion was least influenced by natural fluoride content in irrigation waters compared to other vegetable crops where less decrease in root and shoot length, vigour index, photosynthetic pigments and germination percentage compared to other crops.

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Evaluation of Custard Apple (*Annona squamosa* L.) Growing Soils of Marathwada Region of Maharashtra

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Custard apple growing soils of Marathwada region are reddish brown to yellowish brown in colour, very shallow to moderately deep, granular to sub angular blocky in structure, non sticky non plastic to slightly sticky slightly plastic and silty loam to clay in texture. The bulk density of the studied soils varied from 1.34 to 1.99 Mg m^{-3}, PAWC varied from 25.2 to 111.5 mm and HC varies from 2.67 to 28.8 cm h^{-1}. The soils were slightly to moderately alkaline (7.02 to 8.04 pH) in nature, EC is < 1.0 dS m^{-1}, organic carbon content 0.1 to 0.86 percent and calcareous in nature (1.80 to 21.1 per cent $CaCO_3$). CEC varies from 23.3 to 55.66 cmol(p^+)kg^{-1}. Taxonomically these soils were classified into Lithic Ustorthents typic Ustorthents and Typic Haplustept. The yield of the custard apple showed ranged between 4.10 to 21.38 t ha^{-1} in the study area. The maximum yield was recorded in Lithic Ustorthent (Entisols). The yield of custard apple significantly negative correlation with PAWC and soil depth r = -0.80 and r = -0.69 respectively. This indicated that the PAWC and soil depth increase with decrease in the yield of custard apple. According to FAO (1983), the soils of Lithic Ustorthents (P1) were highly suitable (S1) whereas Typic Ustorthents and Typic Haplustepts were moderate (S2) to marginally (S3) suitable for custard apple. After going through statistical analysis under RBD it is observed that the highest yield of custard apple (17.5 t ha^{-1}) was recorded in very shallow soils (upto 25 cm), silty clay loam, underlined by hard murrum layer, Entisols were significantly superiar over other type of soils. From above result it can be concluded that the very shallow soils, underlined by hard murrum layer, Entisols are highly suitable for custard apple production on sustainable basis.

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Evaluation of Soil Quality for Long Term Rice-based Cropping Systems in the Hot Humid Eastern Plateau of India

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To perform and sustain ecosystem services, healthy soil is essential. Therefore, for assessing soil health, soil quality index (SQI) of Balod district of Chhattisgarh under rice-based cropping system was developed. Soils were characterized and classified into two soil orders *i.e. Inceptisols* and *Vertisols*. In both soil orders four rice-based cropping sequences were selected, *i.e.* Rice-wheat (RW), rice-chickpea (RC), rice-lathyrus (RL) and rice-fallow (RF). Stratified soil sampling was adopted and 10% of total villages of the district were selected randomly. Minimum data set (MDS) of 24 soil properties were generated which include physical, chemical and biological parameters to identify soil indicators using principal components analysis (PCA) and SQI was worked out. In both the soil orders the final selected indicators were field capacity (FC), pH, porosity, potentially mineralizable carbon (PMC), and available boron (AB). Among these soil indicators, field capacity had highest contribution towards the SQI (35.35%), followed by pH (30.52%), porosity (13.58%), PMC (11.82%) and AB (8.73%). ANOVA results indicated that the SQI of *Vertisols* (0.83±0.004) was significantly higher ($p<0.005$) than that of *Inceptisols* (0.73±0.005). Tukey's post hoc test for multiple comparisons revealed that SQI under RC (0.86±0.008) cropping systems was significantly larger than that of RL (0.81±0.006, $p<0.005$), RW (0.76±0.008, $p<0.005$) and RF (0.78±0.007, $p<0.005$). Similarly, SQI under RL (0.81±0.006) cropping system was significantly larger than that of RW (0.76±0.008, $p=0.026$). A good relationship between SQI and crop yield indicated that selected soil indicators had biological significance. Thus, from the study, it is concluded that the inclusion of legumes (chickpea and lathyrus) into cropping systems maintained better SQI and soil functions. Evaluation of SQI is not only used for assessing soil health but also to work out best management practices for sustaining intensive cultivation.

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Effect of FYM and Sources of Water on Growth, Yield and Quality of Wheat (*Triticum aestivum* L) in Salt Affected Soils

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A field experiment was conducted during 2014-15, 2015-16, 2016-17 and 2017-18 at farmers' fields of Sami and Harij talukas North Gujarat Agro-climate Zone of Gujarat to study the effect of FYM and water sources on wheat productivity. The experiment encompassed two levels of FYM *viz.,* F0: 0 t FYM ha^{-1} and F1: 10.0 t FYM ha^{-1} and three sources of irrigation *viz.,* Sole application of tube well water, Sole application of canal water and Alternate application of tube well and canal water. The experiment was laid out in factorial randomized block design with four replications. The results reveal that application of FYM and source of irrigation had a significant effect on grain and straw yield of wheat during all the individual years as well as on pooled basis. The treatment FYM @ 10 t ha^{-1} and alternate application of tube well and canal water gave significantly higher grain yield, straw yield, total number of effective tillers, length of spike and total number of seeds per spike of wheat during all the individual years as well as on a pooled basis for both the locations. The interaction effect between different levels of FYM and sources of irrigation on grain, straw yield, total numbers of effective tillers, length of spike, plant height and total number of seeds per spike was found non-significant during all the individual years as well as on pooled basis.

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Assessment of Crop Suitability in Ebachihalli-1 Micro-Watershed, Chamarajanagar district, Karnataka using GIS Technique based on Land Resource Inventory

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A strong advisory service on agricultural practice is possible if the resource inventory is done for potentiality and crop suitability for the land. The land resource inventory (LRI) of Ebachihalli-1 micro-watershed covering an area of about 368 ha was carried out under Sujala III project, using cadastral map of the village as a base along with high resolution 0.5 m satellite imagery (Quick bird).The major landforms identified in the micro-watershed are undulating uplands, mid lands and low lands. Out of 298 ha of the cultivable land, 268 ha is good cultivable land (IIs) and remaining 30 ha is moderately good cultivable land (IIIs). The major area of the micro watershed is non-gravelly with gentle slope and slight erosion. The soils of the area are deep to very deep in depth with sandy loam as dominant textural class. Soil is neutral (132 ha) to moderately alkaline (143 ha) in reaction with normal electrical conductivity. Organic carbon and available nitrogen content are low in 286.80 ha and 298 ha, respectively, whereas available phosphorus (298 ha) and potassium (229 ha) was medium. Besides, the soils are deficient in available Fe, Zn, Cu and B in major area. Currently, sorghum based cropping system is major one followed by coconut, tomato and sugarcane. Crop suitability maps were prepared using LRI data on GIS platform. Among field crops, sorghum, sugarcane, sunflower, tomato and mulberry and in case of horticultural crops amla, chilly, custard apple, jack fruit, jamun, lime, sapota, coconut, mango and tamarind are highly suitable for majority of the area. Selection of crop, based on the land potential, helps in maximizing the production on sustainable basis.

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Assessment of Crop Suitability through Land Resource Inventory of Ebachihalli-2 Micro-Watershed, Chamarajanagar district, Karnataka Using GIS Techniques

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Land resource inventory of micro-watershed, serves as a blue print to decide the suitability of crops and soil resource management options for a given parcel of land. Under Sujala-III project, land resource inventory of Ebachihalli-2 micro-watershed having a total geographical area of 470.00 ha, of which 405.20 ha is under cultivation, was carried out in order to assess crops suitability. Field traversing to delineate soil series bounders followed by collection of soil samples from representative pedons and surface soil samples from selected fields at 320m grid intervals was done using cadastral maps and remote sensing imageries. Based on laboratory and field data, thematic maps were prepared using GIS. Cultivable lands are nearly level to very gentle sloping and soil depth varies from moderately deep to very deep (263.5 ha) having sandy clay to clay soil texture. Soil is slightly alkaline to strongly alkaline in reaction with normal electrical conductivity. Organic carbon and available nitrogen are low in 388.60 ha and 405.20 ha, respectively. However, available phosphorus is medium in 391.60 ha and available potassium is high in 397.00 ha. Available sulphur is medium in 393.20 ha. Among micro nutrients, iron and zinc deficiency were observed in the area whereas copper and manganese found to be sufficient over entire cultivable land. The available boron is medium in 207.50 ha area. Sorghum based cropping system is predominant cropping system followed by coconut at present. The crops like amla, chilly, coconut, custard apple, jack fruit, jamun, lime, mango, ragi, sapota, sorghum, sugarcane, tamarind and tomato are moderately suitable for the cultivation. Whereas crops like banana, cashew, mulberry and guava are marginally suitable crops. Selection of right crop for a piece of land at right time maximizes productivity and thus enhances socio-economic status of the farmer.

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Distribution of Available Sulphur and Micronutrients (Fe, Mn, Zn and Cu) in Soils of Sugarcane Growing Areas of Vadodara Sugar Area of Gujarat

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In order to evaluate available sulphur and micronutrients (Fe, Mn, Zn and Cu) status of surface and profile soil samples from sugarcane growing soils of South Gujarat, four hundred fifty (total) representative GPS-referenced surface soil samples were randomly collected based on preliminary survey. It covers 27 talukas of 7 districts (Valsad, Navsari, Surat, Bharuch, Tapi, Narmada and Vadodara, encompassing the jurisdiction area of 15 Co-op. sugar industries *viz.* Valsad, Gandevi, Maroli, Bardoli, Chalthan, Sayan, Kamrej, Madhi, Mahua, Pandvai, Vatariya, Copper, Vyara, Vodadara and Narmada) of South Gujarat. Eight pedons were excavated in the representative sites from above area, studied and samples were taken horizon-wise. Soil fertility status of Vadodara sugarcane industrial area revealed that the available N varied from low (64.00 kg ha^{-1}) at village Mandala to medium (288.00 kg ha^{-1}) at village Palej, while available P_2O_5 ranged from low (9.27 kg ha^{-1}) at village Kanjetha to high (97.31 kg ha^{-1}) at village Medhod. Available K_2O varied from low (154.00 kg ha^{-1}) at village Kanthariya to high (885.00 kg ha^{-1}) at village Puniyad. When all the soils were considered it was noticed that mean values of available N, P_2O_5 and K_2O were 153.50, 40.73 and 547.50 kg ha^{-1} respectively indicating chronologically low, medium and high status. The available sulphur varied from very low (2.08 ppm) at village Medhod to high (28.55 ppm) at village Mandala with mean value of 10.41 ppm which indicated an average medium available S status of soils from Vadodara sugarcane industrial area. The results also revealed that DTPA-extractable Fe and Mn of soils were as high as 14.50 and 10.94 ppm respectively at village Chhattral and Sadhali, while the highest values of DTPA-Zn and Cu were 1.44 and 3.00 ppm, respectively at village Kurali. However, mean DTPA-extractable Fe, Mn, Zn and Cu were 8.46, 5.54, 0.51 and 0.70 ppm, respectively which indicated medium, medium, medium and high status, respectively.

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Impact of Wastewater Irrigations on the Chemical Properties of the Soils underTurfgrass (*Cynodon dactylon* L.)

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An investigation was carried out to assess short-term (2013-16) impact of wastewater irrigations on the chemical properties of the soils under Turfgrass (*Cynodon dactylon* L *var.* Selection-1), planted with and without sub-soil porous plastic mulch, in the experimental field of the Water Technology Centre of ICAR-IARI, New Delhi. The investigation comprised of 3-replicates of 2-groundwater irrigation scheduling treatments (each of 50 mm depth) at 100% ETc and 6- treatments of wastewater irrigation scheduling (also of 50 mm depth each) at 75%, 100% and 125% ETc, under with and without sub-soil porous plastic mulch planting. The investigation revealed a non-significant change in the rhizosphere soil pH and EC under all wastewater irrigation treatments. However, a significant (14 to 25%) increase in the soil organic carbon, particularly under the more frequently (i.e. at 75% ETc) wastewater irrigated plots, was observed. These were also found to be associated with increased soil major nutrients (N: 8.5 to 15.2%; P: 45.7 to 62.8%; K: 12 to 34.7%) as well as micro nutrients (Zn: 22.4 to 29.5%; Mn: 16.9 to 27.1%; Cu: 21.9 to 19.2% and Fe: 15.6 to 24.8%). However, there was no heavy metal built-up in such wastewater irrigated soils probably due to their presence within permissible levels in the applied irrigation waters. Thus, the investigations indicated a great potential of improved soil health, with no heavy metal threats, under short-term wastewater irrigation applications urban Turfgrass based landscapes.

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Interactive Effect of Tillage, Irrigation and Phosphorus Fertilizer Management on Growth and Yield of Chickpea (*Cicer arietinum* L.)

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Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). Higher temperatures and evaporative demand, especially in eastern India, often cause water shortage during the reproductive stage of dryland post-rainy season crops, leading to yield reduction. The interactive effect of tillage (both conventional and zero tillage) and irrigation management in chickpea on mitigating soil moisture stress are scarce. Further, quantitative studies on mitigation of soil moisture stress of chickpea through modification of the root distribution pattern and phosphorus fertilizer management are unknown. Keeping these things in view the study was designed to find out the best management practice of chickpea relating to irrigation, tillage and phosphorus nutrition. The study consists of two tillage practices – conventional tillage (CT) and zero tillage (ZT), five irrigation regimes- no irrigation, vegetative + flowering + pod formation, flowering + pod formation, flowering, pod formation and three doses of P fertilizer – 0, 50, 62.5 kg ha^{-1}. The ZT treatments resulted in higher moisture storage in the root zone than the CT treatments, leading to better yield in ZT than CT under no irrigation conditions. The root length density was higher in CT treatments, whereas higher root diameter was recorded in case of ZT treatments. Irrigation regime and phosphorus fertilization also significantly affected the root distribution pattern under various tillage management practices. Highest yield was recorded in case of ZT with irrigation at flowering stage only treatment along with 62.5 kg ha^{-1} P fertilizer dose, which can be evident through higher RLWC and higher chlorophyll content. Therefore, conservation tillage along with irrigation at flowering stage and higher than recommended dose of P fertilizer can be an effective stress management strategy in case of chickpea.

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Effects of Long Term Application of Inorganic and Organic Fertilizers on Soil Physical Properties in Rice-Mustard-Sesame Rotation System

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It is well recognized that long term fertilizer experiments are repositories of valuable information regarding the dynamic change of physical properties over time in agro-ecosystems. However, there is paucity of data on soil physical parameters in most of the long-term fertilizer experiments. A long-term fertility experiment (12 years) in Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal with rice-mustard-sesame system was taken for this study to assess the distribution of hydraulic as well as structural parameters, influenced by 100% NPK, 100% NPK + FYM, 100% NPK + green manure (GM) treatments along with no fertilizer control. Various soil physical properties were measured for surface (0-20 cm) soil after harvest of rice crop and it was found that balanced fertilizers (NPK) showed higher hydraulic as well as structural properties than control. The bulk density (BD) was significantly lower in 100% NPK + FYM over other treatments while the control plot invariably showed higher BD. The 100% NPK + FYM application significantly increased soil organic carbon (SOC) content, mean weight diameter (MWD), water stable aggregates (WSA), volume expansion, water holding capacity (WHC) as well as hydraulic conductivity (Ks) as compared to control plots. Applications of 100% NPK+FYM and 100% NPK+GM significantly improved liquid limit (LL) and increased the percentage of macro-aggregates (>2 mm). A positive correlation was also found between the soil structural parameters and Ks. From the study, it is, thus, concluded that continuous cropping and integrated use of organic and inorganic fertilizers in rice-mustard-sesame rotation system improved soil hydraulic as well as structural properties.

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Estimation of Saturated Hydraulic Conductivity from Physical Properties of Six Different Soil Textural Classes

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Soils with different textural variations cause significant changes in saturated hydraulic conductivity (Ks) because of significant alterations in soil physical properties with different cropping systems. The measurement of Ks is often labour intensive, time consuming and cost inefficient. However, pedotransfer functions (PTFs) provide an alternative by estimating soil parameters from more readily available soil data. 90 surface (0-20 cm) soil samples, collected from seven distinct agricultural experimental farms with different cropping systems under Bidhan Chandra Krishi Viswavidyalaya, located in New Alluvial Zone of West Bengal, were characterized for physical parameters and were employed to develop PTFs for predicting Ks. Six different textural classes were observed and the resulting data were analysed statistically using Pearson correlation and multiple linear regressions (MLR) analysis. The distribution of Ks was low in fine textured soils like silty clay and sandy clay; moderate in loam, clay loam and sandy clay loam; high in sandy loam soils of the study sites. Results showed that Ks was correlated significantly with sand, silt and clay fractions; bulk density, mean weight diameter, aggregate stability and structural coefficient, respectively. Ks had both positive and negative relationships with soil organic carbon. PTFs for Ks were derived by stepwise MLR and fitted by coefficient of Fdetermination (R2) and residual mean square error (RMSE). Some uncertainty of the variation in Ks was observed to fit models probably resulting from sampling from different cropping systems and measurement errors, randomness and soil heterogeneity, or other soil chemical properties that were not observed.

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Characterization of Groundwater Quality for Irrigation in Faridabad District, Haryana

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The present study examined the quality of groundwater in Faridabad district of Haryana located on south eastern part of Haryana state. In the north it is bordered by the Union Territory of Delhi, in the east by Uttar Pradesh, in the south by Palewal and in the North West by Mewat and Gurgaon districts of Haryana. Total geographical area of the district is 2151 km^2. Faridabad district is divided into Two Blocks, namely, Faridabad, Ballabgarh and Faridabad town is the headquarter of the district. In order to ascertain the quality of groundwater, two hundred seventeen samples were collected and analyzed for various haydrochemical parameters *viz*. 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 6.81-9.88, 0.50-9.91 (dS m^{-1}), 2.54-20.05 $(mmoll^{-1})^{1/2}$ and 0.00-5.60 (me L^{-1}), respectively. The trend among the average ionic concentration of cations and anions are $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ and $Cl^- > HCO_3^- > SO_4^{2-} > CO_3^{2-}$. According to AICRP classification, overall in Faridabad district, 30.9, 34.6, 1.4, 12.4, 12.4, 3.7 and 4.6 per cent samples were found in good, marginally saline, saline, high SAR saline, marginally alkali, alkali and highly alkali categories, respectively. Variable maps of EC, SAR, RSC and water quality of groundwater used for irrigation in the Faridabad district were prepared through GIS to study spatial variability.

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Study on Physical Properties Soils of Ganjam District, Odisha

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The information regarding the variability of soil physical properties with respect to soils of Odisha is very scanty. So attempt has been made in present investigation to study the physical properties of loose and core samples collected from 20 blocks of Ganjam district as per Global positioning system (GPS) coordinates. Soil samples were analysed in the laboratory for different physical properties as per the standard procedure. The result indicated that, the highest mean bulk density (1.71 Mg m^{-3}), particle density (2.67 Mg m^{-3}) and porosity (44.69%) was observed with Kabisuryanagar, Kabisuryanagar and Rangeilunda block respectively whereas the lowest values of bulk density (1.29 Mg m^{-3}), particle density (2.35 Mg m^{-3}) and porosity (35.87%) were observed in Belaguntha, Belaguntha and Kabisuryanagar respectively. High sand content of Kabisuryanagar indicated that the soils of this block were coarse textured with high bulk density and permeability. High clay content and low hydraulic conductivity associated with the soils of Seragada rendered them slowly permeable. The available soil moisture capacity of five blocks viz. Khalikote, Belaguntha, Sanakhemundi, Kabisuryanagar and chikiti was low indicating lower crop growth period. The hydraulic conductivity was low in ten blocks viz. Bhanjanagar, Soroda, Patrapur, Dharakote, Digapahandi, Jagannathprasad, Belaguntha, Hinjilicut, Chhatrapur, Seragada, Sanakhemundi and Rangeilunda. From the correlation study, it was observed that the sand content was positively correlated with bulk density and hydraulic conductivity but negatively correlated with silt, clay and porosity. The clay content is positively correlated with porosity and maximum water holding capacity but negatively correlated with bulk density, particle density and hydraulic conductivity.

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Effect of Deep Tillage and Irrigation Regimes on Soil Water Balance, Land and Water Productivity of Direct-seeded Rice-wheat System

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Direct seeded rice (DSR) is being intensively cultivated in northwest India due to increasing labour and water dearth. The hardpan found in the 15-30 cm soil layer in the region due to repeated puddling in coarse and medium textured soils hampers the DSR root proliferation. Deep tillage has been shown to help in mitigating this effect in DSR. However it is imperative to study the deep tillage effects in rice-wheat cropping system as a whole. Field experiments were conducted during 2016-18 in a sandy loam soil to compare the water inputs and outputs, water productivity in direct seeded rice (DSR)-wheat system with three differential tillage practices [deep tillage (DT) in DSR in first crop seasons only; DT in DSR during both the crop seasons; conventional tillage (CT) in both crops and two irrigation regimes [irrigation at 4 and 8-day interval in DSR; irrigation water-cumulative pan evaporation ratio of 1.0 (I1.0) and 0.5 (I0.5). The evapotranspiration (ET) of rice and wheat were higher in frequently irrigated plots. There was no interaction of deep tillage and irrigation regime to affect ET. The land productivity was higher under frequently irrigated conditions (4-d in DSR, I1.0 in wheat and 4-d/ I1.0 for the cropping system) whereas water productivity was higher under less frequently irrigated conditions (8-d in DSR, I0.5 in wheat and 8-d/ I0.5). The deep tillage proved to be profitable in enhancing land and water productivity. But the deep tillage during both the crop seasons of rice did not result in significant improvement of land and water productivity as compared to deep tillage during the first crop season.

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Improvement in Soil Physical Health and Carbon Sequestration under Conservation Agriculture Practices in Wheat Based Cropping Systems of the Indo Gangetic Plains

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Soil samples were analyzed in an eight year old ongoing tillage experiment conducted at the research farm of the Indian Agricultural Research Institute, New Delhi to study the impact of conservation agriculture (CA) *vis-à-vis* conventional tillage (CT) on soil physical health and carbon sequestration in cotton-wheat, pigeon pea-wheat and maize-wheat cropping systems. It was observed that under CA practices, there was improvement in the mean weight diameter (MWD) and percentage of water stable aggregates by 20.4 and 3.4%, respectively compared to CT at 0-5 cm soil depth. Across the cropping systems, Zero tilled flatbed with residue (ZT-FB+R) registered the highest MWD. There was decrease in the BD and increase in maximum water holding capacity under CA than CT at 0-5 cm soil depth. Among the tillage practices, SOC concentration was maximum in Zero tilled broad bed with residue (ZT-BB+R) (10.44 g kg^{-1}) and minimum in the CT (6.81 g kg^{-1}) and among the cropping systems, SOC concentration was maximum in pigeon pea-wheat system (9.65 g kg^{-1}) and minimum in maize-wheat system (7.97 g kg^{-1}) at 0-5 cm soil depth. Among the tillage methods, stratification ratio (SR) of soil organic carbon was maximum in ZT-FB+R (2.19) and minimum in CT system (1.70). Further, in the CA systems, retention of residues could increase the SOC concentration and its stratification ratio. Soil organic carbon stock at 0-30 cm soil depth was maximum for ZT-FB+R (33.15 Mg ha^{-1}) and minimum for CT (26.88 Mg ha^{-1}) and among cropping systems, it was maximum in maize -wheat system (35.16 Mg ha^{-1}) and minimum in the pigeon pea-wheat system (28.47 Mg ha^{-1}). Carbon sequestration potential of CA practices compared to CT was maximum for maize-wheat system (5.45 Mg ha^{-1}) and minimum for pigeon pea -wheat system (2.51 Mg ha^{-1}) and among the CA practices, the carbon sequestration potential was maximum for ZT-FB+R (6.27 Mg ha^{-1}).

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Digital Soil Mapping and Modeling (DSMM) for Development of Spatial Soil Information System in Arid Western India

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Mapping soil properties has been conventionally done through surveying efforts followed by laboratory analysis. Soil maps developed by the conventional approach are generally hard copy map and therefore are not easily accessible to end users. Moreover, mapping units sometimes represent quite large area in field and thus soil properties of interest vary considerably within a unit. With advancement of geostatistics and abundant availability of digital information on earth features, there is possibility to map soil properties utilizing available legacy soil data and digital data on earth features. Moreover in the context of digital India and soil health mission, it is timely and apt to prepare the digital soil maps for different regions of the country. Keeping in mind these requirements, it is targeted in this study to prepare digital maps of soil properties in arid western India following kriging approaches and its variants. The digital maps of basic soil properties have been converted to maps of complex soil properties e.g. soil water retention at field capacity (FC), permanent wilting point (PWP) etc using suitable pedotransfer functions (PTFs). Available legacy soil data for arid western India viz. soil seies database of Rajasthan and Gujarat have been collated and have been further used to prepare spatial maps through digital soil mapping approach. Ordinary kriging (OK) and its advanced variants e.g. regression kriging (RK) and random forest regression have been used for preparing spatial maps of soil properties, which were further validated through k-fold cross-validation approach. RK approach performed better than OK in prepring digital soil maps whereas random forest regression was found comparable with RK. These maps were further used to develop web enabled soil information system. Such information system may help farmers to take suitable soil management decisions for increasing farm productivity.

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Effect of Gypsum, Crop Residue Mulch and Manure on Soil, Nutrient Loss and Soybean Productivity in Table Land of Chambal Ravines

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Table lands are agricultural productive lands adjoining ravine belts. One such table land was found near Chambal ravines of south eastern Rajasthan. Field experiment was conducted with various combinations of amendments like farm yard manure, mustard crop mulch, gypsum and recommended dose of fertilizers laid out in random block design in table lands of IISWC, Research farm, Kota. Various combinations of treatments were Control (without fertilizers and amendments); Recommended Dose of Fertilizer (RDF) for soybean; RDF + FYM (10 t ha^{-1}); RDF + Mulches (3 t ha^{-1})); RDF + Gypsum (2 t ha^{-1}); RDF + Gypsum + FYM; RDF+ Gypsum + Mulches and RDF + Gypsum + Mulches + FYM. Results showed that application of amendments like gypsum along with crop residue reduced soil loss and runoff in all treatments. Highest nutrient and soil loss was recorded in control plots without any amendments. Among the various nutrients, potassium loss was as high as 30-40% compared to nitrogen and phosphorus content. Compared to FYM, addition of crop residues as mulch to the tune of 3 t ha^{-1} was more effective in decreasing runoff and soil loss under soybean. Significant increase in soybean yield was observed where gypsum, crop residue mulch and FYM were applied. Combination of amendments like gypsum, crop residue mulch and FYM improved soil properties and moisture content over control plots. Slight but non significant improvement in soil carbon and other available nutrients was also observed in amendment applied field under soybean crop.

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Assessment of Sustainability of Conservation and Conventional Agricultural Practices in Karnal District of Haryana

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.A study was conducted in the Nilokheri block of Karnal district of Haryana for assessing the sustainability of conservation (CA) and conventional (CT) agricultural practices. Sustainability index (SI) was calculated for Taraori, Gholpur and Sambi villages for 0-15 and 15-30 cm soil depths based on critical limits and relative weighing factors of soil health parameters. Taking limitation to crop production into consideration, critical values for each indicator was decided and relative weighing factor was assigned. The SI was obtained by summing up critical values for each indicator within a depth individually for each field. Sustainability of each field was decided from the cumulative ratings (CR). Scoring of each soil health indicator was done by techniques for order of preference by similarity to ideal solution (TOPSIS) which is a multi criteria decision analysis method. Results showed that CR of CA at 0-15cm soil depth varied between 19 to 25 with SI ranged from highly sustainable to sustainable. A similar pattern was observed for 15-30 cm soil layer too. In case of CT, CR ranged from 25-30 for both the soil layers which indicated a SI of sustainability with high input. Results of TOPSIS indicated that SOC had the highest score of 0.96, thus giving it rank 1. This indicates that SOC contributes maximum to sustainability. Similarly, other parameters like effective rooting depth (ERD), bulk density (BD), texture, and wilting point (WP) ranked 2, 3, 4 and 5, respectively indicating their corresponding weightage of contribution towards sustainability. Thus, CA can be promoted as it is sustainable in terms of soil health and emphasis should be given for improving SOC of soil as it has maximum weightage towards sustainability.

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Benchmarking of Soil and Water Resources in Narmada Canal Command Area of Rajasthan and their Characterization for Monitoring and Assessment

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Benchmarking of natural resources is required to develop base line information for their effective management. The baseline information on soil and water resources for monitoring and assessment was generated for Narmada canal command area of Rajasthan. Identification and characterization of benchmark sites for soil resource characterization in Narmada command area revealed that the soils were mainly classified under Sanchore, Dhorimanna and Chohtan soil series and Alluvial soils. Soils of Sanchore and Chohtan series are fine sand to loamy sand in texture, light yellowish brown to yellowish brown in colour and occurr mostly on nearly level to undulating aeolian lands. Dhorimanna soils are very deep, fine sand to loamy sand, excessively drained, light yellowish brown to yellowish brown in colour, and have severe to very severe wind erosion problem and constitute about 25% of the area. The alluvial soils are characterized by stratified horizons which have been formed by Luniriver and its tributaries. Soils are sandy loam-loam to clay loam in texture, imperfectly to moderately drained and occur on level to gentle sloping lands. Benchmark sites for salinization and water logging assessment were also earmarked and characterized. The development of salinity in the command area has arisen primarily from the pre-existing salt deposits in the sub-stratum with application of irrigation water in some parts of the command area. The pHs and ECe of these soils varied from 7.7-9.5 and 1.6 to 41.5 dS m^{-1}. The area includes three hydrogeological units namely aeolian sands, younger alluvium and older alluvium. The depth of groundwater in the area ranges upto 30m below land surface. The electrical conductivity of groundwater ranges from 3.6-11.5 dS m^{-1} and that of pH from 7.30 to 8.70. The RSC was not found in most of the samples.

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Delineation of Quality of Irrigation Water in Mahisagar District of Gujarat

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A survey work was conducted during 2018-19 for delineation of quality of underground (well/tube well) water of newly established Mahisagar district of middle Gujarat by one hundred and eighty underground irrigation water samples (30 samples from 6 talukas) were collected. The samples were analyzed for their irrigation water parameters viz., EC, pH, various cationas (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), anions (CO_3^{-}, HCO_3^{-}, Cl^{-}, SO_4^{-}) and water quality appraisals (RSC, SSP, SAR) as per standard laboratory procedures/calculations. The results of quality of underground wells/tube wells water revealed that the EC values ranged 0.26 to as high as 8.80 with a mean value of 1.10 dS m^{-1}. The pH of water ranged from 6.60 to 9.70 with a mean value of pH 7.49. The RSC value ranged from 0.0 to 1.30 with mean value of 0.007 me L^{-1}. The mean value of SSP was found 13.07, which varied from 0.11 to 65.95. The SAR values ranged from 0.00 to 11.03 with a mean value of 0.76. Overall, 99.0 per cent water samples were under safe classes with respect to RSC, SAP and SAR indicating the non-hazardous effect of well and tube well water for irrigation in soils of this region.

Looking to the correlation between quality parameters of irrigation water and soil properties, a highly significant positive correlation between ECiw with EC1:2.5 (r = 0.238**), SSP (r = 0.148*), SAR (r = 0.269**) and RSC (r = 0.165*) of soil was observed. However, negative correlation (r = -0.278**) between ECiw and soil ESP was observed. This indicated that irrigation water with higher total soluble salts, increased the EC, SSP, SAR and RSC but did not affect on ESP of soil. The pH of irrigation water had significantly positive correlation with soil ESP (r = 0.298**).

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Characterization of the Soils of Mahisagar District in Gujarat

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A study for delineation of physic-chemical properties and fertility status of the soils of newly established 'Mahisagar' district of middle Gujarat was conducted during 2018-19. Total 180 surface soil samples from cultivated fields were collected and analysed for various physic-chemical properties and fertility status as per standard laboratory procedures. The mean value of soil BD and PD is 1.32 and 2.53 Mg m^{-3}, respectively. The mean value of soil porosity and MWHC is 47.97 and 45.97 per cent, respectively.

In case of chemical properties, the soils were high in OC content ranging from 0.12 to 1.77 per cent with a mean value of 0.81 per cent. The soils are mostly non-calcareous in nature (upto 4.28% $CaCO_3$ in some areas) with mainly neutral to alkaline in reaction (pH value ranging from 6.29 to 8.76 with a mean value of 7.60) in reaction. The mean EC (1:2.5) value was 0.38 dSm^{-1} and ranged from 0.11 to 2.1 dS m^{-1}. The mean CEC value was 24.47 cmol(p^+)kg^{-1}. Overall, the soils of Mahisagar district were low with respect to available N (232 kg ha^{-1}), Medium in P_2O_5 (30.5 kg ha^{-1}), S (16.69 mg kg^{-1}) and available K_2O (228 kg ha^{-1}) status, high in available Fe, Zn, Mn, and Cu with their corresponding mean values of 15.14, 11.59, 1.64 and 1.53 mg kg^{-1}, respectively.

Looking to the correlation among different parameters studies, significant positive relation of EC (1:2.5) with pH (1:2.5) (r=0.156*), SSP (r=0.311**) and SAR (r=0.675**) of the soils was recorded. The soil pH has significantly negative correlated with RSC (r = -0.182*). The SSP was positively significant correlated with RSC (r =0.349**) and SAR (r=0.843++), negatively correlated with ESP (r = -0.419**).

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Soil Health Preservation for Food Security and Social Needs

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.Soil health decline has emerged as a major factor responsible for the stagnation in agricultural productivity in India, posing a serious threat to our National Food Security. Goverenment of India has emphasized on providing "Soil Health Card" for every farmer of India. The importance and duties of respecting the earth has been narrated practically all the religious traditions and scriptures. The *Prithvi Sukta* in *Atharva Veda* (1500 BC), says as *"Mata Bhumihputroham Prithvivyah*" meaning "Earth is my mother, I am her son. Yet one another quote in *Prithvi Sukta* says *'Ahambhuminadadamarayaya'*, meaning "I have bestowed this earth upon humans with the agreement that they shall secure her against environment trespass and shall never let her subject to degradation". The article-51A of the constitution of India says that 'Every citizen is duty bound to respect environment'. Further for protection of environment, Environment Protection Act 1986 has also been passed by Lok sabha. Inspite of religious and social agreement to protect our natural resources and environment, the natural resources have been misused of humans. The existence and importance of organic matter/humus has also been written in *Quran* (*surah Aala versus 4-9*) says that "God has made plant residues then he dried them and converted in black color material (humus or organic carbon). In future people will know their importance and should teach the people for their benefit". *Pagamber Mohd Sahib (pbuh) in his Hadees* (590 AD) for preservation of soil health had asked to be faithful to recycle plant residues stating that, *"One third of what is taken out from soil must be returned to it"*. Soil health can be restored by the Integrated Plant Nutrition System (IPNS)/Integrated Nutrient Management (INM) which is only a system for sustainable agricultural production for present and future Agriculture.

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Attribution of Soil Aggregating Elements in Soil Aggregation under Different Land Uses in Acid Soils of Meghalaya, India

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The land use is an important factor affecting soil organic carbon (SOC) accumulation and storage in soils. The study was conducted at two different areas, Bhoirymbong and Umsning of Ri-Bhoi District, Meghalaya in eight (8) different land-use systems *viz.* Jhum, Upland Rice, Terrace Rice, Rice monoculture, Rice-Potato, Pineapple, Mixed forest, and Broom grass. The soil organic carbon (SOC), particulate organic carbon (POC), soil microbial biomass carbon (SMBC) and hot water extractable carbon (HWEC) were measured in the soil of different land uses. Aggregates were fractionated using a wet-sieving procedure to obtain the distribution of water-stable aggregates. Mean Weight Diameter (MWD) is found highest in Upland Rice (2 mm) and Terrace Rice (1.72 mm) at 0-10 cm and 10-20 cm depth, respectively in the study areas. Furthermore, higher MWD in surface soil was obtained from Upland rice which indicated that as the Upland rice cultivation is traditionally a monoculture activity without much soil manipulation the aggregation might not have broken in the cultivation process. SMBC, SOC, POC, and HWEC show significant (*pde 0.05)* and a strong positive correlation with MWD at both depths of the study sites. At 0-10 cm depth, the highest positive correlation with MWD was shown in SMBC (Bhoirymbong) and SOC (Umsning). And, at 10-20 cm depth, the highest positive correlation with MWD was shown in SMBC in the study areas. So, from the findings of this study it is observed that the proper selection of land use be done according to the state of soil aggregating elements for better soil sustainability.

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Impact of Ground Water on Chemical Properties of Swell-shrink Soils

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The present investigation was carried out during 2015-2016 in Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. To assess the effect of irrigation on soil properties in Katepurna command in Akola district of Maharashtra.

The results indicate that the soil samples having high salinity was observed during pre monsoon and monsoon whereas medium salinity during post monsoon season respectively. Amongst the cations, sodium was dominant cation during all three seasons, whereas calcium and magnesium were dominant during pre monsoon and monsoon seasons. The concentration of potassium was very less during all three seasons. Among the anions, bicarbonate, chloride and sulphate contents were higher during pre monsoon and monsoon but lower during post monsoon season. The anionic and cationic composition of soils and was higher than the ground water during all three seasons.

The study gives an overview of ground water quality and its impact on soil chemical properties which showed that the ground water was significantly correlated with sodium, magnesium, chloride and sulphate during pre monsoon (summer), bicarbonate, sulphate, magnesium, chloride in monsoon (rainy) and sodium, magnesium, chloride, sulphate in post monsoon (winter) season.

Thus, result as showed that the impact of ground water on soil was noticeable in pre monsoon and monsoon season as compared to the post monsoon season, which is suitable for irrigation. Therefore, ground water should be analyzed in all three seasons for safe use.

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Effect of Crop Residue Management on Soil Physical Properties and Productivity under Rice-wheat Cropping System

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Punjab rank first in the generation of surplus crop residue. For maintaining the productivity potential, it is essential that soil must be physically good enough to support optimum crop growth and to permit full utilization of its resources. One of the best options is the incorporation of crop residue. Keeping this in view, a study was planned to evaluate the effect of the rice straw incorporation on soil physical properties and crop yield after 10th cycle of rice-wheat rotation on a sandy clay loam soil of PAU, Ludhiana. Rice straw was incorporated @ 0, 5, 7.5, 10 t ha^{-1}. The results revealed that rice straw incorporation improved the soil physical properties over control. Bulk density changed from 1.40-1.45 Mg m^{-3} to 1.55-1.60 Mg m^{-3} with rice straw incorporation. Moisture content also improved from 14-15% to 19-20% at FC and from 6-7% to 9-10% at PWP. Similarly, other parameters such as hydraulic conductivity, mean weight diameter, soil penetration resistance were also improved with rice straw incorporation. The simulation study with CERES-Wheat suggested that, with change in climate in future, wheat yield would decline by about 10% which could be sustained at present level with incorporation of rice straw @ 10 t ha^{-1}. Water balance components such as the transpiration would increase by about 5% and evaporation component would decrease by about 20% in soil where rice straw was incorporated @ 10 t ha^{-1} over soil with residue incorporation. In conclusion, with the perspective of managing surplus rice straw, improving soil physical properties, crop productivity and mitigation of global climate change, incorporation of rice straw could be the best alternative to residue burning under this region which often has difficulty to cope up with surplus residue generation.

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Effect of Tillage, Residue and Nitrogen Management on Soil Water Dynamics, Grain Yield and Water Productivity of Wheat

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Field experiments were conducted in a sandy-loam soil in the research farm of the Indian Agricultural Research Institute, New Delhi during the years 2017-18 and 2018-19 to evaluate the effect of conventional tillage (CT) and no tillage (NT) both in the absence and presence of maize residue mulch (CRM) @ 5 t ha^{-1} at three different levels of nitrogen fertilizer (60, 120 and 180 kg N ha^{-1}) on soil water dynamics, soil water balance, grain yield and water productivity (WP) of wheat. It was found that the average profile moisture storage due to CRM was higher than no mulch treatments during both the years under study. Under crop residue mulch, deep percolation loss increased but evaporation decreased. Deep percolation loss under CT was higher than that of NT but seasonal evapotranspiration (ET) under NT was higher than that of CT in both the years. Grain yield of wheat was not influenced by tillage and residue management but water productivity of wheat increased significantly due to crop residue mulching during both the years of study. Water productivity of wheat under CT in a dry year (2017-18) was significantly higher than that of NT but during wet year (2018-19), the effect of tillage on WP was not significant. Both grain yield and water productivity of wheat increased significantly with the increase in N dose. Therefore, wheat may be grown under no tillage with crop residue mulch and 180 kg N ha^{-1} to obtain higher yield and water productivity.

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Assessment of Soil Quality Index under Different Tillage, Residue and Nitrogen Management in Maize-wheat Cropping System in an Inceptisol

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Soil quality index (SQI) was assessed in a four year old ongoing experiment on tillage, residue and nitrogen management at Indian Agricultural Research Institute, New Delhi. Soil samples were collected from three depths (0-5, 5-15 and 15-30 cm) after the harvesting of wheat in 2016-17 and analyzed for various soil physical (BD, MWD, WSA, % sand, silt and clay), chemical (Available-N, P, K, pH, EC) and biological (TOC, SMBC, DHA) quality attributes. Then using Principal Component Analysis (PCA), the minimum data set for soil quality assessment was decided. Principal components with eigen values ≥ 1 were selected. The most sensitive parameter in individual PC was selected on the basis of highest factor loading and the parameters within 5% variations were included. When more than one variable was retained under a single PC, correlation was employed to determine if the variables could be considered redundant and therefore eliminated from the SQI. Based on the PCA, the minimum data set selected for SQI were Available-K, EC, BD and Available-P for 0-5 cm, Available-K, EC, BD, Available-P and WSA for 5-15 cm and Available-N, TOC and WSA for 15-30 cm soil depth, respectively. It was observed that the mean SQI for 0-5, 5-15 and 15-30 cm soil depth were 0.774, 0.886 and 0.629, respectively. There was increase in SQI at 0-5, 5-15 and 15-30 cm soil depth under NT than that of CT by 12.5, 6.4 and 5.7%, respectively. The SQI increased due to crop residue mulching at 0-5, 5-15 and 15-30 cm soil depth by 6.5, 7.7 and 2.5%, respectively. The SQI increased with the increase in the N levels. Therefore, NT with crop residue mulching and 150% of the recommended dose of N may be practiced for improving soil quality index in maize-wheat system+++.

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VIS-NIR Reflectance Spectroscopy as an Alternative Method for Rapid Estimation of Soil Available Potassium

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Accurate estimation of soil available potassium (K) is necessary for monitoring soil fertility and sustaining agricultural productivity. Traditional soil chemical analysis is very much laborious, expensive, time consuming and hazardous to environment. The visible near-infrared (VIS-NIR) reflectance spectroscopy is considered as a viable and cost-effective alternative technique for successful prediction of K. Therefore, an experiment was carried out at Ludhiana district of Punjab to investigate the potential of VIS-NIR technique for accurate prediction of K using statistical model. Georeferenced surface soil samples (48 samples of 0-15 cm depth) were collected from a rice-wheat field for chemical and spectral analysis. A statistical algorithm namely partial least square regression was used for spectral modeling by correlating the soil spectra with measured K for predicting available K. Various statistical indices like coefficient of determination (R2), root mean square of error of prediction (RMSEP) and ratio of performance deviation (RPD) were used to evaluate the efficacy of the newly developed spectral model. The result showed that the R2 and RMSEP values were 0.77 and 0.04 for calibration and 0.41 and 0.09 for validation, respectively. The RPD value was 1.44 in the validation dataset. The RPD value indicates that potassium can be predicted using this spectroscopy technique with an acceptable prediction accuracy. So, this reflectance spectroscopy can be reliably and successfully employed for rapid estimation of K.

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Effects of Long-term Nutrient Management on Aggregate Associated Carbon in Rice-wheat Cropping System

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Nutrient management practices on long-term basis differentially influence soil aggregation and carbon storage within aggregates, which in time may affect C stabilization. The present study assessed the impact of long-term application of fertilizers (NPK) either alone or integrated with farmyard manure (FYM), green manure (GM) and crop residue (CR) on soil aggregates and carbon within aggregate classes under rice-wheat cropping sequence. Organic amendments (FYM, GM, and CR) along with fertilizers significantly ($P< 0.05$) improved soil aggregation and mean weight diameter. The proportion of macro-aggregates (MacroA) was maximum in NPK+CR (25.1%) followed by NPK+FYM (23.8%), NPK+GM (20.4%) and minimum in unfertilized control (14.5%). Irrespective of aggregate size, total organic carbon (TOC: g kg^{-1} aggregate) was maximum in NPK+SI treatment with an average of 15.6 as compared to control (8.0). Averaged across treatments, TOC concentration followed the order MacroA>MesoA>MicroA. Correspondingly, results for $KMnO_4$-C followed a similar trend in different treatments and aggregate classes. Application of organic amendments along with inorganic fertilizers (or alone) showed a significant increase in oxidizable organic C fractions and recalcitrant C. In general, C present in large-sized aggregates (MacroA) had higher recalcitrant fractions of SOC compared to small-sized aggregates (Meso and Micro). In conclusion, long-term integrated nutrient management resulted in better soil aggregation which improved C accumulation and stabilization in soils under rice-wheat cropping system.

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Management of Deficit Irrigation Water for Wheat under Changing Climatic Conditions

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A field investigation was conducted at the AICRP on Irrigation Water Management, M.P.K.V., Rahuri, Maharashtra during the years 2015 to 2018 with the objective to study the influence of deficit irrigation to different cultivars of wheat under different climatic conditions (sowing dates). The experiment was laid out in split-split plot design with three replications. The main plot treatments comprised of three sowing dates, three sub treatments of varieties and five sub-sub treatments of irrigation regimes.

The normal sowing date and Samadhan variety and two irrigations at 100% FC at 41st and 62nd DAS have significant highest number of tillers and grains/spikelet and -1000 grain weight while irrigation at critical growth stages (control) has also recorded maximum number of tillers and grains/ spikelet and 1000 grain weight. The normal sowing date and Samadhan variety have shown significantly highest grain yield. while two irrigations upto 100% FC at 41st and 62nd DAS showed significantly highest grain yield as compared to other treatments of irrigation levels. The control treatment with irrigation at critical growth stages recorded maximum yield as compared to other irrigation levels. There is not much influence of sowing dates, varieties and irrigation levels on the soil properties since the dose of fertilizers was same for all the treatments. Amongst the deficit irrigation treatments highest B:C ratio (1.34) was in the treatment with two irrigation upto 100% field capacity at 41st and 62nd after sowing.

Thus, sowing of wheat variety Samadhan in medium black soils of Maharashtra under deficit irrigation for obtaining more yield and returns, it is recommended to follow normal sowing i.e. between 1-15 November and if one irrigation is available, it may be given at 41st DAS, if two irrigations are available, at 41st and 62nd DAS, respectively.

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Identification of Specific Location for Harvesting Structure in Halayapura Microwatershed of Tumkur District, Karnataka using GIS and RS Applications

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Water Harvesting is the best technique that can be used effectively to trap the unutilized surface runoff and thereby increase the groundwater recharge. Water harvesting structures have to be located where runoff water is available in excess and conditions are favourable for enhanced infiltration. Hydrology and land resource inventory will play an important role in suggesting suitable soil and water conservation structures. The study was carried out in Halayapura micro-watershed of Tumkur district, Karnataka located between North latitudes 13°08′31″ and 13°10′04″ and East longitudes 77°05′45″ and 77° 07′19″, covering an area of 503 ha. Out of total average annual rainfall of 851.3 mm, kharif rainfall accounted for 54.3%, rabi rainfall 24.3% and summer rainfall 21.47 per cent. The objective of this study is to identify suitable sites for water harvesting structures as per the Integrated Mission for Sustainable Development (IMSD) guidelines. ArcGIS is used for the spatial analysis and the sites are located by overlaying thematic maps of land use, soil, slope, runoff potential, soil permeability and stream order. Runoff computation was made by rainfall intensity-infiltration capacity method. The results indicated that the 9% of the total area is ideal for constructing farm pond, 8% for checkdam and 645 for percolation pond. Locations of water harvesting structures have been suggested by conducting meteorological and topographical analysis. However, for the practical execution of these structures, viability of other considerations such as economy, social implications, practical feasibility *etc.* need to be considered.

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Soil Health Indicators Based Management Advisory System

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Soil physical, chemical and biological properties are integral components of soil health. Management advice based on their combined status is necessary for applications. Thus, a tool viz. Soil Health Indicators Based Management Advisory System (SHIMAS) was developed for maintenance and improvement of soil health.

Soil health indicators were evaluated using a framework called DUS (Soil) where D represents Distinctness (reflects a distinct functional soil property), U represents Utility (amenability for amelioration or mitigating its impact through agro-techniques) and S represents Simplicity (Simple to estimate in field/small laboratories). Soil texture, pH, soil carbon, water stable aggregates (WSA), porosity and soil macro fauna abundance were selected as suitable indicators in this framework.

The selected indicators were categorized into three classes viz. coarse, medium and fine for texture, low (<6.5), optimum (6.50 to 7.50) and high (>7.5) for pH. Low (<0.5%), medium (0.5-0.75%) and high (>0.75%) for soil carbon and nil, moderate and highly slaking for water stable aggregates. Soil porosity classes were categorized as high (>25% pore space), optimum (10-25% pore space) and low (<10% pore space) while the soil macro fauna classes were poor (<3 macro fauna), moderate (3-6 macro fauna) and high (>6 macro fauna).

A database of management schedules for each class of the six indicators as applicable to the specific biophysical context was developed based on published literature and expert consultation.

A user interface was developed for selecting location and the class of each of the six indicators. The program is executed when all the indicators are selected and the corresponding management advisories are displayed.

Note: *The views expressed in this document cannot be taken to reflect the official opinions of the organizations.*

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Surface Charge as an Innate Property of Soil Chemical Composition

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A study on the distribution of electric charges on some tropical soils of India was made by direct measurement of adsorption of ions in the presence of varying concentrations of electrolyte. The result shows that the pristine point of zero charge varies with soil according to the variation of organic matter and sesquioxide content. The pH value is presented as a measure of pedogenic development. The decrease in the pH value is interpreted as an indicator that the soils are approaching a steady-state with time. Net charge also varies with organic carbon, composition of clay and chemical component of soils. Organic carbon strongly affects the variation of negative charge with pH, but sesquioxide/ allophone is responsible for positive charge variation. Variability in the magnitude of this charge was attributed to the effect of Al or Fe blocked exchange sites or contribution from dissociated organic functional groups.

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Evaluation of Groundwater Quality for Irrigation in Various Mandals of Nellore District in Andhra Pradesh

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A survey was undertaken during the year 2018 to assess the quality of ground water for irrigation in various mandals of Nellore district, Andhra Pradesh. The reaction (pH) varied from 6.0 to 8.9 with a mean of 7.5 whereas electrical conductivity (EC) ranged between 0.20 and 9.3 dS m^{-1} with a mean of 2.31 dS m^{-1}. As for as anions were concerned, HCO^{3-} concentration varied from 0 to 14.8 m eL^{-1} with a mean of 8.39 me L^{-1}, chlorides ranged from 1.22 to 136.80 m eL^{-1} with a mean of 10.89 m eL^{-1}, SO_4^{2-} varied from 0.02 to 15.11 me L^{-1} with a mean of 2.36 me L^{-1} and carbonates were completely absent. Among the anions, chlorides were dominant and followed the sequence of Cl- > HCO^{3-} > SO_4^{2-}. As for as cations were concerned, concentration of Ca^{2+} ranged from 1.2 to 21.2 m eL^{-1} with a mean of 4.81 me L^{-1}, Mg^{2+} concentration varied from 0.01 to 20.4 m eL^{-1} with a mean of 3.77 me L^{-1}, Na^+ concentration varied from 0.30 to 57.41 me $L^{-1}$with a mean of 9.50 me L^{-1} and K^+ concentration varied from 0.01 to 6.27 m eL^{-1} with a mean of 0.35 me L^{-1}. Among the cations, Na was dominant and followed the trend of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$. From the EC values it is observed that 5.28, 52.04 and 42.68% samples were belonging to C2, C3 and C4 salinity classes, respectively. Based on RSC, 60.98, 9.25 and 29.67 per cent samples were categorized under B1, B2 and B3 classes, respectively whereas based on SAR, 86.99, 12.60 and 0.41 per cent samples were placed in S1, S2 and S3 sodicity classes, respectively. As per USSL classification was concerned, 0.40, 5.28, 50.41, 5.28, 30.10, 8.13 and 0.40 per cent samples were classified under C1-S2, C2-S1 , C3-S1, C3-S2, C4-S1,C4-S2 and C4-S3 classes, respectively. However, based on CSSRI limits, 93 water samples (37.8%), were found to be good, 55 samples (22.5%) were marginally saline, 17 samples (7.0%) were saline, 12 samples (5.0%) were high SAR saline, 15 samples were marginally alkali (6.0%), 34 samples (14%) were alkali and 19 samples (7.7%) were highly alkali waters. Suitable management practices were suggested to control salinity and sodium hazards for ground water samples of Nellore district in Andhra Pradesh

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Estimation of Carbon Stock under Different Agro-ecosystems of Jorhat District in Assam

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Soil organic carbon stock estimation at larger scale is useful in predicting the need based strategies to be adopted in the context of land use change and different land management scenarios. The present study aims to develop data base for mapping carbon stock in different agro-ecosystems (AESs) for forest and agricultural lands of Jorhat district in Assam. Profiles (12 nos) surface soil samples (350 nos) were collected from forest as well as agricultural lands covering the entire district. Study revealed that among different agro-ecosystems (AESs), above ground biomass (AGB) carbon was found to be highest for High Land (HL) (1.50 Tg) followed by Humid Alluvial Flood Prone (HAFP) (0.0183 Tg) and lowest for Char Area (CA) (0.0011 Tg), whereas, total biomass C stock was high under Humid Alluvial Flood Free (HAFF) situation followed by HL and then HAFP. Sand content in soils was dominant in all AESs followed by clay and silt content, baring for HL and CA. Profiles under forest land use system exhibited relatively higher SOCD than paddy irrespective of AESs with an exception in one location of HAFF where SOCD under paddy showed higher value than forest land use system. Soil carbon stock (SCS) was highest for HAFF (56.24 Tg) followed by HAFP (35.61 Tg), HL (>12.29 Tg) and lowest was recorded in CA (4.36Tg). SOCD showed negative and significant correlation with pH (r= -0.395**) and positive significant correlation with clay (r=0.443**) and CEC (r=0.291**). Variations in SOCD of 94.20% were found to be predictable from OC, depths, TN and clay content in forest soils, whereas, 89.40% variations in SOCD were predicated from OC, depth and BD in case of paddy soil.

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Optimization of Na_2CO_3 Method for Estimation of Amorphous Silicon Content in Rice and Sugarcane Soils

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Although the 1% Na_2CO_3 method of DeMaster (1981) was used for measuring biogenic silica in marine sediments, it is now mostly used to analyze amorphous silicon (ASi) content in soils. However, the original methodology requires specific attention in case of digestion period and consequently, this study aimed at quantifying the ASi content by optimizing the extraction of ASi from tropical rice and sugarcane soils by using 1% Na_2CO_3 method. Soil samples of two profiles each from rice and sugarcane grown areas were collected from the southern dry zone, southern transition zone, coastal zone and central dry zone of Karnataka. In order to optimize the 1% Na_2CO_3 method, a series of batch experiments for six soils was carried out and analysed the samples from 1 to 8 hours, with an aim to identify the probable digestion period at which 1% Na_2CO_3 dissolves ASi in soils with minimum attack of other Si compounds. The results of batch experiments suggest that 3 to 5 hour digestion period as recommended by DeMaster (1981) is not sufficient enough for ASi determination in tropical soils. It was noticed that there was continuous increase in extracted Si content even upto 6 hours and thereafter, the content of extracted Si decreased for most of the soil samples under investigation. Hence, it is recommended that same method can be adopted for tropical soils with a modification of digestion upto 3 to 6 hours instead of 3 to 5 hours. The results revealed that ASi content varied from 0.62 to 2.94 and 0.60 to 3.77 g kg^{-1} in rice and sugarcane soils, respectively. The results also suggested that ASi content was higher in sugarcane due to incorporation and burning of sugarcane trash into the soil at the time of harvesting, whereas removal of straw from rice field leads to deplete ASi content.

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Impact of Tillage, Deficit Saline Irrigation and Mulching on Soil Health in Sorghum - Wheat Sequence in Salt-affected Soils of North West India

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Salinity deleteriously affects crop performance and degrades soil health in semi-arid ecosystems. A field experiment was conducted at Research farm in Panipat, Haryana to evaluate the impact of tillage, deficit saline irrigation and rice straw mulch on soil properties and their relation with soil health index (SHI) with sorghum and wheat productivity. Tillage treatments *viz.* zero-reduced (ZT-RT), conventional -conventional (CT-CT) and zero-zero tillage (ZT-ZT) were taken in the main plot and saline water (ECiw 8 dS m^{-1}) irrigation with 100, 80 and 60% of wheat crop water requirement (WR) and mulch (0 and 5 t ha^{-1}) in subplots. Soil electrical conductivity (ECe) reduced after harvest of sorghum (5.48 and 3.59 dS m^{-1}) than wheat (8.87 and 6.41 dS m^{-1}) in consecutive years (2015-16 and 2016-17). Except for glucosidases (α and β), soil microbial biomass C, N (MBC/N), activities of dehydrogenase (DHA), urease (URE), and alkaline phosphatase (AlP) decreased with increment of soil ECe at the harvesting of wheat than sorghum. Soil MBC (273.9, 244.5 µg C g^{-1}) and MBN (32.4 and 30.5 µg N g^{-1}) improved by application of deficit saline irrigation with 60 WR compared to 100 WR in soil after sorghum (229.0 and 225.3 µg C g^{-1}) and wheat harvest (29.6 and 29.2 µg N g^{-1}). Adoption of ZT-ZT recorded greater values of MBN than CT-CT in the soil after the harvest of sorghum and wheat, respectively whereas; mulching increased the activity of β-glu and α-glu in soils after harvest of sorghum. Soil enzyme α-glu, MBC, ECe, available N, MBC, MBC:MBN after sorghum harvest were identified as significant contributor towards SHI. Whereas, SHI developed with selected attributes *viz*. MBC:MBN, ECe, MBC, URE, and available N was ineffective in addressing variability in wheat grain yield.

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Effect of Long-Term Rice Straw Incorporation and Nitrogen Application on Zinc Availability in a Sandy Loam Soil

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A field experiment was conducted on a sandy loam soil at Ludhiana to investigate the effect of long-term rice straw incorporation (0-10 t ha^{-1} yr^{-1}) and fertilizer N (0-150 kg N ha^{-1}) application on soil Zn fractions. The treatments were arranged in a split plot design with three replications, with fertilizer N (N0, N90, N120 and N150) in main plots and rice straw (RS0, RS5, RS7. 5 and RS10) in sub-plots. Zinc fractions were significantly increased with graded levels of RS incorporation. The major part of total-Zn was present in residual form and only a minute part was present in readily available forms i.e. WS+EX form. Regardless of the treatments, relative preponderance of these Zn fractions was: WS+EX Zn < SpAd-Zn < MnOx-Zn < OM-Zn < AFeOx-Zn < CFeOx-Zn < Res-Zn. Rice straw incorporation was found to increase all the zinc fractions and significantly higher concentration was found at RS10 as compared to control. The concentrations increased from 0.38 to 0.62 mg kg^{-1} (WS+EX Zn), from 0.75 to 1.12 mg kg^{-1} (SpAd-Zn), from 1.41-2.05 mg kg^{-1} (MnOx-Zn), from 8.83-13.16 mg kg^{-1} (CFeOx-Zn), from 2.61-3.41 mg kg^{-1} (OM-Zn), from 7.44 to 7.57 mg kg^{-1} (AFeOx-Zn), from 54.95 to 60.78 mg kg^{-1} (residual-Zn) and from 76.37 to 88.71 mg kg^{-1} (Total-Zn). The effect of nitrogen application and interaction among rice straw incorporation and nitrogen application was statistically non-significant. With correlation analysis, the data revealed that SOC was significantly and positively correlated with Zn fractions. The Soil SOC was significantly and positively correlated with WS+EX-Zn (r=0.770**), SpAd-Zn (r=0.757**), MnOx-Zn (r=0.781**), CFeOx-Zn (r= 0.774**), OM-Zn (r=0.828**), AFeOx-Zn (r=0.743**), Res-Zn (r=0.837**) and Total-Zn (r=0.817**). The data further revealed that DTPA-extractable Zn was significantly and positively correlated with Zn fractions.

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An Assessment on Potassium Pool by Q/I Measurement of Some Rice Growing Soils of India

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Potassium exchange equilibrium parameters were outcome of quantity-intensity isotherms, viz. potential buffering capacity (PBCK), labile K (KL), specific K (Ko), specific K sites (Kx), equilibrium activity ratio (ARK), non specific K (Ks) and free energy of K replenishment (-ΔG). The potassium (K) supplying capacity of three rice growing soils of India was investigated by employing the quantity-intensity approach. Non specific K values changes among three different soils may be attributed to the changes in clay mineralogy and organic matter content. The values of ARK at equilibrium ranges of three different soils viz. Bhanderdihi, Mohanpur and Moukhali are 0.034, 0.0051, 0.0050 (mol L^{-1}) 0.5. The decreasing trends of ARK values suggested that bulk of K was preferentially held at edge position of the clay crystals. PBCK of three native soils viz. Mohanpur, Moukhali and Banderdihi are 109.1, 116.7 and 111.2 Cmolc kg^{-1} (mol L^{-1}) 0.5. The variation among these soils is associated to the changes in soil-clay mineralogy. These values indicate that all three soils possess good supply of K besides its higher potential to replenish K concentration in soil solution. Potassium potential of the soils expressed as free energy change ranged from -8.26 to -13.35 KJ mol^{-1}. With increasing or decreasing PBCK value free energy change increases or decreases. The changes of Q/I parameters is associated with the contents of clay, organic matter and clay mineralogy of the soil. High exchangeable cation in soil matrix and higher cation exchange capacity (CEC) favours labile K, specific K and specific K sites. Equilibrium activity ratio of potassium increases with decreasing free energy change as well as increasing CEC and exchangeable cations.

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Development of Boron Management Protocol for Improving Productivity and Quality of Tomato (*Lycopersicon Esculentum*)

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Tomato (*Lycopersicon esculentum*), which is one of the important vegetable crop (third in priority after potato and onion) enriched with vitamins, minerals and antioxidants, is grown extensively in the vegetable agri-export zone of West Bengal. Vegetables grown in this region suffers due to inadequate supply of B from soil for their nutrition, which is manifested either through 'hidden hunger' or 'typical deficiency symptoms' of B. Therefore, the study was undertaken (i) to study response of tomato genotypes to B application; and (ii) to develop a B management protocol by adjusting time and method of B application for improving productivity and quality of tomato grown in the vegetable agri-export zone of West Bengal. Seven tomato genotypes were tested with five B application treatments in the C-Block Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal. Among the genotypes, TOLCV-1/2016 was the most responsive to B application whereas combined B application at basal (2 kg ha^{-1}) and foliar at pre-flowering stage (0.025% B) was found to be the best treatment in terms of improving productivity (fruit yield 7.3 Mg ha^{-1}) and quality (total antioxidant content in fruit 236 mg of trolox equivalent 100 g^{-1} fresh weight). Thus, the present study developed a B management protocol to optimize yield as well as quality of tomato for this zone of West Bengal.

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Mobilization of Soil Phosphorus by Low Molecular Weight Organic Acids and its Acquisition by Wheat (*Triticum aestivum*)

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Phosphorus is an essential and structural element of plants, but in most of the agricultural soils its solubility and bio-availability is very low due to its reaction with soil constituents. There are reports that the low molecular weight organic acids (LMWOAs) solubilize the soil phosphorus. Keeping this in view, a pot experiment was conducted to study the effect of LMWOAs on phosphorus bioavailability, yield and yield attributes of wheat. There were twenty seven different treatment combinations of three levels of P (0, 10 and 20 mg P kg^{-1}), four levels of oxalic (5, 10, 15 and 20 mg OA kg^{-1}) and citric (5, 10, 15 and 20 mg CA kg^{-1}) acids. All the yield and yield parameters of the wheat crop showed higher values with the increased levels of phosphorus from 0 to 20 mg P kg^{-1}. At all levels of phosphorus application oxalic acid at 15 mg OA kg^{-1} and citric acid at 10 mg CA kg^{-1} were found to be the best level of acids in increasing yield and yield parameters of wheat. The Olsen P of post-harvest soil after wheat crop showed that at zero phosphorus application, 15 mg OA kg^{-1} and 20 mg CA kg^{-1} and at 10 mg P kg^{-1} and 20 mg P kg^{-1} level of phosphorus, oxalic acid at 10 mg OA kg^{-1} and citric acid at 5 mg CA kg^{-1} were seemed to better levels of organic acids to increase the Olsen P. The results from the present study showed that the use of the LMWOAs can reduce 50% of the phosphorus fertilizer recommendation to the wheat crop.

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Potassium Supplying Capacity of Low-grade Silicate Minerals: Evaluation of Chemical and Biological Methods

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The K supplying capacity of low-grade silicate minerals was evaluated through chemical and biological methods. The silicate mineral samples were collected from different parts of the country. Waste mica was collected from Koderma district of Jharkhand and Nellore district of Andhra Pradesh. Feldspar sample was collected from Gudur, Andhra Pradesh. Two green sand samples were collected from Satna, Madhya Pradesh and Kutch, Gujarat. The details mineralogical compositions of the silicate mineral powder were analyzed by the X-ray fluorescence (XRF) spectroscopic method. The total K (% K_2O) content in the silicate mineral followed the order feldspar (14.9%) > waste mica (7.24-9.72%) > greens and (4.56-5.4%). Different chemical extractants, water, neutral 1 *M* ammonium acetate, 0.01 *M* citric acid and boiling 1 *M* nitric acid were used to study the K release from the low-grade silicate minerals. The K release by different chemical extraction methods showed significant variation. The amount of K release by various extractants followed the order: water < 0.01 *M* citric acid < 1*M* ammonium acetate (NH_4OAc) < 1 *M* boiling nitric acid. To study the plant intervention on K release from silicate mineral powder, a greenhouse experiment was conducted by growing palmarosa (*Cymbopogon martini* var. *motia*) and sudan grass (*Sorghum vulgare* var. *Sudanensis)* in K deficient soil. Results indicate that K recovery from waste mica (39.3-2.5%) is quite higher than feldspar (19.7-22.5%) and greens and (5.4-7.5%) irrespective of plant species. So, these low-grade silicate minerals may be identified as a potential K source for agricultural application.

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Iron Fertilization in Direct Seeded Rice under Sodic Soils

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Direct seeded rice (DSR) required less water, energy and emits low methane compared to transplanted rice (TPR). In DSR, upland rice is grown under non-puddled and non-flooded soil conditions. Despite its usefulness, there are still many constraints like iron deficiency which restrict its adoption by farmers in partially reclaimed sodic soils. Keeping the facts in view, a field experiment was conducted at Indian Council of Agricultural Research – Central Soil Salinity Research Institute (ICAR-CSSRI), Karnal to manage the iron deficiency in DSR. The nine treatments of iron application were experimented under rice (DSR) – wheat cropping system during the 2018-2019. The treatments details were one control (no Fe application); three treatments of soil application of ferrous sulphate ($FeSO_4.7H_2O$) (30 kg Fe ha^{-1}; 40 kg Fe ha^{-1}; 50 kg Fe ha^{-1}) and five treatments of foliar applications (1.5% $FeSO_4.7H_2O$; 3% $FeSO_4.7H_2O$; 0.5% Fe-EDTA Chelate; 0.2% Fe-EDDHA; 0.5% Fe-DTPA). In case of soil application, the ferrous sulphate was applied at the time of sowing of rice crop. In case of foliar application, three times foliar sprays at 30, 45 and 60 days after sowing (DAS) of rice were given. The results showed that among all the treatments the maximum yield (21.2 q ha^{-1}) was recorded in foliar application of 0.2% Fe-EDDHA and it was 17.2% higher than the control treatment (18.1 q ha^{-1}). However, among the soil treatments, the highest grain yield (14.8% higher than control) was recorded from the 50 kg Fe ha^{-1}, followed by 11.1% higher from 40 kg Fe ha^{-1} through iron sulphate. Therefore, the foliar application of Fe either through iron sulphate or iron chelate was more effective than the lower dose of soil application. Thus, Fe fertilization in DSR under partially reclaimed sodic soils proved useful for enhancing the grain yield.

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Influence of Conservation Pits on Growth and Yield of Rubber (*Hevea brasiliensis*) and Soil Properties in the Sloppy Lands of Tripura

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Effectiveness of conservation pits on growth and yield of rubber (*Hevea brasiliensis*) was examined for two consecutive years (2017-19) in the sloppy lands of Tripura. Influence of these pits on soil properties was studied. The experiment was carried out in a complete block design with 150 plants per block having 200 pits per ha. The size of the pits were 4ft × 2ft × 2.5ft and set in between two rows of plants in a staggered manner. In an adjacent plot, a control block was carried out for comparison. Trunk girth of the plants was measured periodically and monthly yield data (g/t/t) of the plants were recorded. The soils that were deposited in pits were excavated to study their chemical properties and compared with bulk soil. Results showed a positive but non-significant improvement in mean trunk girth of the plants during the study period. However, a positive and significant increase in mean yield in the tune of 9.8-11.7% was observed due to adoption of conservation pits. It was observed that about 3.98-5.42 mt soil ha^{-1} $year^{-1}$ was conserved in the pits, thus prevented the possible loss of top fertile soil due to surface run off from the sloppy land. The study revealed that a considerable amount of available N P K was conserved ranged from 21.6 -31.5, 3.1-4.5 and 30.6-35.5 kg ha^{-1} yr^{-1} respectively. Similarly, an amount of 29.14 kg OC and 216.2 kg clay per ha could be rescued per annum from these sloppy lands. Intercepting the surface water run-off into the pits could raise the soil moisture, particularly in the subsurface layer, which can prolong the moisture availability to plants for a longer period resulting an increased latex flow for the plants under conservation pits.

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Nutrient Dynamics under Protected and Conventional Cultivation of Vegetables in Mid Hill Zone of Himachal Pradesh

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Productivity and the sustainability of any production system not only depend upon the management practices but also on the environment as well as on the nature of mobility of nutrients from native reserve. Therefore the present study was undertaken during the year 2015-2016 to assess nitrogen, phosphorus and potassium nutrients dynamics under polyhouse and conventional cultivation of vegetables in Himachal Pradesh, so as to assess the effect of differential cropping and the management practices followed by the farmers under these two systems. To accomplish this, 25 sites both under protected and conventional production system were selected in Mid Hill Zone of Himachal Pradesh which is one of the main areas for vegetables cultivation. All the organic and in-organic fractions of N, P and K were determined using standard methods. A wide variation in the nutrient fractions were observed among different sites. Likewise, differences existed in the various fractions of N, P and K in between the samples from the protected and open field conditions at number of sites. Among different fractions of N, amino acid-N was the dominant fraction and contributed about 25% towards total-N, while, its contribution towards total hydrolysable-N was observed to be 30%. In case of P fractions, inorganic fractions constituted about 84.2% of total P. Among K fractions, Water soluble-K, Exchangeable-K and non exchangeable-K contributed about 0.12, 0.59 and 3.05% towards total-K, respectively. Higher accumulation of total N was observed under protected system of cultivation as compared to open fields. Likewise, comparatively higher accumulation of residual P as well as total P was observed under protected system as compared to conventional system

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Effect of Biochar Application Alone or in Combination with Urea on Nitrogen Dynamics in Sandy Loam Soil

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Globally, nitrogenous fertilizers are applied to sustain higher yields almost in all cropping systems. However, excessive use of N and water in agricultural systems lead to nutrient losses in leaching water due to poor fertilizer N use efficiency. Combined application of nitrogenous fertilizer with biochar could be an alternative strategy to avoid such N losses. Therefore, effect of co-application of urea along with rice-residue biochar (RB) and poultry manure biochar (PB) on N dynamics was investigated by conducting an incubation experiment for 60 days using sandy loam soil. The results showed that use of urea led to greater mineralization due to higher availability of NH_4^+-N produced from urea hydrolysis. Both sole application of RB and PB and co-application of biochar (RB or PB) with urea treatments showed lower N mineralization and nitrification rate (0.11-0.12 micro; g N g^{-1} soil d^{-1} for biochar alone and 0.14-0.16 µg N g^{-1} soil day^{-1} for combined application) than the sole urea application treatment (0.2 µg N g^{-1} soil day^{-1}).With urea application, the rapid production of NH_4^+-N in the initial days of incubation acted as a substrate for nitrification which resulted in higher NO_3^--N content that generally had a tendency to be leached out leading to higher N losses. The lower N mineralization and nitrification rate in sole biochar and biochar plus urea treated soil were most likely caused due to: (i) increased C:N ratio of the treated soil; (ii) adsorption of NH_4^+-N by the biochar; (iii) microbial immobilization of the N in the amended soil; and (iv) lower urease activity in treatments amended with biochar. Thus, combined application of biochar with urea may lead to in lower N loss by acting as slow release fertilizer and makes it available to plants for longer time periods.

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Nitrogen Pools in Nutrition of Crops Grown under Organic Farming System

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Nitrogen management in soil is an enigma, especially under organic systems having no such dedicated soil testing method for plant available N estimation and it is necessary to find out the most contributory N pool towards crop nutrition. With this background, present investigation was performed with four sole organic sources and their combinations for French Bean cultivation in three years of organically converted land where chemical fertilizer treated replicated plots were also maintained as check. Soils were sampled at early growth, full growth, flowering and harvesting stages of bean. Different combinations of chemicals including neutral phosphate buffer (PB), $CaCl_2$, $NaHCO_3$ and basic EDTA were used to extract N pools and conventional alkaline-KM_nO_4 method was also performed for comparison. Using first-order kinetics model, organic N mineralization rate, half-life and mean residence time (MRT) of organic N fractions extracted by respective chemicals were measured under both organic and conventional systems. Overall results showed that PB extractable organic N fraction was qualified as most contributory N pool to crop nutrition by showing significantly higher predicted mineralized N during crop growth period and higher correlation with all the tested chemicals [r ($CaCl_2$) = 0.77**, r ($NaHCO_3$) = 0.78**, r (NaOH) = 0.78**] except KM_nO_4 (r = 0.52) and ranked first on the basis of correlation-sum (Scored: 2.85). It was also strongly correlated with N uptake (r = 0.348**), pod (r = 0.362**) and dry-matter-yield (r=0.299*) of French Bean. Regression analysis showed strong relationship between mineralized N derived from PB extractable organic-N and uptake (r = 0.77**) and DMY (r = 0.69**). PC analysis and regression scoring followed by rank-sum computation established PB extractable organic-N fraction as the most contributory N pool under organic system and help to develop soil test method for routine N estimation to cater the needs of organic farming.

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Long Term Effect of Integrated Nutrient Management Strategy on Aluminium Dynamics in Acid Soils of North-Eastern India

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In the present study, a field experiment was performed over 10 consecutive years (2006-15) to assess the effect of integrated nutrient management (INM) practice on aluminium fractions in three different soil depths *i.e.*, 0-5 cm, 5-15 cm and 15-30 cm in acidic Inceptisol of Assam. The experiment was conducted in randomised block design with four replications and five treatments: T1; absolute control, T2; 100% recommended doses (RD) of inorganic NPK, T3; 50% RD of inorganic NP + 100% K + biofertilizers, T4; 50% RD of inorganic NP + 100% K + 1 tonne enriched compost ha^{-1} and T5; 25% RD of inorganic NP + 100% K + 2 tonnes enriched compost ha^{-1}. Result indicated that at 0-5 cm soil depth, Al was mostly concentrated in the free Al fraction (56.3%) in soils irrespective of the treatments and the lowest share of Al in this soil goes to exchangeable Al (0.66%). At 5-15 cm soil depth result showed that free Al (57.1%) content was maximum in soil followed by amorphous Al (27.4%), strongly organically bound and interlayer Al (10.4%), weakly organically bound Al (4.25%) and exchangeable Al (0.85%), respectively. At 15-30 cm soil depth, due to application of biofertilizer and enriched compost exchangeable Al content and strongly organically bound and interlayer Al decrease significantly, while other fractions *i.e.,* weakly organically bound Al, amorphous Al and free Al increased significantly. Investigation concluded that in all three soil depth, among different Al fractions, exchangeable Al and strongly organically bound and interlayer Al was significantly lower, while other three fractions *i.e.,* weakly organically bound Al, amorphous Al and free Al were significantly higher under 25% RD of NP + 100% RD of K + enriched compost @ 2 t ha^{-1} treatment over other treatments.

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The Dubinin-Radushkevich Adsorption Isotherms of Phosphate, Molybdate, Borate and Silicate by Acidic and Alkaline Soils of North-India

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Dubinin-Radushkevich (DR) adsorption isotherm using Polanyi potential was applied to phosphate, molybdate, borate and silicate sorption by acidic Andretta and alkaline Habowal silt loam soils to study the chemi-sorption of phosphate, molybadate, silicate and borate anions by ligand exchange of surface functional hydroxyl ion. All single anions adsorption experiments were carried out by a batch equilibrium technique. Soil samples weighing 2.0 g (oven dry basis) were placed in a 100 ml Teflon bottles and equilibrated with 50 ml of 0.01*M* KCl electrolytic solution containing varying concentration of P, Mo, B and Si for 6 days in incubator maintained at 25°C. Phosphate sorption by both soils followed a three region DR equation, i.e. the plot of phosphate sorbed versus Polanyi potential of P in equilibrium solution in both soils showed three distinct linear regions. Similarly the DR plots of molybdate and silicate anions in both soils elucidate two distinct linear regions. Whereas, DR isotherm plot of borate in both soils illustrate single linear relationship in relation to Polanyi potential of borate anion. The adsorption maxima for P sorption were markedly higher for region I, II and III in acidic Andretta than for their corresponding regions in alkaline Habowal silt loam soils. The adsorption maxima for Mo sorption was much higher for region I and II in Andtretta silt loam compared to their respective regions in Habowal silt loam. The adsorption maximum for borate sorption was much higher for both regions in an Alkaline Habowal silt loam comparative to borate sorption in acidic Andretta silt loam. The adsorption maximum for Si sorption was slightly higher in Habowal silt loan than in Andretta silt loam. The adsorption of P, Mo, B and silicate on the surface of both soil constituents occurred due to the exchange with different types of surface hydroxyl groups.

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Sorption and Desorption Behaviour of Chromium in Some Soils of Punjab

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Chromium (Cr) is known to be a widespread chemical contaminant of soil. Elevated concentrations of Cr in soils are originated mostly from industrial wastes or spills, particularly, production of steel and alloys, pigment manufacture, leather tanning, wood preservation, and combustion of coal and oil. Sorption and desorption mechanisms of chromium (Cr) were determined in soil samples collected from three different industrial towns (Jalandhar, Ludhiana and Mandi Gobindgarh) of Punjab. Batch equilibrium technique was adopted for the Cr sorption study. Sorption of Cr in soil was carried out by equilibrating the soil samples (3 g of soil samples in triplicate) with 30 ml of 0.01*M* calcium nitrate [$Ca(NO_3)_2$] solutions containing five different concentrations of Cr. The concentrations of Cr used in the present study include 5, 10, 30, 60 and 90 µg ml^{-1} of Cr (equivalent to 50, 100, 300 600 and 900 µg Cr g^{-1} soil), respectively. Potassium dichromate ($K_2Cr_2O_7$) was used as a source of hexavalent Cr. Samples were allowed to equilibrate (in triplicate) for 24 h followed by a 2 h shaking to attain the sorption equilibrium. Chromium in the decanted solutions was determined using ICP-AES. It was observed that with the increase in Cr application rate, amount of Cr sorbed by the soils also increased; however, the percent Cr sorbed decreased. The Cr sorption data of the three selected soil samples were significantly described by Langmuir (R^2=0.95 to 0.99), Freundlich (R^2= 0.98 to 0.99) and Dubinin–Radushkevich (D-R) adsorption isotherms (R^2=0.92 to 0.97). Desorption of Cr was determined by performing five consecutive extractions with Cr free 0.01 *M* $Ca(NO_3)_2$ solution from the same soil samples used for Cr sorption studies. It was observed that Cr desorbed as well as percent Cr desorbed from the selected soils increased with the increase in added Cr concentration.

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Arsenic Removing Capacity of Low-cost Illitic Clay in the Presence of Competitive Anions

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Arsenic adsorption on naturally occurring illitic clay mineral control arsenic bioavailability, mobility in groundwater, soils, sediments and the extent of this adsorption greatly influenced by the presence of competitive anions. The present study aims to investigate the adsorption of As(III) and As(V) from the aqueous solution by the most widely available inexpensive illitic clay in presence of different kind of competitive anions like silicate, phosphate and sulphate. The effects of pH, contact time, initial arsenic concentration and adsorbent dosage on the adsorption of arsenic were studied using batch experiments. Adsorption process was also verified with Langmuir and Freundlich isotherm. The illitic clay shows maximum arsenic adsorption capacity of 881 μg g^{-1} clay and reached arsenic adsorption equilibrium within 10 h. With increasing pH, adsorption of both the species of arsenic reduced significantly from various adsorption sites of illite. The study revealed that the anionic competition could significantly reduce the retention of both As(III) and As(V) over a wide range of pH and the arsenic removing capacity of silicate ion was higher over the phosphate and sulphate ions. The mechanism of arsenic sorption by illitic clay was governed by electrostatic attraction force under lower pH range, ligand exchange in normal pH range and anion exchange in higher pH range. This study thus demonstrated the potentiality of naturally occurring low-cost illitic clay in removing arsenic from aqueous system. The competitive anions interact with arsenic in such a way that the mobility of arsenic species was promoted. It has great significance for evaluating the migration and bioavailability of arsenic in both natural and contaminated environments.

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Impact of Long Term Application of FYM and Fertilizer *N* on Soluble ions in Soils after Harvesting of Wheat under Semi-arid Environment

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This study was conducted in an ongoing long-term field experiment established in 1967 on a coarse loamy, *Typic Ustochrept* soil at CCS HAU, Hisar in Haryana. The experiment consisted of 3 levels and modes of FYM and 2 levels of fertilizer N. The result revealed that all the soluble caions and anions were higher with *rabi* season application of FYM as compared to *kharif* season application. Regardless of the mode of application, soluble ions content significantly increased with the increasing application rate of FYM from 5 to 15 Mt ha^{-1}. After wheat harvest, content of water soluble K^+ and Na^+ in soil varied from 0.18 to 1.71, 0.69 to 1.84 meq L^{-1}, respectively among different treatments. Addition of 120 kg N ha^{-1} along with FYM significantly decreased the K^+ and Na^+ content as compared to FYM applied alone, while Ca^{2+} and Mg^{2+} content showed the reverse trend. Soluble chloride, bicarbonate, sulfate content in soil varied from 0.23 to 0.78, 0.13 to 0.47, 1.68 to 4.35 meq L^{-1} under different treatments. Addition of 120 kg N ha^{-1} along with FYM also significantly increased the chloride content as compared to FYM applied alone. In reverse to chloride, addition of 120 kg N ha^{-1} along with FYM decreased the bicarbonate and sulfate content as compared to FYM applied alone. Thus the results indicated that continuous FYM application could lead to increase the soluble salts content in these soils.

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Soil Phosphorus Fraction Dynamics and Phosphorus Availability as Influenced by Long-term Organic Manure Addition

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Traditional soil P test methods estimate plant available inorganic P but ignore the less available inorganic and organic P pools. In low-input systems where fertilizer P additions are very low to nil, these less available P pools may be a better measure of potential plant available P. The present investigation forms part of an experiment set up at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi in rice-lentil cropping sequence and was aimed at assessing the long term impact of organic fertilization on phosphorus fractions and its availability. The Olsen phosphorus (52.53 ppm) and other forms of phosphorus content were found to be highest in the soil receiving 100% organic fertilization. Al-P was found to be the most dominant inorganic fraction in all soil depths followed by Fe-P. Al-P (84.98 ppm) and Fe-P (47.76) contents were found to be maximum at 0-5 cm depth. Soluble-P content was found least among all the phosphorus fractions. The results of the experiment revealed that P availability was decreased with increasing depth. P fractions found to be highest in order: 100% organic fertilization> 50% organic fertilization > inorganic fertilization. Distribution in different fractions followed the sequence: Al-P> Fe-P> Ca-P> R-P> S-P. The use of path analysis highlights the interactions among P pools. Path analysis showed that Al-P seems to be the sink for P in the 0-5 cm layer whereas the rest of the fractions were the source of P for available P. Fe-P seems to be the primary sink for available-P in the 5-15 cm soil layer whereas S-P and Ca-P also act as sink for available P to some extent.

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Effect of Different Types and Levels of Salinity on Plant Growth, Photosynthetic Parameters, Yield and Quality of Tomato (*Lycopersicon Esculentum* L.)

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In a screen house experiment, tomato (v. *Hisar Arun*) seedlings were raised in chloride and sulphate dominated saline soils under four salinity levels (2, 4, 6 and 8 dS m^{-1}) which were created using chloride and sulphate salts of the Na^+, Ca^{2+} and Mg^{2+}, along with control to investigate the effects of types and levels of salinity on flowering time, plant height, chlorophyll a and b content, photochemical efficiency, fruit yield and quality, in a completely randomized design with three replications. The earliest flowering on 14 DAT was reported at 8 dS m^{-1} under chloride dominant salinity. There was a significant reduction in plant height at 50% flowering and at maturity, chl 'a' and 'b' content and photochemical efficiency as the salinity advanced from 2 to 8 dS m^{-1}. The chlorophyll reduction of fresh fruit yield at an ECe of 8 dS m^{-1} under Cl^- and SO_4^{2-} dominated salinity was 51.5 and 42.5 per cent, respectively as compared to non-saline conditions. Thus there is more than 50% yield reduction at 8 dS m^{-1} in chloride salinity and found to be more stressful than sulphate dominant condition for tomato. There was a significant increase in total soluble solids (TSS), firmness, ascorbic acid and titratable acidity of tomato fruit with increasing level of salinity due to release of compatible osmolites and antioxidants by the plants to mitigate the salt stress. A mild salt stress (up to 6 dS m^{-1}) was found beneficial for improving quality of tomato fruits.

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Effect of Different Feed Materials on Management of Earthworms (*Eisenia foetida*) for Nutritional Quality Enrichment of Vermicompost

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Vermicomposting is an easy environment-friendly technique that supports sustainable agriculture and waste management programme. The most capable earthworm species intended for vermicomposting in West Bengal is *Eisenia foetida* for their tolerance in extensive range of moisture levels and temperature levels. The earthworms (*E. foetida*) were reared in sole cow dung wastes and also with the mixture of cow dung wastes supplemented with water hyacinth compost. The earthworm population, cocoon number, vermicompost quantity, macronutrient contents (N, P, and K), microbial population in the vermicompost, pH and electrical conductivity were examined to assess the effect of sole animal waste (cow dung) and mixture of animal and plant material waste. Further the capability of these waste upon earthworm multiplication, reproduction, vermicompost yield and vermicompost qualities of *E. foetida* was tested. The reproductions were achieved maximum in the mixture of cow dung and sawdust vermicompost. But the amount of vermicompost was found to be maximum in cow dung as sole source of feeding material as compared to the water hyacinth compost mixed with cowdung. High quality vermicompost containing nitrogen, phosphorus, potassium and greater microbial population was obtained from the mixture of water hyacinth compost and cow dung. The vermicompost showed desired level of pH and electrical conductivity values.

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Depth Dynamics of Soil Organic Carbon Pools in Response to Rice based Crop Diversification in Tropical Inceptisols of Odisha

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Rice-based cropping systems have the largest expansion over the entire eastern region of India. Unfortunately, very scanty information is available of this region that covers soil organic carbon (SOC) dynamics due to shifting of land use management from rice monoculture to rice-based crop diversification. The present study assessed the depth dynamics of SOC pools and C restoration potentiality on five rice-based diversified cropping systems viz. uncultivated grassland (UG) as reference, rice-fallow (RF), rice-corn (RC), rice-mungbean (RM) and rice-capsicum/babycorn/groundnut (RG) that systems, with the hypothesis could restoration of SOC positively correlate with crop-diversification and soil depth. C restoration and humification was studied following the analysis of SOC pools *i.e.* reactive C pool (very-labile-C and labile-C) and recalcitrant C pool (less-labile-C and non-labile-C). Humification indices were determined by the quantification of humus-C and its fractions (fulvic-C + humic-C). For depth dynamics, three depths (0-15, 15-30 and 30-45 cm) were considered. Data revealed decrement of SOC fractions and pools with increasing soil depth. RF system had highest reactive C pool, whereas recalcitrant C pool was maximum under UG system. In deeper soil layers (30-45 cm), RG system had highest reactive C pool, even though percent variation in that pool had also lowest across the soil profile (up to 45 cm). Consequently, highest SOC restoration (2.63 Mg C ha^{-1}), rate of humification and dehydrogenase activity were observed in RG system, particularly at 30-45 cm. Besides, RF system had similar and ~ 63% higher CMI value at 0-15 and 15-30 cm, while, ~76% higher CMI value was observed in RG system at 30-45 cm in respect to the reference. Thus at regional scale, RG was found to be the more diversified cropping system with vegetable, cereal and legumes representing more promising cropping practice that maintains temporal soil fertility and soil health.

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Carbon Sequestration Mapping in Arecanut Orchards of Ratnagiri District of Konkan Region

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An investigation was conducted to study the carbon sequestration status of arecanut orchards of Ratnagiri district. It is a coastal district of Konkan region of Maharashtra state situated in the western coast of India and has lies between 17°12′ to 18°4′N latitudes and 73°25′ and 73°12′ E longitudes. The total geographical area of Ratnagiri district is 846145.2 ha divided into 9 tehsils. The total of 160 soil samples from 80 villages at Dapoli, Mandangad, Khed, Chiplun, Sangameshwar, Guhagar, Ratnagiri, Lanja and Rajapur tahsils were collected at the depth of 0 to 15 cm and 15 to 30 cm and analyzed for different soil properties.

The result revealed that the amount of CO_2 sequestered by soil was 4929.77 tonnes at 0 to 15 cm depth and 8554.08 tonnes of CO_2 at 15-30 cm depth. Total carbon stock was found to be 1436.50 tonnes. Above ground biomass of the district was found to be 2280.15 t h^{-1}, below ground biomass of arecanut orchards of Ratnagiri district of Konkan region were found 592.84 t ha^{-1} and copper total biomass of arecanut orchards was 2872.99 t ha^{-1}. Available manganese and 15-30 cm showed positively significant correlation with carbon sequestration at the depth of both 0 to 15 cm and 15-30 cm. In case of organic carbon, it showed positively significant correlation with carbon sequestration at the depth of 15 to 30 cm.

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Integrated Management of Zinc and Iron in Pearl Millet-Mustard Cropping System in Salt Affected Soils

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Decreased activities of micronutrients especially zinc (Zn) and iron (Fe) in salt-affected soils of North-western India result in their low availabilities. Hence, a field experiment was conducted to evaluate the effect of integrated management of Zn and Fe and distribution of different fractions in pearl millet-mustard crop rotation to know their availability to crop plants. The 12 treatments were replicated 3 times in RBD. Zinc and iron were applied through soil in the form of $ZnSO_4.7H_2O$ and $FeSO_4$ $7H_2O$, respectively, at the time of sowing of pearl millet as well as mustard. Foliar sprays of respective nutrients were also applied with same chemicals as in soil application at 30 and 45 days after sowing. Results indicated that combined application of 5 kg Zn + 10 kg Fe + 10 t FYM (T9) significantly increased the water + exchangeable fraction of Zn (0.55 mg kg^{-1}) and Fe (1.85 mg kg^{-1}) which was 52.8% and 33.1% higher over control in soil (0-15 cm) at harvest of final mustard crop. The four years pooled data also indicated that combined soil application of 5 kg Zn + 10 kg Fe + 10 t FYM significantly increased the pearl millet grain yield (36.6 q ha^{-1}) and mustard seed yield (22.7 q ha^{-1}) by 57.1% and 42.8% higher over control. The direct effect of FYM in pearl millet and its residual effect in mustard were found useful in getting higher yield of crops, which might be due to the favourable effect of FYM on soil properties in increasing the availability of nutrients. It is concluded that combined application of Zn and Fe with FYM was effective in increasing the available Fe and Zn in soils by enhancing the pools of exchangeable and organic matter fractions of Zn and Fe through altering the soil environment of salt affected soils.

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Influence of Tillage and Organics on Biological Dynamics, Rooting Behavior and Yield of Cotton under Vulnerable Climatic Conditions of Vidarbha

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An investigation was carried out on Influence of tillage and organics on biological dynamics, rooting behavior and yield of cotton under vulnerable climatic conditions of Vidarbha during 2017-18 at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola, to assess the influence of conservation and conventional tillage on biological dynamics of soil, rooting behavior and seed cotton yield by embracing low external inputs. Study was undertaken on the ongoing experiment having history of six years comprising two treatments i.e. conservation tillage (one harrowing and two weeding) and in conventional tillage (one ploughing, one harrowing, two hoeing and two hand weeding) and eight sub plot treatments of INM consisting of control, 100% RDF and use of chemical fertilizer alongwith organic source of nutrient in which 50% N applied through organic sources (FYM, wheat straw, green leaf manuring, cotton stalk, vermicompost and phosphocompost). The application of FYM, Glyricidia leaf manuring, vermicompost and phosphocomopst in conjunction with chemical fertilizers rendered significant changes in biological dynamics *viz.*, SMBC, SMBN, CO_2 evolution and DHA with use of FYM, phoshpocompost and vermicompost in combination with 50% RDF compared to sole use of chemical fertilizers and control under conservation tillage. Similarly, rooting behavior of cotton was also studied and found superior growth of micro roots under conservation tillage alongwith INM, phosphocompost and vermicompost. Highest seed cotton yield was recorded under conservation tillage using phosphocompost and vermicompost in conjunction with chemical fertilizers. Therefore, it can be concluded that collective and consistent use of organic inputs (FYM, Green leaf manuring, Phophocompost) alongwith 50% recommended dose of inorganic fertilizers under conservation tillage is the most advisable way to maintain the biological sustainability of soil. Similarly, it will exclusively help to minimize the cost of cultivation and to enhance profitability of farmers in long run under vulnerable climatic scenario.

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Effect of Zinc Mobilizing Microbial Cultures and Graded Levels of Zinc on Performance of Soybean in Zinc Deficient Vertisol and Improvement in Soil Properties

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In order to enhance zinc availability for soybean in zinc deficient soils, field experiments were conducted during *kharif* seasons of 2015, 2016 and 2017 at Parbhani on Vertisols. The experimental soil was moderately alkaline in reaction, low in organic carbon, medium in N and P, high in available potassium and also low in DTPA extractable zinc. Experiment consists of four treatments of microbial cultures (Control, *Pseudomonas striata, Bacillus megaterium* and *Trichoderma viride*) and four graded doses of zinc (0, 10, 20 and 30 kg $ZnSO_4$ ha^{-1}) along with recommended dose of N, P and K (30:60:30 kg ha^{-1}). Liquid zinc mobilizing cultures were applied to seed as per treatment @ 100 ml 10 kg^{-1} seed and *Rhizobium* for all the treatments @ 50 ml 10 kg^{-1} seed immediately before sowing. The results indicated that nodulation, grain and straw yield and soil properties were improved with zinc mobilizing cultures and also with the graded levels of zinc. Highest grain yield was noted with seed treatment of *Pseudomona striata* which was 12% higher as compared to uninoculated control. Application of zinc in its graded levels upto 30 kg $ZnSO_4$ ha^{-1} also enhanced the growth attributes and improved the zinc availability to the crop. Significantly highest values of soil available N, P, and K were noted in treatment receiving *Pseudomonas striata* along with 30 kg $ZnSO_4$ ha^{-1}. The DTPA zinc in soil after harvest was noted maximum in treatment receiving inoculation of *Pseudomonas striata* + 30 kg $ZnSO_4$ ha^{-1}. The significant increase in microbial population in soil after harvest of soybean was also noted. Bacteria and actinomycetes were significantly increased with inoculation of *Pseudomonas striata*, while fungal population was found highest with inoculation of *Trichoderma viride* along with RDF.

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Soil Microbial Community Structure in Saline and Non-saline Soils treated with Biochar Derived from Halophyte

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There is a growing interest of cultivating halophytes for food and fuel because they can be grown on saline non-arable soils with seawater irrigation. The biomass of halophyte could be used as feedstock for the production of biochar which is a promising amendment for improvement in soil quality. The biochar produced from *Salicornia brachiata* was added (0.5% biochar w/w) with saline and non-saline soils and incubated for 60 days. At the end of incubation, soil samples were analysed for enzyme activities and soil microbial community structure (using phospholipid fatty acid and next-generation sequencing). The activities of β-Glucosidase, alkaline phosphatase and urease were not significantly influenced by the biochar, however biochar amendment significantly reduced the activity of sulphatase in both soils. The content of total PLFA and PLFA biomarkers of gram-positive, fungi and actinomycetes were not affected by the biochar application. However, the content of gram-negative PLFAs was significantly increased in saline soil by biochar. Multivariate analysis of PLFA profiles revealed that microbial community structure was not affected by the biochar amendment. Predominant phyla were affiliated to Actinobacteria, Proteobacteria, Firmicutes, Acidobacteria, Choroflexi, Gemmatimonadetes and planctomycetes in non-saline while Proteobacteria, Actinobacteria, Bacteroidetes, Firmicutes and Gemmatimonadetes in saline soil. Further it was also observed that bacterial community was not affected by the biochar. The results collectively indicate that the amendment of soils with biochar derived from *S. brachiata* does not adversely affect the soil biological processes.

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Dynamics of Soil Biological Indicators and Yield as Influenced by Cotton Based Pulse Intercropping on Vertisol

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An investigation was conducted on soil biological indicators as influenced by cotton based pulse intercropping in vertisols. Treatments comprised of sole cropping of cotton, green gram and black gram, intercropping of cotton with green gram and black gram with 1:1 and 1:2 row ratios. The significantly maximum soil microbial biomass C and N contents were recorded with sole green gram and black gram after harvest. However, after harvest of cotton, among intercropping, the highest SMBC and N contents were noted with cotton + green gram (1:2) followed by cotton + black gram (1:2) over 1:1 row ratio and sole cotton. After completion of cotton based pulse intercropping, the highest C and N turnover rate (0.026 and 0.058% d^{-1}), dehydrogenase activity (141.72 µg TPF g^{-1} soil 24 h^{-1}), alkaline phosphatase activity (185.20 µg P- Nitrophenol g^{-1} soil 24 h^{-1}), fungal (25.33 × 10^{-4} cfu g^{-1} soil), bacterial (53.00 × 10^{-7} cfu g^{-1} soil) and actinomycetes population (62.00 × 10^{-6} cfu g^{-1} soil) were recorded with cotton + green gram (1:2) intercropping as compared to sole cotton cropping. The highest seed cotton yield (2496.56 kg ha^{-1}) and stalk yield (7340.58 kg ha^{-1}) was produced under sole cotton. Among cotton based pulse intercropping, the higher cotton yield was noticed with 1:1 row proportion as compared to 1:2. However, the maximum seed and straw yield of green gram (1063.25 and 1493.05 kg ha^{-1}) and black gram (934.70 and 1274.21 kg ha^{-1}) were produced under sole cropping. In intercropping with cotton having 1:2 row proportion produced higher yields of green gram and black gram over 1:1 row proportion.

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Soil Aggregates and Associated Carbon as Affected by Long-term Application of Organic and Inorganic Fertilizer in Vertisols and Inceptisols

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After 47 years and 22 years of continuous long-term application of organic and inorganic fertilizer in LTFE-Barrackpore soils (Inceptisol) under rice–wheat–jute fibre cropping system and in LTFE-Parbhani soils (Vertisols) under soybean-safflower cropping system, respectively, the results have been summarized in this paper. It was observed that the amongst treatments, fallow showed better aggregate stability than cultivated soil in both the Inceptisol and Vertisol. Continuous application of 100% N, 100% NP, and 100% NPK significantly reduced larger macro aggregates (>2000 µm). In both LTFE soils of Barrackpore and Parbhani, overall associated carbon concentrations were greater in macro aggregates (>2000 µm) followed by small macro aggregates (250-2000 µm) > micro aggregates (53-250 µm) > silt–clay fractions (<53 µm). Irrespective of aggregate size classes, the concentration of carbon was significantly higher in the 100% NPK+FYM treatment followed by 100% NPK and fallow soils. Regardless of soil type, fallow treatment showed significantly higher TG-BRSP over other treatments. Highest TG-BRSP was recorded in fallow treatment and in soil aggregates size >2000 µm followed by 250-2000 µm, 53-250 µm and < 53 µm in both Barrackpore and Parbhani LTFE soils. In both soils, mean MBC was recorded highest in 100% NPK + FYM treatment. POMC was observed more in fallow and 100% NPK + FYM respectively in Inceptisol and Vertisol. In LTFE-Barrackpore, optimum and balanced application of nutrients (100% NPK + FYM) led to significant increase in DHA. In contrast, in LTFE-Parbhani, dehydrogenase activity was recorded significantly more in fallow treatment followed by 100% NPK + FYM > 100% NP > 100% N > control. In LTFE-Barrackpore, β-Glucosidase activity was observed significantly highest in fallow. Whereas, in LTFE-Parbhani (Vertisols), β-Glucosidase activity was recorded significantly more in 100% NPK + FYM, 100% NPK and 100% NP treatment followed by fallow, control and 100% N.

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Impact of Leaf Fall on Microbial Population during Crop Growth Period and after Harvesting of Soybean

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Soil micro-organisms are important contributors for improving the soil organic carbon and soil fertility. The present study was taken up on "Impact of Soybean leaf fall on microbial population during crop growth and after harvesting". The experiment was laid out at ARI, Rajendranagar by two factors in combination of with and without leaf fall and increasing levels of N with FYM application in CRBD. A high yieldng variety of soybean (ADB-22 (Bhasar)) was sown. The soil was clay, moderately alkaline (pH 8.4), non-saline in nature (EC 0.16 dS m^{-1}) and medium in OC (0.67%). The experiment with five treatments *viz.*, 75% RDF (T2), 100% RDF (T3), 75% RDF + FYM @ 5 t ha^{-1} (T4), 100% RDF + FYM @ 5 t ha^{-1} (T5) and control (T1). Among the intervals highest leaf fall was noticed at 100 DAS, thereafter leaf fall was declined. The highest leaf fall was found in T5 (490.28 kg ha^{-1}) followed by T4 (454.85 kg ha^{-1}) whereas lowest leaf fall was observed with control. The bacterial, fungal and rhizobial population were increased gradually upto 60 DAS and was declined from 80 DAS to 40 DAH, highest population was recorded in T5 (184 × 105 CFU g^{-1}, 45 × 104 CFU g^{-1} and 53 × 105 CFU g^{-1} of soil respectively) and T4 (178 × 105 CFU g^{-1}, 44 × 104 CFU g^{-1} and 52 × 105 CFU g^{-1} of soil respectively). Lowest microbial population was recorded with T1 (70 × 105 CFU g^{-1}, 26 × 104 CFU g^{-1} and 26 × 105 CFU g^{-1} of soil respectively) in all growth periods. The INM treatments (receiving fertilizers + FYM @ 5 t ha^{-1}) along with leaf fall recorded significantly higher bacterial, fungal and rhizobial population as compared to all other treatments.

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Nitrogen Mineralization Dynamics Mediated by Soil Microbes in 44 Years Old Long Term Fertilizer Experiment in a Sub-humid to Humid Alfisol

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Soil management is the crucial requisite for sustainable agriculture and fertilizer application is the necessity to sustain crop productivity. Therefore, long term fertilizer experiment acts as the hotspot for studying the role of microbial interaction in nutrient supplying capacity. In spite of plenty of researches, we are still not certain about response of soil microorganisms to the long term application of fertilizer and manure. Hence, nitrogen mineralization dynamics mediated by soil microbes, their community composition, nitrogen cycling enzymes and soil carbon and nitrogen were studied in a 44 years old long term fertilizer experiment under sub-humid to humid Alfisol. Treatments comprised of control, 100% N (imbalanced fertilizer application), 100% NP (imbalanced fertilizer application), 100% NPK (balanced fertilizer application), 100% NPK + farmyard manure (FYM) at 5 t ha^{-1} (Integrated nutrient management; INM). INM treatment had significant build-up of total organic carbon (TOC), total nitrogen (TN) as compared to imbalanced fertilizer application and control. Similarly, INM also had significantly higher nitrogen mineralization potential and nitrification potential as compared to control and 100% N treatment. Heterotrophic nitrification contributed 24.6-45.5% of total nitrification and caused significant difference among different treatments whereas autotrophic nitrification did not cause any significant difference. Microbial biomass and their secreted extracellular nitrogen cycling enzymes were also promoted substantially in INM. Stepwise discriminant function analysis with phospho lipid fatty acid (PLFA) biomarkers had produced arbuscular mycorrhizal fungi (AMF) and eukaryote as important discriminant biomarker that cumulatively contributed 99.3% of total variations among the treatments and had differentiated the control, imbalanced and balanced fertilizer application, and INM. Multiple regression and path-analysis showed that the TOC and protease activity are the key regulators of nitrogen mineralization process and the NH_4^+-N followed by TOC, microbial biomass are the important controller of geometric mean of enzyme activities.

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Depth-wise Changes in Salinity in the Soils of Deccan Plateau and its Response to Different Reclamation Strategies

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Indian Deccan Plateau endows with different type of soils having smectite rich clay, grey to very dark grey colour and deep soil profiles. These soils have some distinct characteristics such as high stickiness, plasticity and cohesiveness in moist, and very hard and difficult to till on drying. It has chances of rapid dispersion and high degree of sodium saturation. Therefore, alkaline hydrolysis in presence of sodium dominated salts has predominant influence on crop performance and yield. Fifity five geo-referenced sodic soils of four depths (0-0.15, 0.15-30, 0.3-0.45 and 0.45-0.6 m) were collected from Madhya Pradesh (16), Maharashtra (16), Telangana (15) and Tamilnadu (8) from barren as well as cultivated sodic land after harvest of cotton, moong and rice crop. All soil profiles showed an increase in pHs along depth. Soil pHs of surface soils ranged from 7.5-8.6 for Tamilnadu, 7.7-9.8 for Telangana 7.4-9.4 for Madhya Pradesh, 7.1-8.6 for Maharashtra. Generally, soils showed ECe varying from 1.0-11.8, 1.0-4.0; 0.8-4.0 and 0.5-6.6 dS m^{-1} in respective states. The $CaCO_3$ content in surface soils varied from 0.3-12.2% in Maharashtra, 0.5-20.5% in Telangana, 0.7-27.9% in Tamilnadu and 0.2-3.5% in Madhya Pradesh. Clay content increased along depth. Soils were low in oxidizable organic C for surface layer and its content declined along depth for all profiles. For sodicity reclamation, soils need application of gypsum (50GR) with a range from 4.0-29.0 t ha^{-1} in Madhya Pradesh, 5.5-23.0 t ha^{-1} in Talangana, 5.0-15.0 t ha^{-1} in Maharashtra and 5.5-13.0 t ha^{-1} in Tamilnadu. Sole application of gypsum and elemental S based formulation (RCS) and its conjunctive application declined soil bulk density and pHs but improved soil enzymes dehydrogenase and β-glucosidase activity compared to unamended soil. Amending soil with RCS/or its conjunctive application with gypsum improved crop yield.

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Isolation and Characterization of Efficient Strains of Rhizobium from Raikia French Bean Growing Soils of Kandhamal district of Odisha

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The tribal people of Kandhamal district in Odisha has been cultivating a climbing or pole type of French bean known as "Raikia bean" in the rainy season in rainfed hill regions without much cultural practices for its tender, nutritive and fleshy nature for culinary use. An attempt has been made in the present investigation to isolate rhizobia from the rhizospheric soil and root nodules of Raikia bean growing areas of the district. Distinct colonies on YEM plates with circular shape, convex elevation, regular margin, white to pink colour and gummy consistency were selected for further screening through series of confirmatory tests to distinguish from *Agrobacterium*. From root nodule total four isolates viz. RBHR-15, RBHR-21, RBHR-25 and RBHR-26 and from soils only three isolates viz. RBHRS-8, RBHRS-20 and RBHRS-32 were confirmed to be *Rhizobium* which were considered for further biochemical characterization. All the seven confirmed isolates were unable to grow under anaerobic condition and failed to produce ketolactase enzyme. The selected isolates also showed negative response for gelatin liquefaction and Simmon's citrate agar test. All the isolates responded positively towards indole test, MR-VP, TSI test and could produce ammonium from peptone in the growth medium. The isolates RBHRS-8, RBHRS-32, RBHR-15 and RBHR-25 could reduce sulphur producing H_2S. Out of the seven confirmed isolates RBHRS-21 and RBHR-26 could not reduce nitrate while the other five could do so. The isolates varied greatly with respect to their sugar utilization pattern, production of different enzymes and antibiotic sensitivity. The growth of all the isolates was luxuriant in the nutrient broth containing 1% NaCl and decreased with increase in the concentration of NaCl. The test isolates grew profusely in the pH range of 6-8 with some degree of tolerance to pH4, 5 and 9 showing lower growth in YEMA broth.

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Seed Biopriming with *Trichoderma* Improves Nutrient Uptake in Rajmash (*Phaseolus vulgaris* c.v. HUR-137) in Alluvial Soils of Varanasi, Uttar Pradesh

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Red kidney bean (*Phaseolus vulgaris* c.v. HUR-137) were treated with graded dose of fertilizer (100%, 90%, 80% and 70% of recommended dose) along with biopriming with *Trichoderma harzianum* in greenhouse conditions. Results depicted that T2 (100% RDF) showed maximum growth attributes viz. plant height, chlorophyll, leaf area and dry matter production as expected while T5 (90% RDF + Biopriming) showed comparable growth results, followed by T4 (80% RDF + Biopriming), T3 (70% RDF + Biopriming), T6 (Control + Biopriming) and T1(Control). Biopriming also improved NPK uptake with substitution of fertilizer and comparable to RDF when the extent is 10 percent. Among the treatments, the plants treated with full dose of fertilizer without any bio-treatments was found to be the best as per growth and development but the bean plants treated with inorganic fertilizers at 90% dose combined with biopriming was comparable and hence it can be suggested that the use of bio-agents may be used significantly to supplement the nutritional needs of the crop which is reduced as a part of the nutrients. Also, the bean plants treated solely with the bio-agent represented a very good rhizospheric growth without the use of any kind of inorganic inputs suggesting the role of biopriming in development of healthy root growth and increase in root biomass.

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Biopriming: Getting Ready to Tackle Stress under Low Input Sustainable Agriculture

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Agriculture must be practised keeping in mind the points of environmental and economic impacts that are culturally acceptable by the society. Thus, the concept of low input sustainable agriculture is originated to maintain the dynamic interaction between flora and fauna of the ecosystem. On the other hand crops experience simultaneous occurrence of different stresses at various stages of plant development. As profitability of agriculture depends on productivity of crops at low production cost, the stresses become impediments for cost management of seasonal cultivation of crops. The challenge at the hands of the agricultural scientist in such a scenario is to promote a competitive and multifunctional agriculture which will take care resource conservation as well as improvement in human health, climate and biodiversity. In order to successfully meet this challenge over the past decades, there has been increasing evidence demonstrating that among the available options, on-farm seed priming is a simple, proven technology that has been an age old practice, tested, and refined in laboratories, in experimental plots, and by farmers themselves in their fields. Seed treatment with beneficial microbes is becoming increasingly important in the present perspective. Biopriming mediated by fungi and bacteria is becoming a potentially prominent technique to induce profound changes in plant characteristics and to encourage desired attributes in plants growth associated with fungi and bacteria coatings. The seed treatment with bio agents then becomes a system rather than merely a component added to seeds. Thus, it can be said that biopriming must be an initial step of raising crop and has a pivotal role in low input sustainable crop production which cannot be overlooked.

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Screening of Zinc Solubilizing Bacteria Isolated from the Agricultural Soils of Varanasi

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A lab experiment was done in the Soil Microbiology Laboratory, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, for the purpose of selection of zinc solubilizing bacterial isolates. There were 40 bacterial isolates collected from the agricultural soils of Varanasi district through dilution plate technique. These bacterial isolates were investigated for zinc solubilization by using basal agar growth medium supplemented with 0.1% of an insoluble source of zinc such as Zinc Oxide (ZnO). The selection of bacterial isolates was based on their capacity to form halo zone on basal growth medium. Out of forty, three bacterial isolates were selected as zinc solubilizing bacteria (ZnSb) on the basis of halo zone formation. Among all of the three bacterial isolates, there was maximum zinc solubilizing halo zone observed with the isolate ZnSb 1 followed by ZnSb 3 and ZnSb 2 on ZnO amended basal growth medium with the diameter of 12.35 mm, 11.40 mm and 9.30 mm respectively.

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Ecosystem Sustainability through Vermicompost Production System – Case Study at RARS Pattambi

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Scientific management, co-operative interaction and balance of infrastructure, inputs and human resources are essential for sustainability of any system. Regional Agricultural Research Station, Pattambi is the prestigious research institution established in 1927 as Paddy Breeding Station. The mandate crops of the station under Kerala Agricultural University are rice, pulses and vegetables. The crop residues, weed biomass, litter fall from trees etc. constitute the major bio-wastes generated in the campus which amounts to nearly 75 MT per annum. As a part of the project, vermicomposting technology has been adopted for solid waste management with the use of earthworms, the ecosystem engineers. The vermicompost unit has been established utilising a wasted infrastructure of the farm which was a menace to the campus. Formation of a women self help group with output linked remuneration strategy could solve the problem of labour requirement for income generation activities and this strategy was followed in the current project. The vermicomposting technology increased the net return of the farm to the tune of 12 lakhs per annum. The annual production capacity of the unit is 100 tonnes and efforts are being taken for the production of Pseudomonas and Trichoderma enriched composts on large scale which is a boon to the farmers of the state. The integration of technologies viz, waste management, women empowerment through self help groups and the effective utilization of wasted infrastructure is a model for campus sustainability of the Kerala state.

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Yield Sustainability of Pearl Millet and Soil Biological Health with Organic and Inorganic Fertilizers in Arid Environment

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Pearl millet is traditionally a dry land crop, cultivated mostly in marginal environments of the arid and semi-arid tropics of South Asia, Africa and Latin America, characterized by low rainfall, sandy soils with low fertility. Due to variations in rainfall, yield varied from <9 to >4 times of long-term average yield in arid zone. The use of fertilizer is meagre and largely limited to nitrogenous fertilizer in this area. Chemical and organic fertilizers are the most common source applied to improve soil productivity and yield sustainability. Thus, it is tricky to measure sustainable yield levels and manure and/or urea needed to sustain them. A long-term field experiment (1993-2017) was conducted and results were statistically inferred for above purpose. Eighty percent variation in annual grain yield could statistically be attributed to rainfall and 10% to manure/urea and even this response was not significant in all the years. Maximum grain production over 21 years was recorded in 5.0 ton manure + 40 kg urea-N ha^{-1} applications. 2.5 ton manure + 20 kg urea-N ha^{-1} of 2.5 ton manure with 20 kg urea-N ha^{-1} was selected to provide highest food security. Application of FYM @ 2.5 and 5 t ha^{-1} increased the level of soil organic carbon, microbial biomass carbon and soil enzyme activity namely dehydrogenase activity, fluorescein diacetate hydrolysis, β-D-glucopyranosidase, β-D-galactopyranosidase and MBC. The treatments which received only inorganic fertilizer also maintained the soil organic carbon at their initial level. The results clearly indicate about the importance of organic matter for sustainable yield of pearl millet to humble economic status farmers in a fragile ecosystem with the available minimum resources for food, food security and income.

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Compost Quality Assessment using Ligno-cellulolytic Thermophilic Microbes

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Methods for evaluating composts maturity can be categorized into (i) chemical analysis (mass loss kinetics, C/N, CEC, CEC/TOC, water soluble carbon and carbohydrates, biodegradable index, and lignin/cellulose ratios), (ii) physical analysis (odour and temperature) (iii) plant bioassay (germination and plant growth) (iv) degree of humification (HI, DH and HR) and (v) microbial analysis (respiration, abundances of bacteria, fungi and actinomycetes, and activity of enzymes). It was observed that the initial total C/N ratio varied from ~62.38 to 87.28, lignin/cellulose varied from ~0.42 to 0.49. The maximum water soluble carbon and carbohydrate was observed in vegetables waste followed by horticultural waste. The CEC was very low in all these wastes and it varied from ~12 to 14 c mol (p+) kg^{-1} 100 g^{-1} of waste. The total N, P and K varied from ~0.46 to 0.68%, ~0.25 to 0.32% and~ 0.4 to 0.56%, respectively. The loss rate kinetics study revealed that the increased loss rate (K) of about ~1.36 to 2- fold greater in kitchen, vegetable and horticultural waste compost compared to crop residue compost. Further the potential loss percentage was maximum (85.68%) in vegetable waste compost. Maturity parameters such as C/N ratio, L/C ratio, CEC/TOC ratio and degree of polymerisation reached much earlier in vegetable waste compost (20 days) followed by kitchen waste (25 days), horticultural waste compost (35 days) and farm waste compost (45 days). Point sources segregation of domestic waste (Kitchen waste), vegetable waste substantially reduce the content of heavy metals and improve the quality of compost. Thermophilic microbes enhance the decomposition process at ~ 50- to 60 °C. Microbial community has been studied at different stages of decomposition and it was found that thermophilic bacterial community increased at elevated temperature.

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Potential of Differential Carrier Material as Potent Biofertilizer

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Biofertilizers are ready to use substances applied for amending seeds, root or soil containing live viable microbes which colonize in rhizosphere for enhancing nutrient availability and plant growth. They have the ability to convert nutritionally important elements from unavailable to available form through biological processes. The carrier material increases effectiveness as well as shelf life of these natural fertilizers and are helpful in their easy and even application. They help in making solid type biofertilizer products so that easy handling can be done. Different type of carrier material can be used like clay minerals, diatomaceous soil, white carbon, rice, wheat bran, peat, lignite, biochar, peat soil, humus wood charcoal, discarded feed of animal and sodium alginate. It must be noted that clay mineral and rice bran are the most oftenly used carrier materials. Peat is best for seed inoculation. These materials can be sterilized by using autoclave and gamma irradiations which are abundantly having available locally. Carriers help to improve the survival and biological effectiveness of different inoculants by protecting microbes from biotic and abiotic stresses having near neutral or readily adjustable pH and hence said to be have pH buffering capacity. The various results have been obtained by scientists that utilization of different carriers like peat moss exhibits the highest total fungal count while wheat bran recorded the highest total bacterial counts. Talking for different sterilization procedures Gamma irradiation and proved to be superior because this process makes almost no change in physical and chemical properties as compared to steam sterilization by autoclaving in all type of carriers resulting in higher survival density of microbes. It is worth mentioning that sterilized carriers generally support higher populations and display much longer shelf lives. Carrier must have 10^9 cells g^{-1} of inoculant at the time of preparation and 10^7 cells g^{-1} on dry weight basis before expiry.

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Microbial Activity in Earthworm Gut and Enzymatic Activity in Cast as Influenced by Nitrogen and Straw Incorporation in Rice-wheat Cropping System

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Earthworm communities play an important role in terrestrial ecosystems as ecosystem engineers and are used as bio-indicators of soil quality. A field experiment was established in 2010 to study the effect of fertilizer-N application (0-150 kg N ha^{-1}) and rice straw (RS) incorporation (0-10.0 Mg ha^{-1}) on microbial diversity in earthworm gut and enzymatic activity in earthworm cast. Collection of earthworms from the selected field indicated the presence of two species of earthworms belonging to family Megascolecidae- *Lampito mauritii* (Kinberg) and *Metaphire posthuma* (Vaillant). Earthworm gut soil samples exhibited absence of any actinobacteria and fungal genera. The bacterial abundance and diversity were highest for treatment where rice straw was incorporated at rate of 5 Mg ha^{-1} in absence of any inorganic fertilizer application. Among the differential culture media utilized for growth, the nitrate reducers, non-symbiotic nitrogen fixers and PGP-pseudomonas diversity were highest in the same treatment. The bacterial genera involved in the N-cycle in soil were increased, particularly, the nitrate reducers, non-symbiotic and symbiotic nitrogen fixers. The result also showed that straw incorporation at the rate of 10 Mg ha^{-1} along with recommended dose of N fertilizer significantly increased the soil enzymatic activities and organic carbon content in earthworm cast as compared to bulk soil. The microbial diversity in earthworm gut was suitable for use as a sensitive indicator under straw incorporation, although its effect on crop yield was needed to verify on long term evaluation in a rice-wheat cropping system.

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Effect of Organic Manure and Phosphorus Application on Carbon Mineralization under Rice-wheat System

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The present experiment was carried out to study the effect of farmyard manure (FYM), rate and source of phosphorus (P) application on carbon mineralization in soils under rice-wheat cropping system. The treatments included two rates of P *viz.* 0 and 30 kg P_2O_5 ha^{-1} applied through single super phosphate (SSP) and rock phosphate (RP) in the presence and absence of FYM. Mineralizable-C in differentially treated field soil was estimated by conducting a laboratory study at 25 and 35 °C temperatures and field capacity moisture content. Irrespective of treatment, carbon mineralization was higher at 35 °C as compared to 25 °C. The cumulative amount of CO_2-C evolved in different treatments ranged between 158.2 and 528.1 mg C kg^{-1} at 25 °C, and between 259 and 828.5 mg C kg^{-1} at 35 °C. Regardless of the treatments, C mineralization was faster during initial period of incubation followed by a relatively slower rate thereafter. The amount of CO_2-C evolved was highest in soils receiving fertilizer P and FYM (F1P30RP), followed by F1P0 treatment at both the temperatures. Regardless of the temperatures, cumulative amount of CO_2-C evolved in soil followed the order FYM (F1P30RP)>F1P0> F0P30SSP>F0P30RP>F0P0>CK. Thus, the results revealed that the process of organic matter decomposition triggered at higher temperature.

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Influence of Long Term Application of FYM and Fertilizer N on Soil Microbial Biomass under Pearl Millet - Wheat Rotation

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An ongoing long-term field experiment established in October 1967 on (Compensation of fertilizer nitrogen through use of farmyard manure (FYM) under pearl millet-wheat cropping system) at Research Farm, Department of Soil Science, CCS HAU, Hisar was selected to conduct the present study. The treatments consist of 3 levels of FYM (5, 10 and 15 Mg ha^{-1} yr^{-1}), 3 modes of application (*rabi, kharif* and both) and 2 levels of fertilizer N. The soil samples were collected after harvest of pearl millet crop. After 51 years of continuous nutrients application, total organic carbon (TOC) content after harvest of pearl millet varied from 0.57 to 2.17% among various treatments. Both TOC and microbial biomass carbon (MBC) were highest and lowest where 15 Mg ha^{-1} FYM along with 120 kg ha^{-1} N was applied in both seasons and control, respectively. The MBC, microbial biomass nitrogen (MBN) and microbial biomass phosphorus (MBP) content ranged from 108.1 to 1370.9, 11.37 to 131.39 and 13.02 to 143.50 mg kg^{-1}, respectively, under different treatment combinations. Microbial biomass content was increased significantly with increasing application rate of FYM, and addition of fertilizer N along with FYM. With the addition of fertilizer N along with FYM in *rabi*, *kharif* and both seasons, increase in MBC content was 19.0, 13.0 and 16.6%, respectively as compared to FYM applied alone. Improvement in MBN and MBP followed the order of both seasons>*kharif*>*rabi*. Irrespective of modes and levels of FYM and fertilizer N, application of fertilizer N along with FYM significantly increased the MBN and MBP content as compared to FYM applied alone.

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Influence of Potassium Solubilizing Bacteria (KSB) and Potassium Sources on Soil Microbial Dynamics at Different Stages of Maize (*Zea mays* L.)

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Microorganisms play a central role in the natural cycles of potassium (K). Potassium Solubilizing bacteria is present in the soil and rhizosphere. Soil microorganisms help to break down complex minerals in the soil by secreting acid or base and transforming them into a simple form and maintain soil fertility.

A field experiment was carried out at Agricultural Research Farm of Banaras Hindu University Varanasi during *Kharif* 2017 and 2018. Effect of two potassium solubilizing bacteria strains i.e. KSB1 (KJ410663) and KSB2 (KJ410665) were assessed in combination with mineral K and fertilizer K comprising treatments in Randomized Block Design with three replications using Maize (*Zea mays* L.) as a test crop. Data revealed that combination of inorganic source and mineral source i.e. Biotite along with KSB significantly enhanced microbial population i.e. bacteria, actinomycetes, Fungi and potassium solubilizing bacteria at 30, 60 and at harvest of crop over uninoculated control. KSB1 (KJ410663) appeared to be more effective than KSB2 (KJ410665). Significantly higher microbial population was recorded by the use of strain KSB1 (KJ410663). Maximum Bacteria, actinomycetes, fungal and potassium solubilizing bacterial population (cfu g^{-1} of soil) were found to be the higher with treatment 75% RDK + 25% Biotite + KSB1. Higher cfu g^{-1} of soil of colonies was found at 60 DAS of the crop growth after which it decreased. Use of these efficient KSB isolates under favorable conditions certainly will contribute to microbial population.

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Effect of Different Nitrogen Amendmends on Yield attributes of Rice (*Oryza sativa* L.) in Inceptisol of Varanasi

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Rice (*Oryza sativa* L.) is the most important cereal crop of the world, both in respect to area and production. India ranks first in area and second in production after China in the world. The scope for increasing the production by cultivating more land, particularly in developing countries like India is limited and hence, the other alternative lies in increasing the production per unit area. To exploit the yield potential of a variety, the inputs which can bring about a massive increase in production are fertilizers and irrigation. A study on the effect of different nitrogen amendmends on yield attributes of Rice (*Oryza sativa* L.) in Inceptisol of Varanasi was conducted at the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, BHU, Varanasi (U.P.) during the *kharif* season of 2017. Treatment involving split application of polymer coated urea and neem coated urea (50% + 50%) showed a significant increase in grain and straw yield of rice. Application of treatment T12 (50% of RDN through PCU + 50% by NCU 3 Split) showed a significant increase in yield from 112.67 to 200 g pot^{-1}. The maximum yield was observed in this treatment which was significantly higher than single basal of PCU at same rate of application and higher over the other treatment upto 200 g pot^{-1}. The EC, pH and organic carbon were found to be 0.23 dsm^{-1}, 8.1, 0.57%, respecitvely after harvesting in the treatment T12.

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Biodegradation of *In-situ* Incorporated Paddy Straw by Ligno-cellulolytic Microbial Consortia and its Effects on Chemical and Biological Properties of Vertisols

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A field experiment was conducted to evaluate the relative contribution of *in-situ* incorporation of paddy straw with microbial consortia, urea and cow dung slurry in different combinations for improving residue decomposition rate and soil biological properties. The experiment was laid out as a randomized block design (RBD) with three replications. Incorporation of paddy straw in conjunction with urea and *Aspergillus* spp. + *Bacillus spp.* + *Streptomyces* spp. (T6) resulted in maximum total nitrogen, phosphorus and potassium percentage in the soil. However incorporation of paddy straw in combination with urea and microbial consortia resulted increased enzymes activity in the soil such as dehydrogenase activity (12.94 µg TPF $100g^{-1}$ h^{-1}), fluorescein diacetate activity (6.02 µg Fluorescein g^{-1} soil h^{-1}), acid and alkaline phosphatase activity, urease activity (31.08 µg NH_4-N g^{-1} dwt $2h^{-1}$) and â-glucosidase activity (29.24 µg PNP g^{-1} h^{-1}). Results showed that in situ incorporation of paddy straw in combination with urea and microbial consortia inoculation can be used as an effective technique for valuable disposal of paddy residues and to improve the soil health.

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Impact of Conservation Tillage and Nutrient Management Systems on Soil Health through Microbial Enzyme Activity in Soils

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An investigation was carried over by analyzing soil samples drawn from experimental field of AICRP on Maize at Rajasthan College of Agriculture, Udaipur after completion of maize-wheat-green gram cropping sequence. The objectives of investigation were to assess the microbial enzyme activities and soil carbohydrates of soils affected by different tillage and nutrient management practices. The experiment consisted of three tillage (conventional tillage, zero tillage, and permanent bed) and three nutrient practices (farmer's practice, 100% RDF and SSNM) replicated thrice in FRBD. It was observed that zero tillage with reduced soil manipulation recorded higher soil carbohydrate (5.51 mg g^{-1}) and higher acid (176.36 µg PNP g^{-1} h^{-1} soil), alkaline (216.48 µg PNP g^{-1} h^{-1} soil) and dehydrogenease (34.94 µg TPF g^{-1} h^{-1} soil) activities at upper layer. SSNM practice also influenced soil carbohydrates (5.49 mg kg^{-1}) and enzyme activities (169.56, 214.78 µg PNP g^{-1} h^{-1} soil and 33.01 µg TPF g^{-1} h^{-1} soil). Soil enzymes catalyze several biochemical reactions which result in the transformation of organic matter, and the release of inorganic nutrients for plant growth and nutrient cycling. Soil enzyme activities are useful biological soil quality indicators since they are operationally practical, very sensitive, integrative, easy to measure and more responsive to soil tillage and structure than other soil variables. All enzyme activities increased in the soils with the decrease in tillage intensities. Minimum microbial activities were found in conventional tillage and decreased with soil depth. The study evaluates the roles of soil enzymes as well as the implications of their activities for sustaining the soil health under the adoption of conservation tillage with conjoint application of nutrients through SSNM practices.

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Soil Biochemical Changes Associated with Tillage Practices and Cropping System under Indo-Gangetic Plains of Bihar

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Soil management influences soil microorganisms and soil microbial processes through changes in the quantity and quality of plant residues entering the soil. Soil biological and biochemical properties have been suggested and sensitive indicators of changes in soil quality. The effects of three tillage practices (zero tillage, permanent raised bed and conventional tillage) and three maize based cropping systems (maize-maize, maize-wheat and maize-chickpea) on soil microbial biomass (carbon, nitrogen and phosphorus) and soil enzymes (dehydrogenase, acid and alkaline phosphatase) was studied in 2017. Soil microbial carbon, nitrogen and phosphorus ranged from 424-602 mg kg^{-1} soil, 38-66 mg kg^{-1} soil and 11.5-23.9 mg kg^{-1} soil, respectively. Dehydrogenase activity of soils varied from 20.28-25.33 µg TPF hr^{-1} g^{-1} soil while acid and alkaline phosphatase activity ranged between 65.55-95.37 µg *p*-nitrophenol g^{-1} soil hr^{-1} and 150.13-189.92 µg *p*-nitrophenol g^{-1} soil hr^{-1}, respectively. All the contents were higher in plots where zero tillage was practised under maize-chickpea cropping system. The results also revealed that microbial activity as obtained from biomass status and enzyme content was significantly lower under conventional plots as compared to zero tillage plots. The biochemical properties were positively correlated with soil organic carbon status and negatively correlated with soil bulk density. In all the properties a similar trend was followed: Maize-Chickpea>Maize-Wheat>Maize-Maize among the cropping system and Zero Tillage> Permanent raised Bed>Conventional Tillage among tillage system. Zero tillage improved the quality of soil after continuous practice for last 7 years by enhancing biochemical status as reflected through higher values of microbial biomass carbon, nitrogen and phosphorus and soil enzymes in comparison to conventional tillage.

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Effect of Biochar, Carpet Waste, FYM and PGPR on Biological Properties of Soils by Rice under Organic Farming System

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Present investigation was aimed for improving growth and yield of crop using waste products of different activities and also useful in ecological stability of the soil environment. The experiment was conducted in the organic farming plot of the Institute of Agricultural Sciences, BHU, Varanasi during *Kharif* season of rice crop (*Oryza sativa* L.) in 2017. The field experiment was laid out in Randomized Block Design with 10 treatments designated as T1 (Control), T2 (BC1 + CW1 t ha^{-1}), T3 (BC2 + CW1 t ha^{-1}), T4 (BC1 + CW1 + FYM1 t ha^{-1}), T5 (BC2 + CW1 + FYM1 t ha^{-1}), T6 (PGPR Consortium), T7 (BC1 + CW1 t ha^{-1}), T8 (BC2 + CW1 t ha^{-1} + PGPR), T9 (BC1 + CW1 + FYM1 t ha^{-1} + PGPR) and T10 (Biochar + carpet waste + FYM (2+1+1 t ha^{-1} + PGPR) and three replications. The maximum dehydrogenase activity was found in the treatment T10 which was 9.18% superior to the control followed by T5 which is 5.18% and T9 which is 2.05% higher over control. The maximum alkaline phosphatase activity was found in the treatment T10 (Biochar + carpet waste + FYM (2+1+1 t ha^{-1} + PGPR) as compared to the control followed by T5 and T9 respectively. It can be concluded that use of these organic sources has a good impact on the soil health under the long term.

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Dual Inoculation of Bradyrhizobia and PGPR in the Soybean to Mitigate the Temporary Moisture Stress in Mollisol

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Soybean is sensitive to moisture stress during reproductive phase leading to substantial reduced yield. The investigation was carried under pot house condition with the hypothesis that inoculation of *Rhizobium* and PGPR would armour the rhizosphere to mitigate the temporary moisture stress. The experiment comprised sixteen treatments (three rhizobial and one PGPR isolate and control) with and without water stress at R5 stage in Mollisol.

Inoculation with PGPR (Pant 6), irrespective of moisture regimes, supported the highest shoot length at R5 stage. Whereas under moisture stress at R5 stage dual inoculation with *Bradyrhizobium lianigense* + Pant 6 produced the higher shoot length, number of nodules, root volume and trifoliate leaves. Dual inoculation of *B. dequigense* + Pant 6 resulted in highest root length at R5 under moisture stress condition. Highest shoot and root dry weight was facilitated by *B. lianigense* under moisture stress at R5 as well as harvest. *B. dequigense* + Pant 6 supported highest leaf chlorophyll 'a' in leaves whereas under moisture stress Pant 2 + Pant 6 supported highest chlorophyll 'b' in leaves. Under normal as well as moisture stress conditions, highest leaf relative water content was recorded with dual inoculation of Pant 2 + Pant 6. Under moisture stress, Pant 6 recorded the highest leaf proline content. Dual inoculation of *B. dequigense* + Pant 6, under moisture stress, supported the highest grain yield followed by *B. lianigense* alone.

It can be concluded from the study that inoculation with *B. lianigense*, *B. dequigense* and Pant 6 under normal as well as water stress enhanced RWC in leaves, leaf area, chlorophyll, dry biomass, nutrient uptake and yield. The results also indicated the potential of the rhizobial isolates alone or together with PGPR to mitigate the temporary moisture stress of 8-10 days at R5 in soybean.

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Effect of Long-term *In situ* Moisture Conservation in Horti-pasture System on Biological Health of Degraded Land

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In situ moisture conservation practices can conserve fertile topsoil and enhance available water in soil profile. It is hypothesised that reclaiming degraded land with tree + pasture + in situ moisture conservation practices would significantly improve soil organic carbon (SOC) and health. A long-term experiment was conducted involving *Emblica officinalis* trees + pasture (*Cenchrus ciliaris* + *Stylosanthes seabrana*) + in situ soil moisture conservation measures viz. staggered contour trenches (T1), continuous contour trenches (T2), stone mulch (T3), vegetative barriers (T4), control (T5) and fallow land (T6) since 2007. SOC concentration increased by ~51 and 31% in T1 and T2, respectively, over T5 in surface (0-15 cm) soil. Activities of all soil enzymes increased in T1 and T2 (ranging from 42 to 289%) over T5 and T6 in both surface and sub-surface (15-30 cm) layers. Moreover, geometric mean enzyme activity of T1 was ~65 and 33% higher than T5 and T3, respectively, in surface soil. Treated soil quality index (T-SQI) of T1 was ~184% higher than T5. Soil functional diversity was also ~1.24 and 1.22 times higher in T1 and T2 than T5, respectively. Importantly, ~96, 62 and 82% variability of SOC, N and P concentrations, respectively, could be attributed to their corresponding enzyme activities. Adoption of horti-pasture system combined with moisture conservation practices ensured higher above ground biomass yield, SOC, nutrient availability and soil quality and could be recommended for improving health and productivity of degraded lands of central India.

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Fertilizer Prescription on the Basis of Specific Yield of Funnel in Chandauli district of Uttar Pradesh

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The present study was conducted in five locations of Naugarh block in Chandauli district during the year 2018-19, to study the fertilizer prescription, based on specific yield of funnel crop. The fertilizer adjustment equations are derived by the Council of Science and Technology at Institute of Agricultural Science, B.H.U., Varanasi centre. Results revealed that targeted yield of funnel (15 q ha^{-1}) and (20 q ha^{-1}) have been achieved by using the plant nutrients on the basis of targeted yield concept (soil test crop response technology). The maximum net returns of coriander was recorded as: first location (Rs. 36934 and Rs. 66534), second location (Rs. 38853 and Rs. 68754), third location (Rs. 34954 and Rs. 64554), fourth location (Rs. 39453 and Rs. 69054) and fifth location (Rs. 40174 and Rs. 70374). This technology also maintained the soil available plant nutrients. Thus, for obtaining maximum gain and sustaining the soil fertility, application of plant nutrients as per soil test value (STCR technology) is essential.

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Influence of Grafting on Nutrient Acquisition and Yield in Tomato Grafted on Wild Solanaceous Brinjal Root Stock

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Grafting of vegetable seedlings is a unique horticultural technology to enhance the acquisition of nutrients, which can be made use for successfully overcoming problems associated nutrient imbalance like Blossom End Rot (BER) in tomato. The nutrient acquistion was monitored in tomato plants grafted on wild solanaceous brinjal as root stocks. The preliminary studies were carried out for assessment of eighteen wild *Solanaceous* species for nutrient acquisition behaviour and among them two species, *Solanum aculeatissimum* with low B/Ca ratio and *Solanum seaforthianum* with high B/Ca ratio were selected for grafting purpose. The grafting tomato on wild solanaceous species indicated differences in nutrient concentration when compared to un-grafted plants. The mean concentration of K, S, Fe, B and that of B/Ca (12.80) ratio was higher in grafted plants of tomato on *S. aculeatissimum*. The grafting tomato on *Solanum Seaforthianum* resulted in higher concentration of Ca, as well as B, while B/Ca ratio was lowered. The concentration of N, P and K, Zn, Cu and B decreased in tomato grafted *S. aculeatissimum* with application of B @ 50 ppm. Whereas, in tomato plant grafted on *S. Seaforthianum,* only two elements viz. P and Cu decreased marginally, while the B concentration increased from 31.2 to 52.94 ppm. The overall mineral content of grafted plant of *S. aculeatissimum* was 7.23%, while in *S. Seaforthianum* grafted plant the mineral content was 9.69 percent. The cumulative mean yields up to 6th harvest was 17.2 kg plant^{-1} with tomato grafted on *S. aculeatissimum* and 18.0 kg plant^{-1} with tomato grafted on *Solanum seaforthianum*. The preliminary studies indicated that fruits were free of BER. The grafting techniques could be exploited successfully to overcome some of the problems related to physiological and nutritional problems.

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Effect of POLY4 as a Source of Multi Nutrients on Growth and Yield of Chickpea (*Cicer arietinum*)

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A field experiment was conducted to assess the effect of POLY4 on gram variety JG-14 during rabi season of 2018-19 at Banda University of Agriculture and Technology research farm. Experiment was carried out in RBD with fifteen treatments and three replications. Different doses of POLY4 such as 50, 75, 100, 150 and 200% of recommended dose of potash and 50, 75, 100, 125 and 150% of recommended dose of Sulphur respectively were used as source of potash and Sulphur along with recommended dose of nitrogen and phosphorus. Two INM treatments were also included with the use of Vermicompost along with rock phosphate and POLY4. Data were recorded and averaged on plant population, plant height, number of pod per plant, number of grain per plant, test weight, biological yield, grain and straw yield. Data revealed that, overall performance of treatment T7 *i.e.* T2 for NPS + 150% K from Poly 4 (0:150) followed by treatment T13 *i.e.* T2 for NPK + 150 % S from Poly 4 (0:150) were better over other treatments. All the treatments had given higher yield over farmers practice. Maximum grain yield i.e. 2984 kg ha^{-1} followed by 2927 kg ha^{-1} were found in Treatment T7 and T13 respectively. Lowest grain yield was found in farmers' practice (T3) *i.e.* 2164 kg ha^{-1}. Lower yield under farmers' practice may be due to use of imbalance plant nutrition while higher yield in Treatment T7 and T13 may be attributed due to application of multi nutrient content i.e., natural mineral POLY4. Results of first year experiment may be confirmed on the basis of next two consecutive years of experiment.

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Effect of Different Nutrient Sources on Yield and Physico-chemical and Biological Properties of Soils under Rice - Wheat Sequence

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Field experiments were conducted for two years in sandy loam soil to study the direct effect of organic manures i.e. sewage sludge (SS), vermicompost (VC), sesbania (SB) and chemical fertilizers on rice (*Oryza sativa*) and their residual effect on wheat (*Triticum aestivum*) grown in sequence. Among the nutrient sources, the maximum two years pooled grain yield in rice (4.92 t ha^{-1}) was recorded in treatment T3 (100% RDF with S, Zn, B) whereas in wheat (4.64 t ha^{-1}), it was in T4 (customized fertilizer) where it was increased by 21 and 30% over aT2 (100% RDF) for both the crops. Total removal of N, P, K, S and B was higher by rice crop than that of wheat indicating its exhaustive nature of nutrients. As compared to the soil properties in T1 (without fertilizers), pH and EC did not change. The treatment received 75% RDF along with organics (SS, VC and SS) and had higher water holding capacity and lower bulk density of soil during both the years. Organic carbon, available N P K content in post harvest soil increased significantly by application of 100% RDF along with S, Zn, B and customized fertilizer for both the years. Application of S, Zn and B (T3) resulted a significant increase in available S and B content in soil over 100% RDF (T2). Application of vermicompost (T6) significantly increased the bacterial, fungal and actinomycetes population and the urease, phosphatase and dehydrogenase activity followed by application of sesbania (T7) in post harvest soils of rice and wheat.

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Role of Micronutrients in Curving Morpho-physiological and Nutritional Parameters of Fenugreek and Suppression of Diseases

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Micronutrients play a crucial role in enzymatic activities of plants. Therefore, present investigation was carried out with five micronutrients *viz.* Fe-10, Zn-05, Mn-10, Cu-05, B-05 and their effect was compared with control for growth, yield, diseases, nutritional and physiological parameters of fenugreek (*Trigonella foenimgraecum* L.) cv. AM-1. Results revealed that growth parameters like plant height, number of pods, root and shoot parameters, root nodulation were improved by these nutrients. However, seed germination was hastened by Fe, Zn, Mn and Cu, whereas B delayed the germination for more than a day. Seed yield was significantly higher with Fe and Mn and marginally with Zn, Cu and B whereas haulm yield was more with all the elements. The per cent yield increased with Fe and Mn was 18.9 and 20.0, respectively. Uptake of N, K, Cu, B and Mn was enhanced by most of the applied micronutrients. However, P uptake was only higher with Cu and B, while Fe with B and Fe. Moreover, Zn uptake was more with application of B, Cu and Zn. Chlorophyll, a, b, total, carotenoids and soil available nutrients were marginally influenced by these micronutrients. Most interestingly, crop maturity was advanced by all the micronutrients, while the earliest maturity was noticed with B, which was advanced for more than a in comparison to control. In contrary to this, it has been documented that micronutrients delay the fenugreek maturity. Based on the Percent Disease Index, fenugreek blight was suppressed by all the micronutrients very effectively, whereas powdery mildew was lower only with Mn. However, application of Mn, Cu, Zn and B in soils was more effective for the control of downy mildew. Overall effect of Fe and Mn was superior among all the applied micronutrients, whereas role of B was magical for delaying seed germination and hastening maturity.

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Fertiliser Management: Analysis of Multi-locational Trial Data

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Site specific nutrient management is precise use of influential site characteristics. A multilocational trial was conducted with three rice varieties and fertiliser schedules comprising farmer fertilisation (T1), recommended dose of fertiliser (T2) and 'Nutrient Expert' software derived fertiliser dose (T3), in three replications. 18 sites in Karaikal area in Puducherry UT were cultivated with varieties, ADT 46, BPT 5204 and CR 1009 in three, six and nine locations, respectively. The documented average yields of varieties were 6656, 6000 and 5300 kg ha^{-1}, respectively.

Data on grain yield and its difference from average varietal yield were grouped variety wise. Generalised Linear Model (GLM) for T1 highlighted that grain yield was insignificant among varieties whereas yield was significant with R2 of 0.163 and 0.418, respectively. Grain yield differed significantly between BPT 5204 and CR 1009 in T2 and T3. Similarly, yield of CR 1009 with ADT 46 and BPT 5204 in T2 and T3 differed significantly. R2 values for GLM for T2 were 0.391 and 0.651, respectively for grain and yield while in T3, it was 0.364 and 0.640, respectively.

Analysis indicated that yield of BPT 5204 and CR 1009 differed significantly in all treatments. In addition, differences in yield of CR 1009 with ADT 46 and BPT 5204 were also significant in T2 and T3. As far as grain yield was concerned the difference between CR 1009 and BPT 5204 was significant in T2 and T3.

There was a definite increase in yield from farmer's practice to more precise fertilisation using 'Nutrient Expert' with concurrent reduction in gap between realisable and realised yields. The difference between realisable and realised yield was found better in yield analysis than grain yield, which might help in understanding yield gap, a consequence of Gene x Environment x Management interactions.

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Effect of Climate Resilient Management Practices on Carbon Sink Potential in Climate Vulnerable Districts of Eastern India

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In order to meet the growing food demand as per the commitment of COP-21, reduction in the Green House Gases (GHG's) emissions under various production systems without affecting the productivity is one of the important challenges in addressing global warming. To address this, environmentally effective and economically efficient climate resilient management practices were identified under National Initiative on Climate Resilient Agriculture (NICRA) project and these were implemented in the sixteen study villages in four districts of Eastern India. In this study, we estimated the greenhouse gas (GHG) emissions and C balance in terms of tCO_2eq due to adoption of climate resilient technologies in agriculture, livestock and forestry. To estimate the greenhouse gaseous (GHG) emissions and their mitigation potential, EX-ACT model, that was developed by the Food and Agriculture Organization (FAO) of the United Nations (UN), was used. EX-ACT tool was found to be user friendly and easy to assess the C balance in small areas with diverse climate and soil types. This tool primarily focuses on land based system and is developed in Excel using the IPCC 2006 methodology. Based on the output of this model, it has been predicted that there would be significant mitigation benefits by 2030 relative to a baseline scenario-2011 with the adoption of climate resilient practices. Further, this study also predicts that intensive and integrated efforts are still required to reduce the GHG emissions from the livestock, inputs, irrigated rice and land use change.

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Growth and Sink Potential of Rice as Influenced by Balanced Fertilization

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Field experiments were conducted in Padugai series (Typic Ustifluvent) soil during 2016-17 to examine the effect of balanced fertilization on rice. The treatments consists of (T1) Control (T2) Farmer's practice (125, 62.5, 62.5 kg N, P_2O_5, K_2O), (T3) 100% NPKS Zn (120: 38: 38: 20: 5 kg N, P_2O_5, K_2O, S and Zn - kharif and 150: 50: 50: 20: 5 kg N, P_2O_5, K_2O, S and Zn - *rabi*), (T4) T3 minus N, (T5) T3 minus P, (T6) T3 minus K, (T7) T3 minus PK , (T8) T3 minus S, (T9) T3 minus Zn, (T10) T3 minus S Zn, (T11) 75% NPK +S + Zn + PM @ 4 t ha^{-1} and (T12) 50% NPK + S + Zn + PM @ 4 t ha^{-1}. The test crop was rice with variety ADT 43 (*kharif*) and BPT 5204 (*rabi*). The experiment was conducted in RBD design with three replications. The results revealed that there was significant response of rice to different treatments. The tallest plant, highest tiller count, LAI, chlorophyll content, crop growth rate, relative growth rate, net assimilation rate and DMP and highest grain yield (5650, 6080 kg ha^{-1}), straw yield (6910, 7418 kg ha^{-1}) in kharif and rabi respectively was observed with treatment involving 75% NPK + S + Zn + PM @ 4 t ha^{-1} and was closely followed by 100% NPKS Zn. Perceptible reduction in yield of rice, where there was omission of single or two nutrients in the fertilizer schedule. In grain yield, % reduction ranged from 47 to 13 (*kharif*) and 48.1 to 16.4 (*rabi*) and in straw yield, % reduction ranged from 46 to 14 (*kharif*) and 46.8 to 15.1 (*rabi*). The highest reduction was noticed in nitrogen omission plots.

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Response of Rice to the Application of Nitrogen and Silicon in Typic Ustifluvent Soils

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Rice requires large amounts of nitrogen and silicon for growth. Apparently applied Si seems to interact favourably with other applied fertilizer nutrients (namely N, P and K) and offers the potential to improve their agronomic performance and efficiency in terms of yield response. Because of the synergistic effect, Si application has the potential to raise the optimal nitrogen (N) rate, leading to enhanced rice productivity. With this background, field experiments were conducted in Typic Ustifluvent soil with following treatments silicon levels (0, 50,100 and 150 kg ha^{-1}) and nitrogen levels (0, 50,100 and 150 kg ha^{-1}) applied through magnesium silicate and urea respectively. The results revealed that rice grown during kuruvai and samba seasons responded sufficiently to the addition of different doses of nitrogen and silicon applied alone or both over control. The highest value were noticed when both were applied together compared to their individual applications. Accordingly, rice plant which received 150 kg N ha^{-1} + 150 kg Si ha^{-1} registered the highest growth and yield. Grain and straw yield increased linearly with increase in nitrogen and silicon levels. The highest grain yield (5600, 6786 kg ha^{-1}) and straw yield (6811, 8031 kg ha^{-1}) was noticed with 150 kg N ha^{-1} + 150 kg Si ha^{-1}. However it was comparable with 150 kg N ha^{-1} + 100 kg Si ha^{-1} and 100 kg N ha^{-1} + 150 kg Si ha^{-1}. Various nitrogen use efficiency parameters decreased with N levels and maximum value was noticed with 50 kg N ha^{-1}, but NUE increased with Si levels and highest value was noticed @ 150 kg Si ha^{-1}. AESi, PESi and APESi increased with silicon levels. ANRSi, IESi and PFPSi decreased with silicon levels. Increase in nitrogen levels improved various silicon use efficiency parameters.

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Response of Mungbean to Sulphur Application in Coarse Textured Soils of Southern Haryana

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A field study was carried out at CCS HAU, Regional Research Station, Bawal (Haryana) at three different locations from 2013 to 2015 to study the effect of sulphur fertilization in mungbean. The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.32 to 8.39), EC (0.17 to 0.19 dS m^{-1}), low in organic carbon (1.9 to 2.0 g kg^{-1}), medium in available P (10.55 to 11.34 kg ha^{-1}), medium in available K_2O (169.0-170.0 kg ha^{-1}) and low in sulphur (7.17-7.19 ppm). There were five graded levels of sulphur application viz., 0, 10, 20, 30, and 40 kg S ha^{-1}, applied through gypsum. Recommended dose of fertilizers was applied @ 20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}. Seed, straw and soil samples were collected and analyzed for S concentration in seed and straw and available S in soil, respectively. The data was analyzed statistically and economics of S application was worked out. The experimental results revealed that seed yield of mungbean (cv. MH 421) was increased significantly with the application of sulphur upto 20 kg ha^{-1}. The increase in mean seed yield of mungbean was 5.77, 14.21, 18.48 and 20.30% due to application of 10, 20, 30 and 40 kg S ha^{-1}, respectively over control. The mean S-use efficiency varied from 10.10 to 12.50% in mungbean and was maximum (12.50%) with the application of 20 kg S ha^{-1}. The mean post harvest available S status was 4.45, 7.47, 9.38, 10.25 and 11.93 ppm at 0, 10, 20, 30 and 40 kg S ha^{-1}, respectively. Thus, from the finding of this study in coarse textured low S status soil it was observed application of 20 kg S ha^{-1} was found to be optimum for mungbean in terms of crop yield, soil S fertility status and economics.

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Geo-reference Soil Fertility Status in Koderma District of Jharkhand for Nutrient Plan Development

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Total 270 geo-referenced surface (0.0-15.0 cm) soil samples were collected randomly from Koderma district (Lat. 24°19′00.0″ to 24°46′14.5″, Long. 85°25′14.6″ to 85°50′30.6″ E and Alt. 117 to 392 metre above msl) during January-March 2018. Data reveal that soils were strongly acidic to alkaline in reaction (pH 4.25-9.28) with low electrical conductivity (0.01-0.86 dS m^{-1}) and organic carbon content varied from very low (0.36 g kg^{-1}) to high (17.62 g kg^{-1}) status. Micronutrients *i.e.*, Fe, Mn, Zn, Cu and B content were varied from 3.84 to 62.00, 5.92 to 40.00, 0.16 to 4.66, 0.42 to 2.72 and 0.15 to 1.75 mg kg^{-1}, respectively. Iron, Mn and Cu content were well sufficient, while available Zn and B deficiency was observed in about 59.91% and 62.99% soil samples of the district. Sulphur (S) content in soil was observed in the range of 0.69 to 65.13 mg kg^{-1} and about 90.49 per cent soils were found in between acute to marginal (<40 mg kg^{-1}) deficient in sulphur. On the other hand, heavy metals *i.e.*, Pb, Ni and Co content range between 0.01-4.34, 0.04-2.48 and 0.02-2.36 mg kg^{-1}, respectively. As per consideration of the safe limit of Pb (20 mg kg^{-1}), Ni (10 mg kg^{-1}) and Co (20 mg kg^{-1}) in soils, these heavy metals were found within the safe limit and can be use safely for cultivation. Deficiencies of Zn, B and S were most common in soils of Kodarma district. Therefore, for successful and profitable crop production, maintaining soil and plant health is the immediate need to give more attention to make availability of Zn, B and S containing fertilizers at village and block level and to create awareness among the farmers to use these fertilizers in judicious and scientific way.

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Monitoring the Changes in Soil Health during the Five Year Period of Permanent Manurial Experiment of Maize-green Gram Cropping System

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The experiment on permanent Manurial Experiment was started in 2014 using maize green gram cropping system. The main objective is to study the effect of continuous addition of organics, inorganics and its integrated effect on yield attributes, yield and uptake of maize. Maize crop was raised during rabi and green gram crop at summer. Treatments consisted of control, organic, inorganic and integrated nutrient management. In the inorganic treatment blanket recommendation of 250:75:75 kg NPK ha^{-1} was applied. Organic plot received the application of farmyard manure on N equivalent basis, while INM plot received 12.5 t FYM ha^{-1} and blanket recommendation of fertilizer along with biofertilizer. The experiment was conducted in a non replicated trial.

The yield parameters such as grain yield and haulm yield had showed the highest in INM practice followed by inorganic and organic treatments. The grain yield varied significantly due to various treatments and ranged from 573 to 765 kg ha^{-1}. The control recorded the lowest grain yield. Similarly, the nutrient uptake by the crop at time of harvest registered significant difference due to different treatment effects. The N and P uptakes were highest in grain when compared to haulm. Among the treatments, INM practice recorded the highest uptake and available nutrients (NPK) followed by inorganic, and organic, while the control recorded lowest.

The INM practice-higher growth and yield parameters, consequently the higher grain, haulm yield and nutrient uptakes of green gram when compared to others indicated the superiority of INM practice. The same trend was observed in the maize crop also. Increase in OC and available N status were observed in INM practice while available P and K contents were slightly reduced. Soil biological properties were enhanced in the INM plot followed by the organic plot.

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Evaluation of PSBPDS (Paddy Straw Based Biogas Plant Dried Slurry) as a Source of Nitrogen and Phosphorus for Wheat in the Indo-Gangetic Plains of India

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Majority of the farmers burn rice residue after combine harvesting of rice to clear the agricultural field for land preparation and planting of wheat. During burning of crop residues substantial loss of plant nutrients (especially N and S) and organic carbon occurs, which has important implications for soil health. As an effort to utilize this nutrient resource, paddy straw based biogas plant seems to be an emerging technology. In this technology, rice straw and cow dung are mixed in 4:1 and fed to the digester. After 30-40 days of retention period, methane starts coming out of the biogas plant and can cater the cooking needs continuously for four months. After four months the biomass is removed from the digester which gets stabilized during anaerobic fermentation, becomes very good nutrient rich manure and can be used as an important organic source for land management. It contains 1.8% N, 0.73% P and 0.98% K. Adequate information regarding availability of nitrogen and phosphorus contained in PSBPDS to rice in rice-wheat (RW) cropping system is lacking. A field experiment was conducted for two years to study the effect of PSBPDS application to rice as N and P source in RW system. Fourteen treatments were replicated thrice in a randomized block design. Application of 6 t ha^{-1} of PSBPDS to rice saves one third nitrogen. Treatment combinations consist of PSBPDS (0, 6 and 12 t ha^{-1}) and nitrogen (0, 40, 80 and 120 kg N ha^{-1}) with recommended 60 kg P_2O_5. Two other treatments comprised of 6 and 12 t ha^{-1} of PSBPDS along with 120 kg N ha^{-1} and 30 kg P_2O_5 were kept to find the contribution of phosphorus. The results revealed that direct application of 6 t ha^{-1} of PSBPDS to wheat can save one third nitrogen and one half of the phosphorus.

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Response of different Level and Method of Boron (B) and Calcium (Ca) Application on Crop Yield of Mustard under Groundnut - Mustard Cropping System in Acid Alfisol of Jharkhand

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Among the oilseed crops, groundnut and mustard are important oilseed crops of our country and respond well to secondary and micronutrient. Mustard as a *Brasica* crop is very responsive to B application. There are numerous reports on the positive response of mustard to B fertilization.

A field experiment was conducted during rabi 2017-18 at research farm of Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Ranchi to know the response of different level and method of Boron (B) and calcium (Ca) application under groundnut-mustard cropping system. During kharif, test crop was groundnut (*var*. Birsa groundnut-4) and after crop harvest mustrad (*var*. Shivani) was grown in the same plot with same treatments combination. All together 16 different treatments combination with four levels of calcium (0, 1/5 LR, 1/10 LR and 1/15 LR) and four levels of boron (0, 1, 2.0 and 3 kg B ha^{-1}) with 3 replications were laid down in field. The results revealed that application of boron responds positively even at higher dose of Boron application i.e. 3 kg ha^{-1}. There was not any antagonistic effect of lime and boron. Boron content at different growth stages was found higher in leaf followed by shoot and grain. Maximum concentration in plant part was observed at 60 DAS. Available boron status of post harvest soil improved significantly with the increasing level of boron application. Lime application also significantly affected the available Boron status. No significant changes was found in soil pH of post harvest soil.

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Studies on Transfer of Trace Metals from Soil to Edible Part of Plants and Assessment of Potential Health Risk

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Thirty five (35) edible plant parts of different standing crops in the field and side by side soil samples (0.0-15.0 cm) were collected from Koderma district, Jharkhand. Soil and plant samples were analyzed for Trace metals (Fe, Mn, Zn, Cu, Pb, Ni and Co) following standard procedures. Data reveals that the contents of Fe, Mn, Zn and Cu ranged from 5.11 to 29.14, 0.74 to 7.92, 1.35 to 8.50, 0.24 to 1.37 mg kg^{-1}, whereas content of heavy metal *viz.*, Pb, Ni and Co was found in the range of 0.32 to 1.21, 0.10 to 1.70 and 0.47 to 6.72, respectively in edible part of different plants collected from farmers field. Results clearly reflected that concentration of Zn, Cu, Fe, Mn, Pb, Ni and Co in soil is in safe limit as per prescribed values of WHO/FAO. The intake of metals (Zn, Cu, Fe, Mn, Pb, Ni and Co) in human body through plant is not high and was found within the permissible limit as recommended by WHO, Food and Nutritional Board and US EPA. The Hazard Quotient (HQ) or Health Risk Index (HRI) for trace metals had showed an increasing order of Cu<Zn<Fe<Mn<Co<Ni<Pb<1.0 in all the edible plant parts except Pb in dolicous bean, vegetable pea and mustard and hence can be considered safe with no risk to human health. Whereas, in dolicous bean, vegetable pea and mustard, HRI value was found slightly higher to 1.0 and need comprehensive study on soil plant relationship in plateau areas of Jharkhand having a sheath of mines and industries. A wider gap between recommended and supplement amount of Zn, Cu, Mn and Fe can be rectified as dietary allowance per day for people living in rural areas in Koderma district.

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Effect of Graded Levels of Copper on Growth and Yield of Rice (*Oryza sativa* L.) in Typic Haplustalf

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To appraise the response of rice to applied copper (Cu) for arriving at optimal dose, a field experiment was carried out in Typic Haplustalf at Agricultural College and Research Institute, Madurai during 2018-2019 season with 11 treatment combinations (soil and foliar) in a randomized block design (RBD) with three replications utilizing rice variety TKM 13 as the test crop. The results clearly indicated that application of 1.5 kg Cu ha^{-1} favourably enhanced the growth (plant height, number of tillers per hill), physiological (Crop Growth Rate (CGR), Relative Growth Rate (RGR), LAI, SPAD values, yield contributing parameters *viz.*, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$, panicle weight and copper use efficiency parameters. There was a gradual and significant increase in grain and straw yield of rice with the successive levels of added Cu, attaining the highest yield at 1.5 kg Cu ha^{-1} which accounted 41% greater yield over RDF alone and further increase in the Cu level led to decline in the yield. Based on optimization study, the economic optimum level for the rice soils of Madurai districts is fixed as 1.68 kg Cu ha^{-1} (7.0 kg copper sulphate ha^{-1} along with 100% recommended dose of N, P and K) which highlighted the feasibility of using a common fertilizer strategy to achieve sustainable productivity and soil health status.

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Effect of Household Waste based Vermicompost and Fertilizer on Nutrient Availability and Yield of Rice Crop

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A pot experiment was conducted during Kharif 2018 at RPCAU, Pusa with an objective to find out the effect of vermicompost prepared from household waste and cow dung (1:1, w/w) on soil properties and rice yield. Four levels of vermicompost 0, 1.25, 2.5 and 3.75 t ha^{-1} along with three levels of chemical fertilizers *viz.* 0, RDF (120:60:40 kg ha^{-1}. N: P_2O_5: K_2O) and 50% RDF in a completely randomized design. Results indicated a significant build-up of available major and micro-nutrients in post-harvest soil of rice on application of graded dose of vermicompost alone or in combination with different doses of fertilizer. The extent of build-up was higher under higher dose of vermicompost and fertilizer. Grain and straw yield of rice increased significantly with increasing levels of vermicompost up to 3.75 t ha^{-1} and 100% RDF and percent increase observed was higher with combination of vermicompost and chemical fertilizer as compared to their sole application. The treatment involving application of vermicompost (2.5 t ha^{-1}) along with full dose of fertilizer (RDF) emerged out as best treatment combination with respect to nutrient availability, growth and yield of rice crop. However, application of vermicompost @1.25 t ha^{-1} with 50% RDF yielded equally as full dose of chemical fertilizer (RDF) alone which indicates that 50% of chemical fertilizer could be saved on application of vermicompost even at lower dose combined with 50% RDF without reduction in grain yield.

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Assessment of Changes in Soil Fertility of Some Benchmark Sites of Haryana

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Long term monitoring of soil fertility is very necessary to know the changes in fertility under different cropping systems with different management practices. Keeping this in mind some benchmark sites were selected in 2001 under different cropping systems in Haryana to know the periodical changes in soil fertility. The sites were RRS Kaul (rice-wheat), RRS Uchani (Sugarcane), KVK Kurukshetra (rice-wheat), KVK Panipat (rice-wheat), KVK Kaithal (rice-wheat), RRS Bawal (pearlmillet-mustard), HAU Soil Farm (Fallow-wheat), RDS Farm Hisar (Fallow-wheat). These cropping systems were managed with recommended practices of the University. The soil samples collected in 2001 were analyzed for different nutrient contents by adopting standard procedures. Similar methods were followed to know the nutrient status of soil samples collected in 2016. Organic carbon content of soil improved at all sites by adopting recommended doses of fertilizer for last fifteen years. The range of increase of OC varies from 3 to 66%. There is depletion in available nitrogen at all sites after 15 years (5% at Bawal to 35% at Kurukshetra). The available P status was increased at all sites (7% at Kaul to 91% RDS Farm). The available K decreased at all sites (10% at Kurukshetra to 48% at HAU Hisar). The pH was found to be decreased at all the locations, however, no trend was observed in electrical conductivity

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Wheat Productivity and Biological Properties of Soils Influenced by Tillage and Crop Establishment Practices under Rice-Wheat Cropping System in an Inceptisol of Eastern Uttar Pradesh

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In the rice-wheat cropping system, the wheat production and soil fertility are declining under conventional practice of intensive tillage in rice cultivation. Therefore, a study had been undertaken to find out the most sustainable practice for wheat production after rice cultivation under CA-based tillage system. The experiment is operative since 2015. Yield and yield attributes of wheat crop were recorded during rabi season of 2018-19. The experiment comprised of six treatments viz. CTR-CTW (RR), CTR-CTW [RR+RI(MB)], CT DSR-ZTW (Partial CA; anchored residue of rice), CT DSR-ZTW [Partial CA; anchored residue of rice + RI(MB)], ZT DSR- ZTW (Full CA; anchored residue of rice and wheat) and ZT DSR- ZTW [Full CA; anchored residue of rice; wheat + RRT (MB)]with four replications under randomized block design.

Full CA with anchored residue of rice and wheat + residue retention of mung bean treatment showed significantly higher plant height, chlorophyll content and number of tillers as compared to the other treatments, while the lowest growth parameters were observed under conventional tillage rice - conventional tillage wheat (residue removal) treatment. The yield and its attributes were significantly higher under ZT DSR- ZTW [Full CA; anchored residue of rice and wheat + RRT (MB)], followed by treatment ZT DSR- ZTW (Full CA; anchored residue of rice and wheat). The poor yield was reported in treatment CTR-CTW (RR). Lowest CO_2 evolution and dehydrogenase activity was observed in CTR-CTW (RR) while highest CO_2 evolution and dehydrogenase activity was observed in ZT DSR-ZTW [Full CA; anchored residue of rice and wheat + RRT (MB)]. This indicates that conservation agriculture based tillage technology improved the wheat production and biological properties in Inceptisol of eastern Uttar Pradesh.

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Effect of Integrated Application of NPK, Zn and Bio Fertilizer on the Changes in different Fractions of P in Soils in Relation to Yield and Nutrition of Rice (*Oryza sativa* L.)

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Two field experiments were conducted during the *Kharif* seasons of 2015 and 2016 in the new alluvial zone of West Bengal to evaluate the effect of integrated application of NPK, Zn and bio fertilizer on the changes in different fractions of P in soils in relation to yield and nutrition of rice (*Oryza sativa* L.) in an inceptisol using rice (cv. IET-4786) as a test crop with six different treatment combinations in a randomised block design (RBD) with four replications. The results revealed that the periodic changes of different fractions of phosphorus viz. water soluble and loosely bound P, Al-P, Fe-P, reductant soluble-P and Ca-P increased initially and thereafter, the amount of the same decreased with the progress of crop growth irrespective of treatments. However, the magnitude of such changes has been found to be varied with treatments, highest being the amount of calcium bound phosphorus compared to other fractions. The amount of P content in rice biomass was recorded highest (9.32 g kg^{-1}) at 45 days of crop growth in the treatment T3 [50% recommended NPK + organic matter at 5t ha^{-1} + Zn at 5 kg ha^{-1} + PSB (@ 10 kg ha^{-1}] with the simultaneous highest yield of rice grain 7.77 (20.65% over control) and straw 9.45 t ha^{-1} (14.82%), respectively.

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Synthesization and Characterization of ZnO Nanoparticle and its Effects on Sweet Corn (*Zea mays* L. *Saccharata*)

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A field experiment was conducted on the foliar application and seed treatment of synthesized Zinc oxide nanoparticles (ZnO NPs) at Navsari Agricultural University. ZnO NPs synthesized by precipitation method using three chemical compounds *viz.* ZnO-NPs synthesis through mixing the 1M of zinc sulphate [$ZnSO_4$] and 2M of potassium hydroxides [KOH] (M1), ZnO nanoparticle synthesis through mixing of 0.2M of zinc nitrate [$Zn(NO_3)_2$] and 0.4M of potassium hydroxide [KOH] (M2), and ZnO synthesis by 0.5M of zinc nitrate $Zn(NO_3)_2$] and 1M of Urea [$CO(NO_2)_2$] (M3). The ZnO NPs were characterized through scanning electron microscopy (SEM). The results of SEM found that average size of ZnO nanoparticles is 68.83 nm (M1), 66.13 nm (M2) and 63.00 nm (M3) of ZnO-NPs. The impact of ZnO nanoparticles (ZnO-NPs) on yield and quality content of sweet corn were investigated in the study. The effect of foliar application ZnO-NPs (M3) @ 500 ppm (T12) gave significant yield viz. cob yield (18.98 t ha^{-1}), straw yield (7.12 t ha^{-1}) and as well as higher protein (13.52%) and total sugar content (19.57%) of sweet corn.

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Effect of Long Term Application of Treated Distillery Effluent on Soil Properties and Yield of Sugarcane

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The distillery industrial waste water is non toxic, biodegradable, purely of plant origin and contains large quantities of soluble organic matter and plant nutrients and it can be used as nutrient source for crops and maintenance of soil fertility. The only problem with distillery effluent is its high BOD, COD and salt content. Hence to study the long term effect of pre-plant application of treated distillery effluent, field experiment was initiated during 2002 at EID Parry (I) Ltd., cane farm, Edayanvelli, Cuddalore District, Tamil Nadu. The experiment was continued for 13th crop with the same layout. Treated distillery effluent (TDE) was applied @ 1.25, 2.5, 3.75 and 5 lakh L ha^{-1} and allowed for natural oxidation (main plot treatments). Different combinations of fertilizers viz., control, N, NP, NK, PK and NPK were tried to findout the nutrient supplying capacity of the distillery effluent (Sub plot treatments). The long term experimental results revealed that an increased cane yield of 58.7, 67.6, 76.6 and 81.4% occured at 1.25, 2.5, 3.75 and 5.0 lakh L ha^{-1} of TDE applied treatments, respectively over control (M1). Though significant response was observed for N and P fertilizers, differences between applications of N & NK and NP & NPK fertilizers (sub plot treatments) were not significant indicating that the supply of K through TDE is sufficient. The interaction effect revealed that TDE application @ 1.25 lakh L ha^{-1} together with NP fertilizer was the most suitable dose of harvesting appreciable yield of sugarcane. The fertility status of soil in terms of available NPK and micronutrients were improved considerably because of regular application of distillery effluent over the years. Soil health in terms of microorganisms and enzyme activity were also improved due to long term application of distillery effluent without affecting the ground water quality.

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Effect of Speciality Fertilizers and Conventional Fertilizers through Fertigation on Growth, Yield, Nutrient use Efficiency and B:C Ratio in Papaya Cultivation

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Fertigation is becoming a common practice in high value horticultural crops as it increases nutrient use efficiency and water use efficiency. But the high cost of speciality or completely water soluble fertilizers used in fertigation is deterring small and marginal farmers to follow this practice. A field investigation was carried out at IIHR in papaya cv, Red Lady to study the efficiency of conventional fertilizers in comparison to speciality fertilizers in drip fertigation on growth, yield, nutrient use efficiency and benefit-cost ratio (B:C ratio). Speciality fertilizers increased papaya growth significantly by increasing plant height, plant girth, canopy spread and number of leaves. The plant height increased from 162.1 cm to 179.63 cm. Fruit yield increased from 32.96 kg tree^{-1} to 55.1 kg tree^{-1} and number of fruits per tree increased from 37.3 to 45.3 when 100% RD of NPK was given through speciality fertilizers. Average fruit weight increased significantly from 0.88 to 1.22 kg.

Depth wise distribution showed that N, P and K contents were more at 20-40 cm depth whereas most of the root growth of papaya was seen when speciality fertilizers were applied. It may be due to the completely soluble nature of specialty fertilizers which might be the reason for improvement in growth and yield parameters. Speciality fertilizers increased the nutrient use efficiency significantly. Efficiency of N, P and K was 5.47 g kg^{-1}, 0.71 g kg^{-1} and 7.11 g kg^{-1} respectively. Benefit-cost ratio was higher with the use of speciality fertilizers. It was 4.22 and 3.90 when 100% and 75% RDF of NPK was supplied by speciality fertilizers through drip. The experiments showed that use of speciality fertilizers to supply NPK through fertigation is remunerative in cultivation of papaya by improvement in growth, yield, nutrient use efficiency and B:C ratio.

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Optimizing Soil Fertility and Foster Productivity of Tomato: An Appraisal on Soil Fertility Status and Development of Nutrient Delineation Maps of India

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Tomato is one of the major vegetable crops grown widely in India both for fresh market and processing. It is also an important mineral and vitamin rich vegetable crop playing a vital role in Indian economy. The production and productivity of this crop is being affected in different areas due to deficiencies of micronutrients observed primarily due to intensive cropping and imbalanced fertilization. The study aimed (i) to understand the distribution of nutrients and their status in tomato growing soils in transition zone of Karnataka and (ii) Development of boundary map of tomato and delineation of micronutrient deficient areas in India. Soils from 51 villages of Transitional zone of Karnataka were collected and studied for fertility status and their relationship. Results on soil fertility status revealed that the organic carbon and nitrogen status of the soils was low (19 and 73% of studied soils, respectively). Considering low and medium as potential deficient, 82 and 68% of studied area were deficient in zinc and boron respectively.

Based on the categorization of area and production of districts from each leading mango growing state, crop boundary map was prepared. Nutrient deficiency/sufficiency levels in each district were identified based on soil test data, by superimposing each district data. Nutrient delineation maps were prepared and boundaries were demarceted for predictable response to specific nutrient. Out of 106 districts, 58 districts showed zinc deficiency, varying from 50-65% in Andhra Pradesh, and 35-45% in Gujarat and Karnataka. These maps would help to plan strategic guidelines in realizing potential yields in mango by formulating appropriate region specific fertilization schedule.

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Predicting In-season Spring Maize Yield using Leaf Color Chart, Chlorophyll Meter, and Green Seeker Optical Sensor

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Predicting in-season crop yield is a unique tool for drawing important crop management decisions for precision farming. Field experiments were conducted at two locations in different agro-climatic zones for two years to develop algorithms for in-season yield estimation in spring maize during 2017 and 2018. The spectral properties measured with leaf color chart (LCC), chlorophyll meter (SPAD meter) and normalized difference vegetative index (NDVI) measured with Green Seeker optical sensor was used to predict the grain yield. The NDVI measurements made at V9 growth stage provided better in-season estimate of grain yield and explained 60% of the variability in spring maize grain yield, whereas NDVI measurements made at early and late growth stages were not reliable for the purpose. The spectral properties measured with the SPAD meter and LCC rendered better grain yield estimates at all the growth stages and were respectively able to explain 70 and 75% variability in grain yield. Adjusting the LCC, SPAD and NDVI measurements using the component of cumulative growing degree day (CGDD) did not improve grain yield predictability. Equations with and without intercept were established and were used for comparison between predicted and observed grain yield of spring maize. The calculated root means square error (RMSE) was fairly good for LCC and SPAD at all the growth stages and at V9 growth stage for NDVI. The *k* coefficient obtained from best fit between predicted and actual yields was not related with the coefficient of determination between different spectral measurements at different growth stages and grain yield at maturity and is thus unrealistic indicator of accurate yield prediction. Normalizing LCC, SPAD and NDVI readings with CGDD did not improve RMSE and *k* coefficient.

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Short Term Impact of Sugarcane based Cropping System on Microbial Diversity and Soil Quality in Subtropical Condition of India

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A study was conducted to assess short-term impact of sugarcane + mustard-ratoon-cowpea (SmRC) and sugarcane + potato-ratoon-wheat (SpRW) copping systems over traditional sugarcane-ratoon-wheat system (SRW) on microbial diversity, soil quality, crop yields and net returns. The SmRC system led to significantly increased microbial activities (microbial biomass carbon and nitrogen and basal soil respiration), soil enzymes, total carbon and nitrogen, available N, Zn, Cu, Fe and cation exchange capacity (CEC) over SpRW and SRW system. However, available K and S were higher in SWR after completing three year cycle. The C-sequestration was 3.28 and 9.56% higher under SmRC system than SpRW and SRW, respectively. The highest average substrate oxidation rate was 0.0030 cm^{-1} h^{-1} under SmRC, augmented 11.1% (0.0027 cm^{-1} h^{-1}) and 15.4% (0.0026 cm^{-1} h^{-1}) over SpRW and SRW, respectively. Shannon and Mclntosh diversity index and Shannon evenness index led to increase significantly under SmRC system than SpRW and SRW but Mclntosh evenness and Simpson diversity index could not altere significantly in a short-cropping span. The SpRW and SmRC system observed significantly higher cane equivalent yield (120.4 and 109.4 t ha^{-1}) than SRW (92.6 t ha^{-1}) system. However, SpRW system was more productive than SmRC, augmented 10.0 and 30.0% higher CEY over SmRC and SRW, respectively. Therefore, it is distinctly clear that SpRT system is more productive than SpRT and SRW but SmRC system and more effective toward increasing microbial diversity, enzymatic activity and soil quality than SpRW and SRW.

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Studies on Sulphur Fractions in Soils of Long Term Fertilizer Experiment under Finger Millet - Maize Cropping Sequence

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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 applications. The archived soil samples (1986-2016) from this experiment were collected at five years interval and studied for different fractions of sulphur. The fractions of sulphur were in the order of organic>residual>inorganic> water soluble>available forms. All fractions of S showed an increasing trend over 30 years of cropping cycles in all the treatments. However, the treatments which did not receive any source of sulphur decreased initially (1991) in all S fractions and then increased gradually over the years and maintained slightly higher over the initial level. All forms of S were maintained significantly higher over other treatments and found on par with each other in the treatments receiving 100% NPK + FYM + lime, 100% NPK + FYM and in 150% NPK. They were found to be lower in the treatments receiving sulphur free fertilizers (DAP as P source) and imbalanced supply of nutrients. Hence, application of recommended doses of fertilizers (SSP as P source) in combination with FYM is essential in maintaining available sulphur nutrient status and soil health.

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Effect of Inorganic Fertilizers, Organic Manures and Biofertilizers on Soil Nutrients, Dry Matter Production and Yield of Brinjal

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A field experiment was conducted in a sandy clay loam soil with brinjal cv. Annamalai as the test crop in Sivapuri village, Chidambaram taluk, Cuddalore district, Tamil Nadu. The experiment was laid out in randomized block design and replicated three times. The treatments consisted of application of 75% Recommended dose of fertilizers with different organic manures (farm yard manure @ 7.5 t ha^{-1} and 10 t ha^{-1} + vermi compost @ 2 t ha^{-1} and 1.5 t ha^{-1} + pressmud @ 4.5 t ha^{-1} and 6 t ha^{-1}) and biofertilizers (Azospirillum and Phosphobacteria) in different combinations. The N, P and K fertilizers, FYM, vermicompost and pressmud were applied as basal according to the treatments. The post-harvest soil nutrient status (N, P, K, S, Ca and Mg) at harvest stage and dry matter production was recorded for brinjal plant at 30, 60 and 90 DAT and yield was also computed. The results of the experiment clearly revealed that the application of 75% RDF + 7.5 t of FYM ha^{-1} + 4.5 t of pressmud ha^{-1} + 1.5 t of vermicompost compost ha^{-1} + biofertilizers (T9) registered the maximum yield and improved the nutrient status of post-harvest soil (N, P, K, S, Ca and Mg) and increased the dry matter production.

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Characterization of Biochars from different Plant Residues

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The technique of using biochar/charcoal to improve the soil fertility was originated in the Amazon basin 2500 years back. Nitrogen and phosphorus were found to be three times more in the basin soil compared to nearby soil. The so called terra preta soil contains up to 9% carbon, where as only 0.5% in nearby soil. Now, several works on the use of biochar was initiated by the soil scientists to enrich soil fertility. Biochar is a type of charcoal, which is produced when biomass is pyrolyzed in presence of xero to little oxygen at temperature 350-600 °C. The chemical, physical and biological properties of biochar can boost nutrient availability and microbial communities for improving soil productivity. The purpose of this study is to formulate a simple scheme for characterizing biochars before addition to soils. Three types of biochar were produced from Karanj leaves (*Millettia pinata*), Neem leaves (*Azadirachta indica*) and Maize stone (*Zea mays*) at pyrolysis temperatures of 450 °C for one hour with the help of Muffle Furnace. Biochar contains carbon, ranging from 78.25 to 94.0 percent. Out of all Biochars (Karanj leaves, Neem leaves and Maize Stone), maize stone contains highest carbon (94.0%) than others. Biochars have very high CEC than soils. High CEC value indicates ability to retain cationic fertilizers (K^+ and NH_4^+) in the root zone and prevent nutrient leaching. Out of all Biochars, Karanj leaves biochar had highest CEC (245.70 cmol(p^+)kg^{-1}). The concentration of all nutrients except N was higher in all the biochar as compared with feedstock. Among all the biochars, highest P adsorptio maxima (1666.67 µg g^{-1}) was observed in Neem leaves biochar.

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Foliar Application of different Fertilizers on Mitigation of Dry Spells in *Kharif* Maize under Rainfed Conditions

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The productivity of rainfed maize is very low, which might be due to water stress and imbalanced use fertilizers. The problem of water scarcity and unavailability of nutrients to crops under rainfed conditions can be overcome to certain extent by foliar nutrition. Taking these into considerations, field experiment was carried out during *kharif* 2017 and 2018 at AICRPDA centre Ballowal Saunkhri using maize (PMH2) as test crop with 8 treatments *i.e.* Control, Water spray, Urea (1%), Urea (2%), Muriate of Potash (2%), 19:19:19 fertilizers (0.5%), 19:19:19 fertilizers (0.5%) + Zinc sulphate (0.5%), Zinc sulphate (0.5%) with three replications and randomized block design. The spray was carried out during dry spell at 30-35 days after sowing. The foliar application of 19:19:19 (1%) + $ZnSO_4$ (0.5%) treatment resulted in highest grain yield of maize, which was statistically at par with urea (2%), Urea (1%), 19:19:19 (1%), 19:19:19 (1%) + $ZnSO_4$ (0.5%) and significantly higher over $ZnSO_4$ (0.5%), KCl 2%), water spray and no spray treatment, respectively. The increase in grain yield among these treatments was 12.2 to 23.1 per cent over the control treatment. The net return, B: C ratio and rain water use efficiency varied from Rs 19,693-30,683 ha^{-1}, 1.65-2.00 and 3.19-3.92 kg ha^{-1}-mm and was highest in the treatment 19:19:19 (1%) + $ZnSO_4$ (0.5%). The nitrogen, phosphorus and potassium uptake by grain and straw increased significantly with the foliar application of different fertilizers. The nutrient uptake in treatments with the 19:19:19 (1%) + $ZnSO_4$ (0.5%), Urea (2%), 19:19:19 (1%) and Urea (1%) treatment was found to be statistically at par and significantly higher over other treatments. The growth and yield parameters did not show any significant variation with the foliar application of different fertilizers. It was concluded that foliar application of fertilizers may partially compensate the problem of water scarcity and unavailability of nutrients to crops under rainfed conditions.

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Interaction of Seed Bio-Priming with *Trichoderma Asperellum* and NPK Fertilization on Growth and Nutrient Dynamics in Sunflower

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Fertilizer is an indispensable input for present day agriculture and its production is expected to increase in the coming decades to feed ever growing population. Further, fertilizer is also an energy intensive input, which accounts for nearly 1.2% of world energy. Supplementation of part of the energy without impairing the soil health is prerequisite in the present set up. Keeping this in consideration, a pot experiment was conducted in a clay loam soil in 2018 with sunflower cv. PAC 334 at department of Soil Science and Agricultural Chemistry of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experiment comprised of 4 replications and 8 treatments *viz.*, T1 (control), T2 (70% RDF), T3 (80% RDF), T4 (90% RDF), T5 (100% RDF), T6 (70% RDF + bio-priming with *Trichoderma asperellum*), T7 (80% RDF + bio-priming with *Trichoderma asperellum*), T8 (90% RDF + bio-priming with *Trichoderma asperellum*). Urea, diammonium phosphate (DAP) and muriate of potash (MOP) were used as source of inorganic fertilizers. Results revealed that grain yield was highest in T8 which was at par with T5 followed by T7, T6, T4, T3, T2 and T1. Soil available N, P and K of T8 (148.5, 39.82 and 433.18 kg ha^{-1}) is at par with 100% RDF (145.25, 41.58 and 431.3 kg ha^{-1}) and are superior to control (102.85, 26.62 and 344.07 kg ha^{-1}). Soil health indicators like organic carbon and dehydrogenase activity were found highest in T8, which is at par with T5, T7 and superior to control. In the integrated plant nutrient system bio-priming intervention saved the input application to the extent of 10% as compared with normal recommendation.

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Soil Test Based Targeted Yield Equations of Wheat Crop for Acid Alfisol of Ranchi Jharkhand

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Wheat as a test crop was sown in the STCR experimental area of Birsa Agricultural University Ranchi after creating three fertility gradients during 2016-17. Highest grain yield (63.67 q ha^{-1}) of wheat (cultivar K1006) was observed in strip III, where highest dose of fertilizer was applied whereas minimum grain yield (6.67 q ha^{-1}) was observed in control strip with control sub-plot. Mean wheat grain yield was also found maximum (45.97 q ha^{-1}) in strip III whereas 41.06 q ha^{-1} was recorded in strip II where RDF was applied in last cropping season. Post harvest wheat straw was also observed and found maximum (86.56 q ha^{-1}) in strip III where highly fertile soil was there whereas least straw (10.22 q ha^{-1}) was found in control strip with control plot. Total uptake of nitrogen was found maximum (114.62 kg ha^{-1}) in $N_3P_3K_3$ sub-plot of strip III whereas minimum (13.70 kg ha^{-1}) N uptake was found in control strip with control sub-plot where yield was also least. Phosphorus and potash uptake was also found to be in the same trend in strip III and strip I. Average uptake of N, P and K in strip II where RDF was applied were 75.76 kg ha^{-1}, 5.17 kg ha^{-1} and 29.70 kg ha^{-1}, respectively.

Based on the available data, targeted yield equations for wheat crop in acid Alfisol were developed. Developed formulas for targeted yield of wheat were calculated as: $FN = 4.15\ T - 0.52\ SN$; $FP_2O_5 = 2.23\ T - 2.46\ SP_2O_5$ and $FK_2O = 1.90\ T - 0.36\ SK_2O$.

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Effect of Different Nutrient Management Practices on Cotton Productivity

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Cotton is the most important cash crop in India which has a major share in the raw material for the textile industries. Introduction of transgenic cotton in Indian agriculture has resulted in an immense increase in seed cotton yield. Cotton plant being a heavy feeder, needs proper supply of plant nutrients for its successful cultivation. The use of foliar spray of nutrients has found to be effective in meeting the nutritional needs at peak stages. Keeping in mind the above, a field experiment was conducted on Research Farm of Krishi Vigyan Kendra, Sirsa during *kharif* season of 2018-19. The experiment was laid with following treatments i.e. T1 - Control, T2 - RDF on soil test basis (N in three split doses at basal, 45 and 75 DAS), T3 - RDN + *Azotobacter*, T4- 75% RDN + *Azotobacter*, T5 - 75% RDN + *Azotobacter* + 3 foliar spray of 2.5% Urea, T6- 75% RDN + 3 foliar spray of 2.5% Urea, T7- 100 % RDN in four split doses @sowing, 45, 75, 100 DAS and T8 - 75% RDN in four split doses @sowing, 45, 75, 100 DAS + 3 foliar spray of 2.5% Urea. Recommended dose of fertilizers and other package of practices were uniformly adopted in all the treatments for growing healthy crop. All foliar sprays were applied from flowering to peak boll formation stage at 10 days interval. The result revealed application of 75% RDN + 3 foliar spray of 2.5% urea (T6) recorded the highest seed cotton yield (2948.89 kg ha^{-1}), boll weight (4.06 g), seed cotton yield per plant (200.33 g) and number of bolls per plant (49.67). The highest dry matter was in T3 at square formation and flowering stage while at 50% boll opening it was highest in T2.

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The Effect of Foliar Feeding of Nutrients on Growth, Yield and Quality of Ragi cv. CO-14

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Foliar application of nutrients avoids wastage or loss of nutrients, which enhances nutrient use efficiency, cause rapid absorption and reduces the cost of cultivation. A field experiment was conducted during 2018 in farmers holding to find out the effect of soil and foliar feeding of nutrients on the growth and yield of ragi cv CO-14 with treatment details , T1 - Absolute control, T2 - Soil application of 100% RDF, T3 - Soil application of 50% RDF, T4 - Foliar spray of 100% RDF through water soluble fertilizer (FS on 20 and 40 DAT), T5 - Soil application of 50% RDN + foliar spray of 50% RDN and 100% P and K through water soluble fertilizer (FS on 20 and 40 DAT), T6 - Foliar spray of humic acid 0.1% (FS on 20 and 40 DAT), T7-T2 + foliar spray of humic acid 0.1% (FS on 20 and 40 DAT), T8-T3 + foliar spray of humic acid 0.1% (FS on 20 and 40 DAT), T9-T4 + foliar spray of humic acid 0.1% (FS on 20 and 40 DAT) and T10-T5 + foliar spray of humic acid 0.1% (FS on 20 and 40 DAT) conducted in Randomized Block Design (RBD) with three replications. The result of the experiment clearly revealed that the soil application of 50% RDN + foliar spray of 50% RDN and 100% P and K through water soluble fertilizer (foliar spray 20 and 40 DAT) + foliar spray of humic acid 0.1% on 20 and 40 DAT (T10), significantly improved the growth, yield, quality and nutrient uptake of ragi crop (Grain yield 3776.7 kg ha^{-1} and straw yield 8206.8 kg ha^{-1}). Combined application of soil and foliar feeding technique improved the yield and quality of ragi as well as sustained soil fertility.

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Comprehensive Assessment of Bio-priming Intervention in Red Cabbage Production under Middle Gangetic Plains

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With increasing environmental stresses in agricultural production, climate-smart technologies are adopted before the sowing of crop. Field assays (2016 and 2017) were conducted in red cabbage to determine the combined impact of seedling bio-priming and mineral fertilizers on energy balance, soil quality, nutrient use efficiency, yield, nutritional quality, and profitability of the production system. The recommended dose of $N:P_2O_5:K_2O$ was applied @ 120:60:60 kg ha^{-1}. Three primers (Trichoderma harzianum, Pseudomonas fluorescens, and Bacillus subtilis) were applied singly and in combination with 75% of recommended NPK dose. Bio-priming treatments enhanced the nutrient use efficiency (N, P, and K), micronutrient content (Fe, Mn, Zn, and Cu), crop quality (protein content, β-carotene, vitamin C, total sugar, and anthocyanin), and soil biological properties (urease, dehydrogenase, alkaline phosphatase, cellulase, and microbial biomass carbon). The performance of dual consortium was found to be better than triple consortium. Bio-priming treatments showed greater energy efficiency than the lone application of recommended chemical fertilizers in the production process. Energy input requirement was considerably low and energy output-input ratio was higher with the adoption of bio-priming technology. This technique is simple, economical, and eco-friendly. Ecological indicators studied during the investigation suggest wider adaptability, selection of the most efficient bio-agents, and consideration of treatment tit-bits during the application or inoculation process.

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Fertilizer Nitrogen Scheduling for Improving Productivity and Reducing N_2O Emissions in Irrigated Wheat (*Triticum aestivum* L.)

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The literature suggests fertilizer nitrogen (N) schedule of applying fixed N dose in two equal splits at planting and *Zadoks* 14 growth stage in wheat. We hypothesized that applying all N doses to wheat by *Zadoks* 14 growth stage may not sustain N supply till grain filling and cause high N_2O emissions to the atmosphere. Three-year multi-location field experiments were conducted for improving productivity and reducing N_2O emissions in seven timely sown and six late sown wheat varieties. The crop biomass, N uptake and spectral properties were studied using PAU-LCC (PAU-Leaf colour chart), chlorophyll meter (SPAD) and GreenSeeker (GS) optical sensor at different growth stages. Little biomass production and N uptake till *Zadoks* 14 growth stage and wheat response to N application at *Zadoks* 29 growth stage suggested rescheduling fertilizer N dose with low N at planting and moderate N at *Zadoks* 14 and *Zadoks* 29 growth stages. Rescheduled fertilizer N topdressings with 25 kg N ha^{-1} at planting and remaining soil test based fertilizer N dose in two equal splits at *Zadoks* 14 and *Zadoks* 29 growth stages reduced N_2O emission by 40 per cent and 12.7 per cent from the N dose applied at planting and *Zadoks* 14 growth stage. The decreased N_2O emissions and sustained N supply till grain filling with the N dose applied at *Zadoks* 29 growth stage produced an average 8.4 per cent higher grain yield and 5.7 per cent higher grain protein content. The mean agronomic and recovery efficiencies were improved by 21.1 and 22.0 per cent, respectively. The spectral properties recorded at *Zadoks* 29 growth stage governed the wheat response to fertilizer N application and can be used to fine-tune fertilizer N dose to further improve agronomic and recovery efficiencies of applied fertilizer N and decrease N_2O emissions.

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Evaluation of Composts as Mixture with Lime and Ash on Soil Fertility Status and Yield of Tomato after Winter Rice

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A field experiment was carried out at Assam Agricultural University, Jorhat, Assam research farm to evaluate composts as mixture with lime and ash on the growth and yield of tomato (*Lycopersicon esculentum Mill.*), variety – Avinash, and soil fertility status after harvest of the crop. Seven treatments were evaluated comprising recommended doses (75:26.2:50 kg ha^{-1} N:P:K) of fertilizers (RDF) and 10 t ha^{-1} farmyard manure (FYM), ½RDF as mixture with vermicompost (1 t ha^{-1}), vermicompost 1 t ha^{-1} or farmyard manure (FYM) 2.5 t ha^{-1} mixed with quick lime (CaO) powder (10 kg ha^{-1}) and wood ash (1 kg ha^{-1}), vermicompost 1 t ha^{-1} or FYM 2.5 t ha^{-1} mixed with quick lime powder (20 kg ha^{-1}) and wood ash (2 kg ha^{-1}), keeping an unfertilized plot as control. The treatments were replicated thrice in an RBD on a sandy loam soil. Seedlings of tomato were planted on 10th January in 2015 and 13th January in 2016 at a uniform spacing of 30 cm between plants and 50 cm between the rows. FYM 2.5 t ha^{-1} mixed with quick lime powder 20 kg ha^{-1} and wood ash 2 kg ha^{-1} produced significantly higher fruit yield of tomato over rest of the treatments. Recommended dose of fertilizer was at par with vermicompost-lime-ash (1000-20-2 kg ha^{-1}) and FYM-lime-ash (2500-10-1 kg ha^{-1}) mixtures. The lowest fruit yield of tomato was recorded in the unfertilized plot and was at par with vermicompost-lime-ash (1000-10-1 kg ha^{-1}) mixture. The available N content after harvest of tomato was not affected by the treatments. The available nutrient status in soil did not differ significantly after harvest of the crop. The soil pH, nutrient concentrations significantly differed at 30 and 60 days after planting of tomato due to application of FYM-lime-ash mixture, irrespective of doses. The FYM-lime-ash (2500-10-1 kg ha^{-1}) mixture was at par with recommended practice in terms of fruit yield but was better in B:C ratio.

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Effect of Seed Priming with Iron and Zinc for Ameliorating their Deficiencies in Soybean on Calcareous Soil

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Iron and zinc are the most commonly deficient nutrients on calcareous soils. As a result, the crop productivity is decreased. All micronutrients essential for plants are also essential for humans. At present Fe and Zn deficiencies in humans have emerged globally. The most prevalent methods of micronutrient addition are soil and foliar application. But the cost involved and difficulty in obtaining high quality micronutrient fertilizers are major concerns with these in developing countries. Priming is an easy and attractive alternative. The effect of seed priming, or soaking seeds in nutrient solution for 12 hours before drying and sowing them, was undertaken for soybean (*Glycine max*) during the *kharif* season of 2016 *i.e.* from 30-6-2016 to 10-9-2016 in MPKV, Rahuri, Maharashtra. There were seven treatments with three replications following RBD design. Including absolute control and GRDF different concentration of Fe and Zn were tried through priming for 12 hrs to the crop soybean along with seed treatment with Rhizobium @ 250 g 10 kg^{-1} seeds. Better results were obtained from priming the seeds compared to the controlled one. The highest significant grain and stover yields of soybean was observed in the seed treatment with 0.02% $FeSO_4.7H_2O$ and which was at par with the treatment in seed primed with 0.1% Fe-EDTA. Other treatments were significantly lower in grain and stover yield.

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Root Growth of Rice under Different Resource Conservation Technologies in Transplanted and Direct Seeded Condition

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Precise evaluation of root characteristics is essential for understanding the adaptation of rice plants under different resource conservation technologies (RCTs). This study was undertaken to evaluate the root growth parameters of rice under different RCTs for transplanted and direct seeded condition. The sampling of roots was done in between the rows with the help of a sampling core at 0-15 cm depth at panicle initiation stage of rice. The sampled roots were washed and dried in an oven at 65 °C and root weight was record. Root growth parameters (root length, root diameter, root volume and root total absorbing surface area) were analyzed using Winrhizo software. Root length density (RLD) and root weight density (RWD) were calculated by dividing root length and root weight, respectively by root volume. It was observed that zero tillage treatment both under transplanted and direct seeded condition recorded highest root growth parameter values. Root length density and RWD for all the RCT treatments, increased significantly compared to the control and conventional practice; and maximum values were recorded under zero tillage treatment both under transplanting and direct sowing conditions. Similarly, the root growth parameters under green manuring treatment also increased significantly as compared to the control and conventional practice both under transplanted and direct sowing condition.

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Proximation of Carbon and Nitrogen Fractions in the Rhizosphere of Different Rice Genotypes in a Fine Aeric Haplaquept Soil of West Bengal

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Soil and plant samples were collected from the rhizosphere of 100 rice (*Oryza sativa*) genotypes, including some aromatic, indigenous and high-yielding from the fields of an ongoing participatory rice breeding programme at Gontra, Chakdaha, Nadia located at an elevation of 11 m above MSL (36 ft), on 23.08° N latitude and 88.52° E longitude to evaluate the genotypic difference on their contribution towards status of carbon and nitrogen fractions in their rhizospheric soil. Three sub-samples of soil were collected from each plot and analyzed in the laboratory for different fractions of carbon and nitrogen following standard protocols. Root, straw and grain samples of each genotypes were also collected and analysed for their total nitrogen contents. Apart from the usual methods of Pearson's correlation coefficient, regression, descriptive statistics, some advanced statistical tools *viz.*, two-step clustering and Multilayer Perceptron Neural Network were also utilized to work out the interrelationship among different organic carbon and soil nitrogen fractions *vis-a-vis* growth, yield and nitrogen uptake in different rice genotypes. The results indicated high variability among different rice genotypes in furnishing different fractions of both organic carbon and nitrogen in the rhizosphere soil and revealed influence of the level of their yields. The results also suggested interconversion of different organic carbon and nitrogen fractions among themselves in varying degrees under varied genotypes. Some of the high yielding varieties and indigenous non-aromatic varieties have shown better potential for higher yields as well as improvement of rhizosphere soil carbon and nitrogen content while most of the indigenous aromatic rice varieties didn't perform well fulfilling these criteria. While this work has highlighted varietal differences in their potentiality of enriching carbon and nitrogen status of soil, characterization of the secreted root exudates by different genotypes may be undertaken to identify soil enriching genotypes for future.

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Screening of Rice Cultivars for Fe Tolerance and Grain Fe Loading in Fe Toxic Inceptisols of Odisha

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Available iron content in Odisha soils varied from 0.012 to 530 ppm with a mean of 97.9 ppm. Fe is present in sufficient quantity in Odisha soils. In Odisha the low lying rice growing areas occupy an area of 14.82 lakh ha, of which 0.75 lakh ha is subjected to iron toxicity. In spite of soils rich in Fe, people of Odisha particularly women are suffering from Fe deficiency anaemia or mal nutrition. Among different management practices to combat iron toxicity and to get economic benefit from such problematic soil, rice cultivars with variable degrees of tolerance to iron toxicity can be used to reduce its negative impact. The cultivars are grown both under deficient and high/sufficient iron status and produce yield with accumulation of iron in grain. The yield and uptake efficiency indices are used to screen micronutrient efficiency of cultivars. With this background a varietal evaluation study was undertaken in high iron content (457 ppm DTPA Fe) acidic laterite soils of Central farm, Bhubaneswar by growing thirty different high yielding varieties. Significant yield variations were observed with respect to varieties as well as with soil Fe status. Yield performance of different varieties varied from 1.41 to 3.73 t ha^{-1} with mean value of 2.83 t ha^{-1} under toxic condition. There was an yield reduction of 0.2 to 40.8% and increase of -26.1 to -3.5% under Fe toxic condition over non-toxic condition. Yield efficiency and uptake efficiency indices computed ranged from 79.3 to 169.7% and 38.1 to 157.7%, respectively. From scatter diagram efficient and responsive genotypes tolerant to Fe toxicity were found to be Lalat, Prachi,Jagabandhu, Upahar, Mrunalini, Santepheap, Ranidhan, Swarna, Manaswini, Santepheap, Tejaswini, Indravati and IR 64 which can be used for breeding for higher yield and Fe uptake under Fe toxic condition.

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Soil Test Crop Response Based Integrated Plant Nutrition System for the Targeted Yield of Winter Maize (*Zea mays*)

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Soil test crop response correlation studies were carried out following Ramamoorthy's 'indictive-cum-targeted yield' model on an Inceptisol of semi-arid tropics for the development of integrated fertilizer prescription of N, P and K for targeted yield of maize (var. Blund). The basic parameters *viz.* nutrient requirement (NR) and contributions of nutrients from soil (CS), fertilizer (CF), and farm yard manure (CFYM) were computed using soil test and plant analysis data, maize grain yield, and total N, P and K uptake were used for the formulation of fertilizer prescription equations. The mean nutrient requirement for the production of 100 kg of maize grain was 2.39, 0.53 and 2.23 kg of N, P and K, respectively. The per cent contribution of N, P and K from soil, fertilizer and farm yard manure (FYM) were 36.36, 38.59 and 11.72 for nitrogen 66.58, 30.64 and 7.98 for phosphorus and 32.92, 88.46 and 6.27 for potassium, respectively. These parameters were used to prepare the soil test based fertilizer prescription equations involving IPNS for 5 t ha^{-1} targeted yield of maize grain ready reckoners of fertilizer prescription for range of soil test values of N, P and K for desired yield target (± 5-10% of potential yield of the variety) of maize grain with and without integration with FYM.

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Integrated Fertilizer Prescription Equations for Targeted Yield in Winter Rice-Cowpea Cropping Sequence on Inceptisol of West Bengal

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Soil Test Crop Response based IPNS provides effective fertilization as per the crop nutrient requirement. In view of the increasing demand for the adopting promising Rice-Pulse/Vegetables cropping sequence in West Bengal, it is essential to adopt STCR-IPNS technology to increase its productivity with sustainability. Field experiments was conducted on alluvial soil (*Aeric Haplustepts*) of West Bengal by adopting inductive cum targeted yield model to assess the fertility status, fertilizer requirements, and formulation with and without integrated plant nutrient supply fertilizer (IPNS) prescription equation for winter rice and cowpea on soil-test and yield target basis. The basic data [*viz.*, nutrient requirement (NR) and contributions of nutrients from soil (Cs), fertilizers (Cf), and organic manure (Cfm)] were computed for winter rice and Cowpea. Post harvest prediction equations were developed by using Initial soil test value, fertilizers applied and yield/nutrient uptake.

The nutrient requirement of winter rice for nitrogen, phosphorus and potassium were 3.03, 0.38 and 1.82 kg for the production of 100 kg yields of rice whereas in cowpea, nutrient requirements were 3.46, 0.57 and 2.67 for nitrogen, phosphorus and potassium which were comparatively higher than winter rice. It was found that fertilizer efficiency of P (43.12 and 67.49%) and K (58.95 and 134.75%) were higher than the soil efficiency for winter rice and cowpea respectively. For nitrogen, soil efficiency was much higher (107.46%) than fertilizer efficiency in cowpea and inverse relationship was found in winter rice with fertilizer efficiency (61.78%).

Post-harvest soil test prediction equations were also developed for N, P and K in both crops. The high R^2 values (>0.65) suggested that the regression equations could be used with confidence for prediction of available P and K for both the crops whereas in whereas N, moderate and non significant fitness were found in rice and cowpea respectively.

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Spatial Variability of Secondary and Micronutrients in Pulse Growing Soils of Ganjam District, Odisha

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Ganjam district of Odisha is popular for pulse production and soil nutrient status plays an important role in increasing production and productivity. GPS based 565 surface samples from 22 blocks of Ganjam district & two pedons one each from up and medium land were collected and studied in the field & laboratory following standard methods.

It was revealed that the Pedons of upland soils were strong brown, acidic, light texture, shallow, lateritic origin where as medium land pedon showed greyish brown, heavy, alkaline and basaltic. The Ca and Mg content increased downwards from 4.4 to 5.6 cmol(p^+)kg^{-1} & 2.18 to 2.98 cmol(p^+)kg^{-1} and Sulphur content decreased downwards from 8.2 to 3.1 mg kg^{-1} compared to those of pedon2 were 14.4 to 22.52 cmol(p^+)kg^{-1} Ca, 4.32 to 9.40 cmol(p^+)kg^{-1} Mg and 11.29 to 6.99 mg kg^{-1} S. The DTPA-Fe, Mn, Cu, Zn, and HWS-B content was highest in surface soil but decreased down the profile.

In surface soils pH varied from 4.66 to 7.93 with 50% soils acidic. The SOC varied from 0.01 to 1.64% with 39.82 PSD. The exchangeable Ca and Mg content varied from 1.08 to 10.80 and 0.02 to 5.76 cmol(p^+)kg^{-1}. Surface soils were sufficient with respect to Fe,Mn,Cu. But deficiency of S,B and Zn was noticed to the extent of 48, 52.5 and 31.4 PS, respectively. From the above study it was found that S,B and Zn were mostly constraint due to its deficiency which needs to be supplemented to increase the production, productivity and quality of pulses.

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Effect of Soil Properties on Yield and Quality of Nagpur Mandarin on Different Landforms in Hot and Semi-Arid Ecosystem (AESR 5.2) of Rajasthan

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Fourteen mandarin growing orchards have been identified by superimposing the Google image on the soil map of the district generated by Shyampura and Sehgal (1995) on 1:250,000 scale. Jhalawar district comprises mainly of hills with narrow valley and gently to moderately sloping plain in Vindhyan Scarpland, whereas plateau and plain landforms in Malwa plateau. Based on the variation in soils and dominance of mandarin area, 6 orchards from Vindayan scarp lands and 8 from Malwa plateau were selected for soil morphological, physico-chemical investigation and sampling of leaves and fruits from the selected orchards. Significant variations were observed for all the physico-chemical characteristics of 'Nagpur' mandarin fruits collected from different orchards in Jhalawar district. The fruits of orange were found bigger in size higher in total soluble solids, TSS: acidity ratio, juice pH, reducing and non reducing sugars in Vindhyan scarplands while fruits were thinner in skin (peel) having higher juice percentage (44.1) and total sugars in Malwa plateau. However, there was no marked difference was found in juice acidity and vitamin-C (ascorbic acid) content in fruits of both parent materials orchards. The numbers of fruits per plant, fruits kg per plant and fruit yield were recorded higher in the orchards of basaltic parent material (57.7 t ha^{-1}) than the orchards of sandstone with shale and band of limestone (46.8 t ha^{-1}). The soils of all pedons were classified in Inceptisols and Vertisols orders. As per the suitability criteria, soils of all the pedons were found marginally suitable to suitable for Mandarin orange crop.

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An Innovative Approach in Nutrient Management - Crop Specific Sampoorna KAU Multi Mix for Foliar Application in Rice, Banana and Vegetables

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Multi-nutrient mixtures were developed at RARS Pattambi using nutrient carriers for foliar application in rice, banana and vegetable crops. Initially, compatible chemicals were identified by considering the mixing compatibility, solubility and storage properties in a number of permutations and combinations of the component chemical materials. With the compatible nine compound base formula, experiments were conducted to formulate crop specific nutrient mixtures. The nutrient uptake by the crops, status of available nutrients in Kerala soils and the optimum, sufficiency and toxic ranges of the nutrients in the particular crop were considered while fixing the proportion of the compatible chemicals in the mixture. The dosage is fixed based on the requirement and uptake of the nutrients by the crops and pot culture and field experiments were conducted to evaluate the performance. The multi-nutrient mixtures contain potassium, magnesium, sulphur, zinc, copper, boron and molybdenum. The experimental results and toxicity testing trials indicate that foliar application of the mixtures could improve crop productivity. Based on this, the mixtures for foliar application were released into market under the name Sampoorna KAU Multimix. As foliar application decreases the nutrient load in to the environment, multi nutrient mixtures offer a sustainable option for management of nutrient deficiencies.

Sampoorna KAU multimix (Rice) – Foliar spray @ 0.5% in rice nursery and @1% at tillering stage and at Panicle Initiation stage

Sampoorna KAU multimix (Banana) – Foliar sprays @ 1% at 2 Months after planting (MAP), 4 MAP, 6 MAP an 8MAP

Sampoorna KAU multimix (Vegetable) – Foliar spray of the mixture @ 0.5% at 30, 45 and 60 Days after sowing in direct sown vegetables and at 15, 30 and 45 DAP in transplanted vegetables

The Sampoorna KAU multimix (Rice) has been tested and recommended for foliar application at 10 and 20 DAS for seedling augmentation in nursery.

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Spatial Variability of Major and Micro Nutrients in Soils of Middle Gujarat

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With the introduction of high yielding varieties, more irrigation facilities and less use of organic manures, depletion of different nutrients observed in various parts of the country. The studies are important to identify areas, which need immediate attention for managing nutrients deficiencies to sustain productivity of crops and soil health besides good quality food grain production. The GPS based 2596 soil samples were collected from different villages of middle Gujarat region which constitute of nine districts *viz.* Ahmedabad, Kheda, Anand, Vadodara, Panchmahals, Dahod, Botad, Chhota Udaipur and Mahisagar districts. The soil samples were analyzed for important physico-chemical properties as well as macro & micronutrients from the soils using the standard procedure. The nutrient index and categorization of available nutrients in low (<1.67), medium (1.67-2.33) and high (>2.33) was calculated by formula given by Ramamurthy and Bajaj (1969). In general, soil reaction (pH) and Electrical conductivity (EC) were normals, whereas the organic carbon was under low status in all the districts. Available sulphur (S) status was under low which ranged from 0.15 to 204.50 mg kg^{-1}. Available P_2O_5, DTPA-Fe and DTPA-Zn were under medium fertility status category ranged from 0.8 to 586.4 kg ha^{-1}, 0.5 to 166.4 mg kg^{-1} and 0.04 to 16.84 mg kg^{-1}, respectively. Available K_2O, DTPA-Mn, DTPA-Cu and HWS-B were under sufficient status in all the districts of middle Gujarat which varied from 62 to 1855 kg ha^{-1}, 0.5 to 143.5 mg kg^{-1}, 0.02 to 21.66 mg kg^{-1}, and 0.03 to 9.79 mg kg^{-1}, respectively. So far as the availability of nutrients is concerned S, Fe and Zn were found alarming nutrients after nitrogen and phosphorous in soils of middle Gujarat region.

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Influence of Inorganic and Organics on Soil Microbial Activities, Yield and Quality of Elephant Foot Yam - Blackgram Cropping System in Alfisols

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A field experiment was conducted to study the effect of inorganic nutrients on soil microbial activities and yield performance of elephant foot yam-blackgram cropping system in an Alfisol of Odisha. Incorporation of FYM @ 10 t ha^{-1} combined with 40, 15 and 40 kg ha^{-1} of NPK has recorded highest corm yield of elephant foot yam (24.32 t ha^{-1}). Potassium has shown higher yield response than N and P. Combined application of NK has recorded higher yield response (41.3%) rather than PK (29.4%) and NP (28.5%), whereas application of NPK has recorded higher yield response (56.6%). Incorporation of FYM @ 10.0 t ha^{-1} alone has recorded a yield response of 22.5% over control. Significantly highest dry matter (25.02%) and starch (11.43%) in the corms were observed due to application of FYM + N40P15K40.

Significantly highest grain and haulm yields of blackgram (6.15 and 21.5 q ha^{-1}, respectively) as an inter crop with elephant foot yam were recorded due to application of FYM + N40P15K40. Dehydrogenase and urease activities were found maximum (1.216 µg TPF h^{-1} g^{-1} and 172.28 µg NH4-N g^{-1} h^{-1}, respectively) with the application of 80-30-80 kg ha^{-1} of NPK, respectively. The FDA and acid phosphatase activities were found maximum (1.352 µg g^{-1} h^{-1} and 82.17 µg PNP g^{-1} h^{-1}, respectively) with the application of FYM and 40-15-40 kg ha^{-1} of N, P and K, respectively.

Corm yield had significant relationship with enzyme activities and the 'r' values were found to be 0.779**, 0.545*, 0.758**, 0.596* and 0.638* in respect of dehydrogenase, FDA, urease, acid phosphatase and alkaline phosphatase activities. Application of lower doses of NPK along with FYM not only produced sustainable crop yields with good quality tubers of elephant foot yam and black gram but also enhances the microbial activities of the soil.

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Paddy Crop Residue Degradation through Halophilic Microbes for Nutrient Cycling to Enhance Productivity of Salt Affected Soils

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Rice-wheat cropping system is dominant in northern India and especially in Indo-Gangetic Plains. Huge quantities of rice straw are left for disposal after harvest of crop and most of this remains unutilized in the field. The most common practice adopted by farmers is burning that implicated for causing pollution and affecting soil fertility adversely. An attempt was therefore made to identify the efficient microbes for faster decomposition of crop residues. Bio-augmentation of crop residues with efficient cellulose and lignin degrading microbes were aimed that can help in degrading residues and recycling of soil nutrients. These efficient degrading microbes degrade crop residues, helps in buildup of soil C that can facilitate reclamation of sodic and saline-sodic soils and overall soil health. Salt tolerant cellulose and lignin degrading bacteria were isolated from different sources including sodic soils and were purified and screened. The three efficient strains were tested on left over stubbles of paddy on sodic soil through spray of culture broth of efficient strains individually and in combination with whey to compare their performance on degradation of the stubbles and straw with respect to time. The microbial culture strains reduced the stubble weight by 39.2, 31.9 and 40.1% after 35 days while. Consortia of degrading bacteria along with whey resulted in decrease in stubble weight by 46.7% compared to the initial weight of stubble. The C:N ratio of the residue material decreased to maximum of 24:1 from 66.5:1 in 35 days after inoculation of consortia with use of whey. Among the strains, cellulose and lignin degrading bacteria strain CDM2 with whey reduced the C:N ratio to the extent of 58.6% after 35 days. The three season data indicates that inoculation of residue with consortia of degrading microbes along with the use of whey helps in faster *in-situ* degradation of paddy residues.

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Evaluation of Nitrogen Use Efficiency of Rice in Southern Tamil Nadu, India

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Field experiment was conducted during *pishanam*, 2017 (October to January) with 32 rice varieties/ cultures grown in Tamil Nadu province as main plot and N levels (0, 50, 100 and 150% recommended N) as subplot in split plot design replicated twice at Rice Research Station, Ambasamudram to delineate rice varieties into efficient and responsive (ER), efficient and non responsive (ENR), non-efficient and responsive (NER) and non efficient and non responsive (NENR) to nitrogen application. The experimental soil was sandy loam in texture with acidic pH (4.16) had 0.35% organic matter, available nitrogen - 270 kg ha^{-1}, available phosphorus - 10 kg ha^{-1} and available potassium - 63 kg ha^{-1}. As the agronomic use efficiency gives responsiveness of variety and the physiological efficiency indicates utilization efficiency of applied nitrogen, the AE vs PE model was compared with the existing Cartesian model and Fageria and Kulthcouski model to evaluate nitrogen use efficiencies and delineate efficient and responsive rice cultures. The scattered diagram of AE vs PE model, divided graph in to four equal quadrants by drawing intersect line at the average agronomic and physiological efficiencies which grouped the varieties in to four classes based on the efficiency and response to applied nitrogen. This model grouped cultivars into 9 efficient and responsive class (ADT 45, ADT 39, TPS 5, PM 12009, TM 10085, CB 06803, AD 09206, ACK 14001, EC 725224), 4 responsive and non-efficient cultivars, 6 efficient and non-responsive cultivars and 13 non-responsive and non-efficient cultivars.

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Effect of Humic Acid on Soil Fertility and Productivity of Blackgram (*Vigna mungo* L.) in an Alfisol

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A pot culture experiment was conducted to study the effect of humic acid from poultry manure, FYM and sewage sludge on soil fertility and productivity of blackgram (DBGV-5) in an Alfisol during *kharif* 2018 at the Main Agricultural Research Station, UAS, Dharwad with thirteen treatments and three replications laid out in completely randomized design. Soil application of humic acid from poultry manure at 10 kg ha^{-1} with 0.2 per cent concentration foliar spray at 40 DAS significantly improved the growth parameters namely plant height, chlorophyll content and number of effective nodules and increased the number of pods (32.10), seed yield (7.29 g $plant^{-1}$) and seed protein (25.38%) content in blackgram. There was increase in the concentration of major nutrients in index leaf and the total uptake of major and micro nutrients. There was significant improvement in soil physical properties, organic carbon content, microbial biomass carbon and available nitrogen (258.00 kg ha^{-1}), phosphorus (43.30 kg ha^{-1}), potassium (284.50 kg ha^{-1}) and sulphur (25.90 kg ha^{-1}) and DTPA extractable micronutrients namely Cu (1.44 mg kg^{-1}), Fe (14.04 mg kg^{-1}), Mn (4.81 mg kg^{-1}) and Zn (0.86 mg kg^{-1}) status in soil due to application of humic acid at 10 kg ha^{-1} with 0.2 per cent foliar spray. The effectiveness of humic acid extracted from different organics followed the order: poultry manure > sewage sludge > FYM. Application of humic acid from poultry manure to soil at 10 kg ha^{-1} and 0.2 per cent foliar spray significantly increased seed yield and protein content in blackgram.

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Effect of Different Levels of Phosphorus, Potassium and Sulphur on Growth, Yield and Quality of Bt Cotton {Var.G.Cot.Hy.8 (BG II)}

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The field experiment conducted on Bt cotton during 2015-17 to study the Effect of different levels of Phosphorus, Potassium and Sulphur on growth, yield and quality of Bt Cotton {Var.G.Cot.Hy.8 (BG II)} at TRTC, AAU, Devgadhbaria. The results revealed that the effect of phosphorus, potassium and sulphur application on seed cotton yield ware found significant. The highest seed yield by phosphorus levels is recorded under treatment P2 (40 kg P_2O_5 ha^{-1}) that was 2724, 3018, 3111 and 2951 during 2015, 2016, 2017 and pooled analysis, respectively. Treatment P1 (20 kg P_2O_5 ha^{-1}) was at par with treatment P2 (2651, 2915, 3052 and 2873 during 2015, 2016, 2017 and pooled analysis, respectively). The highest seed yield by potassium levels is recorded under treatment K2 (80 kg K_2O ha^{-1}) that was 2615, 2876, 2990 and 2827 during 2015, 2016, 2017 and pooled analysis, respectively. Treatment K1 (40 kg K_2O ha^{-1}) was at par with treatment K2 (2508, 2794, 2883 and 2728 during 2015, 2016, 2017 and pooled analysis, respectively). The highest seed yield by sulphur levels is recorded under treatment S1 (40 kg S ha^{-1}) that was 2572, 2841, 2921 and 2778 during 2015, 2016, 2017 and pooled analysis, respectively. The highest seed yield by sulphur levels is recorded under treatment S1 (40 kg S ha^{-1}) that was 2572, 2841, 2921 and 2778 during 2015, 2016, 2017 and pooled analysis, respectively. The effect of phosphorus, potassium and sulphur application on Growth and yield attributing characters such as plant height, number of branches, number of Bolls and Bolls weight were found significant. Significantly taller plants 145 cm of cotton were found under treatment P2 (40 kg P_2O_5 kg ha^{-1}) and 141 cm were found under treatment K2 (80 kg K_2O kg ha^{-1}).

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Effect of Methods of Zinc Application on Zinc Use Eficiency and Yield of Maize in an Inceptisol

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The present investigation was undertaken on medium deep black soil belonging to Inceptisol order at Post Graduate Institute, Research Farm, Department of Soil Science and Agricultural Chemistry, MPKV, Rahuri, during the *summer* 2018-19. Experimental soil showed moderately in alkaline reaction, normal in electrical conductivity, moderately high in organic carbon content and high in $CaCO_3$ content. Soil fertility was very low in available nitrogen, medium in available phosphorous and very high in available potassium content. However, deficient in available Zn and sufficient in available Fe, Mn and Cu. The experiment was laid out in a randomized block design with three replication and nine treatments. The available nutrients N, P and K at harvest were found to be significantly increased due to treatment GRDF + soil application of $ZnSO_4$ @ 20 kg ha^{-1} with 100 kg FYM incubated for one week and treatment GRDF + soil application of cow dung slurry with $ZnSO_4$ @ 20 kg ha^{-1}. Total uptake of iron, zinc, manganese and copper were found to be significantly higher in treatment of GRDF + application of $ZnSO_4$ @ 20 kg ha^{-1} incubated with FYM for one week. The grain and stover yield of maize was significantly increased (66.40 q ha^{-1} and 77.23 q ha^{-1}, respectively) in treatment of GRDF with soil application of 100 kg FYM + $ZnSO_4$ @ 20 kg ha^{-1} incubated for one week. The higher zinc use efficiency (9.4%) and agronomic efficiency (16.06 kg kg^{-1}) was found in treatment of soil application of $ZnSO_4$ @ 20 kg ha^{-1} incubated in 100 kg FYM for one week along with GRDF.

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Implications of Soil Properties Analysis for Sustainable Agriculture

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After independence, around 4-5 decades we enjoyed an increase in food production due to the Green revolution. Although this revolution helped us to overcome the "ship to mouth" situation but later on due to the introduction of high yielding varieties (HYVs) we faced side effects of such intensive farming practices. Such types of agricultural practices caused soil and environment-related problems thus can't be sustainable. So our interest is to shift towards more sustainable farming approaches which can help us to reduce fertilizers dose so that we can mitigate the problems associated with fertilizers *e.g.* emission of nitrous oxide (a GHG), groundwater contamination, decline in soil microbial population, etc to certain extent as fertilizer alone constitute more 50% of the input cost. In India, Indo-Gangetic plain is one of the most important agricultural-belt, where a sharp decline in productivity was noticed under agriculture due to deterioration in soil quality because of excessive fertilizer use for a long period. To get rid of this problem we did soil testing of two villages of Mirzapur (Gangpur and Bhawanipur) belonging to Uttar Pradesh. We tried to find out the fertility status of the soil by means of chemical analysis so that on this basis we could recommend fertilizer dose to farmers and could avoid excessive fertilizer application. This can not only help to cut input costs but most importantly addresses environmental issues related to indiscriminate agrochemical (fertilizer) use under agriculture.

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Impact of Controlled Release Urea on Carbon Fractions under Different Established Methods of Rice Cultivation

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The study was aimed to assess the distribution of different fractions of SOC under three rice establishment methods viz. direct seeded rice (DSR), system of rice intensification (SRI) and transplanted puddle rice (TPR) with different coated nitrogenous fertilization [*viz.* T1=N0PK, T2=100% NPK (NCU), T3=75% N (NCU)+PK+25% N (Organics), T4=100% NPK (PSCU), T5=75% NPK (PSCU)+25% N (Organics)]. Soils of three depths (i.e. 0-15, 15-30 and 30-45 cm) were collected from Jaguli Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya where the experiment was initiated in 2015. Soils were neutral to slightly alkaline in reaction. Depth-wise increase in soil bulk density was observed while lower values were found in the organics treated plots. Highest available nitrogen was found under PSCU treated plots whereas greater availability of phosphorus and potassium were associated with plots where organic manure applied with controlled release urea (CRU). Comparing Walkley-Black carbon (WBC) and total organic carbon (TOC), highest values were associated with T5 followed by T4, T3, T2 and T1. SRI system with T5 was proved the best combination in terms of TOC stock upto 45 cm (72.29 Mg ha^{-1}). Percent changes in TOC stock over initial value was comparatively higher under SRI followed by TPR and least was recorded under DSR. Highest potential of sequestering C was recorded in T5 treatment (47.99% increase) of SRI system. Higher positive relationship of F3 with TOC (r=0.929, p=0.01) and TOC stocks (r=0.940, p=0.01) imparts better stability and relatively long turnover time of C under SRI system.Under TPR system higher correlation between F1 and TOC stock (r=0.783, p=0.01) compared to SRI supports the lower values of TOC stock in this system while under DSR system highest positive relation between F1 and TOC (r=0.844, p=0.01) and its stock (r=0.849, p=0.01) indicating more susceptibility of C towards oxidation and mineralization loss.

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Effect of Potassium on Forage Sorghum (*Sorghum bicolor* L. Moench.) and Different Forms of Soil Potassium in Loamy Sand

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Afield experiment was conducted during summer, 2018 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar entitled "Effect of potassium on forage sorghum (*Sorghum bicolor* L. Moench) and different forms of soil potassium in loamy sand". The texture of experimental site was loamy sand with low in available nitrogen (162.3 kg ha^{-1}) and potash (136.06 kg K_2O ha^{-1}),while medium in available phosphorus (31.28 kg P_2O_5 ha^{-1}) with 7.2 pH. Five different doses of potassium *viz.,* T1 (0 kg K_2O ha^{-1}), T2 (40 kg K_2O ha^{-1}), T3 (80 kg K_2O ha^{-1}), T4 (120 kg K_2O ha^{-1}) and T5 (160 kg K_2O ha^{-1}) were evaluated in Randomized Block Design (RBD) by replicating four times and forage sorghum (GFS5) was used as test crop. The growth and yield attributes of forage sorghum such as leaf weight per plant (green and dry), stem weight per plant (green and dry), green and dry fodder yields were significantly affected by potassium application. Significantly the higher values for yield attributes were recorded with T5 (160 kg K_2O ha^{-1}) over T1 (0 kg K_2O ha^{-1}). Green and dry fodder yield of forage sorghum was increased with T5 (160 kg K_2O ha^{-1}) over T1 (0 kg K_2O ha^{-1}) to the tune of 31.3 and 32.3 per cent, respectively. The difference in fresh and dry yield of forage sorghum due to 40, 80, 120 and 160 kg K_2O ha^{-1} was found non-significant. Potassium application @160 kg K_2O ha^{-1} (T5) significantly influencedthe potassium content in forage sorghum over T1 (0 kg K_2O ha^{-1}). From the results of one-year experimentation, it is concluded that forage sorghum crop should be fertilized with 40 kg K_2O ha^{-1} along with recommended dose of 80:40 kg N:P ha^{-1} in loamy sand having low status of available potassium for avoiding unnecessary addition of chemical fertilizer.

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Effect of Tillage and Potassium Levels on Productivity, Nutrient Uptake and Profitability of Wheat under Rainfed and Limited Irrigation Conditions

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The present study was conducted at the experimental farm of Department of Soil Science, CSK HPKV, Palampur, during *Rabi* 2016-17 with the objective to evaluate the effects of different tillage methods, irrigation and potassium levels on productivity and nutrient uptake by wheat crop. The treatments comprising two tillage methods *viz.* conventional and conservation tillage, two irrigation levels *viz.* no irrigation and two irrigations of 2.5 cm each at tillering and flowering stages only and three potassium levels *viz.*100 per cent, 125 per cent and 150 per cent recommended dose of potassium, were evaluated in a split plot design. Wheat (var. HPW 236) was sown on 26th December, 2016. The results indicated that treatment in which conservation tillage was followed had higher grain (2.66 t ha^{-1}) and straw yield (3.95 t ha^{-1}) as well as the nutrient uptake by wheat in comparison to the conventional tillage. Among the irrigation levels higher grain (2.84 t ha^{-1}) and straw (4.11 t ha^{-1}) yields were recorded when crop was irrigated twice as compared to no irrigation. Application of 150 per cent recommended dose of potassium recorded highest grain (2.84 t ha^{-1}) and straw (4.18 t ha^{-1}) yields as well as the nutrients uptake. The treatment comprising two irrigations coupled with application of 150 per cent recommended dose of potassium under conservation tillage recorded higher gross returns (Rs. 97106 ha^{-1}), net return (Rs. 62860 ha^{-1}) and B: C ratio (2.84).

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Influence of Different Organics Application on Zn Fractions in Mollisols of Uttarakhand

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A laboratory incubation study (120 days) was conducted during 2017-2018 in Department of Soil Science, GBPUA&T, Pantnagar to examine the influence of different organics on zinc fractions in sandy loam (Typic Hapludoll) soil. The treatments were farmyard manure (FYM), mushroom compost, poultry manure, vermicompost, biogas slurry and biochar each used @ 15 t ha^{-1} besides a control in a two factorial completely randomized design with two replications. Acid washed quartz sand and soil (each wt. 300 g on oven dry w/w) were filled separately in plastic containers having a glass wool pad (1 cm height) and basal drainage pores. The leachate from each container were allowed to pass through other plastic containers having a beds of weakly basic cation (IRC86) and weakly acidic anion exchange (IRA96) resin spread over a basal glass wood pad. During incubation, the moisture content was maintained near to 50 percent of void space through regular make up. On each observation day, the beds of cation and anion exchange resins were recharged with 25 ml of 1 *N* HNO_3.

After incubation study, the dominant Zn fractions found was residual->iron oxide bound-> carbonate bound->organically bound-> and water soluble and exchangeable fraction. Application of mushroom compost and poultry manure increased the average content of Zn in soil by 21.8 and 20.4%, respectively in comparison to control. Among different organics, the use of specifically poultry manure and biochar significantly increased the carbonate bound fraction nearly 2.5 times and the use of poultry manure, vermicompost and biogas slurry significantly increased the iron oxide bound fraction of Zn nearly 2.0 times as compared to control. The findings of the present investigation can help in identifying potential organic source of zinc.

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Effect of Poor Quality Irrigation Water on Performance of different Wheat (*Triticum aestivum* L.) Varieties in South-west Punjab

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A field experiment was carried out to find out suitable wheat (*Triticum aestivum* L.) varieties under saline water irrigation environments and the effect of saline sodic water irrigation on soil properties and water expense efficiency in loamy sand soil at Punjab Agricultural University, Regional Research Station, Bathinda. The experimental field was non saline and alkaline in reaction having EC 0.230 dS m^{-1} and pH 8.4, organic carbon (0.26%), available phosphorus 13.1 kg ha^{-1} and available potassium 311 kg ha^{-1}. The experiment was planned with five varieties of wheat *viz.* PBW-343, DBW-17, KRL-19, PBW-590 and PBW-550 under three replication in randomised complete block design. The crop was sown during *Rabi* season in the month of November every year under canal water and poor quality tubewell water. The recommended package and practices of Punjab Agricultural University were followed for raising the crop. The crop was harvested and observations on yield and yield attributing characteristics were recorded. Soil samples were collected after harvesting the crop and analysed for pH, EC and other soil charactersitics as per standard methods. The results of the experiment revealed that the yield of different wheat varieties differed under poor quality irrigation as compared to canal water conditions. The varieties PBW-550 and DBW-17 performed better under saline water than canal water. Whereas, significant difference in yield of different varieties were also observed among themselves under both conditions. The water expense efficiency was higher in canal water as compared to tubewell water. The pH, EC and SAR increased under irrigation with poor quality water.

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Tillage and Residue Retention Effects on C Pools within Aggregate and Oxidative Stability of C under the Wheat-based System in Sub-tropical India

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The conventional mode of agriculture through intensive agricultural practices was successful in achieving goals of production but simultaneously led to the degradation of natural resources. Over the past three decades, rapid strides have been made to evolve and spread resource conservation technologies like zero tillage for better management of crop residues which increase soil organic C and help to achieve the goal of sustained agricultural production. But, the potential of conservation agriculture (CA) on soil organic carbon (SOC) pools within aggregates and oxidative stability (OXS) of C in deep layers and aggregates are less highlighted. Thus, our aim was to study the long-term (9 years) effects of contrasting tillage treatments and residue addition on C pools and OXS in bulk soils and aggregates. For this an experiment was laid out in a split-plot design with two tillage practices in main plots (zero-tillage: ZT and conventional tillage: CT) and four residue management practices in sub-plots (No residue: NR, wheat residue: WR, soybean residue: SR and wheat + soybean residue: WR+SR) in 2008. Soil samples collected from 0-5, 5-15, 15-30 and 30-60 cm layers were analyzed. In macroaggregates of first two soil layers, recalcitrant C was (a) ~57, 76 and 63%; and (b) 85, 59 and 40% greater in WR+SR, SR and WR plots over NR, respectively. The OXS of C in ZT was ~21% more than CT, but residue addition had no impact on OXS. In deep soil layers, tillage had no impact on OXS. In 15-30 and 30-60 cm soil layers, OXS in WR+SR plots were ~28 and 31% greater than NR. Hence, zero-tillage could significantly enhance OXS of SOC in top layers and residue addition is capable of enhancing OXS in deep soil layers, thus CA practices could be adopted for enhancing stable C in soil profiles.

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Rothamsted Carbon Model (RothC) - A Model for Turnover of Carbon in the Soil

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Soil organic matter is of fundamental importance in maintaining soil fertility and sustainable crop productivity. Its contribution in improving the physical, chemical and biological properties of soils and sustaining their productivity is immense. Soil organic carbon (SOC) is relatively dynamic and is influenced greatly by agricultural practices. Increases in SOC storage in cropland soils can benefit soil productivity and environmental health. A depletion of SOC can not only reduce the productivity of the soil but also contribute to climate change as carbon is partly lost through carbon dioxide emissions. Thus, the study of SOC particularly, prediction of its behaviour in soil in advance can help agricultural policy makers to develop a decision support system for augmenting agricultural production.

SOC modeling is gaining importance to understand and manage terrestrial carbon cycle. SOC models help in predicting changes in carbon sequestration for coming years within short period. These models have immense potential for application in the agricultural decision support systems. Rothamsted Carbon (RothC) model is one of the carbon turnover models, which is used to understand the interactions of the factors influencing carbon stocks in soils. It simulates SOC dynamic based on relatively few parameters and input data that are easily obtainable. It is one of the best performing model across the world, tested in different climatic regions using long-term experiments.

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The Influence of Reversal of Conservation Tillage on Soil Carbon and Nutrient Availability in Vertisol

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No till and reduced till fields when converted to conventional tillage will have a detrimental impact on soil carbon storage and nutrient availability. The soil of the present study was taken after 3 growing periods of short term conventional tillage of 8 years long-term experiment under conservation tillage in soybean-wheat system. The experiment comprised of four tillage treatments (NT-CT, NT, RT-CT and RT) with three levels of fertilizer (T1: NPK (RDF), T2: NPK + 1.0 FYM-C (t ha^{-1}) every year and T3: NPK + 2.0 FYM-C (t ha^{-1}) every year). After three growing periods of converting 8 years long-term experiment under conservation tillage in the soybean-wheat system, the results revealed that the NT system had the highest SOC content in the surface 0-5 cm layer only. The relative increase in SOC concentration for 5-15 cm soil depth was observed with reversal of no tillage (NT) and reduced tillage (RT) to conventional tillage (CT); this could be attributed to increased decomposition and mineralization of incorporated crop residue in NT-CT and RT-CT treatments. The soil nutrient content (N and P) was not significantly affected by the interactive effect of tillage and fertilizer on the surface soil layer (0-5 cm). Interactive effect of tillage and fertilizer was found significant on available P content at 5-15 cm soil depth. In contrast to N, soil available P relatively increased with reversal of tillage in NT and RT. In comparing the tillage systems, tillage reversal (NT-CT, RT-CT) and RT had significantly higher available potassium than NT in 0-5 and 5-15 cm soil layers.

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Influence of Long-term Soil Management on Soil Organic Carbon Storage in Soybean-based Cropping Systems of Central India

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Soybean based cropping system is the predominant cropping system in black soils of central India. Soil management exerts a considerable influence on the storage of soil organic carbon (SOC) and related soil properties in different agro-climatic regions (ACRs). Therefore, in this paper, we studied the effect of long-term soil management on the change in SOC storage and related soil properties in soybean-based cropping systems under different ACRs. Soil samples were collected from surface 0-15 cm soil layer after harvest of soybean in 2018 from three soybean-based cropping systems (1) Bhopal (ACR: Vindhyan Plateau; 10 years of soybean-wheat system) (2) Indore (ACR: Malwa Plateau; 20 years of soybean-fallow) and (3) Jabalpur (ACR: Kymore Plateau & Satpura Hills; 47 years of soybean-wheat system). The results revealed that SOC sequestration was significantly higher in Bhopal and Jabalpur receiving higher rainfall than Indore in the surface soil layer (0-15 cm). Soybean-wheat cropping system sequestered more SOC than soybean-fallow cropping system. Integrated use of nutrients (100% NPK + FYM) increased SOC storage and enzyme activities compared to NPK fertilization at all sites. Across sites, reduced tillage together with residue retention and application of 100% NPK + FYM @ 6 t ha^{-1} had the highest SOC sequestration (0.37 Mg ha^{-1} yr^{-1}) at Bhopal. The SOC sequestration ranged from 0.009 Mg ha^{-1} yr^{-1} (Conventional tillage, Indore) to 0.374 Mg ha^{-1} yr^{-1} (reduced tillage + integrated use of nutrients, Bhopal). The results indicate that compared with the control and NPK treatment, organic amendments (FYM and or crop residue) produced more favorable effects on SOC storage and soil biological activity in soybean-based cropping system.

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Effect of Engineered Nano-titanium dioxide Polymorphs Spraying on Nutrient Uptake by French bean (*Phaseolus vulgaris* L.) in Inceptisol of Varanasi, Uttar Pradesh, India

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Nanotechnology is the science which deals with materials within dimension of 1-100 nm. Titanium (Ti) is considered a beneficial element for plant growth. Titanium dioxide (TiO_2) nanoparticles (NPs) are known for photocatalytic activity, high stability and low costs. A pot experiment was performed to assess the effect of engineered nano-TiO_2 polymorphs *i.e.* anatase (14 nm) and rutile (52 nm) application on nutrient uptake pattern of french bean (*Phaseolus vulgaris* L.) in an Inceptisol of Varanasi, Uttar Pradesh. Nano-TiO_2 polymorphs *i.e.* anatase and rutile were synthesized in laboratory by the sol-gel method using titanium tetraisopropoxide as titanium-precursor and 2-propanol as solvent. The present investigation was carried out in net house where suspension of six different concentrations (in water) of each nano-TiO_2 polymorphs *i.e.* anatase and rutile (0, 0.01, 0.02, 0.03, 0.04 and 0.05% respectively) were sprayed twice *viz.* during vegetative stage (28 days after sowing) and reproductive stage (57 days after sowing). The nutrient uptake pattern *i.e.* of nitrogen, phosphorus, potassium and sulphur was assessed during three different stages of crop growth *i.e.* at 45, 60 and 90 days after sowing. It was noticed that uptake of N, P and S were significantly higher in rutile (0.03 and 0.04%) treated french bean pod than control. Thus, the nutrient uptake (N, P and S) could be improved by the spraying 0.03 to 0.04% rutile suspension during vegetative and reproductive phases of french bean crop.

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Effect of Continuous use of Chemical Fertilizers and Amendments on Yield and Quality of Maize in an Acid Alfisol

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The present investigation was carried out in an on-going long-term fertilizer experiment, initiated during 1972 at experimental farm of Department of Soil Science, CSK HPKV Palampur. The study aimed at to evaluate the effect of continuous application of fertilizers and amendments on productivity and quality of maize (*Zea mays* L.) in an acid Alfisol under maize-wheat cropping system. The soil of the experimental site was silt loam and classified taxonomically as Typic Hapludalf. The experiment consisted of eleven treatments with varying levels of NPK fertilizers, and FYM; lime as amendments. Continuous application of fertilizers and amendments for forty-six years significantly influenced the yield and grain quality of maize. The highest grain (4.65 t ha^{-1}) and stover yield of maize (7.7 t ha^{-1}) was recorded in the treatment comprising 100 per cent NPK + FYM and was at par with 100 per cent NPK + lime. Omission of S and K decreased the grain yield by 55 and 53 per cent, respectively, whereas continuous application of N alone resulted in zero yield. Grain samples were analyzed to assess grain quality parameters. Integration of FYM and 100 per cent NPK recorded the highest value of crude protein, crude fat, crude fibre, carbohydrates, starch, reducing and non-reducing sugar, ash, P, Mg and Fe contents. It can be inferred from the study that integrated use of chemical fertilizers and amendments not only increased the yield but also the quality of maize grains.

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Nanotechnological Interventions for Improving Crop Productivity

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Present agriculture is chemical intensive, involving more doses of chemicals for insects, diseases, weeds and nutrient management, to get maximum production per unit area without caring about the natural resources and ecosystems. At present, fertilizers contribute to the tune of 50 per cent of the agricultural production. Despite the resounding success in food grain production, it has been observed that the yields of many crops have begun to stagnate as a consequence of imbalanced fertilization and declined organic matter of soils. In other words, more amounts of fertilizers are required to produce the same quantity of grain output. In order to achieve a target of 300 million tonnes of food grains and to feed the burgeoning population of 1.4 billion in 2025, the country will require 45 million tonnes of nutrients as against a current consumption level of 23 million tonnes. Using higher doses of fertilizers don't guarantee to improve crop yield, but it may lead to several problems like degradation of soil and pollution of surface and underground water resources. Nanotechnology have great role in crop production with environmental safety, ecological sustainability and economic stability. The nanoparticles produced with the help of nanotechnology can be exploited in the value chain of entire agriculture production system.

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Effect of Boron Application on Growth, Yield, Nutrient Concentration and Availability of Boron in Rice (*Oriza sativa* L.) Crop under the Inceptisole Soil of Varanasi

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Boron is an essential micronutrient element required by the plants for their normal physiological processes and growth. Boron is associated with one or more of the following processes: calcium utilization, cell division, flowering and fruiting, carbohydrate and nitrogen metabolism, disease resistance, water relations, and catalyst for certain reactions. There is a narrow range of concentration between deficiency and toxicity of B in soil - plant systems. The study involved a pot experiment conducted in the net house followed by laboratory analysis of the plant, grain and soil samples in the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, for study the effect of boron application in rice on growth and yield of rice. Occurrence of acidic soils, with mean boron contents of 0.55, 0.49, 0.66 and 0.62 mg kg^{-1} in Chandauli, Mirzapur, Sant Ravidas Nagar and Varanasi districts, respectively showing deficiency in 55, 61, 30 and 37 per cent soil samples. Rice is the most important staple food crop in the world and mainly grown in the Indo-Gangatic Plains of South Asia. It was found that application of boron did not increased grain yield of rice significantly over RDF. However, application of B @ 2 kg ha^{-1} or higher doses significantly decreased the rice grain yield.

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Effect of ZnO Nanoparticles on Mungbean (*Vigna radiata* L.)

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An experiment to assess the efficacy of ZnO nanoparticles on mungbean, was conducted at College of Agriculture of G.B. Pant University of Agriculture and Technology, Pantnagar. The experiment was laid out during *kharif* 2017, in a three factorial experiment with Completely Randomized Design with two modes of application (seed soaking and foliar spray) using two sources of ZnO nanoparticles (ZnOG and ZnOC) in different concentrations (10, 20 and 50 ppm) along with a control. The whole experiment was carried out in a controlled glass house condition with each treatment replicated thrice. The results revealed that ZnO nanoparticles at varying levels of concentration *i.e.* 10, 20 and 50 ppm significantly increased the yield and yield attributing traits over the control. The response of 20 ppm concentration was more effective in enhancing the number of pods per plant, grains per pod, grain yield, straw yield and biomass yield as compared to other treatments, whereas zinc concentration in grain was found maximum in treatment with 50 ppm concentration. However, both the source of ZnO nanoparticles (ZnOG and ZnOC) showed comparable effects on yield and yield attributing traits of mungbean. Between the two modes of application, the response of seed soaking was better to foliar spray during early growth periods whereas foliar spray was better during later stages of the mungbean crops.

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Long Term Effect of Fertilizer and Organic Manure on Microbial Biomass Nitrogen and Enzymes Regulating N-mineralization in Soil

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Sustainable agriculture requires careful optimization of the use of organic and inorganic fertilizers to improve crop productivity and soil health while minimizing any harmful environmental effects. Long term fertilizer experiments in India thus play a crucial role to study the effect of mineral fertilizer and manure on soil nutrient cycling processes mediated by soil microbes. A study was conducted to explore the role of soil microbes and nitrogen cycling enzymes in nitrogen mineralization process under a 21 years old long-term experiment in Vertisol (LTFE-Parbhani). The targeted treatments were control (no fertilizer and manure), fallow, 100% N, 100% NP, 100% NPK, and 100% NPK + FYM. Results of the study revealed that, the integrated nutrient management treatment *i.e.* 100% NPK + FYM had the highest activity of urease, amidase and protease enzyme. Similarly INM also had higher arginine ammonification activity which is equivalent to fallow plot. Microbial biomass nitrogen in INM was 70% and 29% higher as compared to 100% N and 100% NP treatments respectively. Similarly potentially mineralizable nitrogen under 100% NPK + FYM treatment was 20% and 11% higher as compared to 100% N and 100% NP treatment, respectively. The study showed that balance application of organic and inorganic nutrient is necessary to maintain microbially mediated biogeochemical processes and biological soil health.

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Establishment of Spatial Variation Pattern for Major Nutrients of BHU Farm Obtained through Geostatistics

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With the aim of obtaining more productivity to satisfy the crying need of food for the ever growing population, unabated land degradation and soil health deterioration is clearly observed everywhere. Fertility maps are the tools to provide a picture about nutrient supplying capacity of the land area and guide the producers to supply fertilisers economically. It can ultimately lead to optimum return from investment of inputs along with minimization of their negative impact on environment by Site specific nutrient management (SSNM) approach. Global Positioning System (GIS) is a potential tool for easy access and manipulation of voluminous data and obtain information about the unsampled points out of logical geostatistical prediction from sampled point data. it can create fertility map of large land area as a whole by using sample point GPS coordinate data and their tested values. The soil fertility maps for major plant nutrients are prepared using ArcGIS 10.3 software with 545 surface soil samples collected during the month of April-May, 2017 from the BHU agricultural research farm. Mapping is done by interpolating the point values to get variability trend of the entire area with spatial interpolation tools *i.e.* IDW (Inverse Distance Weightage), spherical and exponential kriging. From the interpolation techniques, different model is chosen for individual parameter by observing the geostatistical parameters namely nugget/sill ratio and R^2 value. The map objects are used from insert option in ArcGIS 10.3 to obtain final maps. pH of the entire farm was alkaline mostly with small neutral patches. Available nitrogen, phosphorus and potassium content were found to be low, medium to high and low to medium respectively. High correlation was found between oxidisable organic carbon content and available nitrogen content of the farm soil.

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Forms of Soil Potassium as Influenced by STCR-based Fertilizers and Manure Application under Vertisol of Jabalpur, Madhya Pradesh

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Balanced fertilization is important for soil health and sustainability. A field experiment was conducted in *Kharif* season of 2016 with Paddy crop var. Kranti under the on-going AICRP on STCR at the Jawahar Lal Nehru Krishi Vishwa Vidalaya (JNKVV) research field, Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur (M.P.) in vertisol. The field experiment was laid out in four replications and six treatments *viz.*, T1: Control, T2: GRD (120:60:40 kg N, P_2O_5 and K_2O ha^{-1}), T3: Targeted Yield 50 q ha^{-1} (115:90:49 kg N, P_2O_5 and K_2O ha^{-1}), T4: Targeted Yield 6.0 t ha^{-1} (157:125:70 kg N, P_2O_5 and K_2O ha^{-1}), T5: Targeted Yield 50 q ha^{-1} (115:90:49 kg N, P_2O_5 and K_2O + 5 t FYM ha^{-1}) and T6 : Targeted Yield 6.0 t ha^{-1} (157:125:70 kg N, P_2O_5 and K_2O + 5 t FYM ha^{-1}) in Randomized Block Design (RBD). Urea, diammonium phosphate (DAP) and muriate of potash (MOP) were used as source of inorganic fertilizers and FYM was used as a source of organic manure.

0-15 cm depth soil samples at 60 DAS and after harvesting of crop were analyzed for potassium fractions. Water soluble-K, exchangeable-K, non exchangeable-K, lattice K and total-K decreased from 60 DAS to harvest. All the forms of potassium showed higher content in T6 (157:125:70 kg N, P_2O_5 and K_2O + 5 t FYM ha^{-1}) treatment. Potassium fractions were fully influenced by the fertilizers doses with FYM applied based on targeted yield of rice. Maximum available potassium, which is present in the form of water soluble, exchangeable, non- exchangeable and lattice forms were found maximum in treatment T6 (157:125:70 kg N, P_2O_5 and K_2O + 5 t FYM ha^{-1}). Water soluble-K was the important fraction of potassium contributing towards crop yields and total K uptake.

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Secondary and Micro-nutrient Status of Geo-referenced Soil and Development of Fertility Maps of Cuttack District, Odisha

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A survey was carried out to study the distribution of secondary and micronutrients in the surface soils of Cuttack district, Odisha. Out of 350 geo-referenced surface samples collected from 14 blocks, it was observed that 85.72 per cent of soil was acidic followed by 10.57 per cent neutral and 3.71 per cent alkaline. Soil organic carbon (SOC) varied from 0.15-1.66 per cent with 34.57 per cent soils coming under lower range. The exchangeable calcium and magnesium content were found to be sufficient with a range of 0.60 to 4.20 cmol(p^+)kg^{-1} and 0.2 to 2.60 cmol(p^+)kg^{-1}, respectively. The available Sulphur content varied from 3.56-98.37 mg kg^{-1} and 41.14 per cent of soils were found deficient. The DTPA-Fe, Mn, Cu ranged from 4.85 to 257.36, 5.84 to 218.84 and 0.29 to 47.80 mg kg^{-1}, respectively and found to be sufficient. The DTPA-Zn and hot water extractable B content showed a range of 0.13 to 39.72 mg kg^{-1} and 0.09-3.70 mg kg^{-1} with 42.57 and 44.57 per cent of soils having deficiency, respectively. The single nutrient deficiency was in the order of B>Zn>S. Multi-nutrient deficiency of Zn+B, S+Zn, S+B and S+B+Zn were observed to the extent of 20.86, 20.57, 19.71 and 11.71 per cent, respectively. GIS based soil thematic maps on pH, SOC, S, Fe, Mn, Cu, Zn and B were prepared using Arc GIS (10.6).

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Nutrient Status of Soils and Plants under Stunted Growth Condition of Cotton Crops in Bathinda District of Punjab – A Case Study

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Cotton, known as the "King of fibres" is an important cash crop grown in India. Presently, this crop is grown under varying agro-climatic conditions. Cotton crop due to its intrinsically perennial habit has a vigorous growth profile and absorbs selective amounts of major/micro-nutrients from the soil. Followed by the initial 30 to 40 day lag phase, the exponential phase coinciding with squaring, flowering and boll development has the maximum requirement of nutrients. In nutrient deficient soils, plants are unable to take up nutrients as per the need and show stunted growth along with deficiency symptoms. A crop survey was conducted in *Kharif*-2018 to collect the soil and plant samples from stunted growth field. Sixty fields from different villages of Bathinda district were surveyed and 23 samples from problematic fields were collected. The soil and plant samples were processed as per standard methods to nutrient analysis. All the fields were non-saline and normal to slightly alkaline in reaction, low in organic carbon, and medium to high in phosphorus and high in available potassium. All the problematic field soils were deficient in iron (Fe) and manganese (Mn), whereas zinc (Zn), deficiency was reported in some field. However, no copper (cu) deficiency was reported in soil. Similar to soil nutrient status, 48 per cent and 79 per cent plants showed iron (Fe) and manganese (Mn) deficiency. It is advised the farmers of the region to apply macro and micro-nutrients on soil test bases, used good quality water and timely sowing of crop for good crop production.

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Impact of Boron Application on Partitioning of Boron in Soybean and it's Fractions in a Vertisol

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The investigation entitled "Impact of boron application on partitioning of boron in soybean and it's fractions in a vertisol" was carried out during *Kharif* season of 2016 to study the concentration of boron in different plant parts of Soybean and it's fractions in soil as affected by periodicity and levels of boron application. Field experiment was undertaken in a *Typic Haplustert* soil of Research Farm, JNKVV, Jabalpur. Experiment was laid in split plot design with three main treatments of periodicity (single year, alternate year and each of year B application) and five sub treatments of levels of B application (0, 0.5, 1.0, 1.5 and 2.0 kg B ha^{-1}) replicated thrice along with recommended dose of NPK. Partitioning of boron in soybean was done at 30, 45, 60, 90 DAS and at harvest of the crop. Boron concentrations in leaf, stem and root at different days interval was significantly affected by B application and found maximum under 2.0 kg B ha^{-1} treatment. Significant change in concentration of B in seed and stover as influenced by B application was also found. Different fractions of boron in soil were estimated before sowing, at 45 DAS and after harvest of the crop. At all the intervals these fractions were significantly affected by periodicity and levels of B application. Water soluble fraction contributed least to total B, while residual fraction contributed maximum. Proportion of various B fractions in total B followed the order WS < NSA < SA < OB < RES. Linear relationship between WS and NSA, SA and OB boron, and SA and NSA boron was also found with good predictability.

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Impact of Organic and Inorganic Sources of Nutrients on Growth and Yield of French bean (*Phaseolus vulgaris* L.) and Soil Properties

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A pot experiment was conducted to study the influence of organic and inorganic sources of plant nutrients on growth and yield of French bean (*Phaseolus vulgaris* L.) and soil properties during August, 2017 to May, 2018. Results showed higher plant height (48.55 cm), no. of pod plant^{-1} (10.60), weight of seed plant^{-1} (10.66 g) and, no. of seed pod^{-1} (4.00) respectively, was recorded with application of poultry manure @ 5 t ha^{-1}. The soil pH ranged between 8.4 to 8.7 due to application of treatments. Water holding capacity varied between 49.12 to 45.77%. Higher organic carbon (0.69%), available nitrogen (327.00 kg ha^{-1}) was observed with the application of FYM @ 10 t ha^{-1} whereas lower organic carbon (0.55%) and available nitrogen (305.46 kg ha^{-1}) was observed with application of RDF 50%. The greater soil available potassium (239.00 kg ha^{-1}) content was noticed with 100% RDF. The organic fertilizers FYM, compost, green leaf manure, poultry manures had better effect on the growth and yield parameters of French bean than inorganic RDF. Soil fertility was favorably influenced by the application of organic manures in terms of increment of soil organic carbon, available nitrogen and phosphorus status.

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Effect of Zinc Land Time of its Application on Zinc Fractions in Maize-wheat Cropping System

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Zinc availability for plants is linked with its distribution in various fractions and these fractions are influenced by the application of Zn fertilizers at different rates. The present investigation was carried out in the pre-established experiment initiated in year 2012 (*rabi* season) at the Research Farm of Department of Soil Science in Punjab Agricultural University, Ludhiana in randomized block design with thirteen treatments replicated three times. Surface (0.0-0.15 m) and sub-surface (0.15-0.30 m) soil samples were collected after harvest of maize crop in sixth year of maize-wheat cropping system to study the effect of zinc application at different levels (2.5, 5.0, 7.5, and 10.0 kg ha^{-1}) and phasing of zinc (once, alternate year and every year) and one control on the distribution of zinc fractions and grain yield. All the fractions of zinc were noticeably higher in treatments with highest amount of added Zn at 10 kg Zn ha^{-1} every year than the lower doses. Among the fractions, majority of Zn was distributed in res-Zn, cryst Fe-Zn and amor Fe-Zn while the rest of the fractions occupy a small portion of the total Zn present in the soil. Zinc application to maize at 10 kg ha^{-1} of every year had the highest grain yield which was statistically similar with Zn application at 7.5 kg ha^{-1} in alternate year. Hence, zinc application at 7.5 kg ha^{-1} at alternate years is the lowest rate at which maximum grain yield can be obtained. The zinc fractions in the soil after harvest of maize crop were positively and significantly correlated with each other and crop yield which indicated a dynamic equilibrium among the fractions.

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Impact of Pyrolysed Rice Straw on Phosphorus Availability in Soils with Contrasting pH

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Phosphorous (P) deficiency is being considered as one of the most limiting factor facing modern system of agricultural crop production. Low soil solution concentration and high fixation/precipitation of P under various soil ecosystems demands introduction of alternative strategies for fulfilling crop P demand. Pyrolysed biomass, a product of thermo-chemical conversion of agricultural waste, has received immense global importance for sequestering C but its impact on alleviating phosphorous demand remains largely inconsistent. An incubation experiment to study the interactive effect of pyrolysed rice straw (PRS) and inorganic-P on phosphorous dynamics in soils with contrasting pH (acidic, neutral and alkali soil) was conducted for 60 days. Treatments comprised of 0 and 20 g kg^{-1} (w/w) pyrolysed rice straw added to the experimental soils with three rates of inorganic-P (KH_2PO_4) (0, 25, 50 mg kg^{-1}). Application of PRS alone or in combination with Inorganic-P in experimental soils resulted in significant increase in P pools possibly due to: i) high available P content in PRS itself and; ii) PRS induced decrease in P sorption in all experimental soils, due to increase in competition for the P sorption sites by the surface functional groups. Among the P pools, content of Fe-P and Al-P pools were greater in acid soils whereas, Ca-P content was higher in neutral or alkali soils, irrespective of PRS and Inorganic-P treatments. Further, P rich PRS's ability to decrease phosphor-monoesterase activity was also indicative of its value to act as both source and sink of P. Thus, pyrolysed rice straw can be used as a potential ameliorating strategy in the context of sustainable P management under various soil ecosystems.

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Cropping System and Antecedent Carbon Level Effects on Soil Organic Carbon Dynamics

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Land-use and agricultural management are known to impact organic matter dynamics in soil. Besides climatic conditions, the effect of land-use and management depends on the choice of the cropping sequence that governs the magnitude and composition of plant-derived carbon (C) input to soil, and the soil organic C status which is central to most of the physical, chemical and biological processes. Although the effect of cropping systems on soil organic carbon (SOC) is fairly documented, yet the information on their influence on soil C dynamics *vis-a-vis* antecedent C level is scanty. In the present study, impact of maize-wheat and soybean-wheat cropping (in reference to continuous fallow) on total and labile pool of SOC in four soils of different antecedent C level was investigated. In surface soils (0-7.5 cm) of low to intermediate C level, cropped soils lost 11.7 to 21.6% C compared to continuous fallow, however, in a high C soil the cropped soils could maintain soil C status similar to fallow soil. Compared to antecedent C stocks, the average soil C stocks in the plough layer (0-15 cm) under the three land-uses were improved (0.55 to 1.41 Mg ha^{-1}) in soil of low antecedent C level, but depleted (0.04 to 3.64 Mg ha^{-1}) in soil of high antecedent C level. Depending on the antecedent SOC status, the cropping systems had 16.5 to 29.2% lower concentrations of labile C ($KMnO_4$-oxidizable) compared to fallow soils. Both cropping systems exhibited lower C mineralization (31 to 54%) than fallow in low to intermediated C levels; but cropped and fallow soils exhibited similar C mineralization in high C soil. In conclusion, choice of a cropping sequence in a soil must consider the antecedent soil C status in predicting the magnitude and direction of changes in SOC and its labile pool.

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Potassium Fractions Changes under Intensive Cultivation of Rice-Maize-Greengram in Acid Inceptisol of Odisha

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An experiment was conducted in the farmer's field for three consecutive year (2013-14 to 2015-16) at Puri district, Odisha, to study the effect of intensive cultivation of rice-maize-greengram cropping system under site specific nutrient management (SSNM) on changes in soil potassium (K) fraction over three years. The experiment was carried out based on nutrient omission technique and comprised of 10 treatments (SSNM, SSNM-N, SSNM-P, SSNM-K, SSNM-S, SSNM-Ca, SSNM-B, SSNM-Zn, farmer practice and absolute control). Rice and Maize crop received complete doses of inorganic fertilizers based on SSNM and FYM was applied @ 3 t ha^{-1} common to all treatment except for absolute control. Green gram was taken as residual crop after maize (no fertilizers applied only seeds were inoculated with Rhizobium). The initial soil was sandy loam in texture and strongly acidic (4.91) in nature with low organic carbon (4.1 g kg^{-1}), and base saturation percentage (51.4%). Available K was medium (125 kg ha^{-1}). The study indicated that, compared to initial year total soil-K was decreased in surface soil (0-15 cm), whereas it was increased in sub-surface soil (15-30 cm). The structural-K was increased for both surface and sub-surface depth as compared to initial year. Non-exchangeable-K was declined over initial year and contribute about 47.5% of total-K in surface soil and 31.3% in sub-surface soil in complete SSNM package. Water soluble-K and exchangeable-K was declined in surface soil over the initial year by 33.3% and 24.2% respectively in complete SSNM package, whereas, there was buildup of both fraction observed in sub-surface soil. The information revealed that plant available pool of K-fraction was declined in surface soil (0-15 cm). It was indicating for rescheduling of nutrient addition, in sense that the greengram need not to be residual atleast for K.

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Study of Physico-Chemical and Biological Properties and Response by Wheat (*Triticum aestivum* L.) under Organically vs. Inorganically Managed Soils of Middle Gujarat

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Under survey work, soils (0-20 & 20-40 cm depth) were collected organically and adjoining conventionally managed fields of four districts of middle Gujarat. The results revealed that significant improvement in 26.82% in SOC, 59.67% in humic acid under organically managed soils over inorganic under both the depths. The exchangeable cations like Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and CEC, ESP were significantly influenced by long term (> 10 years) application of organic manures under all the districts. The available nutrients showed significant increases were 84.02%, 18.87% and 115% for available P_2O_5, K_2O and S due to long term application organic manures over conventional fertilizer application. Amongst micronutrients, there were not much differences in soils. The total macronutrients N, P and K showed significant increases for total N and P were 42.85% and 40.28% due to soil management practices. Overall increase in total microbial count was 15.89% and at 0-20 cm 24.62% in organically over inorganically managed soils.

The grain and straw yields as influenced by organically and conventionally managed soils showed that there were no significant differences in both grain and straw yields. The results of total content of P, K and Fe were significantly increased in wheat grain under organically managed soils. The increase in OC, available N, P_2O_5 and K_2O under organically managed soils was 39.39, 11.79, 117.77 and 36.45% compared to inorganically managed soils due to soil management practices. Overall results revealed that substantial improvement in physical, chemical and biological properties of soils due to long term effect of organically managed soils over conventionally managed soils.

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Amelioration of Sodic Soils by using different Amendments and its Effect on Soil Properties and Yield of Wheat (*Triticum aestivum* L.)

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A pot house study was conducted at the Net House, Regional Research Station, AAU, Anand during *rabi* season of 2018-19 on wheat (GW-496) as a indicator crop. The treatments comprised of six different sodic soils (S1, S2, S3, S4, S5 and S6) and amendments *viz.*, control (no amendments, A0), Gypsum at 50% GR (A1), Vermicompost at 4.0 t ha^{-1} (A2) and Sulphur at 50 kg ha^{-1} (A3). The result indicated that the soil amendments significantly decreased the pH, EC and ESP of sodic soils. The order of pH decreased from 8.75 to 7.89 by application of amendments remained as: vermicompost>sulphur>gypsum. Among all the amendments vermicompost proved as a better in respect to decreasing pH, EC and ESP of all the soil. Effect on available nutrients in soil after harvest of wheat and the highest OC (0.73%), available P_2O_5 (65.71 kg ha^{-1}), available K_2O (207.1 kg ha^{-1}) content in soil was recorded when vermicompost applied at 4.0 t ha^{-1} followed by sulphur and gypsum, but available S was the highest in sulphur treatments. The plant height & grain yield of wheat crop was the highest under application of vermicompost at 4.0 t ha^{-1}. Nutrient content of wheat straw and grain *viz.*, N, P, K and micronutrients like Fe, Mn, Zn and Cu were highest under the vermicompost treatments. The overall effect of vermicompost at 4.0 t ha^{-1} was found better for the amelioration of sodic soils as compared to gypsum and sulphur.

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Effect of Different Levels and Sources of Sulphur on Soil Properties, Yield and Nutrient Uptake by Mustard (*Brassica juncea* L.)

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A field experiment was carried out at Research Farm, Narendra Deva University of Agriculture & Technology, (Kumarganj), Ayodhya (U.P.). During *Rabi* season 2015-16 to study the effect of different levels and sources of sulphur on soil properties, yield and nutrient uptake by mustard (*Brassica juncea* L.). The trial was laid out in Randomized Block Design. Seven treatments *viz.* RDF (NPK: 120:60:60 kg ha^{-1}), RDF + 20 kg S ha^{-1} through SSP, RDF + 40 kg S ha^{-1} through SSP, RDF + 20 kg S ha^{-1} through Sulphur Bentonite, RDF + 40 kg S ha^{-1} through Sulphur Bentonite, RDF + 20 kg S ha^{-1} through Phosphogypsum, RDF + 40 kg S ha^{-1} through phosphogypsum with three replications on silt loam soils.

The growth characters like plant height, number of branches were significantly higher under RDF + 40 kg S ha^{-1} through SSP as compared to other treatments. The yield components like number of siliqua $plant^{-1}$, length of siliqua (cm), grain yield (t ha^{-1}) and stover yield (t ha^{-1}) were significantly higher under RDF + 40 kg S ha^{-1} through SSP.

The oil content in grain and N, P, K, S content and uptake in crop were obtained higher with RDF + 40 kg S ha^{-1} through SSP which was significantly higher than rest of treatments. The soil pH , EC and OC in soil of experimental field were not influenced significantly due to different levels and sources of sulphur, but available N, P, K, S were significantly maximum with the treatment RDF + 40 kg S ha^{-1} through SSP. The maximum net return (Rs. 41553 ha^{-1}) and B-C ratio (1.70) were obtained at RDF + 40 kg S ha^{-1} through SSP. Thus, it can be concluded that a dose of RDF + 40 kg S ha^{-1} through SSP may be most suitable nutrient combination for achieving higher yield , better seed quality and economics of mustard.

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Effect of Boron on Yield and Growth Characteristic of Urd Bean (*Vigna mungo* L.) in District Varanasi

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The micronutrient boron is an essential element required for the growth and development of (*Vigna mungo* L.) plant. Boron act as new cell developer in meristematic tissue, fruit and seed setting; is involved in regulation of the carbohydrate metabolism and its transport within the plant. Boron is associated with the reproductive phase in plant and its deficiency is often found to be associated with sterility and malformation of reproductive organs, consequently, limiting the yield. To study the effect of boron on growth and yield of Urdbean (*Vigna mungo* L.) a field experiment was conducted adopting randomized block design with six treatments and three, replications. Observation were recorded on the effect of treatments on urdbean, growth attributes (plant height number of branches), yield attributes (pods per plant, test weight, grain and stover yield) and nutrient status. With the boron application increase in the plant height, number of branches, number of pods and grain & stover was noticed. Based on the result of the study, it could be concluded that application of boron is essential for better growth and yield of urdbean as compared to without boron. Besides the yield advantage, residual soil fertility in terms of organic carbon, available nitrogen, phosphorus and boron was also improved.

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Effect of Lime, Zinc and Boron on Yield and Nutrient Uptake by Soybean

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A field experiment was conducted at Botany farm, College of Agriculture, Dapoli Konkan (Maharashtra) to study the effect of lime, zinc and boron on soybean yield and uptake of nutrients. The experiment was laid out in randomized block design with nine treatments and three replications. The treatments included absolute control, RDF and two levels of liming *i.e.* ½ L.R. and 1 L.R. in combination with soil and foliar application of Zn and B singly or in combination. The soil of the experimental plot was lateritic (Alfisol) and acidic in reaction. It was very high in organic carbon, moderately high in available N, low in available P_2O_5 and very high in available K_2O. The soil was deficient to marginal in Zn and B. The results of the experiment showed significantly increased the grain (2.552 t ha^{-1}) and straw (3.729 t ha^{-1}) yield of soybean due to application of RDF + 1 L.R.+ Zn @ 20 kg $ZnSO_4$ ha^{-1} + B @ 5 kg Borax ha^{-1} through soil application + Zn and B as foliar application @ 0.5 per cent $ZnSO_4$ and 0.1 per cent Borax, respectively. The uptake of N, P, K, Ca, Mg and S by soybean was also significantly increased by this treatment.

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Energy and Nutrient Balance Studies in Rice-based Cropping Systems under Partially Reclaimed Sodic Soil

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A Field experiment was conducted with eight different rice-based cropping sequences for four consecutive years (2012-13 to 2015-16) to work out the energy and nutrient balances under partially reclaimed sodic soil (pH 8.4, ECe- 4.2 dSm^{-1}). Among tested sequences, Rice-potato-green gram cropping system was found to be the most exhaustive cropping system which removed maximum quantities of N (299 kg ha^{-1} yr^{-1}), P (50 kg ha^{-1} yr^{-1}), K (354 kg ha^{-1} yr^{-1}), followed by rice-frenchbean-okra system, having corresponding values 286, 46 and 339 kg ha^{-1} $year^{-1}$. Systems including vegetable crops showed maximum positive N balance owing to the addition of 10-15 t FYM ha^{-1} yr^{-1} in vegetables. Phosphorus balance was found to be positive in all the systems ranging from 23 to 76 kg ha^{-1} yr^{-1}. The highest gap between addition and removal was observed in potassium, for which balance was negative in all the systems. Heavy removal of N and K by fodder crops also resulted in negative balance of N and K. The results indicate an alarming situation in terms of mining of indigenous K. Inclusion of pulses and vegetables in the system with turning their crop residues into the soil after harvest markedly improved the organic carbon and available NPK content in the soil. The systems included vegetables and pulses required more input energy as compared to the systems having fodder and pulse crops, while the reverse was true for the total output energy. The result showed that maximum net energy (balance) was obtained from rice-lentil-sudanchari (442.0 × 103 MJ ha^{-1}), rice-gram-maize + cowpea (377.40 × 103 MJ ha^{-1}), while the systems having vegetable crops *viz.* rice-cauliflower-cowpea (veg.) (168.25 × 103 MJ ha^{-1}) cropping system showed minimum net energy. The intensification of the system by fodder and pulse crops were proved more energy efficient and energy productive than conventional rice-wheat system.

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Technique to Reduce Animal Malnutrition by Enrichment of Oats Fodder with Zinc through Biofortification

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Micronutrients such as Zn deficiency in soil affect yield and quality of forage crops severely. In oats production, main constraint in achieving crop full potential is imbalanced and overuse use of fertilizers which results into micronutrients deficiency *viz.* Zn, Cu, Fe and Mn in crop's grain and straw. Keeping this in view a field experiment was conducted at Research Farm of PAU, Ludhiana and KVK, Taran. The experiment was laid out in randomized block design with eight treatments which consists of Control, Soil application of Zn @ 25 kg ha^{-1}, Soil + foliar application of Zn @ 0.5% at 60 days after sowing (DAS) (jointing stage), Soil + foliar application of Zn @ 0.5% at 90 DAS (booting stage), Soil + foliar application of Zn @ 0.5% at 60 DAS (jointing stage) and 90DAS (booting stage), Foliar application of Zn @ 0.5% at 60 DAS (jointing), Foliar application of Zn @ 0.5% at 90 DAS (booting stage), Foliar application of Zn @ 0.5% at 60 DAS (jointing stage) and 90 DAS (booting stage) with three replications. Application of Zn had significant effect on Zn concentration in oats at 110 DAS of oats fodder. At 110 DAS maximum Zn concentration was observed with T5 (soil Zn @ 25 kg ha^{-1} + 0.5% foliar Zn at 60 and 90 DAS) which was 70.7 mg kg^{-1} and 69.2 mg kg^{-1} at both Locations resulting in increases in Zn concentration by 100 percent over the control. Zn application had significant effect on Zn uptake by oats fodder. The data on Zn uptake revealed that increase of 170.1 and 192.6 per cent was recorded over the control with treatment receiving soil Zn @ 25 kg ha^{-1} + 0.5% foliar Zn at 60 and 90 DAS at location-I and location-II respectively.

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Distribution of Chemical Fractions of Mn in Soils under Different Land-uses in South-Western Plains of Punjab, India

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The present study was conducted to study the distribution of chemical fractions of Mn in soils under three land-uses *viz.* cropland (cotton-wheat), horticultural land (Guava) and uncultivated land. Samples were collected from Dhanaula (30°18′N, 75°27′E), Bhucho (30°15′N, 75°03′E) and Phul (30°19′N, 75°14′E) of south-western Punjab from four depths (0-15, 15-30, 30-60 and 60-90 cm) and were analyzed for selected basic parameters along with total Mn and its fractions. Soils were slightly saline in nature and sandy loam to loamy sand in texture. SOC content followed an order horticulture > cropland > uncultivated land in upper two layers while a different trend of horticulture > uncultivated land > cropland was recorded in two subsequent layers. The total Mn content varied from 147.83-200.17 mg kg^{-1}. Total Mn and its fractions were recorded higher under horticulture over croplands and uncultivated lands pronounced in 0-15 cm depth. Sudden rise in concentration of total Mn and most of fractions beyond 30 cm might be due to their positive correlation with finer particles that increased with depth. The fractions exhibited a trend of Residual (RES) > Mn-oxide bound (MnOX) > crystalline Fe-oxides bound (CFeOX) > amorphous Fe-oxides bound (AFeOX) > specifically adsorbed (SpAd) > organically bound (OM) > water soluble + exchangeable (WSEX) fraction. The dominance of RES-Mn might be due to presence of oxides and clays providing reactive sites for the chemisorptions of Mn which is almost irreversible. Greater WSEX and SpAd fractions under horticulture might be attributed to the higher organic matter input under orchards they exhibited significant positive relationships ($R2$WSEX=0.661, P<0.05; SpAd $R2$SpAd=0.814, P<0.01) with SOC. Again, higher concentration of WSEX fractions in horticultural land-use indicated their mobilization from occluded fractions viz., CFeOX and AFeOX to bound fractions due to presence of higher amount of OC.

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Long Term Effects of Manures and fertilizers on Productivity, Soil Biological Properties and Apparent Balance of Nutrients in Soybean-Safflower Cropping Sequence in Vertisol

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Long term effects of manures and fertilizers on productivity, soil biological properties and nutrient balance in soil under soybean-safflower cropping sequence were monitored after 10th and 11th years of experimentation in the year of 2015-16 and 2016-17. The treatments comprised of 50% NPK, 100% NPK, 150%NPK, 100%NPKwith hand weeding,100%NPK + Zn, 100%NP, 100%N, 100% NPK + FYM @ 5t ha^{-1}, 100%NPK-S, only FYM @10 t ha^{-1} and absolute control. The result indicated that soybean and safflower yields were highest with 100%NPK + FYM @ 5 t ha^{-1}, this treatment also gave maximum and significantly more counts of bacteria and actinomycetes than all other treatments except fungi in only FYM @ 10 t ha^{-1} after crop harvest. The soil microbial biomass C, soil microbial biomass N after soybean safflower were highest with 100% NPK + FYM @ 5 t ha^{-1} which were significantly higher over all the other treatments. The activities of soil enzymes like dehydrogenase, acid phosphatase and alkaline phosphatase and Co_2 evolution rate with 100% NPK + FYM @ 5 t ha^{-1} were also found significantly higher over the other treatments. Fertilizer treatments with 100% NPK and 150% NPK were comparable and significantly better than application of 50% NPK, 100% NP, 100% N and 100% NPK (-S) in various studied in soil biological properties. Integrated use of 100% NPK with FYM sustained the higher yields and soil biological properties under soybean safflower cropping sequence in Vertisol. The maximum and positive apparent balance of nitrogen (32.13 and 33.68%), phosphorous (12.25 and 12.75%) and potassium (1.99 and 1.88%) were recorded by INM treatments than imbalance use of fertilization after harvest of both the crops in consecutive years of experimentation.

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Effect of Farm Yard Manure and Vermicompost on Yield of Tomato (*Solanum lycopersicum* L.) and Residual Fertility of Inceptisol of Varanasi, Uttar Pradesh

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Organic farming provides quality 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 clay loam (Inceptisol) soil during *rabi* 2018-19 with tomato cv. Kashi Vishesh using farm yard manure (FYM) and vermicompost (VC). The experiment comprised of 11 treatments *viz.* T1 (control), T2 (FYM @ 4.5 g kg^{-1} soil), T3 (FYM @ 9.0 g kg^{-1} soil), T4 (FYM @ 13.5 g kg^{-1} soil), T5 (VC @ 4.5 g kg^{-1} soil), T6 (VC @ 9.0 g kg^{-1} soil), T7 (VC @ 13.5 g kg^{-1} soil), T8 (50 per cent N and full dose of P and K through fertilizer + 50 per cent N through FYM), T9 (50 per cent N and full dose of P and K through fertilizer + 50 per cent N through VC), T10 (50 per cent N and full dose of P and K through fertilizer + 25 per cent N through FYM + 25 per cent N through VC) and T11 (N, P and K from inorganic fertilizer). Urea, diammonium phosphate (DAP) and muriate of potash (MOP) were used as fertilizer. Experiment result showed that the highest tomato yield was found with VC @ 4.5 g kg^{-1} soil (T5) which is 1.5 and 78.89 per cent higher as compared to that recorded with T11 and T1 respectively. VC @ 13.5 g kg^{-1} soil (T7) showed increased plant available N, P and K content in soil after harvesting of crop which were at par with VC treatment @ 4.5 and 9.0 g kg^{-1} and FYM @ 9.0 and 13.5 g kg^{-1} soil. The study indicated that the application of FYM and VC resulted in higher tomato yield and found beneficial for improving soil fertility.

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Effect of Various Amendments on Properties of Sodic Soil and Performance of Greengram

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The field experiment was carried out to study the effect of various amendments on properties of sodic soil and performance of greengram to know the reclaiming ability of different amendments in sodic soils in combination with seed priming chemical at Anbil Dharmalingam Agricultural College and Research Institute, Trichy, Tamil Nadu. The experiment comprised of eight treatments *viz.*, 50% GR (T1), pressmud @ 20 t ha^{-1} (T2), aluminium sulphate @ 2 t ha^{-1} (T3), 25% GR + pressmud @ 10 t ha^{-1} (T4), 25% GR + aluminium sulphate @ 1 t ha^{-1} (T5), aluminium sulphate @ 1 t ha^{-1} + pressmud @ 10 t ha^{-1} (T6), 12.5% GR + pressmud @ 5 t ha^{-1} + aluminium sulphate @ 0.5 t ha^{-1} (T7) and control (T8) were imposed. Field experiment was laid out in Factorial Randomized Block Design (FRBD) using greengram variety Vamban-2 as test crop and replicated thrice. Recommended dose of fertilizers were applied to all the treatments. Two factors maintained were seeds soaked with distilled water (F1) and seed treatment and foliar spray at growth stages of crop with 80 µM SNP (F2) respectively. The results of field experiment revealed that application of gypsum @ 50% GR + pressmud @ 10 t ha^{-1} recorded significantly higher grain yield and significantly reduced the soil pH (9.02 to 7.85), exchangeable sodium percentage (22.15 to 14.36) and also increased the nutrient availability.

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Effect of Integrated Use of Chemical Fertilizers, FYM and Bio-fertilizers on Crop Productivity and Soil Fertility under Onion (*Allium cepa* L.)

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A field experiment was conducted during 2016-17 to evaluate the influence of integrated use of chemical fertilizers, FYM and bio-fertilizers on crop productivity and soil fertility under onion. The treatments were control (T1), 50% NPK (T2), 50% NPK + FYM (10 t ha^{-1}) + VAM (10 kg ha^{-1}) (T3), 100% NPK (T4), 100% NPK + FYM (10 t ha^{-1}) + VAM (10 kg ha^{-1}) (T5), 150% NPK (T6), 150% NPK + FYM (10 t ha^{-1}) + VAM (10 kg ha^{-1}) (T7) and FYM (10 t ha^{-1}) + VAM (10 kg ha^{-1}) + PSB + Azotobacter (T8). Application of 100% NPK along with FYM (10 t ha^{-1}) and VAM (10 kg ha^{-1}) *i.e.* T5 significantly increased the growth and yield as well as soil fertility status as compared to chemical fertilizers alone. Significantly higher plant height, number of leaves per plant, bulb diameter and bulb yield of onion and soil properties in terms of organic carbon, available NPK and S were obtained with application of 100% NPK + FYM (10 tons ha^{-1}) + VAM (10 kg ha^{-1}) (T5) in comparison to other treatments. Significantly higher NPKS uptake was also observed with T5. This experiment indicated the superiority of integration between chemical fertilizers; FYM and bio-fertilizer (VAM) over chemical fertilizer alone at all level of fertility.

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Effect of Integrated use of NPKZn and FYM on Soil properties and Performance of Mustard (*Brassica juncea* L.)

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A field experiment was conducted during winter (*rabi*) season of 2016-17 in the Research Farm of Udai Pratap College, Varanasi to evaluate the effect of conjunctive use of NPKZn and FYM on mustard growth and yield. The experiment was conducted in randomized block design with 3 replications. The treatments were control (T1), 100% NPK + Zn (T2), 100% NPK + FYM (10 t ha^{-1}) + Zn (T3), 125% NPK + Zn (T4), 150% NPK + Zn and 50% NPK + FYM (10 t ha^{-1}) + Zn (T6). Application of 100% NPK + FYM (10 t ha^{-1}) + Zn (T3) significantly increased the growth and yield as well as improved soil fertility status as compared to chemical fertilizers alone. Significantly higher plant height, effective branch $plant^{-1}$, Grain $siliqua^{-1}$, grain and straw yield, oil content and soil properties in terms of organic carbon, available NPK and S were obtained with application of 100% NPK + FYM (10 t ha^{-1}) + Zn (T3) in comparison to other treatments. Significantly higher NPKS uptake was also observed with application of 100% NPK + FYM (10 t ha^{-1}) + Zn (T3). Results of this field trail indicated the superiority of integration between chemical fertilizer and bio-fertilizer over chemical fertilizer alone at all level of fertility.

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Effect of Antitranspirants Application on Nutrient Uptake by Rice Grown under Water Stressed Condition

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A pot experiment was carried out to find out the effect of application of leaf reflectance type antitranspirants, *viz*. Kaolin and Green Miracle on nutrient uptake grown under water stress condition in Varanasi, Uttar Pradesh. The present investigation was conducted in net house and rice (HUR-105) was grown under water stressed condition. The Kaolin (0%, 4%, 6% and 8%) and Green Miracle (0.0%, 0.15%, 0.3% and 0.6%) water suspension/solution respectively, were sprayed twice *viz.* in during vegetative stage (50 days after transplanting) and panicle initiation stage (70 days after transplanting). Results indicated that nutrient uptake by rice was not significantly affected by antitranspirants treatments, but interaction between water levels and antitranspirants significantly affect the nitrogen, potassium and sulfur uptake. The highest nutrient uptake *viz.* N, P and K was associated with submerged condition. Kaolin application as antitranspirants under water stress was performed better than long chain fatty alcohol antitranspirants (Green Miracle) in rice grown in inceptisol of Varanasi, Uttar Pradesh.

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Impact of Improved Sulphur Formulations on Nutrient Acquisition by Mustard in an Inceptisol

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Allocation of essential nutrients to plants is important function of soil out of many priorities in the present perspective. Sulphur (S) is becoming the 4th most important nutrients after N, P and K whose deficiency can severely limit the growth and yield of crops especially oilseeds. Intensive agriculture along with use of high analysis fertilizers free of secondary nutrients like S and continuous ignorance making soil deficient in S. In order to correct S deficiency and improve the efficiency of traditional sulphur fertilizer a field experiment was conducted to evaluate the effect of improved S formulations on nutrient acquisition by mustard in an inceptisol. The experiment was carried out in sandy loam soil with pH 7.65 and EC 0.24 dS m^{-1} at agriculture farm, Banaras Hindu University, situated at an altitude of 87m above MSL and on 25°18′ N latitude, 83°03′ E longitude. Experiment consist of 6 treatments replicated 3 times which include absolute control, gromor sulphamax @ 10 kg $acre^{-1}$, gromor rapid blue @ 5, 7.5 and 10 kg $acre^{-1}$ and micronized S @ 3 kg $acre^{-1}$. From the experimental results it was revealed that micronized S proves most efficient in reference to sulphur while S uptake was found highest when gromor rapid blue was applied @ 7.5 kg $acre^{-1}$ which is 82% more than absolute control.

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Responses of Organic Potassium Fertilizer on Nutrient Uptake Pattern of Rice and Soil Fertility

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India is dependent on foreign countries (Canada, Belarus, Israel *etc.*) in terms of potassium fertilizers. For minimization of foreign investments and establishment of organic sources of K for organic farming in India, a pot experiment was conducted with thirteen treatments and three repetitions in CRD in *kharif* season of 2018-19 at net house of Banaras Hindu University in Varanasi. Organic sources of potassium *viz.* potassium citrate (KC), potassium gluconate (KG), potassium humate (KH) were applied as foliar spray (50%, 100% and 200% of RDF of K) or in combination with inorganic source *i.e.* potassium sulfate (KS). Both grain yield (41.0 g pot^{-1} to 56.1 g pot^{-1}), straw yield (167.3 g pot^{-1} to 224.3 g pot^{-1}) and root biomass (24.1 g pot^{-1} to 35.3 g pot^{-1}) were significantly increased over absolute control treatment by the treatments of 50% of RDF-K as basal application of KS and 50% of RDF of K as foliar spraying of organic fertilizers. Nitrogen, phosphorus, potassium and sulfur contents of both straw and grain were positively influenced with the application of organic potassium fertilizers. There was hike in nitrogen uptake (0.698 g pot^{-1} to 0.979 g pot^{-1}), phosphorus uptake (0.119 g pot^{-1} to 0.182 g pot^{-1}), potassium uptake (0.590 to 1.433 g pot^{-1}) and sulfur uptake (0.052 g pot^{-1} to 0.111 g pot^{-1}) of rice with use of organic potassium fertilizers. Soil fertility status was also influenced as soil organic carbon content (4.67 to 6.86 g kg^{-1} soil), plant available N (105 to 126.33 mg kg^{-1} soil), available P (10.4 to 13.66 mg kg^{-1} soil), available K (118.83 to 136.31 mg kg^{-1} soil), available S (4.62 to 8.24 mg kg^{-1} soil) were also influenced with application of organic potassium fertilizers. KC and KG (present in fruit peels) and KH (extractable from lignite coal) could be used as alternative sources of K for plant nutrition both in INM and organic farming.

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Effect of Foliar Application of Manganese on Wheat (*Triticum aestivum* L.) Grown under Rice-wheat Cropping System in South-western Punjab

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Manganese deficiency in light textured soils has been severely affecting the growth and grain yield of wheat sown after rice in a rice-wheat cropping system. On-farm trials (OFTs) were therefore, conducted at nine different farmers' field locations during 2016-17 and 2017-18 to assess the effect of foliar application of 0.5% $MnSO_4$ on wheat grown on Mn deficient soils (DTPA-Mn < 3.5 mg kg^{-1}). Three treatments *viz.* farmers' practice (T1): two sprays of 0.5% $MnSO_4$ at weekly interval on appearance of deficiency symptoms, recommended practice (T2): four foliar sprays at weekly interval starting from three days before first irrigation to wheat, and an intervention (T3): three sprays at weekly interval starting from three days before 1st irrigation, and 4th spray at ear emergence were compared at all the locations. Data pooled for two years revealed that wheat grain yield varied between 41.0 and 45.8 q ha^{-1} in T1, compared with between 46.5 and 51.5 q ha^{-1} with recommended practices (T2). In comparison, intervention resulted in wheat grain yield between 49.3 and 52.3 q ha^{-1}. Four foliar sprays of 0.5% $MnSO_4$ (T2) resulted in wheat grain yield by 11.4% compared with T1 of two foliar applications of $MnSO_4$ on appearance of Mn deficiency symptoms on crop. However, four sprays of 0.5% $MnSO_4$ (T3) resulted in 15.2% increase in wheat grain yield, compared with T1. It was also observed that four foliar sprays of 0.5% $MnSO_4$ resulted in complete amelioration of Mn deficiency and disappearance of deficiency symptoms on wheat crop.

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Soil Test Crop Response based Fertilizer Recommendations under Integrated Nutrient Management for Higher Productivity of Rice

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An Experiment was conducted during *kharif* season 2018 at farmer's field, in the village Lahiya of Varanasi District, to study the impact of nutrient management technologies under irrigated rice in alluvial soil with concentrated organic manure and various levels of inorganic fertilizers targeted yield of rice (4.0 t ha^{-1}) and (5.0 t ha^{-1}) have been achieved by using the plant nutrients on the basis of targeted yield concept STCR (soil test crop response technology). Results of the experiment indicated that in the location, the achievement of the target yield was within + 5% variations proving the validity of the equations for prescribing integrated fertilizer doses for rice. The highest increment in yield was recorded with yield target of 5.0 t ha^{-1} (38.70%) followed by 4.0 t ha^{-1} (18.31%) over RDF. The highest grain yield and benefit cost ratio were recorded in target yield of 5.0 t ha^{-1}. The remarkable net benefit of rice transplanted at location (Rs. 33,140.00 and Rs. 39,201.00) under treatments where plant nutrients applied as per soil test value (STCR treatment). Though fertilization significantly improved the rice productivity over control, the application of NPK and FYM in combination was found more effective in increasing rice productivity than their application alone.

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Productivity Trends of Pearl Millet - Mustard Cropping Sequence under Continuous Fertilizations in an Alluvial Soils

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The fertilizer use was becoming a key factor for increasing agricultural production and its consumption was increasing rapidly year after year, so a need was felt for studying the long term impact of fertilizer application on increasing crop yield and improvement in soil fertility and environment under intensive cropping systems. Keeping this views the experiment being conducted since 2003 under pearlmillet - mustard sequence in an alluvial soil (typicustochrept) of Gwalior with different nutrient combinations of N, P and K alone or with FYM. Under present study pooled data of 12 years (2003-2015) was analysis and the results indicate that various nutrient treatments significantly increased the grain yield over control. Continuous cropping without inorganic fertilizers reduced the yield from 2030 to 1743. In general reduction in yield was recorded year after year. Maximum grain yield was recorded in 100% NPK + FYM +Azo. + PSB and was higher over remaining treatments. It is interesting to note that this trend was found in each year of experimentation. This was followed by 100% NPK + FYM, but was at par with 150% NPK. Gradual reduction in mustard seed yield year after year was recorded by omitting P and S and K from fertilizer schedule. Thus it appears that besides P, S also is a major limiting nutrient for sustainability of mustard yield. It is thus obvious that imbalanced use of 100% N, 100% NP and 100% NPK-S could not sustain high productivity of mustard. There was a gradual decline in the yield over a period of cropping. Graded level of NPK also could not produce sustainable yield, although 50% and 75% gave higher yield over control but much less than 100%. However for marginal farmers who cannot afford much investment having limited resources can opt 50 & 75% NPK levels.

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Impact of Integrated Nutrient Management on Yield and Nutrient Uptake of Wheat (*Triticum aestivum* L .)

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A field experiment was conducted during *Rabi* Season of 2018-19 on wheat crop in sandy loam soil at the pot culture house of Department of Soil Science and Agricultural Chemistry, C.S. Azad University of Agriculture and Technology, Kanpur with the objective of to studying the influence of integrated nutrient management practice on productivity and nutrient uptake of wheat crop. The eight treatment combination ie. (T1) Control (T2) N120P60 (T3) N120K60 (T4) N120P60K60 (T5) N120 + FYM 10 t ha^{-1} + PSB 10 kg ha^{-1} (T6)N120P60 + FYM 10 t ha^{-1} + PSB 10 kg ha^{-1} (T7) N120K60 + FYM 10 t ha^{-1} + PSB 10 kg ha^{-1} (T8) N120P60K60 + FYM 10 t ha^{-1} + PSB 10 kg ha^{-1}were evaluated in Randomized Block Design with three replications. Result showed that maximum grain yield of wheat (5.28 t ha^{-1}) was noted with (T8) N120P60K60 + FYM 10 t ha^{-1} + PSB 10 kg ha^{-1}. The yield was at par to T6 & T7 in which K and P was omitted respectively in the treatment of T8.

The grain yield at T6, T7 and T8 were recorded as 5.1,5.0 and 5.2 t ha^{-1} respectively and these all three treatments found significantly superior over all rest treatment under study. Straw yield of wheat noted as 8.4, 8.3 and 8.1 t ha^{-1} at T6, T7 and T8 respectively. Significant increased in straw yield observed in T6, T7 & T8 treatments over other treatments. Highest NPK uptake 102.74, 21.02 and 11.76 kg ha^{-1} in wheat grain & 39.29, 14.30 and 149.87 kg ha^{-1} in straw respectively recorded with T8. Exclusions of P and K from T8 did not differ significantly in nutrient uptake of wheat crop. Omission of P reduced yield and nutrient uptake more than omission of K from treatment of T8.

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Impact of Soil Test and Targeted Yield Based Integrated Fertilization on Productivity and Economics of Rice-Wheat Cropping Sequence

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A field experiment was conducted during two consecutive years of 2014-15 and 2015-16 at the Research Field of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur, to evaluate the impact of soil test and targeted yield based integrated fertilization on productivity and economics of rice and wheat under rice-wheat cropping sequence. Experiment was laid out in permanent plots with six treatments (T1: Control; T2: GRD; T3: T.Y. 50 q ha^{-1} for rice and 45 q ha^{-1} for wheat; T4: T.Y. 6.0 t ha^{-1}; T5: T.Y. 5.0 t ha^{-1} for rice and 4.5 t ha^{-1} for wheat + FYM 5 t ha^{-1} and T6: T.Y. 6.0 t + FYM 5 t ha^{-1}) of nutrients application based on soil test values and targeted yield of rice and wheat which were replicated four times in randomized block design. Integrated effect of applied nutrients significantly increased grain yields of rice and wheat and maximum average yields of rice (5.8 t ha^{-1}) and wheat (5.3 t ha^{-1}) of both the years were recorded with higher fixed targeted yield of 60 q with FYM 5 t ha^{-1} (T6), which were deviated by ± 2.65 and 10.10 per cent, respectively. However, the minimum grain yields of rice (2.8 t ha^{-1}) and wheat (2.6 t ha^{-1}) were registered under control. The highest average response (2.9 and 2.7 t ha^{-1}) and cost of response (Rs. 45940 and 45635 ha^{-1}) in rice and wheat were obtained with higher fixed targeted yield of 6.0 t + FYM 5 t ha^{-1} in both rice and wheat crops, However, the average B:C ratio (3.49 and 7.87) and yard stick value (3.15 and 6.73) of rice and wheat were found maximum under treatment T3 having fixed targeted yield of 5.0 t ha^{-1} in rice and 4.5 t ha^{-1} in wheat crops, respectively.

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Performance of Rice grown in a Vertisol under STCR Approach

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A field experiment was conducted at the Research Field of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur during *kharif* season of 2015-16, to study the effect of soil test based fertilizers application integrated with and without organic manure on growth, quality and yield of rice grown in a Vertisol of Madhya Pradesh. The experiment consisting of six treatments based on soil test values and targeted yield of rice was laid in randomized block design with four replications. Results showed that significantly increased with maximum number of tillers (2.57, 6.83, 8.85 and 8.73 plant^{-1}) at 30, 60, 90 days after sowing and at harvest were recorded with application of 147, 117 and 64 kg N, P_2O_5 and K_2O integrated with 5 t FYM ha^{-1} (T6) over control. However, highest content of chlorophyll 'a' (1.68, 2.53, 1.97 and 1.73 mg g^{-1}) in rice leaves was obtained under treatment T6 having higher fixed targeted yield of 60 q ha^{-1} and minimum in control at 30, 45, 60 and 75 days after sowing. Further it was found that maximum grain (5.753 t ha^{-1}) and straw (7.573 t ha^{-1}) yields of rice were recorded under T6 consisted of highest doses of NPK by fertilizers integrated with 5 t FYM ha^{-1} which was significantly superior over rest of the treatments except T4 (5.3 and 7.1 t ha^{-1}) and T5 (5.1 and 6.987 t ha^{-1}) as those were statistically at par to T6. However, minimum grain and straw yields of 2817 and 4367 kg ha^{-1} were registered under control having without applied fertilizers. The integrated application of highest doses of NPK and FYM was increased grain yield by 51.03 and 27.12 per cent, respectively, over control and general recommended dose of rice.

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STCR based Gradient Experiment with Sorghum (*Sorghum bicolor* L.) to NPK Fertilizer in the Alluvial Soil

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To study the effect of N, P, K fertilizer on sorghum a gradient experiment was conducted at the Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India, during *rabi*, 2018-19. The aim of study was to developed fertilizer recommendation equation for cultivation of sorghum. $N_0P_0K_0$, $N_1P_1K_1$ and $N_2P_2K_2$, fertilizer level were applied to I, II, and III, respectively. NPK were applied through Urea single super phosphate and muriate of potash fertilizer respectively. Sorghum cv. CSH-9 was grown as a gradient crop. At harvest plant samples were collected and analysed for NPK content and calculated total uptake of nutrients. Grain and straw yield of sorghum were recorded. The result revealed that an application of graded levels of NPK fertilizer significantly influenced NPK uptake, grain and straw yield of sorghum.

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Effect of Mining Subsidence on Primary Macro Nutrient Content of Soil in South Eastern Coalfields Limited Region

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As a consequence of increased demand for coal, more and more coal are being mined and processed. The underground coal mining has caused a large amount of land subsidence leading to farmland losses and undulation of land surface. So, it was considered desirable to study the impact of underground mining subsidence on the land characteristics with particular reference to the availability of different nutrients and whether the wasteland of mining areas could be used for cultivation of crops. Soil samples were collected from six sites *i.e.*, unaffected site, crack-1, slope-1, maximum subsidence, crack-2 and slope-2 site of South Eastern Coalfields Limited region from 3 different depths *i.e.*, 0-15 cm, 15-30 cm, 30-45 cm. The available nitrogen was highest in soils of maximum subsidence site at all the three depths and was minimum in soils of crack-1 site at the depth of 0-15 cm and 15-30 cm whereas, at the depth of 30-45 cm, lowest available nitrogen was recorded in soils of slope-2 site. There existed a significant variation in available phosphorus content of soils in mining area at the depths of 0-15 cm, 15-30 cm and 30-45 cm. The maximum subsidence site had the highest available phosphorus content at all three depths. With the increase in slope, the available K content of soils increased from crack-1 site to maximum subsidence site at depths of 0-15 cm and 15-30 cm, whereas the same pattern was not followed in soils of 30-45 cm depth.

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Residual Effect of Nickel and its Interaction with Zinc on Growth and Yield of Cowpea Crop (*Vigna unguiculata*)

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Pot experiment was conducted to evaluate the residual effect of nickel on growth and yield of cowpea and on concentration and uptake of zinc by the crop and to study the residual effect of nickel on soil properties. The soils were previously cultivated with soybean crop and different treatment combinations of Ni and Zn were applied in replications and during the residual experiment, the soils were supplied with 2.5, 5 and 10 mg kg^{-1} zinc in different treatments by applying $ZnSO_4.7H_2O$. Nickel is known to be the main component of plant enzyme urease which helps in metabolism of urea nitrogen into usable ammonia in the plants. Experiment shows that the uptake and accumulation of zinc in plant tissue was more in the treatments where 5 and 10 mg kg^{-1} of Ni was applied as compared to the treatments where 2.5 mg kg^{-1} was applied or no Ni was applied at all. As the soil was already deficient in Ni status (collected from Sikhar block of Mirzapur district of Uttar Pradesh), the treatments where no Ni was applied (only recommended doses of nitrogen, potassium and phosphorus was applied) showed visual deficiency symptoms like chlorotic leaves with necrotic tips and the growth was also inhibited. Both vegetative and reproductive growth was adversely affected in the treatments where 20 mg kg^{-1} Ni was applied in the previous experiment and in the residual experiment 2.5 and 5 mg kg^{-1} Zn was applied. The number of flowers and pods were observed to be less in these treatments as compared to the treatments where the dose of Ni was same but more amount of Zn (10 mg kg^{-1}) was applied. However, toxicity symptoms like reduced chlorophyll content and dry weight was observed in all the treatments where 20 mg kg^{-1} Ni was applied, germination of seeds was delayed and senescence was also induced early as compared to other treatments. This study showed that positive interactions take place between nickel and zinc.

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Evaluation of Critical Limits of Iron in Soil for Pearl Millet Grown on Swell Shrink Soils

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Pot culture experiment was conducted at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule during *Kharif* 2018 to determine the critical limits of iron in swell shrink soils for pearl millet. Experiment was laid out in factorial completely randomized design comprising of three levels of iron status in soil *viz.*, low iron status soil (< 4 mg kg^{-1}), medium iron status soil (4-8 mg kg^{-1}), high iron status soil (> 8 mg kg^{-1}) as main treatments, two levels of iron application *viz.*, control and optimum level (25 kg $FeSO_4$ ha^{-1}) and three replications. The soil as above three categories was collected from different eighteen locations for filling the pots. Iron rich variety of pearl millet cv. Dhanshakti was used for the investigation. The nutrient uptake and Bray™ per cent yield of pearl millet were calculated. The critical levels of iron in soil were worked out according to graphical and statistical method of Cate and Nelson (1965 and 1971). As per the graphical method of Cate and Nelson (1965) the critical level of iron in soil for pearl millet was 5.25 mg kg^{-1}. However, as per the statistical method of Cate and Nelson (1971) the critical level of iron in soil for pearl millet was 5.26 mg kg^{-1}. The N, P, K, Fe and Zn uptake by pearl millet showed significant negative correlation with soil pH and $CaCO_3$ content and showed significant positive correlation with organic carbon content. The study concluded that application of balance fertilization along with iron containing fertilizer is essential for increasing the availability of the nutrients and their uptake by pearl millet. The iron rich and high yielding pearl millet variety Dhanshakti responds to the application of iron in soils having less than 5.25 mg kg^{-1} DTPA extractable Fe in swell shrink soils of Dhule region of Maharashtra.

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Effect of Vermicompost and Zinc Application on Soil Health and Productivity of Maize

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A field experiment on effect of vermicompost and zinc application on soil health and productivity of maize was conducted at the Instructional farm, Rajasthan College of Agriculture, MPUAT, Udaipur during *kharif,* 2018. The experiment consisted of 10 treatment comprising vermicompost and zinc and their combinations. The experiment was laid out in randomized block design with three replication. The soil of experimental field was sandy clay loam in texture having slight alkaline reaction. The results showed that application of vermicompost (4.5 t ha^{-1}) + zinc (5.0 kg ha^{-1}) recorded significantly increased plant height (30, 60 DAS and at harvest), leaf area index (30, 45, 60 DAS) and chlorophyll content in leaves at 45 DAS compared to control. Similarly, Application of vermicompost (4.5 t ha^{-1}) + zinc (5.0 kg ha^{-1}) found significantly superior in increasing number of grain cob^{-1} (457.09), weight of grain cob^{-1} (95.04 g), seed index (33.65 g), grain yield (3.896 t ha^{-1}), stover yield (5.415 t ha^{-1}) and biological yield (9.311 t ha^{-1}). The bulk density, particle density, porosity, pH and EC was found non-significant but organic carbon, nitrogen, phosphorus, potassium and micronutrient (Zn, Fe, Mn, Cu) was found significantly higher with the application of vermicompost (4.5 t ha^{-1}) + zinc (5.0 kg ha^{-1}).

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Impact of Long Term Fertilizer Application on Productivity of Soybean-wheat Cropping Sequence

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The present study was conducted under the ongoing all India Coordinated Research Project on Long-Term Fertilizer Experiment (AICRP-LTFE) with soybean-wheat sequence. This experiment was commenced from 1972 to assess the impact of continuous fertilizer application on productivity of soybean-wheat cropping sequence in black soil. 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. On the other hand, the deficiency of S with DAP addition manifested through yield reduction in comparison to SSP application. 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.

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Effect of Continuous Application of Fertilizers and Manure on Nutrient Status

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Knowledge about the fertility status of soils is of prime importance for its appropriate use and management for increased crop production. The present study was conducted under an ongoing AICRP on Long Term Fertilizer Experiment which was commenced from 1972 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP) to assess the effect of application of fertilizers and manure on nutrient availability under soybean-wheat cropping sequence. The findings revealed that the application of recommended dose of N, P and K with organic manure (FYM) @ 5 t ha^{-1} proved significantly superior treatment with respect to soil fertility. The results indicated that 100% NPK with 5 t FYM ha^{-1} improved the organic carbon content of soil over its initial value and observed a marked buildup of available P. The available S status was found to be declined over the years of experiments when sulphur was not included in fertilizer schedule. Thus, the integrated use of inorganic fertilizer and organic manure improved and sustain the soil fertility.

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Enhancement of Nutrient Uptake through Customized Fertilizers in Rice Crop (*Oryza sativa* L.)

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In India, fertilizers have contributed 60 per cent of recent increases in food production. Balanced fertilization is the major strategy used with an ideal N: P_2O_5: K_2O ratio of 1:0.5:0.25 for grain-based production systems. India is already in the era of multiple nutrient deficiencies with N, P, K, S and Zn being the most widespread. Nutrient depletion can be attributed to insufficient fertilizer use and imbalanced fertilization. The decline in productivity of rice with continuous cropping was related to the deficiency of P, K, S, Zn and imbalanced nutrition. Customized fertilizers are enriched with both macro and micro nutrients and are manufactured through a systemic process of granulation with stringent quality checks. In other words, customized fertilizer is a multi-nutrient carrier precisely tailored to meet specific basal nutritional needs of the crop. A field experiment was conducted at farmer's field near Narendra Deva University of Agriculture and Technology, Ayodhya, India. To apply the customized fertilizers (macro + micro nutrients) significantly improved uptake of N, P, and K nutrients over-application of RDF, farmer's practices and no fertilizer. The crop fertilized with STR (N-140: P_2O_5-60: K_2O-30: S-30:Zn-5: B-2 kg ha^{-1}) accumulated highest N, P, and K in grain and straw thereby significantly enhanced the total uptake of nitrogen, phosphorus and potassium as 18.62%, 21.23%, 16.91%, over T2 (RDF) and 35.19%, 41.30% and 35.32% over farmers practices, respectively. The application of Indo-Gulf Customized Fertilizer (N-30, P_2O_5-65, K_2O-45, S-12.5 & Zn-1.25 kg ha^{-1}) + N-115 kg ha^{-1} was found the next best treatment. The application of customized fertilizers (Indo-gulf and TCL customized fertilizers) proved equally effective however, both significantly improved N, P, and K uptake by grain, straw and total over no manure application. Application of balanced fertilization helped in maintaining soil fertility after crop harvest.

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Effect of Soil Application of Zinc on Growth, Yield, Zinc Use Efficiency and Bio-fortification of Zinc in Hybrid Rice Grown in Inceptisol of Varanasi

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Zinc (Zn) biofortification, not only gives better productivity of cereals but also highly beneficial for alleviation Zn malnutrition to improve human health. A pot experiment was conducted in completely randomized design at net house of the department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, during kharif 2018 to evaluate the efficacy of soil application of zinc on growth, yield, zinc use efficiency and biofortification of zinc by hybrid rice. Experiment comprised of ten treatments *viz.*, control, RDF, RDF along with 2.5,5,7.5,10,12.5,15,17.5 and 20 kg Zn ha^{-1}. Early maturing hybrid rice variety 'Arize 6444 Gold' was taken as a test crop. Significant effects were noted on yield components such as no of tiller, biological yield and harvest index. The maximum yield was recorded at 12.5 kg ha^{-1} Zn soil application which was 23.97% higher over RDF. It was found that with increase in Zn application, Zn use efficiency decreased. The maximum Zn use efficiency was recorded at 2.5 kg Zn ha^{-1} soil application. Zinc enrichment had significant positive impact on nitrogen and potassium concentration and negative on phosphorus, iron, magnesium, copper and boron concentration in both straw and grain. The maximum Zn enrichment in unpolished grain was recorded at 12.5 kg Zn ha^{-1} soil application. Zinc enrichment in unpolished grain had significant negative effect on phytate concentration. The lowest phytate in un polished grain was recorded at 15 kg ha^{-1} Zn application. Only 7-8 per cent of fortified Zn remain bioavailable to human. Soil application of Zn did not affect the postharvest soil properties like pH, EC and organic carbon content.

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Eco-friendly Utilization of Sugar and Distillery Industrial Waste on Growth Parameters and Yield of Rice

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Sugar and distillery industry wastes act as a potential source for organic matter and plant nutrients especially potassium. Value added productswere prepared from the molasses by biodigestion, evaporation and reverse osmosis.Theseare mainly of plant origin and helps to boost the soil health, fertility and improves the crop growth that leads to save the fertilizer cost. A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Trichy, Tamil Nadu using one of the value added product (K boost) from sugar industry with seven treatments comprising T1 (absolute control), T2 (50% STCR K through VAP), T3 (75% STCR K through VAP), T4 (100% STCR K through VAP), T5 (125% STCR K through VAP), T6 (50% STCR K through inorganic + 50% STCR K through VAP), T7 (100% STCR K through VAP) with three replications in randomized block designusing rice (TRY 3) as a test crop. The nitrogen and phosphorus was applied as inorganic fertilizers in all the treatments based on STCR recommendations.. The growth parameters like height of the plant, leaf length, leaf breadth, number of leaves, number of tillers per plant and yield were recorded during active tillering, panicle emergence and harvesting stage. The results revealed that application of value added product slowly and steadily released the nutrients and maintained the nutrient availability throughout the crop period, and hence increased the crop yield. Even though the growth parameters and crop yield were enhanced in the treatments receiving 75%, 100% and 125% and 100% STCR K through value added product, 75% STCR K through value added product could be best one economically. Hence the application of value added product might be a valuable substitute for inorganic potassium fertilizers and facilitate reduction in pollution load in the ecosystem to get sustainable production.

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Assessment of Ground Water Quality in the Jurisdiction of Sugar Factory at Kopargaon, Dist. Ahmednagar

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In present investigation assessment of groundwater quality in the jurisdiction of Karmaveer Shankarrao Kale Sahakari Sakhar Karkhana Ltd., Kopargaon, Dist. Ahmednagar was conducted during April 2017. The study was undertaken to assess the quality of ground water and its suitability for irrigation and also the extent of causing accumulation of heavy metals in ground water. The average value of pH and EC were 7.76 and 2.06 dS m^{-1}, respectively. The total cation concentration were in the range of 4.1 to 17.8 me L^{-1} Ca^{2+}, 3.6 to 10.3 me L^{-1} Mg^{2+}, 0.26 to 3.3 me L^{-1} Na^{+}, 0.01 to 0.27 me L^{-1} K^{+}. The cationic concentration in ground water were in following orders Ca^{2+}> Mg^{2+}> Na^{+}> K^{+}. The relative concentration of CO_3^{-} was absent. The HCO_3^{-} concentration was dominant in ground water. The total anion concentration were in the range of 4.4 to 15.4 me L^{-1} HCO_3^{-}, 2.1 to 9.3 me L^{-1} Cl^{-}, 2.9 to 9.2 me L^{-1} SO_4^{-}, 1.2 to 6.1 me L^{-1} NO_3^{-}. The relative proportions of anion were in the following order HCO_3^{-}> Cl^{-}>SO_4^{-}> NO_3^{-}. The average value of SAR, RSC, SSP and Ca:Mg ratio were 0.20, -9.50, 19.02 and 1.70 respectively. As per the rating of suitability classes the water samples were safe and suitable for irrigation. The amounts of organic constituent were measured mainly with biological oxygen demand and the average value of BOD was 8.5 which is safe for irrigation. The COD content of post biomethanated spentwash affected ground water samples was 43.25. The micronutrient and heavy metal content in ground water samples were found below permissible limit and it was safe for irrigation. Thus it is concluded that 65.45 percent samples were classified under C3S1 class and 34.55 per cent samples were classified under C4S1 class.

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Biochar and Carbon Sequestration

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Biochar is a soil amendment which contains charcoal and made from biomass by pyrolysis. Biochar can be an approach to carbon sequestration, as it has the potential to help mitigate climate change. Pyrolysis is the direct thermal decomposition of biomass in the absence of O_2 (preventing combustion), which produces a mixture of solids (biochar proper), liquid (bio-oil), and gas products is known as pyrolysis. The specific yield from the pyrolysis is directly influenced by condition, such as temperature, residence time and heating rate. Temperatures of 400-500 °C (673-773 K) produce more char, while temperatures above 700 °C (973 K) favor the yield of liquid and gas fuel components. The increasing heating rate will also lead to a decrease of pyrolysis biochar yield, while the temperature is in the range of 350-600 °C. Typical yields are 60% bio-oil, 20% biochar, and 20% syngas. Slow pyrolysis can produce substantially more char (≈35%).

At present the utilization of biochar to sequester carbon in the soil has received considerable research attention and this is also a climate smart agricultural practices. Biochar is basically carbon (70-80%) so it can potentially store more carbon than plant residue of similar mass. Furthermore, around 60% of this biochar OC is of high stability and therefore resists decomposition more-so than plant material that has not been processed into biochar. Soil texture plays a key role in determining the persistence of biochar carbon. Biochar becomes stabilized in the soil by interacting with soil particles.

In conclusion we can say that biochar is a burning topic for research study to mitigate the climate change and also for soil sustainability. However, many questions remain before definitive conclusions about what conditions allow for biochar to positively contribute to soil carbon sequestration.

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Status of Different Forms of Sulphur in Soils of Ashoknagar District of Madhya Pradesh

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Sulphur is one of the essential elements for plant growth. It is an important constituent of many enzymes and amino acids. Sulphur has been found to help the synthesis of amino acid and hence increase protein content of plants, boosts the oil content. In Indian agriculture, the information regarding different forms of S is very limited. Today, the S research has extended to various soils, crops and cropping systems and different sources of sulphur. Keeping in view, One hundred twenty five GPS based surface soil samples (0-15 cm) were collected from five blocks (Mugavali, Chanderi, Ishagarh, Ashoknagar and Sadora) of Ashoknagar district during April to May 2016. Soils were studied for their Physico-chemical and status of different forms of sulphur and their relationship with different soil properties.

The soil of Ashoknagar district of Madhya Pradesh is slightly alkaline in reaction and normal to soluble salts. Surface soil samples were non calcareous with low organic carbon content. The different forms of sulphur, *i.e.* water soluble, available, organic and total-S were observed in the range of 1.23-7.67, 4.36-40.25, 89.08-194.53 and 167.45-422.20 mg kg^{-1} under different villages of investigated area with the average value of 4.09, 14.68, 124.21 and 309.17 mg kg^{-1}, respectively. Out of 125 surface samples, 36 samples (28.8%) were found under deficient, 72 (57.6%) under medium and 17 (13.6%) samples was found in sufficient category. Availability of sulphur increased with an increase in organic carbon and clay content in soil It suggested that organic matter was main contributing factor affecting the sulphur availability in soil. Total S maintained a significant positive association with all the forms of sulphur. Such relationship suggests that sulphur exists in a state of dynamic equilibrium in these soils.

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Effect of Potassium and Zinc Solubilizing Micro-organism on Growth, Quality and Productivity of Mungbean

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A Field experiment was conducted during *kharif* season 2016-17 at experimental farm of Department of Soil Science and Agricultural Chemistry, College of Agriculture, Badnapur (Maharashtra) using mungbean as a test crop to studies on effect of potassium and zinc solubilizing micro-organism on growth, quality and productivity of mungbean. The experiment was laid out on Vertisols with five treatment combination, replicated four times in randomized block design. The results indicated that the seed inoculation with KSB and ZSB significantly increased highest number of total and effective number of nodules per plant, number of pods, dry matter production, total biomass production, quality parameter like protein content and grain yield (1229 kg ha^{-1}) over the rest of treatments. Therefore, potassium and zinc solubilizing micro-organism may be recommended for increasing growth and productivity of mungbean.

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Effect of Different Level of Zincobensulf Application on Growth and Productivity of Wheat

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A field experiment was conducted during *rabi* season 2017-18 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agricuture and Technology, Meerut (Uttar Pradesh) to evaluate the effect of different level of zincobensulf application on growth and productivity of wheat (*Triticum aestivum L.*). The area situated at a latitude of 290 40′ N and longitude of 770 42′ E with an elevation of 237 m above mean sea level. The soil of experimental field was well drained, sandy loam in texture, slightly alkaline in reaction (pH 8.01). It was low in organic carbon, available nitrogen and zinc, medium in available phosphorus, potassium and sulphur with an electrical conductivity of 0.30 dS m^{-1}. Nine treatments comprising recommended NPK, S, Zn and farmer's practice were tested in RBD with three replications. The crop was grown with the recommended package and practices for wheat with exception of zinc and sulphur application which was variable. The data on growth, yield and its contributing traits content and uptake of nutrients at harvest stage along with available NPK, S and Zn in soil were estimated as per the standard procedures. The result revealed that growth attributes (plant height, number of tillers), yield attributing traits (panicle length, number of grains per panicle and test weight), yields viz. grains, straw in wheat differ significantly among different treatments. The highest value recorded in the treatment T6 (RDF + Zinco bensulf @ 45 kg ha^{-1}).

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Nitrogen Management on Growth and Yield Attributing Character of Late Sown Wheat (*Triticum aestivum* L.) Crop

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A field experiment was conducted during *rabi* season 2016-17 at CRC of SVPUAT, Meerut to evaluate the nitrogen management for late sown wheat (*Triticum aestivum* L.) crop. The soil of the experimental field was well drained, sandy loam in texture, alkaline in reaction (pH 7.80), low in available N, and medium in available P and K with an EC 0.25 dS m^{-1}. Eleven treatments comprising Control, RDN for timely as well as late sown wheat with different application schedule were tested in RBD with three replications. The crop was grown with the recommended package and practices for wheat with exception of nitrogen application which was variable. The data on growth, yield and its contributing traits content and uptake of nutrients at various stages along with available NPK in soil were estimated as per the standard procedure. Growth parameters were significantly better in the treatments where major portion of N was applied during early growth period. The highest grain yield and harvest index was recorded in T8 where 60% of recommended N in accordance to timely sown wheat was applied at sowing. This treatment was found statistically similar to T4, T6 and T10. Growth and yield attributing character were comparatively higher in T8. Available nutrient in soil after harvest of wheat were variable under different treatments. From the study it may be concluded that application of nitrogen in accordance to late sown wheat recommendation is not sufficient and it should be increased. The effect of N application schedule on performance of late sown wheat was observed only with the nitrogen application on the basis of timely sown condition while no significant effect was observed in case of late sown condition.

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Influence of Integrated Nutrients on Ambrette Yield and its Post-Harvest Soil NPK Status

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Ambrette (*Abelmoschus moschatus* Medic.) is an aromatic and medicinal plant. It checks vomiting and cure diseases due to kapha and vatha and also useful in treating intestinal disorders. A field experiment was conducted at Sivapuri Village, Cuddalore (District), Tamilnadu during May to October, 2018. The treatments comprised of T1: Control, T2: 100% RDF, T3: 75% RDF-N (NCU), T4: 75% RDF-P (EPMC), T5: 75% RDF - N (NCU) + P (EPMC), T6: T3 + SWE, T7: T4 + SWE and T8: T5 + SWE. The experiment was laid out in a randomized block design with three replications. The trial was conducted with the RDF of 120: 30: 40 kg NPK ha^{-1}. Neem coated urea (NCU) prepared at 5:1 ratio by weight. Enriched pressmud compost prepared @ 1000 kg ha^{-1} with SSP. These were applied during field preparation as basal. Sea weed extract (SWE) was applied as foliar spray three times at 30 days interval. Ambrette was grown with proper cultural practices. The results revealed that application of 75% RDF + N(NCU) + P(EPMC) + SWE registered the highest yield (pod yield: 2361.32, seed yield: 1464.59 kg ha^{-1}, respectively). The post-harvest soil samples were collected and analyzed for their NPK status. There was a significant influence between the treatments and soil available nitrogen, phosphorus and potassium status. It was ranged between 192.27 to 224.81, 10.67 to 23.06 and 216.85 to 287.72 kg ha^{-1}, respectively

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Impact of Different Sources of Silica with Varying Levels through Soil and Foliar Application on Yield and Quality of Alphonso Mango in Soils of Konkan

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Mango is known as a "King of Fruits". The holdings of the farmers are very less in the coastal region of Maharashtra so the field crops could able to fulfill their own requirements only. Silicon is well known beneficial nutrient which helps in overcoming the abiotic stress. With consideration of all the facts an investigation entitled "Impact of different sources of silica with varying levels through soil and foliar application on yield and quality of alphonso mango soils of *Konkan* Region" was carried for consecutive two years. The objectives of study were to check the suitable source of silica for application to the mango tree which could be able to give the maximum yield and also to determine the rate of application through foliar and soil. For the experiment, four sources of silicon were used with three different levels. For foliar application two sources were used Stabilized silicic acid and potassium silicate however for soil application two sources were used calcium silicate and rice husk ash. The all above sources were varied with three different levels. The results were obtained from the study showed variations with the application of sources, the application of foliar spray of 1.5 ml L^{-1} ortho silicic acid through Silixol showed beneficial effect on per cent fruit retention, average weight of fruit and fruit yield at various stages. The foliar application of stabilized silicic acid *i.e.*, Silixol improves the quality parameter of fruits such as total soluble solid, total sugar, ascorbic acid, titratable acidity and pH. Foliar application of 1.5 ml L^{-1} Silixol increased the shelf life of fruit as compare to other treatments. Soil characteristic was not much affected by foliar application. Soil application of silica source *i.e.*, Rice Husk Ash was found to be beneficial in improvement of soil properties

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Evaluation of Rabi Maize Productivity through Application Method of Fertilizers

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Field experiments were conducted at farmers field of Katihar district by Krishi Vigyan Kendra, Katihar, (Bihar Agricultural University Sabour, Bhagalpur) during two consecutive years of 2015-16 and 2016-17 to study the impact of application method of fertilizers on productivity, fertility and economics of rabi maize. The experiment was laid out in alluvial soil with three treatments and ten replications in RBD. The details of treatments was {(T1–Farmer Practices (60:0: 0 :: N:P:K Basal + 50:40:20 N:P:K at 30 DAS + 30 kg N at 60 DAS), T2–RDF (60:60:40 :: N:P:K Basal + 45 kg N at 30 DAS+45 kg N at 60 DAS), T3–RDF (60:60:40:25 :: N:P:K:Zn Basal + 45 kg N at 30 DAS + 45 kg N at 60 DAS)}. Healthy and bold seeds of maize var. Pioneer 3522 were dibbled into the soil @ 1 seed hill^{-1} at a spacing of 60 cm × 20 cm. The growth and yield attributes of maize *viz.*, plant height, plant diameter, leaf length, leaf width, cob length, no of cob per plant, no of grains per cob, kernel and stove yield were significantly influenced by different method of nutrient application. There was a progressive increase in the growth and yield attributes with each application methods of nutrients applied from T1 to T2 and further increase in growth attributes were noticed when the graded levels fertility were supplemented with Zn as soil application T3. There was a gradual and progressive increase in growth and yield attributes with basal application of PK and zinc in comparison to T1 where PK applied at 30 days after sowing.

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Soil Nutrient Status and Nut Composition in Arecanut Orchards of Ratnagiri District of Konkan Region

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An investigation was conducted to study the soil nutrient status and nut composition of arecanut orchards of Ratnagiri district. The total of 160 soil samples from 80 villages at Dapoli, Mandangad, Khed, Chiplun, Sangameshwar, Guhagar, Ratnagiri, Lanja and Rajapur tehsils were collected at the depth of 0 to15 cm and 15 to 30 cm and analyzed for the soil properties *viz.*, soil reaction (pH), Electrical Conductivity (EC), Organic Carbon, Available N, Available P_2O_5, Available K_2O, DTPA extractable Fe, Mn, Zn and Cu. The 80 fruits samples collected from 80 villages of Ratnagiri district of Konkan region were analyzed for their macro and micro nutrient status.

It was observed that, the soil of the arecanut orchards of Ratnagiri district is strongly acidic to neutral in reaction and EC was in normal range, in case of organic carbon soils of arecanut orchards of Ratnagiri district were found medium to high in organic carbon, available nitrogen were found medium to moderately high, available phosphorus were found very low to medium and available potassium were found medium to high in arecanut orchards of Ratnagiri district. In case of DTPA extractable micronutrient Fe, Mn, Zn, Cu and hot water soluble B, all nutrients were found to be marginal to sufficient in the soils of arecanut orchards of Ratnagiri district of Konkan region. The total nitrogen, phosphorus and potassium in the fruit ranged from 0.98 to 0.476% with a mean value of 0.733%; 0.007 to 0.032% with a mean value of 0.019% and 0.007 to 0.036% with a mean value of 0.253% respectively amongst the all orchards of 80 villages under study.

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Residual Effect of Silicon and Sulphur Fertilization on Yield, Nutrient Content and Uptake after Harvest of Wheat Crop under Rice-Wheat Cropping Sequence

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The field experiment was conducted to study the residual effect of silicon and sulphur fertilization on yield, nutrient content and uptake after harvest of wheat crop under rice-wheat cropping sequence during the *kharif* and *rabi* seasons for two years 2016-17 and 2017-18 at Regional Research Station farm, AAU, Anand. The experiment was laid out in RBD with factorial concept, comprising twelve treatment combinations of four levels of silicon (Si) (0, 150, 300 and 450 kg ha^{-1}) and three levels of sulphur (S) (0, 20 and 40 kg ha^{-1}) with three replication were applied to rice as a basal along with RDF and the residual effect of treatments were studied in wheat crop.

The grain and straw yields of wheat were noticed significantly higher due to residual effect of 450 kg Si ha^{-1} and 40 kg S ha^{-1} which was at par with 300 kg Si ha^{-1} and 20 kg S ha^{-1} application. Significantly highest average Si content and uptake in grain and straw were found under residual effect of application of 450 kg Si ha^{-1} over rest of the treatments. The maximum average S content and uptake in grain and straw were noticed at maximum level of residual effect of 450 kg Si ha^{-1} and 40 kg S ha^{-1} application. Significantly higher P content and uptake in grain and straw of wheat was found under residual effect of application of 450 kg Si ha^{-1}. No significant change in S content in grain and straw were observed with residual effect of S application.

It is concluded that to get optimum residual effect on yield and improvement in nutrient status of wheat, application of 300 kg Si ha^{-1} and 20 kg S ha^{-1} with recommended dose of fertilizer are recommended in rice crop.

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Residual Effect of Biofertilizers Application in Mungbean on Succeeding Wheat and Soil Properties

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Residual effect of mungbean crop on succeeding cereal crops in terms of saving chemical fertilizers is well documented, however, information on the contribution of biofertilizer application component in mungbean on residual effect in terms of productivity of succeeding crop and soil health is scanty. Present study was conducted to examine the residual contribution of Biofertilizers (*Rhizobium* sp. and PGPR) application in mungbean (*Vigna radiata* L.) on productivity of succeeding wheat (*Triticum aestivum* L.) during 2017-18. Treatments in mungbean consisting inoculation with *Rhizobium* sp. PGPR (*Bacillus cereus*), *Rhizobium* sp. + PGPR, RDF and uninoculated control were randomized in main plots following split plot design. Each main plot was divided in to 3 sub plots after mungbean harvesting for raising succeeding wheat (cv. PBW 550) at 50, 75 and 100% of recommended N.

Irrespective of N levels, *Rhizobium* sp. and PGPR inoculation in mungbean resulted in 3.85 and 3.87 t ha^{-1} wheat grain yield as compared to 3.65 t ha^{-1} with uninoculated mungbean. Their combined application further increased the grain and straw yields by 9.1% over the uninoculated mungbean. Dual inoculation of *Rhizobium* sp. and PGPR in mungbean also significantly increased soil available N, by 15.3 and 16.9% and soil available P, by 26.8 and 49.0%, at 45 and 75 DAS of wheat over the uninoculated mungbean, respectively. This treatment also gave 28.0 and 24.4% more dehydrogenase activity, 8.6 and 11.5% more microbial biomass carbon, 21.1 and 25.1% more acid phosphatase and 18.1 and 25.3% more alkaline phosphatase activity in soil at 45 and 75 DAS over the uninoculated control, respectively. Increasing levels of N significantly increased the wheat grain and straw yields, available N and P, microbial biomass carbon and dehydrogenase, acid and alkaline phosphatase activities in soil at 45 and 75 DAS.

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Effect of Zinc Application on Productivity and Uptake of N, P, K and Zn by Rice Varieties

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A field experiment was conducted at Breeder Seed Production Farm of JNKVV, Jabalpur during *Kharif* season of 2017 on rice to study the effect of Zn levels on productivity and nutrients uptake by rice cultivars. Experiment was laid out in split plot design with three main treatments of rice varieties (Kranti, MTU 1010 and PS-5) and five sub treatments of Zn levels [control, foliar spray of 0.25, 0.50 and 0.75% $ZnSO_4$ at 30 and 60 days after transplanting (DAT) and soil application $ZnSO_4$ @ 25.0 kg ha^{-1} along with recommended dose of NPK under three replication with optimum agronomic management practices. Results of the study revealed that productivity and uptake of N, P, K and Zn by rice was significantly affected by rice cultivars and levels of Zn application. Highest productivity was recorded in Kranti supplied with 25.0 kg $ZnSO_4$ ha^{-1} as soil application. Yield of rice was significantly influenced by Zn application and highest seed (3.7 t ha^{-1}) and straw (5.2 t ha^{-1}) yields were obtained under soil application of 25.0 kg $ZnSO_4$ ha^{-1} treatment which were at par with foliar spray of 0.75% $ZnSO_4$ at 30 and 60 DAT. Uptake of N, P, K and Zn were also significantly affected by rice cultivars and Zn levels and found maximum under 25.0 kg $ZnSO_4$ ha^{-1} treatment. Present study concludes that rice (cv. Kranti) supplemented with 25.0 kg $ZnSO_4$ ha^{-1} as soil application or foliar spray of 0.75% $ZnSO_4$ at 30 and 60 DAT performed superior.

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Effect of Liquid Biofertizer on Growth, Yield and Economics of Soybean

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Trials on farmers' field were conducted 3 years during *Kharif* 2014-2016 at the adopted villages of Krishi Vigyan Kendra, Dewas. The experimental soil had pH 7.8, electrical conductivity 0.40 dSm^{-1}, organic carbon 0.45%, alkaline $KMnO_4$ extractable N 180 kg ha^{-1} and 1N ammonium acetate extractable K 395 kg ha^{-1}. There are three practices were adopted [Farmers practices (18 kg N and 46 kg P_2O_5 ha^{-1}), recommended practices (25 kg N, 60 kg P_2O_5, 40 kg K_2O and 20 kg S ha^{-1}) and improved practices (25 kg N, 60 kg P_2O_5, 40 kg K_2O and 20 kg S ha^{-1} + seed treatment with 1 L ha^{-1} rhizobium + 1 L ha^{-1} liquid PSB in soil treatment) on farmers field. All the doses were applied at the time of sowing. Thirteen farmers' fields were selected for the experiment. A common pest management practices were adopted for the experiment

The growth and yield parameters were influenced by the treatment. Highest pods $plant^{-1}$ (65.7), branches $plant^{-1}$ (6.6) and seed yield (16.9 q ha^{-1}) were recorded under improved practices against the farmers practices *i.e.* pods $plant^{-1}$ (51.5), branches $plant^{-1}$ (4.5) and seed yield (13.9 q ha^{-1}). Highest increase in yield (21.4%) was recorded in improved practices over farmer practices. Highest cost of cultivation (Rs. 32290 ha^{-1}) gross return (Rs. 52815 ha^{-1}), net return (Rs. 20525 ha^{-1} and B:C ratio (1.6) were recorded under improved practices. However, lowest cost of cultivation (Rs. 30068 ha^{-1}) gross return (Rs. 43410 ha^{-1}), net return (Rs. 13343 ha^{-1}) and B:C ratio (1.4) were recorded under farmers practices.

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Effect of Fertility Management in Pearl millet - Mustard Cropping Sequences in alluvial Soils

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Field experiment was conducted during 2018-19 at Morena under supplemental irrigated conditions. The treatments consisted of control, 100% PK, 100% NPK, 150% NPK, 100% NPK, 100% NPK, 100% NPK, 100% NPK, 100% NP and 100% NK in *kharif* and control, 100% PK, 100% NPK (80:40:20 NPK kg ha^{-1}), 150% NPK, 100% NPK + S 40 kg ha^{-1}, 100% NPK + Zn @ 25 kg $ZnSO_4$ ha^{-1}, 100% NPK + B @ 1 kg B ha^{-1}, 100% NPK FYM @ 2 t ha^{-1}, 100%NP and 100% NK in *rabi.* The experiment was laid out in RBD with three replications. Full dose of P_2O_5, K_2O, S, Zn, and B and half dose of N were given as basal dressing at the time of sowing and remaining half dose of N was top dressed in standing crop, 35 days after sowing for both the crop.

The seed yield of peal-millet was significantly increased with increasing levels of fertility. The significant higher yield of pearl-millet (4418 kg ha^{-1}) was recorded with 150% NPK of RDF over all fertility levels. The control plot produced lowest yield (1105 kg ha^{-1}). The fodder yield of pearl-millet (7500 kg ha^{-1}) was found significantly higher under in 150% NPK of RDF over all the fertility levels while it was at par with 100% NPK (7233 kg ha^{-1}) and 100% NP (7200 kg ha^{-1}). The minimum fodder yield (4533 kg ha^{-1}) was obtained with control plot. Similarly nutrient was also noticed in soil as well as plant of pearl-millet.

The seed yield of mustard significantly increased with increasing fertility levels. The significantly higher seed yield (2961 kg ha^{-1}) was recorded with 150% fertility levels and it was at par with 100% NPK + FYM @ 2.5 t ha^{-1} (2835 kg ha^{-1}). The lowest seed yield (989 kg ha^{-1}) was obtained with the control plot. Similarly nutrient was also noticed in soil as well as plant of pearl-millet.

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Nutrient Management for Optimization of Fertilizer doses for *Kharif* Brinjal (*Solanum melongena* L.) through Soil Test Crop Response approach in Mollisols

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Brinjal (*Solanum melongena* L.) is one of the important vegetable grown throughout the year mainly due to its better adaptability to varied agro climatic condition. Balanced application of fertilizer ensures increasing yield, quality and profitability of vegetable production as well as helps in sustaining the fertility of soil. Soil Test Crop Response (STCR) is a step towards precision nutrient management which takes into account soil test and crop response ensure balanced application and economic use of fertilizer. Keeping the above point in view, the study has been under taken with the objective to develop fertilizer prescription equations for desired yield targets of brinjal with conjoint use of farm yard manure and chemical fertilizers. Field experiment was conducted at N.E. Borlaug Crop Research Center of, G.B. Pant University of Agriculture and Technology, Pantnagar during *Kharif* season of 2018-19, to study the soil and nutrient response of applied balanced fertilization of brinjal. In first phase of the experiment, artificially fertility gradient was created in order to bring heterogenity into experimental soil for the test crop. In second phase, response of brinjal were studied to applied combinations of three levels of FYM (0, 10 and 20 t ha^{-1}), four levels of nitrogen (0, 60, 120 and 180 kg ha^{-1}), four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and four levels of potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) in different soil fertility strips. Basic data for fertilizer prescription was computed by using soil and plant analysis data. Fertilizer prescription equations are generated with the help of basic data. Using these fertilizer prescription equation the application of fertilizer is recommended for brinjal as per soil test values and yield targets according to the suitability of farmers economic conditions.

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Effect of Foliar Application of Calcium Nitrate and Potassium Nitrate on Growth, Yield and Quality of Chickpea

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The field experiment on chickpea comprised of nine treatments of different spray of calcium nitrate and potassium nitrate at 30 DAS and 45 DAS and RDF application through soil at the time of sowing was conducted during *rabi* 2018-2019. The result revealed that the foliar application of different concentrations of calcium nitrate and potassium nitrate significantly influenced nutrient content in seed and straw and nutrient uptake by chickpea. The grain Nitrogen, phosphorus, potassium and micronutrient concentration and uptake was significantly higher with the application of treatment T5 (2.0 per cent calcium nitrate) than all treatments. The application of different concentration of calcium nitrate and potassium nitrate was influences growth parameters, such as plant height, plant nodule, number of branches and total dry matter content, yield and yield parameters of chickpea. The foliar application of calcium nitrate and potassium nitrate did not influence the soil DTPA-Fe, Mn, Cu and Zn at harvest. The soil pH, electrical conductivity, organic carbon and calcium carbonate were not influenced by foliar application of calcium nitrate and potassium nitrate. The significantly highest plant height (55.29 cm), highest plant nodule (44.16 plant^{-1}) at 60 DAS was recorded due to application of treatment T5 (RDF + 2.0% calcium nitrate spray) over rest of the treatments. The lowest plant height (42.33 cm) and plant nodule (27.26 plant^{-1}) were found due to application of treatment T1 (RDF + water spray). The highest number of pods plant^{-1} (50.53 pods plant^{-1}), highest straw yield (1908.79 kg ha^{-1}), highest grain yield (1350.27 kg ha^{-1}), highest seed index (wt. of 100 seed) (25.36 gm) was observed due to treatment T5 (RDF + 2.0% calcium nitrate spray) over rest of the treatments.

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Integrated Nutrient Recommendations through STCR approach for Forage Oats Grown in a Mollisol

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Field experiment was conducted at GBPUAT, Pantnagar (29°N latitude, 79°29′E longitude), Uttarakhand during 2018-19 to optimize Integrated Nutrient Recommendations through STCR approach for forage oats grown in Mollisol.The experiment was conducted as per the technical programme and methodology of AICRP on STCR. Forage oats (var. Pant Forage Oat-3) was taken as test crop whose response to selected combinations of three levels of FYM (0, 5 and 10 t ha^{-1}), four levels each of nitrogen (0, 40, 80 and 120 kg N ha^{-1}), phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and potassium (0, 20, 40 and 60 kg K_2O ha^{-1}) were studied at different soil fertility levels.

The value of Organic-C, Alkaline-$KMnO_4$ N, Olsen's-P and NH_4OAc-K in the field ranged between 0.47-1.01%, 75.26-150.53 kg N ha^{-1}, 10.77-31.68 kg P ha^{-1} and 117.60-176.96 kg K ha^{-1}, respectively. The forage yield range varied from 216.61-749.79 with an average of 525.99 q ha^{-1}. Total average uptake of N, P and K was 146.31, 17.45 and 169.56 kg ha^{-1}, respectively. Nutrient requirement to produce one quintal forage yield was 0.27 kg N, 0.03 kg P and 0.32 kg K. Percent contribution of N, P and K was 71.37, 33.72 and 59.93 from soil, 73, 7.51 and 90.37 from FYM, 89.57, 50.84 and 302.72 from chemical-fertilizer and 102.43, 52.93 and 351.54 from conjoint use of chemical fertilizer with FYM. Coefficient of determination (R2) between forage yield, soil test values, applied fertilizer doses, FYM and their interaction was found highly significant (0.7954*). Maximum response of forage oats to applied fertilizers was obtained at 80 kg N, 30 kg P_2O_5 and 20 kg K_2O ha^{-1}.

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Effect of Integrated Nutrient Management on Soil Health and Productivity of Onion (*Allium cepa* L.)

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A field experiment was carried out during the late *kharif* season in 2018-19 at the Horticulture cum Instructional Farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur, Rajasthan. The objectives of experimentation were to evaluate the effect of integrated nutrient management on the growth and yield of onion and soil physio-chemical and biological properties. The soil of experimental site was medium black clay loam soil, slightly alkaline in reaction, medium in organic carbon (0.58), low in available nitrogen (185.58 kg ha^{-1}), medium in available phosphorous (23.18 kg ha^{-1}) and medium in available potassium (254.48 kg ha^{-1}). The experiment comprised of 12 treatments. From the results it is found that the application of 100% RDF + Azotobacter + PSB recorded significantly maximum growth parameters in terms of plant height and fresh weight at 30, 60 and 90 DAP (19.53, 29.81 and 42.03 cm) and (75.05, 127.10 and 149.39 g) respectively. Similarly, the yield components of onion *viz.*, bulb weight (52.04 g) and yield per hectare (11.56 t) followed by treatment T8 with the application of 75% RDF + 25% through FYM + Azotobacter + PSB. After harvest of the crop, the maximum organic carbon (0.76), maximum bacteria, fungi and actinomycetes population (79.76, 29.76 and 39.50 cfu g^{-1} of soil) with microbial biomass C and N (232.52 mg kg^{-1} and 63.29 mg kg^{-1}) significantly increased with the application of (T12 treatments) 50% RDF + 50% through FYM + Azotobacter + PSB over control. After harvest of the crop, the maximum available NPK in soil (202.82 kg ha^{-1}, 31.82 kg ha^{-1} and 270.13 kg ha^{-1}) were recorded with the application of T4 treatment in comparison with control and available Fe, Mn, Zn and Cu (4.32, 4.08, 2.16 and 2.55 mg kg^{-1}) were recorded with the application of T12 treatment in comparison with control.

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Studies on Boron Balance for a Long-term Experiment with Rice-based Cropping System

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Influence of different nutrient management practices on boron (B) availability in soil and its nutrition of crops were studied using an 18-year long-term experiment with rice-based cropping system in an *Inceptisol* located in Gayespur, Bidhan Chandra Krishi Viswavidyalaya, West Bengal. Five nutrient management practices *viz.*, control (no fertilizers), NPK (recommended dose of N, P and K), NPK+GM (green manure), NPK+FYM (farmyard manure), and FYM+BF (bio-fertilizer) were selected and their effects on B availability in soils using four extractants *viz.*, hot-$CaCl_2$ (HCC), hydrochloric acid (HCl), KH_2PO_4 (PDP) and tartaric acid (TA) were evaluated. Different reserve pools of B *viz.*, oxide-bound, organically-bound and total B were tested in relation to B nutrition of rice, mustard and sesame. Amounts of B extracted by the different methods followed the order HCC>HCl>TA>PDP across treatments. The stock of plant available, oxide-bound, organically-bound, total B in 0-0.45 m soil varied from 2287 to 2657, 8394 to 9026, 8685 to 9607, 103656 to 105436 g ha^{-1}, respectively. Across treatments, 2.4, 8.4, 8.9% of total B in soil was plant available, retained by oxides, organic matter, respectively. Averaged over the extractants, nutrient management practices with NPK+GM, NPK+FYM and FYM+BF resulted 10-12% increases in available B in soil over the control, which caused 20-30% increase in plant tissue B concentration. Such increases with integrated (NPK+FYM) and organic (FYM+BF) nutrient management practices maintained available B in soils and plant tissues above its critical limits of all the three crops. Boron balance study showed a net B accumulation over time as applied irrigation water and FYM contained (211 and 141-212 g B ha^{-1} $year^{-1}$) and maintained (86-242 g B ha^{-1} $year^{-1}$) more B than removed by harvested crops. Of the four methods used, HCC was the best for assessment of availability of B in soils under long-term cultivation.

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Potash Fertilization to Enhancing the Productivity of Pearlmillet-Safflower Sequence for Doubling the Farmers Income in Dryland Agriculture

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Indian Rainfed and Dryland agriculture is predominantly dependant on monsoon rainfall accounts for 55.3% (about 78 m ha) of the net cultivated area in India and plays an important role in country's economy. Generally farmers takes only one crop, either sorghum or safflower on medium deep black soil in scarcity zone of Maharashtra. Taking double or sequence cropping might be one of the alternative for doubling the income of farmers. Keeping such aspects in view the present investigation was undertaken. The field experiment with following potash fertilizer levels. A) Main (Pearlmillet) P_1. 05:00:00 (Farmers practice), P_2. 50:25:00, P_3. 50:25:25, P_4. 50:25:50 and P_5. 50:25:75 N:P_2O_5:K_2O kg ha^{-1} respectively. B) Sub (Safflower) S_1. 00:00:00 (Farmers Practicce), S_2. 50:25:00, S3. 50:25:10, S_4. 50:25:20 and S_5. 50:25:30 N:P_2O_5: K_2O kg ha^{-1} respectively, for pearlmillet-safflower was undertaken at AICRPDLA, Solapur for three years (2015-2016 to 2017-2018) with three replications in randomized block design for *kharif* crop and split plot design for *rabi* crop. In the sequence cropping of pearlmillet-safflower showed significantly higher yield and MUE of *kharif* pearlmillet and rabi safflower with application of 50 kg K_2O ha^{-1} and 20 kg K_2O ha^{-1} respectively. The non-exchangeable K increased where potassium applied to both crops, which could be maintained the exchangeable and water soluble K in soil solution, which might be contributed to significantly higher uptake of K and moisture use efficiency by both the crops as compared to farmers practice.

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Effect of Sulphur Levels and Farm Yard Manure on Yield, Oil Content and Nutrient Uptake of Safflower under Dryland Agriculture

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Most of the Indian soils are deficient for sulphur content and due to its deficiency the yield and oil content of different oil seed crops might be affected. Considering the role of sulphur particularly in oil seed crops under dryland agriculture, the present investigation was undertaken. The experiment on levels of sulphur in combination with farm yard manure and recommended dose of fertilizer to safflower was undertaken during 2014-15 to 2017-18 at Zonal Dryland Agriculture Research Station, Solapur (Maharashtra) in *rabi* season.

From this investigation it was observed that, the application of sulphur to safflower @ 40 kg ha^{-1} with 1 tonne of farm yard manure with recommended dose of N:P:K(50:25:00) kg ha^{-1} recorded significantly higher grain and oil content (16.38 q ha^{-1} and 31.48%) over the control where, the sulphur was not applied (10.03 q ha^{-1} and 30.28%) of safflower. Whereas, application of sulphur @ 30 kg ha^{-1} with recommended dose of NPK was found on par under dryland condition.

As regards to nutrient uptake, the highest N, P and K uptake (43.33, 17.92 and 111.94 kg ha^{-1}) was observed in application of sulphur @ 40 kg ha^{-1} in combination with FYM and recommended dose of fertilizer under dryland condition.

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Response of Potash Fertilizer Management to Blackgram-Sorghum Sequence in Dryland Agriculture

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Our country is going to have another 575 millon mouth by 2050 AD. This calls for an estimated productivity of 5 tonnes ha^{-1} of economic biomass. In view of this the present investigation was carried out with following potash fertilizer levels A) Main (Black gram) B_1 - 00:00:00, (Farmers Practice), B_2 - 25:50:10, B_3 - 25:50:20 and B_4 - 25:50:30 N:P_2O_5:K_2O kg ha^{-1} respectively. B) Sub (Rabi Sorghum) - S_1 - 40:00:00 (Farmers Practice), S_2 - 50:25:00, S_3 - 50:25:25, S_4 - 50:25:50 and S_5 - 50:25:75 N:P_2O_5:K_2O kg ha^{-1} respectively for cropping sequence of blackgram-*rabi* sorghum, for three years (2015-2016 to 2017-2018) with three replications in randomized block design for *kharif* crops and split plot design for *rabi* crops. In the sequence cropping of blackgram-*rabi* sorghum showed significantly higher yield of *kharif* blackgram with application of 20 kg K_2O ha^{-1} and 50 kg K_2O ha^{-1} for *rabi* sorghum. The non-exchangeable K increased where potassium applied to both crops, which could be maintained the exchangeable and water soluble K in soil solution, which helped in higher uptake of K and moisture use efficiency as compared to farmers practice. Due to potash fertilizer management in Dryland field crops of black gram-rabi sorghum the increase in yield by 39 per cent in blackgram and 13 per cent in rabi sorghum, with higher monetory returns and B:C ratio over farmers practice.

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Soil and Foliar Application of Zinc on Growth, Yield and Uptake of Nutrients of Cauliflower (*Brassica oleracea* var. *botrytis* L.)

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A field experiment was conducted in the farmer's field during *kharif* 2018 with an objective to study the effect of soil and foliar application of zinc on growth, yield and uptake of nutrients of cauliflower. The experiment was laid out in a randomised complete block design with 9 treatments and three replications. The experimental results revealed that application of 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 per cent Zn through zinc sulphate as foliar spray along with RDF (150:100:125 $N-P_2O_5-K_2O$ kg ha^{-1}) + 25 t of FYM per hectare significantly increased growth parameters of cauliflower such as plant height (61.27 cm), number of leaves $plant^{-1}$ (22.83), plant spread (65.63 cm in N-S and 72.87 cm in E-W) and chlorophyll content (60.09 SPAD reading). Significantly higher yield attributes such as curd diameter (16.65 cm) weight of curd (0.678 kg) and yield (33.16 t ha^{-1}) was recorded in the treatment which received 4 kg of Zn ha^{-1} through $ZnSO_4$ as soil application + 0.5 per cent Zn through zinc sulphate as foliar spray along with RDF and FYM. Significantly higher uptake of nitrogen (98.13 kg ha^{-1}), potassium (89.63 kg ha^{-1}), sulphur (21.44 kg ha^{-1}) and zinc (139.73 g ha^{-1}) by cauliflower was recorded in the treatment which received 4 kg of zinc ha^{-1} through zinc sulphate as soil application + 0.5 per cent zinc through zinc sulphate as foliar spray along with RDF and FYM).

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Effect of Calcium, Zinc and Boron Application on Growth, Yield and Nutrient Uptake of Foxtail Millet (*Setaria italica* L.)

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A field experiment was conducted in the farmer's field during *kharif* 2017 with an objective to study the effect of calcium, zinc and boron application on growth, yield and nutrient uptake of foxtail millet. The experiment was laid out in a randomised complete block design with 11 treatments and three replications. The experimental results revealed that application of 16 kg K_2O ha^{-1} + 10 kg calcium ha^{-1} + 3 kg zinc ha^{-1} + 1 kg boron ha^{-1} along with RDF and FYM has recorded significantly higher growth parameters *viz.*, plant height, number of leaves per plant, number of tillers per plant and chlorophyll content. Soil application of 16 kg K_2O ha^{-1} + 10 kg calcium ha^{-1} + 3 kg zinc ha^{-1} + 1 kg boron ha^{-1} along with RDF and FYM recorded significantly higher yield attributes such as panicle length (15.57 cm), test weight (3.71) grain yield (15.27 q ha^{-1}) and straw yield (39.25 q ha^{-1}). Significantly higher uptake of N (57.72 kg ha^{-1}), P_2O_5 (30.38 kg ha^{-1}), K_2O (66.3 kg ha^{-1}), calcium (54.36 kg ha^{-1}), magnesium (41.96 kg ha^{-1}), sulphur (27.42 kg ha^{-1}), zinc (501.97 g ha^{-1}), and boron (300.8 g ha^{-1}), by foxtail millet were recorded in the treatment which received 16 kg K_2O ha^{-1} + 10 kg calcium ha^{-1} + 3 kg zinc ha^{-1} + 1 kg boron ha^{-1} along with RDF and FYM.

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Productivity of Soybean (*Glycine max* L. Merril) as Influenced by Combined use of Enriched Compost and Biofertilizers

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The field investigation was carried out at Agronomy Instructional farm, Rajasthan College of Agriculture, MPUAT, Udaipur, to the evaluate influence of combined use of enriched compost and biofertilizers soybean nutrition grown under typic *Haplustepts* clay loam soil. The field comprised of 10 treatments replicated in randomized block design. The results obtained from field investigation indicated a significant improvement in various growth attributes *viz;* chlorophyll content, total number of root nodules, and effective root nodules and yield and yield attributes *viz;* number of pods plant^{-1}, number of seeds pod^{-1}, seed yield, straw yield, biological yield. The data indicates that application of enriched compost (5 t) ha^{-1} along with *Rhizobium* + PSB recorded significant higher seed yield (1.65 t ha^{-1}), haulm yield (2.34 t ha^{-1}), and biological yield (3.69 t ha^{-1}). However, enriched compost (5 t ha^{-1} + *Rhizobium* + PSB) was found statistically at par with enriched compost (4 t ha^{-1} *Rhizobium* + PSB), enriched compost (5 t ha^{-1} + *Rhizobium*), enriched compost (5 t ha^{-1} + PSB). In case net return treatment enriched compost (5 t ha^{-1} + *Rhizobium* + PSB) gave highest net return (41805.9) while the highest B:C (1.83) was obtained by the application of enriched compost (4 t ha^{-1}*Rhizobium* + PSB).

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Assessing Sulphur Nutrition to Enhance the Yield and Quality of Small Onion (*Allium cepa* var. *aggregatum*) Grown in Sulphur Deficient Soil

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A field experiment was conducted to assess the impact of sulphur fertilisation on the yield and quality of small onion (CO (On) 5) grown in S deficient black soil (Vertic Ustropept) which was sandy loam in texture with available S content of 7 mg kg^{-1}. Ammonium sulphate and Single super phosphate were the two sources of sulphur applied at the levels of 0, 20 and 40 kg S ha^{-1} along with recommended doses of N, P, K and VAM. The bulb yield increased significantly with the application of ammonium sulphate with recommended dose of fertilizers at the higher level of 40 kg S ha^{-1} which was 82.70% higher over the control. However, application of VAM with ammonium sulphate and RDF at higher levels was also statistically on par with the same combination without VAM. The highest sulphur content (0.9%) and sulphur uptake in bulbs (33.33 kg ha^{-1}) were higher with application of ammonium sulphate @ 40 kg S ha^{-1} + RDF. The quality parameters of small onion like ascorbic acid and pyruvic acid were also higher with the application of ammonium sulphate and recommended dose of fertilizers at 40 kg S ha^{-1}.

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Chromium (VI) Removal from Contaminated Soil by Bulk Liquid Membrane Technique

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Chromium (VI) contaminated soil is usually detected in industry areas such as metal plating, textile and wood preservation, tanning etc., Hexavalent chromium in soil is highly mobile and lead to pollution of ground water. It is recognized as a toxic carcinogen worldwide and is a fatal environmental pollutants. Many papers have been discussing the separation of chromium (VI) with emulsion liquid membrane and supported liquid membrane techniques. Bulk liquid membrane (BLM) system consists of donor and acceptor phase and separated by an immiscible liquid membrane. Tri-n-butyl phosphate (TBP) has been used as a carrier for removal of Cr(VI) via hexane bulk liquid membrane. The removal efficiency of Cr(VI) by TBP was investigated under various conditions such as pH of feed phase, concentration of receiving phase, the concentration of TBP in the membrane, rate of strirring, transport time, the effect of temperature. The removal rate efficiency, increased with increasing carrier concentration from 6.5 × 10-2 to 2.26 × 10-1 mol L^{-1}. At high, stirring speed the removal efficiency of chromium (VI) from feed phase was completed. The flux rate has been found to be 2.85 × 10-7 mol $m^{-2}s$.

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Assessment of Soil Organic and Inorganic Carbon Stock in Prominent Cotton Growing Talukas of Bharuch, Narmada and Surat districts•

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Cotton growing belt of South Gujarat encompassing 11 talukas (Bharuch, Hansot, Jhagadia, Jambusar, Amod, Vagra, Narmada, Tilakwada, Dediapada, Sagbara and Surat), it is obvious that within the area of 11 talukas soils in their quality and aggregate size classes would vary from one to another site due to differences in organic and inorganic inputs, tillage practices along with other external inputs over the years as a result of differences in cotton canopy coverage, leaf litterfall, root bulk volume, irrigation as well as rainfall situation. To fulfill the objectives of present research GPS based representative 22 nos. of pedons (11 irrigated and 11 rainfed situations) were dug out, studied and depth-wise samples of above 11 talukas were collected. Mean SOC stock at 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil depth of irrigated profiles were 15.0, 12.6, 21.5, 19.3 and 15.3 t ha^{-1}, respectively. Similarly, mean SOC stock at an above various soil depth of rainfed profiles were 12.2, 10.0, 19.3, 15.6 and 12.7 t ha^{-1}, respectively. Further, higher soil inorganic carbon (SIC) stock (t ha^{-1}) up to 30 cm soil depth, which though help in higher C sequestration and less release of CO_2 in atmosphere, but could create problems relating to root proliferation and nutrients availability and uptake, were P5 (20.5), P21 (16.3), P17 (13.4) and P15 (11.8) in irrigated and P8 (25.9), P22 (25.8), P14 (20.1) and P20 (18.5) in rainfed profiles. Up to 30, 60 and 120 cm soil depth from surface, the mean total carbon (TC) stock of irrigated profiles were 37.2, 74.2 and 165.4 t ha^{-1}, respectively. Up to the same soil's depths from the surface, the mean TC stock of rainfed profiles were 37.4, 85.7 and 203.1 t ha^{-1}, respectively.

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Soil Enzymes and Microbial Elemental Stoichiometry: Bio-indicators of Soil Quality in Vertisols

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Comprehensive information on carbon (C), nitrogen (N), phosphorus (P) and sulphur (S) cycling enzymes, microbial elemental stoichiometry and soil functional diversity are scanty in organic vis-à-vis conventional systems across the globe. We considered four major cropping systems of India *i.e.* soybean-wheat, soybean-mustard, soybean-pea and soybean-linseed under six nutrient management practices, namely, M1 (mineral fertilizers as used by farmers), M2 (recommended dose of mineral fertilizers), M3 (50% Inorganic + 50% Organic), M4 (25% Inorganic + 75% Organic), M5 (75% Organic + Innovative) and M6 (Organic; 100% Organic) in a Vertisol. Enzyme activities were significantly ($P < 0.05$) increased by organic amendments (~50-75%). Exceptionally, phenol oxidase and peroxidase activities were ~51 and 50% higher in subsurface than surface soils. However, soil functional diversity was nearly 10 and 20% lower for M6 than M3 and M1, respectively. Discriminant function analysis confirmed SOC, arylsulfatase activity and available P to be the most effective discriminant factors between the conventional and organic nutrient management practices in India. The GMEA was ~55% higher for M6 than M1. It was strongly and positively correlated with treated soil quality index. Further, GMEA was cross validated with an independently performed principal component analysis to find its suitability as soil quality index. The GMEA was correlated ($P < 0.05$) with scores of first component and proved to be consolidative enough for explaining functional distinction between conventional and organic management by reducing the several soil enzyme activities to a single numerical point. Thus, GMEA is proposed to indicate soil quality quickly and accurately in Vertisol.

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Estimation of Soil Organic Carbon Stock (SOC) in Uttar Pradesh for Carbon Management Planning

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Soil carbon storage is the third largest carbon pool in the Earth System. Global soil carbon map indicated that India has low carbon stock than many other south Asian countries like Sri Lanka, China, Bangladesh, and Afghanistan. Soil organic carbon stock of surface layer (0-30 cm) for all districts of Uttar Pradesh has been estimated by ICAR-NBSS&LUP and linked with global carbon data base. Soil carbon map of Uttar Pradesh has been developed using 3227 georeferenced points indicated that northern part of Saharanpur district capable to maintain relatively higher SOC stock (30-35 Mg ha^{-1}). Part of Saharanpur, Bijnor, Rampur, Pilhibhit, Kheri, Balrampur, Siddharthnagar, Maharajganj, Kushinagar, Chandoli and Sonbhadra capable to maintain moderate SOC stock (25-30 Mg ha^{-1}). Majority of districts of state are under low (20-25 Mg ha^{-1}) to very low (15-20 Mg ha^{-1}) in SOC stock. Mathura, Agra, Mahamayanagar, Jalaun, Jhansi, Hamirpur, Mahoba, Kanpur, Fatehpur, Kanpur Dehat, Auraiya and Chitrakoot are more vulnerable with respect to SOC stock. A quick action may be taken to restore the organic carbon in these vulnerable districts. Intensifying crop production and addressing the issue of climate change must be integrated in sustainable way. We have delineated the district wise spread and productivity for major crops and also delineated the potential areas of these crops in state. Effective management of agricultural ecosystems such as land use as per the potential crop zone can restore the soil carbon and support to mitigate the effect of climate change.

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Effect of Graded Levels of Sodicity on Growth and Yield of Sorghum Varieties in Calcareous Sodic Soil

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A field experiment was conducted to study the effect soil Exchangeable Sodium Percentage (ESP) on growth and yield of sorghum varieties. In the existing experimental field, ESP levels *viz.*, 8, 16, 24, 32, 40 and 48 were artificially created using sodium bicarbonate and gypsum. The experimental plot was brought to optimum soil tilth and the ridges and furrows were formed and sorghum varieties were sown with a spacing of 45×15 cm with the application of fertilizers *viz.*, 90:45:45 kg N, P_2O_5 and K_2O (50% of N at basal and remaining 50% at 30 DAS). The experiment was carried out with five levels of ESP in main plot and four sorghum varieties in strip plot design with three replications. The results revealed that among the different levels of ESP, the growth and yield of sorghum was declined with increased ESP levels from 8. However, more than 50 per cent yield could be achieved up to 32 ESP level in the sorghum varieties *viz.*, Co30, Red sorghum (local) and Irungu (Black local) whereas in the variety K12, 50 per cent yield was achieved at the ESP of 24 above which the yield was reduced to less than 50 per cent. Among the varieties, the performance of Co30 was superior over rest of the varieties. The highest grain and straw yield was recorded in Co30. Similar trend with respect to the individual yield parameters was also recorded. Hence, it is concluded that the sorghum varieties *viz.*, Co30, Red sorghum (local) and Irungu (Black local) can be grown in sodic soil up to the ESP level of 32 whereas the variety K12 can be grown in sodic soil up to the ESP level of 24 where the 50per cent of yield could be realized.

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Study the Phytoremediating Efficiency of different Plant Species to Remove Cr (VI) from Contaminated Water Sources

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To find out the efficiency of a range of aquatic plants to remove Cr(VI) from the polluted waters, an experiment was carried out with four Cr(VI) levels e.g. 0.2 (T5), 0.71 (T4), 0.83 (T3), 1.07 (T2) and 1.29 (T1) mg L^{-1} in 0.6 m^3 of water in two factorial CRD with three replications in cemented tanks under net-house conditions. An amount of 200±10 g each of *Pistia stratiotes, Salvinia minima, Ipomoea aquatica* and water hyacinth (*Eichornea crassipes)* were placed on 16 February 2018. Live weight, and Cr(VI) concentration in each plant species were estimated after 5, 15, 20, 25, 31, 37 and 43 days of starting the experiment. The plant growth rate reduced from T1 to T3 after 5 days, enhanced there after as 6.64 to 69.6, 18.15 to 38.78, 3.26 to 16.54 and 33 to 71.63 times in Pistia, Salvinia, Ipomoea and Water hyacinth, respectively.

Among the species, Salvinia removed relatively more Cr followed by Pistia and Water hyacinth; it removed 0.37 to 7.03 times more Cr from T1, T2, T3 and T5 and Pistia removed 0.94 to 1.72 times more Cr from T4 than other plant species. There was 65 to 94% reduction in Cr in the treatments inconsistently with the observation period and Cr concentration levels. It was reduced to safer level i.e. 0.1 mg L^{-1} up to 0.71 mg L^{-1} across the treatments. Decrease of plants' biomass from T1 to T3 and their subsequent decompositions may attributed to the inconsistent trend in Cr concentration. However growing Salvinia at ≥ 1.0 mg L^{-1} and Pistia at < 1.0 mg L^{-1} Cr (VI) levels may be preferred to remove Cr than Ipomoea and Water hyacinth as evident from the result.

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Potential of Multivarietal and Monocropped Mango Orchards in Carbon Sequestration for Mitigating Climate Changes in Semi-arid Climate of Andhra Pradesh

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The increasing carbon (C) emission is of major concerns and sequestering-C in tree-based-systems has the potential to offset a substantial portion of the future atmospheric increase in CO_2 concentration. An estimate of the C-sequestration potential of fruit-orchards in India is, therefore, essential for any strategic-planning and for trading C. This study was designed to quantify C-sequestration potential of multiple-variety-mango-orchard and monocropped-mango-orchard systems in Chittoor district, Andhra Pradesh. Based on the diversity of mango varieties, 21 farmers orchards were selected consisting of 15 multiple-variety and 6 monocropped-orchards. The orchard size varied from 4 to 30 ha. The multiple-variety-orchards contained minimum 4 varieties and maximum 19 varieties. Monocropped-orchards selected were three Totapuri orchards and one each of Baneshan, Neelum and Rumani. On per tree basis the mean above-ground-biomass was more in multiple-variety-orchards (218.5 kg tree^{-1}) than in monocropped-variety (176.12 kg tree^{-1}). The below-ground-biomass also followed the similar trend of above-ground-biomass with a mean below-ground-biomass of 71.94 kg tree^{-1} in monocropped-variety and 89.3 kg tree^{-1} in multiple-variety-orchards. The mean total tree C-sequestered per tree was 113.78 kg tree^{-1} in monocropped-orchards and 138.9 kg tree^{-1} in multiple-variety-orchards. Weeds and litter represent the floor-level C-sequestration. Monocropped-orchards had higher weed biomass (581.8 kg tree^{-1}), hence captured higher C (265.3 kg tree^{-1}) than multiple-variety-orchards. However, the litter biomass was more in multiple-variety-orchards (1361 kg tree^{-1}) than monocropped-orchards (1218.1 kg tree^{-1}). The proportion of this fraction of weeds and litter in total C-sequestration is very low. In multiple-variety-orchards and monocropped-mango-orchards, the floor C represent 8.44% and 10.47% of the total C-sequestered, respectively. The mean C-sequestered in monocropped-orchards varied from 67.31 to 81.35 t ha^{-1} with a mean of 76.2 t ha^{-1} and in multiple-variety-orchards from 71.45 to 86.22 t ha^{-1} with a mean of 78.55 t ha^{-1}. From this study, it can be hypothesized that monocropped-mango-orchards follows a pattern similar to that observed in multivarietal-mango-orchards for mitigation of negative impact of climate change.

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Effect of Fertilizer Management and Rice Establishment Methods on N_2O Emissions in Rice-Wheat Cropping System

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Agricultural use of nitrogenous fertilizers are the major anthropogenic sources of nitrous oxide (N_2O) emissions, a potent greenhouse gas. Rice-wheat cropping system is the prominent cropping system of Indo Gangetic Plain of India and occupied 2.8 million ha area in Punjab. Assessment of N_2O emissions in the rice-wheat system under different crop establishment methods and fertilizer management is important to identify low N_2O emission production technologies. The present study was conducted to estimate the effect of rice establishment methods (puddled transplanted rice: PTR and direct-seeded rice: DSR) under different fertilizers treatments (control, 100% NPK (RDF), 100% PK + leaf colour chart (LCC) based N application, 150% N of RDF (Farmers' Practice), 100% NPK + FYM (Farmyard manure), 100% NPK + GM (Green manure) and 100% NPK + SI (Straw incorporation) on N2O emissions under rice-wheat cropping system. Gaseous N_2O-N emissions were significantly influenced by rice establishment methods (REM) and fertilizer application in rice-growing season. DSR emitted 9.3% higher N_2O compared to PTR thus has higher global warming potential (GWP) than PTR. A significant effect of fertilizer management on N_2O emissions in the rice-growing season was observed compared to control treatment. Integrating organic manures and fertilizer decrease N_2O emissions compared to the sole application of chemical fertilizer. Nitrous oxide emissions in wheat were not affected by REM in the rice-wheat system. However, fertilizer application had a significant influence on N_2O emissions in wheat and maximum emissions were recorded under 150%NPK (FP). The overall N_2O emission of PTR-wheat was lower by 5.8% compared to DSR-wheat cropping system. Conjoint application of organic manures with NPK fertilizer and N management using LCC had lower N_2O emissions compared to the sole application of recommended NPK fertilizer in the rice-wheat cropping system.

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Nutrient Fertilization and Residue Alter Moisture Sensitivity of Soil Organic Carbon and Nitrogen Mineralization in an Indian Vertilsol

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Uneven distribution and intensity of rainfall in subtropical semi-arid vertisol has a great impact due its mineralogical constituents. The impact of soil moisture levels and the moisture sensitivity of soil carbon (C) and nitrogen (N) mineralization with fertilization and residue incorporation are obscure. To clarify this, laboratory incubation experiment was conducted with four moisture (M1: 24, M2: 32, M3: 40 and M4: 48%, w/w), two fertilizers (F0 and F1; at N: P_2O_5: K_2O :: 150: 60: 60 kg ha^{-1} equivalent), and two residue levels (R0 and R1; at 10 t ha^{-1} equivalent) to evaluate the effects of fertilization and residue incorporation on moisture sensitivity of soil cumulative C-(Ccum) and N-mineralization (Ncum) and dehydrogenase activity. Ccum was amplified with increase in soil moisture content from M1 to M3, but decreased at 48% soil moisture. Application of fertilizer induced positive priming effect for CO_2-C and increased by ~28%. Residue- and F×R- application accelerate the Ccum by ~108 and 125%, respectively. Residue application caused initial N-immobilization. R×F×M interaction influenced Ccum antagonistically at M1, M2 and M3; whereas synergistic interaction was observed at M4. Contrasting with Ccum, fertilization led to highest moisture sensitivity of Ncum. Increased moisture level amplified dehydrogenase activity in incubated soils. Strikingly, moisture sensitivity of C and N mineralization was reduced by residue incorporation irrespective of fertilization. Thus, residue incorporation could be recommended as obligatory practice in subtropical vertisols to decrease its moisture sensitivity and to maintain positive C balance and soil health.

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Persistence and Dissipation Kinetics of Chlorantraniliprole in the Soil of Sugarcane Ecosystem

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Shoot borer is one of the prominent insect pest of sugarcane which has been widely controlled by the application of granular formulation of chlorantraniliprole across the sugarcane growing areas. An experiment was conducted to determine persistence and dissipation kinetics of chlorantraniliprole in sugarcane grown soil. The experimental plots were subjected to application of chlorantraniliprole 0.4G (0.1 kg a.i. ha^{-1}) at 60 days after planting of sugarcane. The soil samples were periodically collected at 0 (2 hrs.), 1, 3, 5, 10, 20, 30, 60 and 90 days after application of chlorantraniliprole. Prior to analysis, acetonitrile based extraction and dispersive clean-up approach adopted to quantify the residues of chlorantraniliprole with LC-MS/MS from soil, sugarcane leaves and juice were verified on method performance verification parameters. The analytical method was accurate, sensitive and precise enough as per SANTE guideline. Residues of chlorantraniliprole was observed upto 30 days after application and reached below quantification level at 60 days after application. chlorantraniliprole followed the second order dissipation kinetics. The half life of chlorantraniliprole was 1.21 days, respectively which indicates that chlorantraniliprole is non-persistent (DT50 and 30 days) in the soil under sugarcane growing condition of South Gujarat. However, sugarcane leaves and juice contains negligible amount of residues of phorate and its metabolites which are well within the safety limits.

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Chromium Dynamics under Soil-Plant Ecosystem

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Metal dynamics under soil-plant system is an important part of environmental research across the globe. Fractions of heavy metals in ecosystem may mediate soil process and plant metabolic activities. Anthropogenic activities are enhanced the distribution in virgin areas and a significant concentration was also reported in agricultural fields. Chromium (Cr) is one of the toxic metals and mainly contributed by the lather industries, dye and pigment, wood preservative, refractory material, catalysts, metal polish, plating and metallurgical industries etc. These industries are generating a significant volume of effluent, which is mostly mixing with household wastewater and using as irrigation in water scarcity area. The Cr concentration reaches plant parts with the help of roots from soil. Long-term application of tannery effluent for crop production enhanced the Cr concentration about 28-30 times more than tubewell irrigated fields. The experimental data showed that soil properties (soil pH, organic C, clay content) extensively affected the availability of Cr in soil solution. Presence of soil organic matter enhanced the Cr adsorption kinetics in soil and reduced the phytotoxicity concentration of Cr in soil. Enhancing Cr levels reduce the soil C mineralization rate, soil biomass activity, availability of macro and micro nutrients in soils. Whereas, increasing concentration of Cr in plant reduce germination, plant growth, uptake of plant nutrient by inhibiting the xylem process. Results showed that Cr concentration was more in root part as compared to shoot part in vegetable crops. Application of sulphur fertilizers reduced the Cr concentration in spinach crop through mediating plant nutrient dynamics. The regular monitoring of Cr dynamics in effluent, soil and plant systems are required with respect to spatial and temporal variation. Use of modern tool and techniques for precision quantification of Cr to remove from ecosystems is a need of hours.

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Interaction Effects of Elevated Carbon Dioxide and Water Deficit Stress on Soil Enzyme Activities and Bacterial Population in Relation to Nitrous Oxide Emission in Tropical

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Anticipated elevated atmospheric carbon dioxide (ECO_2) and water deficit stress (WDS) are the two important factors likely to affect the microbial dynamics, nitrogen (N) mineralization and nitrous oxide (N_2O) emission from rice soil. We designed a field experiment under open top chambers (OTCs) to examine the influence of ECO_2 and different water regimes on N mineralization and N_2O emission from rice soil. Experimental data revealed that labile N fractions such as microbial biomass-N increased by 31% whereas NH_4^+ and NO_3^- concentration decreased by 41 and 33%, respectively under ECO_2 over ambient CO_2 (ACO_2). Rhizospheric denitrifier population was 35% higher whereas nitrifier population decreased by 38% under ECO_2 as compared to ACO_2 in well-watered condition. Decrease in denitrifier population under WDS condition for ACO_2 and ECO_2 was 26 and 18%, respectively as compared to well-watered condition, whereas the decrease in nitrifier population was 29 and 38%, respectively. The ECO_2 increased N_2O emission and decreased mineralization rate of N in rice soil. Increased N_2O emission under ECO_2 was due to increased denitrifier and decreased nitrifier population and enhanced activities of extracellular enzymes. The study suggested the need for precise N management practices for ensuring higher N use efficiency under future drier and high CO_2 conditions.

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Carbon Pools and Thermal Stability of Soil Organic Carbon as affected by different Nutrient Management Practices in Long Term Fertilizer Experiment

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The Permanent Manurial Trials (PMT) - (tall and dwarf) and the All India Co-ordinated Project on Long term fertilizer experiment (LTFE) have been laid out at Regional Agricultural Research Station, Pattambi with the main objective of studying the effect of continuous application of plant nutrients (NPK) in organic and inorganic forms and in combinations on sustainable production in the rice-rice cropping sequence

The percentage contribution of different carbon pools towards total soil organic carbon in paddy soil of the present work can be rated as: passive (54%) > slow (36%) > active (10%). In LTFE with 20 years history, it was seen that all the carbon pools (active, slow and passive) contributed towards yield whereas in PMT, with 44 years history, it was the slow pool of carbon that showed higher correlation with crop yield. Data on analysis of different carbon pools revealed that slow pool is the most predominant yield determining pool in the long run.

An incubation study was conducted at four different temperature regimes (15, 25, 35 and 45 °C) using the soil collected from the plots of LTFE as well as PMT. The values on activation energy and the rate constants provided a good insight on decomposability of organic matter and the pace of mineralization in soil. Thermal stability studies indicated that the rate of reaction decreases with increase in temperature indicating exhaustion of labile pools available for microbial decomposition. Q10 values were also lesser than 1 in both the experiments. Treatments with inorganics recorded lowest activation energies indicating the instability of even recalcitrant or passive pools. The study fortifies INM as a stable practice for sequestering soil organic carbon and crop productivity in the context of rising temperature scenario.

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Arsenic Mitigation in Soil-plant (Rice) System through Irrigation Management and Organic Amendments

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An experiment was conducted to assess technological options for arsenic mitigation in soil-plant (rice) system through irrigation management and organic amendments using strip plot design in farmer's field at Dakshin Panchpota village, Chakdah block, Nadia district (23°00′N, 88°60′E,11m AMSL, 0.51 mg L^{-1} As in groundwater).

In the first year, rice (cv. IET-4786) was grown to assess the arsenic curbing efficiency of organic amendments (vermicompost @3.0 t ha^{-1}, FYM @10.0 t ha^{-1} and mustard cake @1.0 t ha^{-1}) and water saving [alternate wetting & drying (AWD) and saturation] options. The combined effect decreased grain arsenic load by 53.16% while increased grain yield by 35.42%, as against the farmer's practice (no manure and continuous submergence). AWD and vermicompost facilitated maximum reduction in arsenic accumulation in grain and emerged as a transferrable strategy.

To validate it, in the second year, ten NFSM/BGREI recommended and local popular paddy varieties *viz.* IET-22066, IET-6141, IET-21845, IET-17730, IET-22752 (GB-3), IET-9947, Local (Gosai), IET-21261, IET-22836 and IET-12875 were exposed to the emerged transferrable strategy to compare arsenic uptake against farmers' practice in the same field. Yield of most varieties increased, but IET-22066 lost yield by 24% while IET-22752 was at par. More importantly, a marked decrease in grain arsenic load created an environmental safeguard. IET-22066 and IET-22752 grains had lower As load. IET-12875 had maximum efficiency of 46% as reduction.

To find possible clauses of reducing As load in grain and to save the human races from As related grievances through dietary exposure (rice), our intervention may thus be adopted as a viable alternative to the existing solutions.

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An Assessment of Vulnerability to Climate Change for districts of Madhya Pradesh

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Assessing vulnerability to climate change is important for defining the risks posed by climate change and provides information for identifying measures to adapt to climate change impacts. An assessment was done to study the overall implications of climate change on climate vulnerability for 51 districts of Madhya Pradesh to identify the vulnerable districts to climate change in current (1981 to 2010) and projected climate scenarios RCP 4.5 and RCP 8.5, mid-century (2021-2050) and end of century (2071-2100) by using indicators indices for precipitation and temperature calculated from Cordex South Asia daily weather datasets, Indian Institute of Tropical Meteorology, Pune and NEX-GDDP data. Using indicator-based methodology vulnerability indices were calculated and districts of Madhya Pradesh have been classified into various vulnerability categories. The overall climate vulnerability of the Madhya Pradesh districts is projected to increase towards mid-and end-century as compared to the current conditions for both emission scenarios of RCP 4.5 and RCP 8.5. Districts vulnerability under RCP8.5 scenario is projected to be higher as compared to RCP 4.5 scenario. The projected increase in vulnerability towards end-century is higher than that of mid-century for RCP 8.5 scenario while the projected increase in vulnerability towards end-century is relatively lower than that of mid-century for RCP 4.5 scenario. The four districts of M.P. which have very highly venerability to climate change in the current scenario are Jhabua, Alirajpur, Rewa, Dhar, and the six districts which have very low vulnerability are Anuppur, Seoni, Shahdol, Chhindwara and Umaria.

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Modifying CERES-N Routine for Simulating Decomposition of Ambient and Elevated CO_2 Grown Rice and Wheat Residues

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CERES model, a modification from PAPRAN model is very widely used to simulate C and N dynamics in soil. However, there is an inherent problem in using fixed values of rate constants for predicting C and N mineralization from residue amended soil. The actual values used in the model in particular conditions should be obtained by adjusting the decay rates based on environmental conditions. Keeping in view of the above, a decomposition study was conducted in phytotron chambers wherein ambient (350±50 µmol mol^{-1}) and elevated CO_2 (600±50 µmol mol^{-1}) grown rice and wheat residues were allowed to decompose in litterbags. The data obtained were used for evaluating the ability of the CERES-N model to simulate carbon and nitrogen minearlisation from those residues. The original version of the model overestimated the C and N mineralization processes. The modified decay parameters derived through a number of trials for carbohydrate, cellulose and lignin were 0.38, 0.01899 and 0.0035 day^{-1} in case of rice residues grown under ambient CO_2. The respective values were 0.32, 0.01691 and 0.00266 day^{-1} for rice residues under elevated CO_2, 0.31, 0.01561 and 0.0013 day^{-1} for wheat residues under ambient CO_2 and 0.29, 0.01508 and 0.0011 day^{-1} for wheat residues under elevated CO_2. The process of decomposition and N mineralisation from ambient and elevated grown rice residues fitted well to the modified CERES model. In case of wheat, decomposition from ambient and elevated CO_2 grown residues fitted well to the modified CERES model, while N mineralisation was underestimated especially in case of elevated grown residues. A single value rate constant for decomposition of a particular class of compound (e.g., carbohydrate, cellulose and lignin) is not enough to predict its decomposition under different ecosystem.

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Characterization of Sources of Biochar and its Influence on Soil Properties

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Use of biomass by converting it as biochar, a pyrolysis product, is the way to manage environmental pollution, carbon sequestration and soil fertility. In this context, the present work was carried out by taking five sources of biomass like paddy straw, paddy husk, maize stover, maize cob and arhar stover. The pyrolyzed products were characterized and found all were in alkaline range (pH 9.42 to 9.72). The total organic carbon (88.48%), N (1.62%), Ca (0.33%) and Mg (0.14%) content was found highest in maize cob biochar as compared to others sources of biochar. The total P (0.51%) and K (1.30%) content was found higher in maize stover biochar and the total S content was found to be more in paddy straw biochar (0.65%). To test the use efficiency of biochars, an incubation study was carried out in the Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar with ten treatments replicating thrice in a CRD statistical design. Application of maize cob biochar @ 2% of soil weight, had a significant impact on increase in soil pH to 8.11, decrease in exchangeable acidity from 0.22 to 0.06 cmol (p^+) kg^{-1} soil, increase in CEC from 5.40 to 6.14 cmol(p^+)kg^{-1} and also an increase in water holding capacity from 30.0% to 48.04% over other treatments. However, the paddy husk biochar applied @ 2% of soil weight, had the highest SOC of 8.20 g kg^{-1} soil over other treatments. Different peaks obtained from FT-IR study of biochars were correlated with the exchangeble cations and acidity in soil.

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Effects of Inorganic Anions on Lead (Pb) Fractions and Absorption by Indian Rape (*Brassica compestris* var. Toria)

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Contamination of soil with heavy metals has become a major environmental concern. Among heavy metals Pb is a widespread contaminant of soil all over the world. This study reports the effects of inorganic anions on lead (Pb) fractions and absorption by Indian rape (*Brassica compestris* var. Toria) in a lead spiked soil. In a greenhouse pot experiment a sandy loam soil was spiked with four levels of Pb (0, 50, 100, 200 mg Pb kg^{-1} soil) and the treated soils were amended with four levels of potassium salts of different anions ($H_2PO_4^-$, Cl^-, SO_4^{2-}, CO_3^{2-}). The amended soils were equilibrated for 30 days and Indian rape was grown. Results indicate that plant shoot dry biomass and seed yield of Indian rape were significantly reduced by the contamination of increasing amounts of Pb. However, addition of $H_2PO_4^-$ and CO_3^{2-} anions decreased the magnitude of reduction in shoot dry biomass and seed yield with Pb contamination but addition of Cl^- enhanced it. Absorption of Pb in shoots and seeds also increased linearly and significantly with increase in Pb contamination levels. Correspondingly, Pb uptake by Indian rape decreased with the addition of $H_2PO_4^-$ and CO_3^{2-} and increased with the addition of Cl^-. Addition of $H_2PO_4^-$ and CO_3^{2-} decreased the water soluble and exchangeable Pb and reduced Pb uptake whereas addition of Cl^- and SO_4^{2-} increased these fractions and Pb uptake. Application of $H_2PO_4^-$ @ 240 mg kg^{-1} soil was most effective in reducing Pb bioavailability. The results suggests that addition of $H_2PO_4^-$ and CO_3^{2-} anions lowers the bioavailability and enhances the geochemical stability of soil Pb indicating their potential for in situ remediation of Pb-contaminated soil.

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Influence of Ageing, Amendments and Soil Moisture Regimes on Ni availability in Soils

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To estimate the effect of ageing on different fractions of nickel (Ni), relationship between fractions of Ni in soil and period after contamination were investigated for addition of lime, farmyard manure (FYM) and zinc (Zn) as amendments. The soil was spiked with Ni @25 mg Kg^{-1} soil through nitrate solution. Lime, FYM and Zn were added @5%, 20 t ha^{-1} and 25 mg kg^{-1}, respectively. So treated soil samples were incubated for 1 day, 45 days and 90 days at two soil moisture regimes *viz.* field capacity and submergence. Different fractions of Ni were extracted by employing the scheme given by Ma and Uren (1998) and Ni contents were determined on atomic absorption spectrophotometer. There was a temporal decrease in water soluble and exchangeable fractions with ageing and it was in the order of 1day > 45 days > 90 days. The magnitude of this decrease was higher with the addition of amendments and it was in the order of lime > FYM > Zn > unamended soil. On the other hand a temporal increase in organically bound, oxide bound and carbonate fractions with addition of amendments was observed, but the percent distribution among these fractions varied. Not much variation was observed in the residual fraction as affected by ageing, amendments and moisture regimes. Overall, soil moisture regime did not change the direction and pathways of transformations of Ni, but it increased the transformation rate and submerged conditions showed higher metal reactivity compared with field capacity resulting in the pronounced transformation of Ni towards stable fractions. The results enable us to understand natural attenuation of Ni contamination and also to assess the effect of different amendments and moisture regimes on Ni transformations to work out the capacity of soil to serve as a source of supply of Ni.

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Carbon Sequestration in Grass based Agroforestry Systems in Loamy Sand Soils of Arid Rajasthan

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The arid region is characterized by low rainfall, frequent drought, high temperature and soil erosion. Growing sole crops is always risky in this region due to extremes of climate. Under such conditions, soil conservation practices involving grasses could play an important role in reducing soil erosion, improving productivity and sequestering carbon. Hence an experiment was conducted on biomass production and carbon sequestration in grass based agroforestry systems in loamy sand soils of arid Rajasthan. The study was conducted at research farm of Central Arid Zone Research Institute, Regional Research Station, Bikaner, India in eleven years old agri-pasture systems consisting of two grasses (*Lasiurus sindicus* and *Cenchrus ciliaris*) planted in strips with rainfed crops (clusterbean and mothbean) grown in alleys left in between the strips of grasses in 3:1 grass strip ratio. The crop was grown as rainfed with recommended package of practices. There was significant difference between the total biomass production of grass based systems as compared to sole cropping of mothbean or clusterbean. Between the two grass based systems, *L. sindicus* based systems produced higher biomass as compared to *C. ciliaris* based cropping systems. The *L. sindicus* + clusterbean and *L. sindicus* + mothbean system produced 24.4 and 12.4 percent higher biomass as compared to *C. ciliaris* + clusterbean and *C. ciliaris* + mothbean cropping system, respectively. Rate of carbon sequestration by vegetative biomass was higher in grass based system as compared to their respective sole cropping system. The *L. sindicus* + clusterbean showed maximum vegetative carbon sequestration rate over rest of the treatments. Among all the treatments, *L. sindicus* + clusterbean sequestered maximum soil organic carbon (0.40 t C ha^{-1} y^{-1}). The *L. sindicus* + clusterbean system mitigate maximum carbon (1.55 t CO_2 ha^{-1} y^{-1}) as compared to other treatments.

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Impact of Lignite Coal Originated Humic Acids on Nitrate Leaching from Vertical Soil Columns of an Inceptisol of Varanasi, Uttar Pradesh

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Humic acid (HA) is a most important component of humic substances which are the major organic constituents of soil, peat, lignite. India is rich in lignite (particularly in Rajasthan) which has sizeable amounts of humic acid that can be extracted and utilized effectively as organic fertilizers to boost up agricultural production. The lignite coal of distinctly three different layers (yellow, brown and black) was collected from Matasukh Coal Mines, Dist. Nagaur, in Rajasthan. The humic substances were then extracted and purified in laboratory following standard protocol. A vertical soil column (PVC column length: 30 cm and redius: 2.5 cm) leaching experiment was carried out in the laboratory of the Department of Soil Science and Agricultural Chemistry, Banaras Hindu University, Varanasi, Uttar Pradesh with seven different levels of three different types of lignite coal originated (yellow, brown and black) humic/fluvic acid [i.e. 0.0 (H0), 10 (HY1), 20 (HY2), 10 (HB1), 20 (HB2), 10 (HK1) and 20 (HK2) mg HA $500g^{-1}$ soil]. The vertical soil column studies were carried by spiking the solution (1063.2 mg NO_3^-) on the top of the saturated soil columns followed by constant water head flow of water at definite time interval (1,2,3,4,5,6,10 and 24 hours). It was observed that the amount of leachates from humic acid treated soil was comparatively low in which addition of (20 and 10 mg) black humic acid followed by brown humic acids as compared to control. NO_3^- and N content will be determined by colorimetric methods. The chelation and complexation of nitrogen in the form of NO_3^- by humic substances originated from lignite coal was the basic cause of the diminishing nitrate leaching soil column.

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Studies on Carbon Sequestration in Subabul based Silvipastural Cropping System under Rainfed Agriculture

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Carbon sequestration is need of the hour owing to its impact on world climate. Studies on sequestering organic carbon above and below ground under perennial tree component i.e., subabul by taking up various perennial fodder crops as intercrop were conducted. Eight year old subabul trees were intercropped with perennial grasses (APBN-1 and *Cenchrus ciliaris*) and perennial fodder legumes (*Desmathes virgatus* and *Stylosanthes hamata*), respectively. Every year three to four cuts of each intercrop were harvested. The carbon emitted besides, carbon mitigated were studied. The mean green fodder yield during three years of experimentation was highest in APBN-1+ Desmanthes intercrop (85.20 t ha^{-1}), but was closely followed by APBN-1 + Desmanthes under Stylo ground cover (80.26 t ha^{-1}) and APBN-1 alone (80.52 t ha^{-1}). Carbon sequestration in crop biomass (above + below ground) was significantly highest in sole APBN-1intercrop and this was on par with APBN-1 + Desmanthes and APBN-1 + Desmanthes under Stylo ground cover, respectively); while lowest was observed under sole crop of subabul (20.83 t ha^{-1}). There were no significant differences between the treatments with regard to soil carbon sequestration. Total CO_2 sequestered in the system (crop + soil) was highest under APBN-1 + Desmanthes (55.26 t ha^{-1}) while APBN-1 alone or coupled with Desmanthes sequestered commendable atmospheric carbon.

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Groundwater Chemistry of Upper Berach River Basin of Udaipur district of Rajasthan

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The gross catchment area of the Upper Berach river basin is 1101 km^2 and the entire area is having undulating topography. For groundwater monitoring 95 wells were identified and their GPS locations were also recorded. The pre and post monsoon water samples for 2016 and 2017 were collected and water quality maps were prepared under GIS environment. The different water quality parameters of groundwater in pre and post monsoon water samples of the study area were determined using standard methods.

The pH of groundwater varied from 7.1 to 8.7 with a mean of 7.9 in pre monsoon period and 7.1 to 8.6 with a mean of 8.01 in post monsoon period. The electrical conductivity (EC) varies from 0.38 to 7.62 dS m^{-1} with a mean of 2.35 dS m^{-1} during pre monsoon and 0.28 to 5.54 dS m^{-1} with an average of 1.56 dS m^{-1} during post monsoon period. Concentration of TDS, a measure of quality, ranged from 258 to 5230 mg L^{-1} with a mean of 1397.99 mg L^{-1} during pre monsoon and 172 to 3120 mg L^{-1} with a mean of 896.20 mg L^{-1} in post monsoon period. The mean concentration of major ion in groundwater is in the following order: cation:- sodium>magnesium>calcium>potassium during both pre monsoon and post monsoon period and anions:-chloride>bicarbonate>sulphate>carbonate during both pre and post monsoon period. The major ion chemistry data revealed that sodium and magnesium are the most predominant cationic constituents followed by calcium and potassium during pre monsoon period as well as post monsoon period.

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Chairperson : Dr. B.P. Singh, Ranchi
Co-chairperson : Dr. (Mrs.) G. Padmaja, Hyderabad
Rapporteur : Dr. O.P. Aishwath, Ajmer

Session II: Soil Fertility and Plant Nutrition–II
Chairperson : Dr. B.N. Swami, Udaipur
Co-chairperson : Dr. K. Sammi Reddy, Hyderabad
Rapporteur : Dr. Devraj, Hisar

Session III: Soil Chemistry and Soil Engineering and Technology
Chairperson : Dr. D.K. Sharma, Karnal
Co-chairperson : Dr. Sachidulal Roychaudury, Bhubaneswar
Rapporteur : Dr. Nirmalendu Basak, Karnal

Session IV: Soil Biology
Chairperson : Dr. M.C. Manna, Bhopal
Co-chairperson : Dr. N. Chandrasekharan, Coimbatore
Rapporteur : Dr. P.R. Kadu, Akola

Session V: Soil Fertility and Plant Nutrition–III
Chairperson : Dr. V.P. Ramani, Anand
Co-chairperson : Dr. B.K. Aggarwal, Ranchi
Rapporteur : Dr. Nilay Borah, Jorhat

Session VI: Soils and the Environment
Chairperson : Dr. T.K. Biswas, Australia
Co-chairperson : Dr. Sobaran Singh, Pantnagar
Rapporteur : Dr. M.L. Dotaniya, Bharatpur

Session VII: Soil Physics and Soil Education and Public Awareness
Chairperson : Dr. R.S. Chaudhary, Bhopal
Co-chairperson : Dr. P.K. Bandyopadhyaya
Rapporteur : Dr. Ashish Kumar Dash, Bhubaneswar

Session VIII: Soil Morphology; Soil Geography; Soil Genesis; Soil Classification; and Soil Evaluation and Land Use Planning
Chairperson : Dr. Jagdish Prasad, Nagpur
Co-chairperson : Dr. Krishnendu Das, Kolkata
Rapporteur : Dr. Pravin H. Vaidya, Parbhani

Session IX: Soil Fertility and Plant Nutrition–IV
Chairperson : Dr. Priyankar Raha, Varanasi
Co-chairperson : Dr. Rajeev Sikka, Ludhiana
Rapporteur : Dr. Amlan Ghosh, Varanasi

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